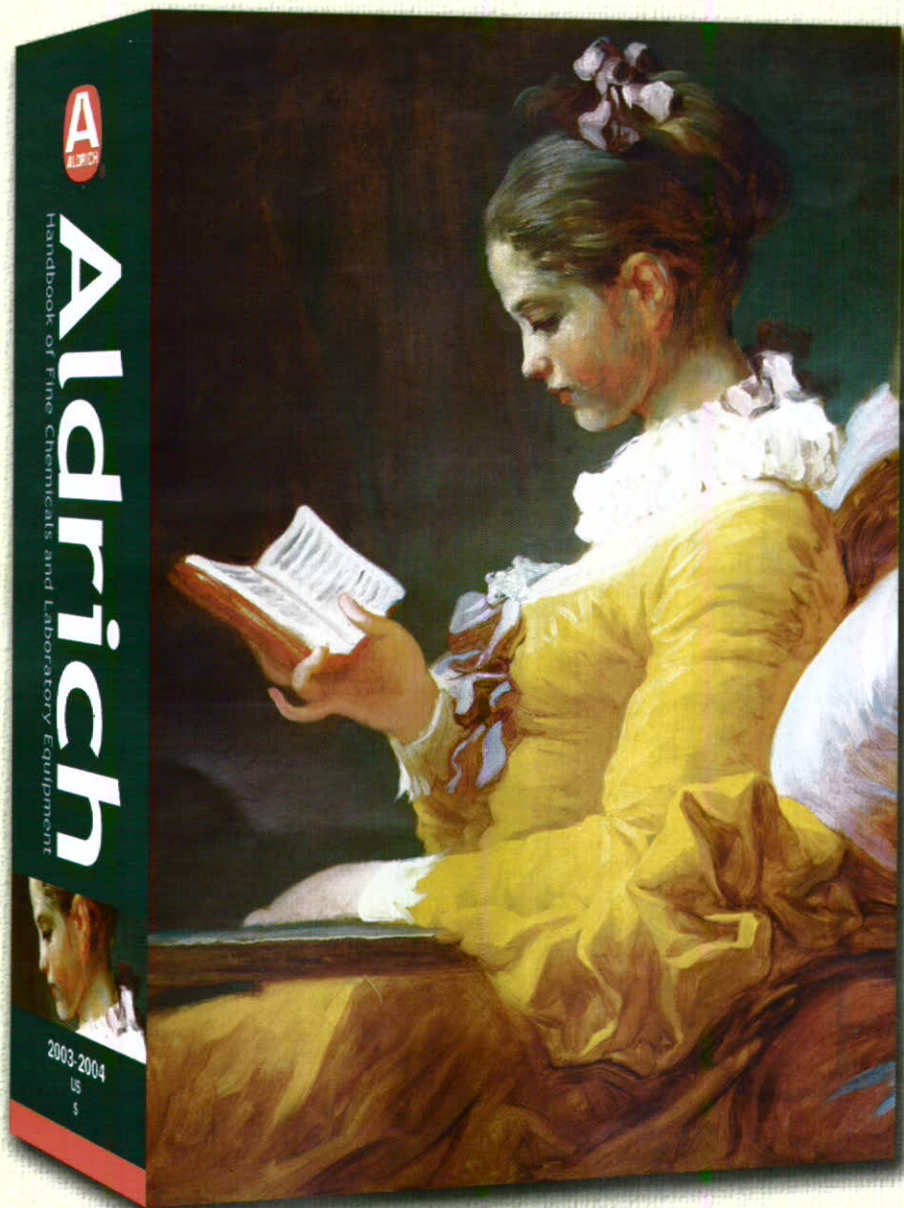




Chemistry

IN NEW ZEALAND

ISSN 0110-5566



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A Modern Classic

ALDRICH

On the cover ...

The 2003-2004 Aldrich Handbook of Fine Chemicals and Laboratory Equipment is now available. No chemistry lab should be without it!

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A Modern Classic

The 2003-2004 Aldrich Handbook of Fine Chemicals and Laboratory Equipment is now available. In it you will find more than 4,700 new products, including solvents, reagents, tools, books and computer software products.

More than just a catalogue, our handbook contains extensive technical data, application information and helpful reference materials, making it an indispensable resource. No chemistry lab should be without it!

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Aldrich is committed to new product development in several key areas including:

Combinatorial Chemistry

As a result of adapting the drug screening process to *in vitro* high throughput screening methods the pace of drug discovery has been tremendously accelerated over the past decade. The productivity enhancement in screening thousands of compounds per year has created an imperative to increase the speed with which new drug leads are synthesized. Solid phase peptide synthesis and solid phase organic synthesis are examples of synthetic methods that have been adapted to the automated, high throughput synthesis of lead compounds to answer this need. In addition to our extensive selection of building blocks for combinatorial chemistry, our chemists have developed over 100 new resins and reagents for solid and solution-phase chemistry.

The use of polymer-bound reagents to assist in the purification step of solution-phase reactions has been gaining momentum over the past few years. Scavenger resins are added to the pot after the reaction is completed in order to quench and selectively bind to excess reagents or by-products. Filtration of the reaction mixture separates the polymer-bound impurities from the product yielding pure compounds. Scavenger resins ease the purification process by providing an alternative to extractions and chromatography. Multiple scavenger resins can be used in parallel; thus, multiple reagents and by-products can be removed concurrently. The choice of scavenger resin is determined by the functionality of the impurity. Aldrich now offers two discrete supports for sequestering reagents from solutions.

CombiKits™

The emerging importance of combinatorial and high-throughput methods in chemistry has resulted in a need for specialized kits of chemicals. We are able to provide a variety of these kits by combining Aldrich's vast chemical inventory and our customized weighing process. Some of our more popular kits have included carboxylic acids,

arylboronic acids, amines, and alcohols; we are now pleased to add isocyanates to this list. Please contact us - we can create a kit tailored to your specific requirements.

Suzuki Coupling

The synthesis of biaryl compounds via the reaction of aryl halides with arylboronic acids, commonly referred to as Suzuki coupling, is an important area of growth in both synthetic and combinatorial methodologies. Of the wide variety of cross-coupling reactions, Suzuki coupling is the most general and widely used. Arylboronic acids are the favoured reagents due to their stability, low toxicity and limited side reactions in the coupling reaction. There are now over 150 arylboronic acids listed in the 2003-2004 Aldrich catalogue.

Organic Synthesis

"Fluorous Phase Organic Synthesis" (FPOS) is a novel separation and purification technique that has attracted great current interest in organic synthesis and process development, *e.g.* in the immobilization of expensive metal catalysts.¹ The unique physical properties of perfluorinated hydrocarbon compounds, *i.e.* their hydrophobicity that makes them immiscible with water and with many common organic solvents, their ability to form a homogenous solution at elevated temperatures with several of these solvents, their inertness, their solubility in supercritical CO₂ and their ability to dissolve gases contributes to the increasing popularity of the "Fluorous Phase" in organic syntheses.²⁻⁷

Catalysis performed in a two-phase reaction mixture consisting of a perfluorinated solvent and an organic solvent, also called "Fluorous Biphasic System" (FBS) was first reported by Horvath and Rabai.¹ By introducing perfluorinated ligands a catalyst is solubilized and simultaneously immobilized in the "Fluorous Phase".

By elevating the temperature the biphasic system forms a homogenous solution and the catalytic process can take place. Cooling down the reaction mixture leads to the reformation of two separate phases. Afterwards, easy product isolation and the recovery of the perfluoro-tagged metal catalyst can be achieved by simple phase separation.^{8,9} The isolation and recovery of perfluorinated components can be accomplished not only by a phase separation of immiscible liquid layers but also by solid-liquid extraction using a perfluorinated non-polar stationary phase like "Fluorous Reversed Phase" (FRP) Silica Gel.¹

Non-polar perfluorocarbon species show increased solubility in supercritical CO₂ and have been used in the design of CO₂-philic surfactants, chelating agents and ligands in order to improve the solubility of polymers, metals and catalysts.^{11, 12} The high solubility of gases,

especially oxygen, in perfluorocarbon solvents allows for efficient and selective aerobic oxidation reactions under mild conditions.^{13, 14} The "Fluorous Phase" is also discussed as a promising substitute for the solid phase in combinatorial chemistry. It permits the immobilization of a wide variety of reagents by introducing perfluorinated tags and it enables an easy, efficient isolation and recovery of perfluorinated species by liquid-liquid or solid-liquid extractions.^{4, 6, 15}

Aldrich now offers hundreds of new products in the area of organic synthesis including reagents for fluorous phase organic synthesis, aryl acetylenes, isocyanates from Carbolabs, novel organometallic catalysts, and new reagents such as the Dess-Martin Periodinane.

Grubbs' Catalysts & MacMillan's OrganoCatalysts™

In today's fast-paced environment, ready access to leading edge developments in catalyst technology by the modern synthetic chemist is a defining competitive advantage. Aldrich is pleased to announce a partnership with Materia, Inc. to offer research quantities of novel organic and organometallic catalysts from Materia's technology portfolio. Materia's olefin metathesis and OrganoCatalyst™ technologies enable the production of fine chemicals and materials in fewer steps, higher yields, and with fewer byproducts than traditional routes. Olefin metathesis is a synthetically powerful transformation in which a net exchange of olefin substituents occurs. The reaction between substrate and catalyst proceeds via the reversible formation of a metallacyclobutane intermediate. A significant evolution in the development of olefin metathesis catalysts involves the use of ruthenium-based catalysts discovered in the laboratories of Professor Robert Grubbs at Caltech.

The synthetic utility of ruthenium-based catalysts is derived from their ability to orchestrate additional metathetical transformations, including Ring-Closing Metathesis (RCM), Ring-Opening Metathesis Polymerization (ROMP), and Acyclic Diene Metathesis Polymerization (ADMET). These transformations enable the production of novel compounds and high-performance materials for the pharmaceutical and materials science markets.

Rare Chemical Library

The Library contains over 100,000 research samples for high-throughput screening, acquired from thousands of academic scientists. In keeping with our motto, "Chemists Helping Chemists in Research and Industry," we have supplied the scientific community for years with thousands of difficult-to-obtain compounds. We will continue our commitment to provide a unique service to the researcher by constantly adding to this broad spectrum of small-molecule compounds. The quality, diversity and flexibility of this service make the Library the preferred supplier of rare chemicals to the biotech, pharmaceutical, and agrochemical industries.

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Boomerang 20

The *Boomerang 20*, a device that uses extremely high energy electrons to create very bright, pinpoint beams of light a million times brighter than sunlight, will be housed at Monash University in Melbourne. The synchrotron light can be split up into different component wavelengths, such as intense X-rays, on "beamlines" so providing essential tools for science and industry for investigating molecular structures, other material properties and for medical and industrial applications. Another A\$50 million is required for the construction of the proposed initial set of nine beamlines.

Dr Gainsford has first hand experience travelling to the United States to use a Synchrotron for important research. As a small molecule crystallographer he needed to analyse the complex compounds of Immucillin H molecules with absolute certainty. His research assisted Industrial Research scientists to path the complex manufacturing process of powerful anti-cancer drugs currently in Phase I clinical trials.

Other uses of synchrotrons worldwide have been to:

- Trace the distribution of pollutants in a wetland
- Manufacture microscopic machines such as motors so small they can fit through the eye of a needle
- Analyse ore samples to establish the value of a possible mining site
- Analyse a hair sample for trace elements to determine whether Beethoven died of lead poisoning.
- Test wood to determine its load bearing capacity
- Make light bulbs that use less electricity

Contact: Graeme Gainsford, Industrial Research Ltd.
Email: g.gainsford@irl.cri.nz
Web: www.synchrotron.vic.gov.au

NZ SCIENCE SCENE

James Cook Research Fellowships Announced

Four new James Cook Research Fellowships have been announced by the Royal Society, which administers the fund on behalf of the New Zealand Government. The Governor General has now ratified the decisions of the latest James Cook Research Fellowships and the four new Fellows are listed below. The Fellowships are for two years and are full-time positions.

The New Fellows are:

Biological Sciences: Associate Professor Russell Gray, Department of Psychology, The University of Auckland, for research entitled "Language trees meet computational biology".

Social Sciences: Professor Charles Higham FRSNZ, Department of Anthropology, University of Otago, for research entitled "The origins of the civilisation of Angkor".

Health Sciences: Dr Michael Berridge, Malaghan Institute, Wellington, for research entitled "Cell surface respiration in health and disease".

Engineering Sciences and Technologies: Associate Professor Andrew Pullan, Department of Engineering Science, The University of Auckland, for research entitled "Detailed computer modelling of gastrointestinal bioelectric activity".

Professor Gaven Martin, Department of Mathematics, The University of Auckland, has been granted a one-year extension to his James Cook Research Fellowship from 1 May 2003.

The objectives of the James Cook Research Fellowships are the encouragement of sustained excellence within the particular disciplines covered by the Fellowship and the strengthening of existing and new research within the particular disciplines covered by the Fellowship. The Fellowships are awarded to researchers who are New Zealand

citizens or permanent residents and who have the requisite qualifications and experience and are able to demonstrate that they have achieved national and international recognition in their areas of scientific expertise.

Tertiary Education Commission Panels Announced

The Tertiary Education Commission has announced the chairs of the 12 review panels for the Performance Based Research Fund. They are:

- Professor Mason Durie CNZM FRSNZ, Assistant Vice-Chancellor (Maori) at Massey University, who will chair the Maori knowledge and development panel;
- Professor Erik Olssen ONZM FRSNZ, James Cook Research Fellow and Emeritus Professor, University of Otago, will chair the humanities and law panel;
- Professor Dame Anne Salmond CBE FRSNZ, Professor in social anthropology and Maori studies and Pro Vice-Chancellor (Equal Opportunities), The University of Auckland, will chair the social sciences and other cultural/social studies panel;
- Professor John Hattie, Professor of Education, The University of Auckland, who will chair the education panel;
- Professor Richard Walcott FRS FRSNZ, Emeritus Professor, Victoria University of Wellington, will chair the physical sciences panel;
- Professor Carolyn Burns CBE FRSNZ, Professor and Head of Zoology Department, University of Otago, will chair the agriculture and environment panel;
- Professor Vernon Squire FRSNZ, Chair of Applied Mathematics and Head of Mathematics and Statistics Department, University of Otago, will chair the mathematical and information technology and sciences panel;
- Professor Robert Park OBE

FRSNZ, Emeritus Professor, University of Canterbury, engineering, will chair the technology and architecture panel;

- Professor Patrick Sullivan FRSNZ, Professor of Biochemistry and Head of the Institute of Molecular BioSciences, Massey University, will chair the medicine and public health panel;
- Professor Peter Joyce, Professor and Head of Department of Psychological Medicine, Christchurch School of Medicine & Health Sciences, will chair the health panel;
- Professor Kerr Inkson, Professor of Management, Massey University, will chair the management, economics, commerce, business administration and marketing panel;
- Professor Peter Walls, Chief Executive of the New Zealand Symphony Orchestra (on leave from Victoria University), will chair the creative and performing arts panel.

SEAL Represented By Ai Scientific In New Zealand

As of January 1st 2003, Ai Scientific will supply and support SEAL products in Australia and New Zealand. SEAL is a leading manufacturer of robotics-based discrete analysers for environmental applications and is recognised as a world leading innovator in automated chemistry analysis.

For further information contact Ai Scientific. Phone 0800 08 60 60 or Email: aimail@aiscientific.com

Ai Scientific And Markes International Partnership

Markes International Limited is now represented by Ai Scientific in Australia and New Zealand. Markes is a specialist manufacturer of analytical instrumentation with products designed to automate and enhance the measurement of trace

level volatile and semi-volatile organic chemicals (VOCs and SVOCs) in real-world samples. Ai Scientific will supply and support Markes products through its network of offices across Australia and New Zealand.

For further information contact Ai Scientific. Phone 0800 08 60 60 or Email: aimail@aiscientific.com

Call For Nominations For Leeuwenhoek Medal

The Leeuwenhoek Medal, granted every 10 years to a scientist who has made outstanding contributions to microbiology over the previous decade, is being awarded this year. Nominations, which should include a description of work, relevant biographical data, and a list of publications, are due on 1 May.

For more information contact Ms Marjo Langewen, Phone: +31 20 551 0746 Email: afdelingen@bureau.knaw.nl

Fellowship Scheme To Manchester

The Department of Policy Research in Engineering, Science and Technology (PREST), in the Institute of Innovation Research at the Victoria University of Manchester, UK, wants to become a host organisation within the Commonwealth Professional Fellowship Scheme for the year 2003/2004. This new scheme provides funding for mid-career professionals residing within the Commonwealth (who are not academics), with at least five years of relevant work experience, to benefit from education, training and skills development in the management and development of science and technology policy and strategy. The Fellowship, which pays for transport, living, and conference attendance, lasts three months starting in the week beginning 5 January 2004.

Individuals interested in coming to PREST as part of this scheme should contact Dr Carol Grant-Pearce at carol.grant-pearce@man.ac.uk for an application form and other details.

Details of PREST's courses and activities can be obtained from [\[les.man.ac.uk/PREST/\]\(http://les.man.ac.uk/PREST/\) and further details of this scheme can be obtained from the Association of Commonwealth Universities website at <http://www.csfp-online.org>](http://</p></div><div data-bbox=)

New Zealand Honours

The Royal Society wishes to encourage all members of the science and technology community to put forward nominations for New Zealand Honours and seek Royal Society support of such nominations, and to particularly consider under-represented groups.

Information on how to make a nomination is available on the Honours Secretariat website at <http://www.dpmc.govt.nz/honours/nominations/index.html> and nominations for consideration in the New Year List must be received by the Secretariat no later than 1 August.

To seek support from the Royal Society for a nomination, please advise Kath Evans at kath.evans@rsnz.org or P. O. Box 598, Wellington, by 29 May. Enclose a copy of the nomination (please keep the original) for consideration by the Council of the Royal Society at its 12 June meeting. If Council agrees to support the nomination, a letter of support will be sent to include with it.

The Royal Society hopes to see a greater representation of scientists and technologists recognised in the New Zealand Honours Lists.

New Pro Vice-Chancellor At Victoria University

Dr David Bibby has been appointed Pro Vice-Chancellor, Dean of Science and Dean of Architecture & Design at Victoria University of Wellington. He replaces Professor Peter Englert who left last year to become Chancellor of the University of Hawaii at Manoa.

Dr Bibby, currently general manager of science policy at Industrial Research Limited, will start at Victoria in a month. He will be a member of the University's senior management team, reporting directly to the Vice-Chancellor, and the line manager

to whom the Heads of the schools of architecture, biological sciences, chemical & physical sciences, design, earth sciences, mathematical & computing sciences and psychology report. As Dean of Science and Dean of Architecture & Design, he will be responsible for the academic programmes in the Faculty of Science and Faculty of Architecture & Design, chairing the Faculty Boards and managing enrolment staff.

Biodiversity Condition And Advice Funds

Applications for the Biodiversity Condition and Advice Funds for 2003 are now open. The funds are a Government initiative to enhance management of indigenous biodiversity outside public conservation lands (e.g. private land or Maori land). This includes areas of native vegetation, wetlands, and the habitats of native fish, birds and other species.

A total of \$2.3 million is available for allocation; \$0.81 million in the Biodiversity Advice Fund, which focuses on providing advice to land managers, and \$1.5 million in the Biodiversity Condition Fund, which aims to improve the condition of indigenous vegetation, species and habitats. The closing date for applications is 2 May 2003. For more information on applications see <http://www.biodiversity.govt.nz/land/nzbs/land/condition.html> or contact the Department of Conservation at: Biodiversity Funds, Department of Conservation, P. O. Box 10420, Wellington, Phone: 04 471 3296, Email: biofunds@doc.govt.nz

Nominations Open For Green Ribbon Awards

Nominations are now open for the 2003 Green Ribbon environment awards.

Nominations close on 30 April and the winners will be announced on World Environment Day, 5 June. In the past 12 years, 47 individuals, businesses, voluntary organisations, schools and councils from all over New Zealand have received Green Ribbon Awards.

Information can also be found at: <http://www.mfe.govt.nz/withyou/awards/green-riNaon.html>

FRST Awards

The Foundation for Research Science and Technology is holding its Research, Science and Technology Scholarship Awards in Christchurch on Wednesday 4 June at the Hotel Grand Chancellor, 161 Cashel Street, and in Auckland on Thursday 3 July at the Waipuna Hotel & Conference Centre, 58 Waipuna Road, Mount Wellington.

Both awards events will be preceded by full-day Career Development Workshops for scholars and fellows of the Foundation's Research, Science and Technology Scholarship Programmes.

Information on the programmes and guest speakers will be posted shortly on <http://www.frst.govt.nz>

For further information contact Tracey Lewis, tracey.lewis@frst.govt.nz

Buy's Ballot Medal Call For Nominations

Every ten years the Royal Netherlands Academy of Arts and Sciences (KNAW) awards the Buy's Ballot Medal, in recognition of outstanding contributions to the field of meteorology.

Selection for the 12th Buy's Ballot Medal winner will be based on worldwide nominations, considered by a jury established by the Science Division of the Royal Netherlands Academy of Arts and Sciences. Candidates should be scientists whose achievements in the field of meteorology are outstanding and have been a source of inspiration to others. The award will be presented to an individual. The laureate of the twelfth Buy's Ballot Medal will be invited to the Netherlands to receive the award in person.

Nominations can come from institutions or individuals, but self-nominations are not accepted. Candidates should not be informed of their nominations.

Nominations should be sent by 1 June 2003, in writing (with a curriculum vitae, description of work, list of candidate's publications, and one or two key publications), to Royal Netherlands Academy of Arts and Sciences, Jury

Buy's Ballot Medal, P. O. Box 19121, 1000 GC Amsterdam, The Netherlands. To request nomination forms, please email: awards@rsnz.org

German Academic Exchange Service

The German Academic Exchange Service (DAAD) sponsors undergraduates, graduates, postgraduates and academic staff from all over the world in over 100 different programmes. The programmes are open to all disciplines. They range from language courses and work placements/internships in industry, to semester/scholarships for students, study and research scholarships for graduates, shorter research and teaching visits, and guest lectureships for academic staff lasting several years.

For information please contact the DAAD Study Information Centre NZ at daad@auckland.ac.nz or see: <http://www.daad.de>

Dr James Watson Elected President Of The Royal Society Of New Zealand

Dr James (Jim) Watson will take over from Sir Gil Simpson as President of the Royal Society, New Zealand's science academy.

Dr Watson is Chief Executive of Genesis Research and Development Corporation Limited, a New Zealand-based biotechnology company. He was research director of the company from 1994 to 1998. Dr Watson completed a PhD in Microbiology from The University of Auckland in 1967, then undertook postdoctoral work at Syntex Corporation, Palo Alto (1967-9) and the Salk Institute for Biological Studies in La Jolla (1969-75). He was Professor in the Department of Microbiology at the University of California (1976-80) before returning to The University of Auckland as Professor of Microbiology. He founded the Department of Molecular Medicine and served as Head of Department from 1983 to 1993.

Dr Watson said, "I am honoured to serve as the President of the Royal

Society. Ours is a time of great change in the way science is recognized and used in the world. I look forward to the challenges of promoting science to youth, using science and technology to help grow our economy, and achieving recognition for scientists, whose great talents and creativity have such a profound impact on the society in which we all live."

Chief Executive of the Royal Society, Dr Steve Thompson, said, "Sir Gil has taken a strong lead, through his role as President of the Royal Society, in linking New Zealand's knowledge base, its industry, society, science and technology into a closer working relationship. As he reaches the end of his presidency, Sir Gil's pioneering effort will be enthusiastically taken up by another pioneer in linking science and business to the profit of both: Dr. Jim Watson."

Dr Watson will take over from Sir Gil at the 13 June meeting of the Royal Society Council in Wellington.

World-Leading Designers Immerse New Zealand Businesses In Innovation

Some of the world's leading industrial designers have been confirmed to lead New Zealand business people through the process of design and innovation at the design industry's third annual series of workshops, to be held in Christchurch in April.

This year's workshops centre on six themes – engineering, plastics, environmental, timber, industrial technology and packaging. They will be held at the University of Canterbury's School of Engineering. The international designers confirmed to guide the workshops are:

- Janice Kirkpatrick (Scotland)
- Mats Theselius (Sweden)
- Oliver Vogt (Germany)
- Hermann Weizenegger (Germany)
- Jan Konings (The Netherlands)
- Matt Sindall (France)

As understanding grows among the New Zealand business community that design-led companies enjoy greater success in the market, the design industry workshops are coming

into their own as the only hands-on innovation process available in New Zealand.

The designers and business leaders taking part live, eat, breathe and create innovation.

Participants immerse themselves in the design process for five days, exploring themes such as engineering, plastics, environmental and industrial technology, timber, and packaging.

"The emphasis is on answering the question: 'How can I increase the margins in my business?'," says Dorenda Britten, who established the workshops in 2000. "The workshops enable decision makers to integrate design into the way their business works – not necessarily as a form of ornamentation, but as a force that propels their product or service to the front of the queue in terms of buyer desire."

"Our experience – and that of previous participants – is that design-led product development that stands out in your market is a key way to command a higher margin and to ensure more sustainable market success," she says.

German industrial designer Hermann Weizenegger, who with his business partner Oliver Vogt set up the acclaimed Berlin-based Vogt & Weizenegger (V&W) design studio, will lead one of the six design industry workshops in April. Vogt is also leading a design industry workshop.

Weizenegger was behind the Sinterchair, which was created at the Tendence trade fair in Frankfurt last year using the sintering technique usually applied to build vehicle and aviation prototypes. Based on an idea that furniture could be designed like made-to-measure suits, Vogt and Weizenegger designed, generated and manufactured the chair before visitors' eyes.

Weizenegger says he aims to help participants understand the role played by design in the entire manufacturing process from creation to distribution. "Design can create an identity for a company that is different to that of the competition. It can be the engine of the entire history of a company," he says.

The well-designed products of well-designed companies.

Commercial refrigeration and heating equipment designer and manufacturer Skope sponsored the 2002 workshops and enrolled its marketing manager in one of the workshops.

Managing director Guy Stewart says his company supports the workshops because they help New Zealand businesses to create a more desirable, more competitive and better product than businesses in countries competing in the same arena. "Design will allow New Zealand to grow as a niche design source with higher margins that take products through their first growth stages before the maturity stage, when high manufacturing volumes give the cost and skill advantage to other countries."

Industry New Zealand southern regional manager Paul Claridge says the design industry workshops segue well into the Government's drive to put New Zealand innovation on the map. "Design industry workshops support our goal of seeing New Zealand businesses attracting higher value, enabled by design-led principles, by helping business leaders to think from a fresh perspective."

The workshop dates are Sunday to Friday, April 6 – 11; Saturday to Thursday, April 12 – 17; and Monday to Saturday, April 21 – 26.

For more information, profiles of the designers and case studies, visit www.designindustry.co.nz/workshop Contact: Dorenda Britten, Director, Design Industry.

Phone: (03) 963 9585

Free Phone 0800 FOR DESIGN

Email: admin@designindustry.co.nz

New Zealand Scientists Endorse Australian Synchrotron Project

Industrial Research scientists hope to boost New Zealand's involvement with the Australian Synchrotron project – a multi-million dollar "bigger, better and brighter" light source known as *Boomerang 20*, due to start-up in 2007.

New Zealand scientists joined over 300 Australian experts at a Synchrotron Users workshop in Melbourne last month, to make recommendations on the A\$157.2 million project.

Although Prime Minister Helen Clark has already officially endorsed the project, the New Zealanders wanted to emphasize to the Australian scientific community the importance of our researchers having access to world leading technology such as the synchrotron.

The New Zealand contingent, Drs Graeme Gainsford and Donald Pooke from Industrial Research, Associate Professor Jim Metson, New Zealand's representative on the national scientific advisory committee, and Dr Geoff Jameson from Massey University, believe the potential of this project is huge for New Zealand.

"Currently both New Zealand and Australian scientists requiring synchrotron facilities must fly to Japan, Europe or the United States which obviously adds costs to the exercise," Dr Gainsford said.

As representatives of Industrial Research, Drs Gainsford and Pooke were also interested in any appropriate uses for Industrial Research's High Temperature Superconductor (HTS) wire or HTS coils in either the applications or the storage ring part of the synchrotron.

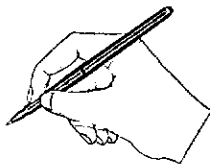
"We are keen for Industrial Research and New Zealand contractors to be a part of this project. There might be some spin-off business – either with the construction phase of the Synchrotron building(s) and associated facilities, or any of the components.

"To this end we have invited the *Boomerang 20's* Technical Director, Alan Jackson, to visit Industrial Research's Gracefield site later this year to discuss New Zealand's possible involvement in the project, particularly in the construction phase," Dr Gainsford said.

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Letter To Editor

Dear Editor,

Recently I was in Waihi Beach and went into a health food shop. For a large amount of money, you can buy from this shop a product called C4 water. According to the <Fact> sheet:

"Energised Micro Cluster C4 sets a previously unachievable standard for bottled mineral water. C4 is natural spring water with an ideal balance of minerals. Average or normal water is made of H₂O with "molecule groups" of 10-18. These groups are commonly referred to as "Clusters". C4 water has molecule clusters of 3-4. Small clusters produce softer water with less surface tension. Less surface tension means better cell penetration. This means "better cell hydration".

Correct hydration means:

Softer vibrant and healthier skin. Healthy metabolism and increased energy. Optimum mental alertness, concentration and motivation. Efficient elimination of wastes and toxins. Better use of available nutrients. Fluid and electrolyte balance. A healthier and longer life. Better heat and cold tolerance.

Incorrect hydration means:

Poor nutrient uptake. Sluggish cell elimination of wastes and toxins (may lead [sic] to chronic disease). Disturbed metabolism (low energy and weight gain). Reduces skin elasticity and recoil ability (old looking skin/premature signs of aging).

Reasons for consuming C4 water: Supreme hydrating qualities. Can be used as everyday drinking water. Cleansing and detoxification programmes. Digestive problems. Disease prevention. For enhanced health and longevity. Circulation problems.

FACT Smaller molecule clusters will hydrate tissue cells (human body) far more efficiently than larger molecule clusters. Optimum hydration is achieved at room temperature".

I would be interested in comments from the NZIC community on these facts (?) and whether members feel that NZIC (through Council) should or would take issue with the manufacturer and claim maker.

Regards,

Evan Jones

Technical Manager Water Treatment Division
Spirax Sarco Ltd.

Comments from readers are welcome(Ed.)

Treated

- The

The recent past has seen much activity in the media and among environmentalists with concerns about the safety of treated timber, the leaching of copper chrom arsenate into playground soils, and the ability of children to be over-exposed to such chemicals merely from playing on decks constructed from treated timber. We reproduce below (with permission) two short articles by Chris Mirams that appeared in *The Dominion Post* on 4 December 2002. A counter article by Jack Hawkins (President, New Zealand Timber Institute Federation) appeared in the same paper and, while we were given permission to reproduce this also, we elected to solicit an article by Dr. Mike Hedley of the Forestry Research Institute as Mr. Hawkins cites him frequently. The environmental issues raised by Mirams cite Dr. Richard Maas of the University of North Carolina Environmental Quality Institute. He has accepted an invitation to provide the conclusions from his environmental/analytical studies in the June issue of *Chemistry In New Zealand*. *The Dominion Post* has more recently reported through Chris Mirams that the EEC has now agreed to ban use of these preservatives.

Brian Halton (Ed.)

Ministry urged to test soil in playgrounds*

*Reproduced with permission from *The Dominion Post*,
Wednesday December 4, 2002, p.A4

The Health Ministry has been called upon to initiate health warnings and local councils have been urged to conduct soil testing in playgrounds with equipment made from arsenic-treated timber. Green Party health spokeswoman Sue Kedgley said the ministry must take a more proactive role in the growing debate over timber treated with chromated copper arsenate (CCA) and its health side effects. "We know there is a risk, so it is essential that all councils take these steps to reassure parents and to minimise the risks to children of harm from exposure to CCA treated timber," Ms Kedgley said.

The ministry said it issued notices to public health services early last month and again yesterday. A spokeswoman said the department had no control over local councils or how that information was used to inform the public. The updated version sent out yesterday stated that food should not be placed directly onto CCA wood and that children should wash their hands before drinking or eating after touching contaminated soil or the timber itself. It also included significant "industry related" information including a background on its history of use, how it is fixed to the wood and that "in New Zealand no alternative preservatives are commercially available."

Ms Kedgley also urged councils to begin testing playgrounds for arsenic and chromium levels in the soil,

Timber In New Zealand

Debate

and to start sealing the timber that is in parks and playgrounds. Treated timber has been proven to leach both carcinogenics into soil, and there is new evidence that the chromium can, when washed with some oxidising solutions, revert to its highly toxic hexavalent form made infamous in the Academy Award winning film *Erin Brockovich*. Long term, Ms Kedgley wants councils to look at non-toxic alternatives, begin a programme of replacing CCA timber in use, and to remove toxic soil from playgrounds.

Wellington City Council has already started a soil testing programme, prompted by tests conducted by *The Dominion Post* last month that revealed excessive levels of arsenic in some playgrounds. The council gave no indication of what parks had been tested or when results might be made public, but said early indications were it "will not be significant." The council did concede that "assumptions about timber to hand and hand to mouth transfer of arsenic are critical factors in the debate." It also said it would not erect signs in parks with equipment made from treated timber unless the Health Ministry thought it necessary.

Hutt Valley City Council said the cost of soil testing – \$1000 to \$1300 for each of its 55 playgrounds, exceeded its entire maintenance and inspection budget of \$65,000. "We are continuing to monitor this issue, and in the absence of any national directive [from the Health Ministry] we would be loathe to act unilaterally, particularly when you consider that there is quite a bit of conflicting expert advice around," the council said in a statement. "Our view is that we would need to be directed by either the Ministry of Health or the Playgrounds Standards Committee before we took any significant action. We also believe any action should be adopted in concert with other local authorities. Any steps that may be proposed must be appropriate and reasonable."

Leading timber industry figures met with the Forestry Minister, Jim Sutton, on Friday.

Chris Mirams

Expert wants to assess New Zealand risk levels*

*Reproduced with permission from *The Dominion Post*, Wednesday December 4, 2002, p.A4

New Zealanders will be able to test the level of arsenic in treated timber around their homes and be part of the first major research project on the subject here headed by leading American researcher Rick Maas. Dr. Maas' research on the lifetime risk of cancer from being in contact with treated timber was presented to America's Environmental Protection Agency in February. It highlighted greatly enhanced risks of cancer from being in contact with treated timber in everyday situations. Now,

Dr. Maas wants to run a similar project to assess the levels of risk for New Zealanders. No testing programme has ever been done in New Zealand on treated timber and its health risks.

Dr. Maas, who has a PhD in environmental chemistry, founded the Environmental Quality Institute at the University of North Carolina and has presented several reports on lead in water and arsenic-treated timber to the United States Environmental Protection Agency.

A test-kit, bought online, enables people to do a wipe-test on a treated timber surface and have it analysed at the university. The results will be returned within two to three weeks along with options to minimise the risks of danger should high levels be found. Dr. Maas said the collated statistical data – not individual reports – would be available to government organisations such as the Environmental Risk Management Authority and the Health Ministry. A total of 200 samples would return strong scientific results and anything near 1000 "would be a powerful study and irrefutable".

"Each person who sends in [a test] will have a different aged deck, a different history of treating the deck, different conditions," Dr. Maas said. "The more samples we have, the more we will be able to say about things like deck sealants and the amount of arsenic that comes off a playset, a deck railing and other items."

The authority said late last week that it would review data on treated timber with the objective of deciding if the registered pesticide should be put on its priority list for reassessment next year. ERMA's chief executive Bas Walker said the authority would consider any information provided by Dr. Maas as a result of the study. "Of course we'd look at the material. At this stage everything is grist to the mill," Dr. Walker said. The ministry said it would also review data from such a study.

The University of North Carolina first used test-kits in 1988 in checking levels of lead in drinking water. Since then, approximately 140,000 have been received for analysis of drinking water as well as arsenic in treated timber. A paper compiled from such tests on the presence of lead in water was presented to United States authorities and helped set new laws.

"This would be a way for every family in New Zealand to protect itself," Dr. Maas said. "About 40 per cent of the people who sent in kits in the US got good news. The test will tell you if you have a hazard or not." The results would also contribute to ongoing research at the university on what sealants are effective long term. That research indicates at present that sealants appear to block out arsenic on treated timber surfaces for only six months.

Chris Mirams

Copper Chrome Arsenate Wood Preservatives: Their Use And Their Future In New Zealand

Mick Hedley BSc, PhD

Forest Research, Rotorua, New Zealand

Development of Wood Preservation in New Zealand

Although, by far, now the country with the highest per capita use of preservative treated wood, the industry in New Zealand had a hesitant start. During the second quarter of this century, it became obvious that because of dwindling supplies of quality durable timber from indigenous forests and scarcity (and thus increased costs) of imported naturally durable timber, plantation grown species - chiefly radiata pine - would increasingly have to supply most of the country's timber needs.

In the 1940s, a Government Agency - the State Advances Corporation (SAC) - was the principal financier of domestic dwellings, both as owner of rented properties and as mortgagor for privately owned properties. Mortgages were usually spread over 25 or 30 years, and since the property was security, it followed that SAC required a minimum life of 25 or 30 years for the property.

In the late 1930s, the Corporation, already expressing some concern at the quantities of borer-susceptible sapwood of indigenous timbers being used, was positively alarmed at the prospect of building with plantation exotic species. As a result, the Department of Scientific and Industrial Research (DSIR) set up an organisation known as the *Timber Protection Research Committee* in 1938 for the purpose of testing and approving wood preservatives. Its secretary and most active member was the SAC Technical Officer. He developed a simple dip treatment based on dilute zinc naphthenate, which was adopted by the Corporation as the only approved treatment for building timber.

How effective this treatment was is not known, but after the end of World War II, a Mr. Wright, who had been New Zealand Scientific Liaison Officer in England during the war, returned to New Zealand to establish a branch of Hickson Timber Impregnation Co. Hickson's pressure treatment with Tanalith® U - a fluor-chrome-arsenate-phenol formulation - was readily accepted by the Corporation and, in turn, it became the only approved preservative treatment.

Meanwhile, in Australia, the increasing use of Lyctus-susceptible hardwoods had led to the development of borates to immunise such timber against attack. This work was taken up at the DSIR in New Zealand and it was demonstrated that effective treatment of indigenous timbers and radiata pine, to protect against insect borer attack, could be achieved by a momentary dip/diffusion treatment.

Conflicting claims made by the proponents of pressure treatment with Tanalith® U and boron dip/diffusion treatments resulted in the Corporation's refusal to accept the latter for treatment of internal building timber. To resolve this conflict, in 1952 Government set up a Committee of Enquiry into the effectiveness of treatment

with the DSIR borax-boric acid process. Evidence provided by DSIR was accepted as proof of effectiveness of borates as wood preservatives and the Committee found in its favour. However, the Committee was deeply concerned with lack of co-ordination between government agencies and private sector groups involved with wood preservation. It recommended:

1. The publication of a standard specification of timber-preservation treatment.
2. The enactment of legislation to provide for a particular Government agency to control timber preservation generally, to approve treatment plants, and to police timber preservation, such legislation to include provisions regarding the branding, marking or colouring of treated timber according to the type of timber and the type of treatment.
3. The establishment of a comprehensive and continuing series of field tests accompanied by accurate service records.
4. The setting up of a timber preservation authority to control and co-ordinate activities in relation to timber preservation generally.

A result was the establishment in 1955 of the *Timber Preservation Authority (TPA)* and enactment by parliament of the *Timber Preservation Regulations*. In 1987 this was disbanded following the government of the day's policy of deregulation of industry in New Zealand. The Timber Preservation Council, an industry organisation and part of the New Zealand Timber Industry Federation replaced it. It issued new timber treatment specifications that were based on the old TPA specifications. These are in the process of being raised to a full standard by Standards New Zealand.

Copper Chrome Arsenate Wood Preservatives

Copper chrome arsenate (CCA) preservatives were invented by Sonti Kamesam at the Forest Research Institute and Dehra Dun (India) and were patented by him in 1933. In CCA, copper and arsenic salts or oxides are the principal biocides, which are "fixed" in the wood by chromium salts (or oxide) in a series of complex reactions that are discussed later. The original formulation was prepared from copper sulfate, arsenic pentoxide, and potassium dichromate. Over the years a number of different formulations have been developed with the dual aims of increasing biocidal effectiveness and improving fixation.

Both the arsenic and copper components are derived from waste products; arsenic from arsenic trioxide, a by-product from copper and gold mining, and copper from redundant telephone lines. Approximately 60,000 tonnes of arsenic trioxide are produced annually. It has been noted that if CCA preservatives were banned, the production of arsenic would not cease and the problem of what to do with this unwanted arsenic trioxide emerges.

History of Use in New Zealand

CCA preservative (Tanalith® C) was first used in New Zealand in 1958 as a replacement for Tanalith® U, a formulation based on fluoride-chrome-arsenate-phenol formulation, although testing of CCA under New Zealand conditions had commenced earlier, in 1955. This soon became the dominant preservative for treatment of timber that was to be used in moderate to high decay hazard situations (above ground exposed to the weather and in ground contact). Use was later extended to the protection of timber exposed in seawater. Only for some timbers, such as Douglas fir and larch, which are impermeable to water-borne preservatives, and for the treatment of railway sleepers, where protection against splitting and corrosion are important, has a place been found for the oil-based preservatives creosote and pentachlorophenol. A number of changes to formulations were made over the years, but in 1982 results from field tests had demonstrated that AWWA Type C formulations were the most effective in controlling decay.

Originally application was by full cell vacuum/pressure treatment of air-dried stock. This process differed little to that patented by John Bethell in 1838! Fungal degradation of roundwood during air-seasoning saw the development of steam conditioning to reduce wood moisture contents as an alternative to air-seasoning. A treatment process that employed short oscillating cycles of pressure and vacuum that gradually forced the preservative solution into the wood followed this. A variant of this, the Alternating Pressure Method uses similar cycles, but instead of drawing a vacuum during each cycle, the pressure is returned to atmospheric pressure. This process is now almost invariably used for the treatment of roundwood.

The traditional Bethell Process saturates the wood during treatment, which leads to difficulties in re-drying after treatment. Low uptake processes, in which the initial vacuum reduced or overcame these difficulties, were subsequently developed. An advantage of such low uptake processes is that fully machined timber can be treated without causing undue swelling. The wood does not have to be planed after treatment and thus potential problems with disposal of treated shavings are avoided.

CCA Fixation

The chemistry of CCA fixation is complex and is still not fully understood. The pH of CCA treatment solutions is about 1.8-2.0 while wood has a pH of around 4.5. Fixation begins when the solution is injected into wood and continues for an indeterminate time after. The general reaction scheme can be divided into three phases:

- A rapid (minutes) initial absorption of chromium(VI) [CrO_4^{2-}] and Cu(II) to wood components in which about 50% of the total Cr(VI) is removed from the solution.
- Subsequent main reactions in which free Cr(VI) is reduced to Cr(III) over a reaction time of several hours and accompanied by a rise in pH. A number of low solubility compounds involving all components are formed. These include CrAsO_4 , CuCrO_4 , Cu(OH)CuAsO_4 , $\text{Cr}_2(\text{OH})_4\text{CrO}_4$, and wood complexes with Cr(VI), Cr(III) and Cu(II).
- These are followed by possible long-term reactions that may extend over several months and which involve fluctuations in pH; reports of these reactions are limited.

For practical purposes, fixation is considered to be complete when all the Cr(VI) is converted to Cr(III). This is determined by a chromotropic acid test on samples taken from the treated wood.

Most CCA fixation at treatment plants occurs under ambient conditions; most operational guidelines suggest a minimum period of 48 to 72 hours. However, the rate of fixation is highly temperature dependent and during winter months it may take several weeks before fixation is complete. Because of this, a number of processing options have been developed to accelerate fixation, the most popular of which is use of steam.

During the 1990s, scientists at Forest Research, in co-operation of Koppers-Hickson Timber protection (now Koppers Arch Wood protection) developed a process that utilises hot (75 °C) CCA solutions and a unique application schedule in which treatment and accelerated fixation is achieved simultaneously. Called the *Multiple Phase Pressure Process* (MPP), greater than 95% fixation was achieved using a processing time of under two hours with the timber emerging from the treatment plant touch dry. The process generates a waste stream containing residual CCA at the ppm level. To date some technical/economic problems associated with the disposal of this waste have not been resolved sufficiently to allow commercial application of the process.

Importance Of CCA Treatment To The New Zealand Economy

In its natural state radiata pine is not resistant to decay. Without preservative treatment its use would be limited to feedstock for pulp manufacture, fibreboard, furniture, and packaging materials. Preservative treatment has increased its versatility enormously, and, with very few exceptions, it can be used for any timber commodity. Under the influence of the Timber Preservation Authority, the industry grew remarkably stable, and public confidence in the use of treated timber and durability expectations increased. Indeed, the typical "man-in-the-street" in New Zealand probably knows more about treated timber than his counterpart in any other country. Likely reasons for this are:

- New Zealanders are, often by necessity, great exponents of "do-it-yourself".
- Wood has always been the principal construction material.
- The New Zealander knew which native timbers could be used for which purposes (in-ground, above ground, or interior).
- Hence, when these were no longer readily available, people had to recognise different forms of treated pine for different uses.

There can be little doubt that people were helped by advertising (chiefly by the TPA and New Zealand Wood Preservers' Association), typically through wall charts displayed at timber merchant outlets explaining the meaning of different treated-timber brands.

The role of Hickson Timber Impregnation Ltd in this advertising cannot be over-estimated in creating this awareness. "Tanalised®" - the Hickson (now Koppers Arch) trademark - quickly came to be "tanalised®" and synonymous with "treated for exterior use or ground contact".

Today, “tanalised” still remains the recognised and most used adjective for treated timber, even though a significant proportion of timber treated with CCA is not treated with Tanalith®. But “tanalised” is associated with almost limitless durability and “tanalised timber” is expected to last almost indefinitely in virtually all exposure situations.

Since the mid-1960s, CCA treatment has steadily expanded, and over the past decade it has accounted for 70-75% of all timber treated in New Zealand. It is, without doubt, the most cost effective treatment to confer long-term durability. Similarly, there is no doubt that the rapid expansion of kiwifruit orchards and vineyards, which has occurred during the past 25 years, could not have taken place without the availability of CCA-treated radiata pine posts.

Current Issues With CCA Preservatives

Restrictions on the use of CCA preservatives have been in place in several countries for many years, particularly in Scandinavia, Switzerland, Germany, and Japan. There have been a number of reasons for this, mainly a perceived potential for adverse impact on the environment, and issues of disposal at the end of service life. These restrictions have had, and have, little impact on the timber treatment industries in those countries. For example, CCA has never been popular in Germany where copper-chrome-boron and copper-chrome-fluoride have been the main preservatives where heavy-duty use is required.

A much greater impact on the preservation industry began in the mid-1990s, when use of CCA preservatives came under the spotlight in the USA. This was mainly through class action suits against preservative manufacturers, and treaters, by people claiming to have illnesses or injuries from exposure to CCA-treated wood. Added pressure from environmentalists resulted in the USA wood preservation industry agreeing, in February 2002, to the voluntary restriction in use of CCA by December 2003. This will virtually eliminate CCA treatment of timber used in the domestic environment, such as decks, playsets and domestic fencing. The European Commission has now promulgated similar restrictions, with a similar time-line for implementation.

An important factor in the USA decision has been the link between arsenic in drinking water and cancer, particularly bladder and lung cancer, and proposed changes to the limits of arsenic in drinking water from 50 µg/L to 10 µg/L. The change was primarily based on dose-response models and extrapolation from a cancer study on a Taiwanese population exposed to high levels of arsenic in its drinking water.

A number of scenarios were then developed concerning the lifetime risk of developing lung or bladder cancer to levels of arsenic in drinking water. However, even at the highest risk estimates, it was concluded that increases in cancer due to arsenic in drinking water would be difficult to detect statistically in the US population. It was also noted that a lifetime excess risk of bladder cancer incidences in males of 45 per 10,000 population would represent only 13% of the total risk for bladder cancer in the USA from all causes.

These risks were then applied to hand contact with CCA-treated timber - the amounts of arsenic likely to be

dislodged by such contact (estimated from “wipe tests”) - and the potential for ingestion (particularly by young children) by transfer from hand to mouth. The US Consumer Products Safety Commission (CPSC) estimated that the increased cancer risk to children who contacted CCA-treated timber ranged from 2 in 1 million to 100 in 1 million. By comparison, 1 in 10,000 non-smokers (0.01%) gets lung cancer! So, based on the CPSC estimates, playing on CCA-treated playground equipment might increase one’s lifetime risk of lung cancer from a base-line lifetime risk of 0.01% to between 0.0102% to 0.02%. Despite all the risk assumptions made to date, there is not the slightest evidence linking cancer to contact with CCA-treated wood.

When the US EPA announced the voluntary restrictions on use of CCA, it noted:

“EPA has not concluded that CCA-treated wood poses unreasonable risks to the public for existing CCA-treated wood being used around or near their homes or from wood that remains available in stores. EPA does not believe there is any reason to remove or replace CCA-treated structures including decks or playground equipment; EPA is not recommending that existing structures or surrounding soils be removed or replaced.”

Also, an independent panel of eminent physicians appointed by the Florida State Department of Health recently concluded that CCA-treated wood is safe for use in playgrounds and recreational facilities after a year-long review of this issue. It seems unlikely that there will ever be a sensible resolution to this issue, particularly as emotion will tend to rule over any scientific argument.

Alternatives To CCA

In New Zealand two wood preservatives have been registered as alternatives to CCA. Both are free of arsenic and chromium:

- Alkaline copper quaternary (ACQ) - a mixture of a copper salt and dimethyldidecyl ammonium chloride, formulated as an alkaline mixture – an ammoniacal solution is most common.
- Copper Azole (CuAz) – an aqueous mixture of a copper salt and a triazole fungicide, plus boric acid.

Both have been evaluated in field tests in New Zealand for a number of years. For ACQ there is also a considerable amount of data from tests in USA sites, notably at the very high decay hazard site at Hilo, Hawaii. In most ground contact situations their performance to date has been comparable with CCA, although on test sites that contain populations of copper-tolerant decay fungi, they perform less well than CCA.

Only Copper Azole has been tested in New Zealand in above ground (H3) situations and to date performance has been equivalent to that of CCA. However, ACQ has been tested in an above ground situation in Australia (Innisfail, North Queensland), where performance has been equivalent to that of CCA. It would not be unreasonable to assume that ACQ will perform at least as well in H3 Hazard Class uses under New Zealand conditions.

Since it is expected that any market increase in use of ACQ and CuAz will be predominantly in the H3 situation and not H4 (ground contact), the lesser effectiveness of these preservatives in ground contact may not be a significant commercial issue.

Conclusions For The Future

There is little doubt that by adopting CCA preservatives as a standard, the wood preservation industry in New Zealand picked a winner. When used to treat permeable softwoods, these preservatives have been shown to impart almost limitless durability and for forty years or more, CCA-treated timber has been in New Zealand, an indispensable commodity.

With permeable species, such as radiata pine, where deep penetration can be guaranteed, durability becomes a function of retention. Thus, when premature decay of horticultural posts became evident in New Zealand in the 1980s, merely increasing the preservative retention apparently solved the problem.

Due mainly to environmental and, now, health concerns, use of these preservatives is set to decline in favour of "new generation" products perceived as being more "sensitive responses" to the environment and health issues. Both old and new are likely to co-exist for some time, but it is probably inevitable that use of CCA will become restricted in New Zealand, although perhaps not to the same extent as in the USA and Europe. For example, it is difficult to conceive an economical alternative in New Zealand to CCA-treated posts in agriculture and horticulture – uses for which CCA is now being withdrawn in USA and Europe.

New Zealanders have come to expect long-term durability (50+ years) for CCA-treated timber and there are supplier guarantees for this length of serviceability for some commodities. Whether or not the replacement products will perform as well remains to be seen. Although it can be argued that this is desirable, the very "sensitivity" or "environmental friendliness" of the replacements would seem to make this unlikely in practice.

But this should be an acceptable "trade-off" and in many respects it may have more benefits than drawbacks, so long as durability expectations are established at the outset. Thus, if one can predict that the service life of a product treated with the "new" will be half of that treated with the "old", but at the same time, being able to demonstrate that at the end of this shortened service life there are few, if any, of the disposal problems associated with the "old", from several viewpoints there may be net social and environmental gains.

Coupled with the provisions in the New Zealand Building Act, this allows much scope for "designer" preservatives, viz. ones that will confer a predictable, limited life, but which allow environmentally acceptable disposal

options at the end of that life. Thus, it becomes increasingly important that protocols for evaluating new preservatives are designed and conducted in a manner which will allow for accurate prediction of service life, together with some realistic limit on the extent of reduction in expected durability.

Perhaps unfortunately (in Australasia at least), there is still the temptation to "benchmark" performance of new formulations against CCA preservatives as the only criterion for acceptability. It would seem more logical (indeed, more rational) to "benchmark" wood treated with them against competing non-wood products. In this case, durability (resistance to biodeterioration) is but only one of several measurable parameters that contribute to "fitness for purpose".

It then becomes less a question of: *Does a timber deck treated with "Envirocuddlee" last as long as one treated with CCA?*, but more a question of: *How does an Envirocuddlee-treated deck stack up against competing, non-timber products?* This, of course, brings us into the world of Life Cycle Assessment; a world using criteria which, when applied to preservative-treated wood, make it capable of more than holding its own against competing materials.

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NZIC Presidents Report 2002

Patrick Holland, NZIC President 2002

Cawthron Institute, Nelson

The Presidential Report was presented at the NZIC Annual General Meeting held at Victoria University on Wednesday 6 November 2003.
(Ed.)

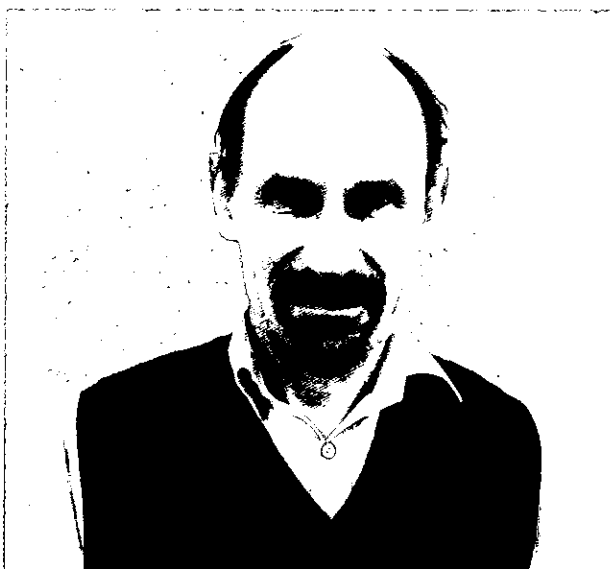
The operations of the NZIC for 2002 have been mainly steady-as-she-goes. Being a conference year most of the action has revolved around the Branches. During my tour of the Branches I was pleased to meet with many members and gauge the generally good levels of enthusiasm and wide range of activities taking place. However, there was a common problem of only a small proportion of members attending meetings regularly and executive responsibilities being shouldered by the few. My thanks, on behalf of the whole Institute, to the Branch Committees for their efforts.

The revival of our NZIC Journal, *Chemistry in New Zealand*, begun in 2001, has continued under the editorship of Brian Halton. He is demanding and achieving high standards for every issue with the assistance of each Branch in rotation. Branch News is one of the most popular sections of the journal and it is pleasing to see the increased level of chemistry news, views and articles in recent issues. Our journal is now superior to the RACI product and long may this continue. I encourage Branches to maintain their commitment to these editorial efforts. It should be recognized, however, that the journal is now also a significant cost to the Institute as the publishers ANCAT are requiring \$2000-\$3000 per issue to top up revenue from advertising.

Administratively, the ANCAT secretariat provides a stable arrangement but these services are under constant review as to cost-effectiveness. New database software has recently been installed. There are a number of potential benefits for accounting and tracking of membership that are yet to be fully realized.

The mail survey of members' views on current and future potential benefits of NZIC membership has provided some valuable guidance to Council (see *Chemistry in New Zealand*, 2002, 66(3), 8-9 – some more returns have raised the overall participation but not changed the conclusions). In addition to the specifics on likes-dislikes, the survey has highlighted the need for some strategic planning on the future of the Institute. Although membership numbers

are stable, we are an aging population of chemists and these demographics will strongly influence our future. We need to review the nature of the services provided to long-standing members while enhancing our appeal to younger chemists so as to capture their interest in membership. The President, Past-President and Vice-President have taken responsibility to develop a strategic plan during 2003 covering all areas of the Institute's operations. This will provide some guidance and continuity for future Councils.



The other area of strategic activity has been through the Royal Society of New Zealand. The efforts of Chief Executive, Steve Thompson, to raise the profile of New Zealand science and engage professional societies in dialogue with government are strongly supported by the NZIC Council. Our second Vice-President, Andrew Brodie, has joined the RSNZ Council. We see this as the most practical route of achieving members wishes, namely that NZIC be more

proactive with respect to national issues.

Council has seen fit to support two initiatives to raise the profiles of three of New Zealand's most distinguished scientists. Grants have been made to a memorial being established in Havelock to Rutherford and Pickering, and towards a portrait of Maurice Wilkins to be unveiled in February next year.

Other significant national activities include ChemNZ (Alan Happer, Denis Hogan – Eds.) with finance from the Royal Society for Chemistry, and the Chemistry Olympiad (Robert Maclagan - Organiser). Both are coordinated from Christchurch and have a degree of independence from the Institute. However, they are of high national and international significance and deserve more support from the other Branches than currently appears to be the case. My thanks go to Alan, Denis, and Robert for their efforts.

Finally, my thanks to our Hon. Gen. Secretary, Grant Boston. He has shouldered many administrative burdens during a year when he has been stretched by restructuring in his job with Fonterra Research. With this I welcome to the chair Dr David Bibby (Industrial Research Ltd, Lower Hutt) as President-Elect for 2003.



NEWS

2003 NZIC President

Dr. David Bibby



David Bibby has been working on the Gracefield science campus in Lower Hutt since immigrating to New Zealand in 1975, initially at Chemistry Division, DSIR, and then, with the formation of the Crown Research Institutes in 1992, at Industrial Research Ltd (IRL). Very recently David

was appointed as Pro-Vice Chancellor, and Dean of Science and Architecture and Design at Victoria University of Wellington, and will be taking up that position in early April.

David began his career in chemistry by working in the Boots pharmaceutical laboratories in Nottingham (UK), and went on to study at Loughborough University. He gained a BTech (Hons) in Industrial Chemistry in 1967 and then a PhD in Nuclear Chemistry in 1970 for research into the applications of 14 MeV neutron activation analysis. In 1996 he was awarded a DSc for research carried out in the DSIR Chemistry Division on the synthesis, characterisation, and applications of zeolites, particularly those used as catalysts for methanol-to-gasoline conversion in the Motonui Synfuels plant.

David has published widely in this and other fields of chemistry, including studies of trace elements in diamond using neutron activation analysis, work done during the five years he was employed at the Nuclear Physics Research Unit, University of Witwatersrand (South Africa). He also found Barbara, a physicist, at that University and some chemistry seems to have occurred since they bonded in 1973.

David has been actively involved in the science community over the years, through NZIC, Royal Society, and the Association of Scientists. David has held all the offices in the local branch of NZIC over the years, has been on the organising committees of various Conferences, and is President this year.

David is interested in the wider aspects of science and society and in 1991 he published a paper in *New Zealand Science Review* entitled *Scientific Manpower Projections*;

New Zealand and the Growing World-wide Shortage of Scientists and Engineers, which highlighted his concerns regarding the likely difficulties in meeting the future needs for science professionals. Twelve years later the trend is increasingly apparent.

While all areas of science are important, the core discipline of chemistry has never been more essential, and today David is even more convinced of the need for excellence in research and teaching, and in communicating the excitement and importance of chemistry to the wider community.

New Royal Society Fellows

Dr. Ken MacKenzie and Professor Rob Smith were elected to Fellowship of the Royal Society of New Zealand in November last, while Dr. Jilly Evans became an Honorary Fellow. A profile on each of them appears below. (*Ed.*)

Dr. Jilly Evans

Dr. Jillian Frances Evans is an ex-patriot New Zealander educated in New Zealand rural district schools, including chemistry on correspondence, until she went to The University of Auckland in 1970. She obtained her BSc and MSc from The University of Auckland in Cell Biology in 1972 and 1974, respectively. Jilly studied under Dr. Michael Smith (Nobel Prize in chemistry 1993) to obtain her PhD from the University of British Columbia (Canada) in biochemistry in 1978. After postdoctoral studies in biochemistry at McGill University, Montreal, Jilly joined Merck Frosst Canada in 1983. She was part of the developmental teams at Merck Frosst for the anti-leukotriene, anti-asthmatic drug, Singulair and the COX-2 inhibitor, anti-arthritis drug Vioxx. Jilly has actively promoted careers for women in science with seminars and workshops to high school and university students. She moved to Merck West Point Pennsylvania in 1998 to become a Director in the human genetics department with a focus on discovery of novel G-protein coupled receptors (GPCRs) as potential drug targets. She is now a Director in the Department of Pharmacology at West Point and is still actively involved with the Singulair and Vioxx projects through both basic research and marketing activities. In 1999 Jilly and her colleagues at Merck and the University of Virginia succeeded in the cloning and characterization of the GPCR target of Singulair, namely the CysLT1 receptor. Jilly is actively pursuing studies on Vioxx in colon cancer chemoprevention and treatment.



Above: Jilly Evans with the late Mrs. Jean Struthers.

During her career with Merck Jilly has received a Merck Managerial Award in 1998, the Merck Marketing Award for Excellence, VIOXX Team (2002), and the Merck HSA Award for Excellence, SINGULAIR Team. Currently Jilly is a Board Member of the American Inflammation Research Association, the Lymphangiomyomatosis (LAM) Foundation, and Rubicon NZ. She has close on 100 scientific publications and patents.

Of her schooling Jilly says "For my sixth form University Entrance I had a wonderful chemistry correspondence teacher, Mrs Jean Struthers, who was 70 years old at the time. I met her 30 years later for the first time when she was 101 years old (see photo). She was still talking of her delight in chemistry". Mrs Jean Struthers died peacefully last year.

Ken MacKenzie

Dr. Ken MacKenzie holds the joint position of Associate Professor of Materials Chemistry in the School of Chemical and Physical Sciences, Victoria University of Wellington, and Distinguished Scientist of the Materials Technology Group of Industrial Research Ltd.



Above: Ken MacKenzie with the IRL 500 MHz NMR instrument.

After graduating MSc with first class honours in Chemistry from Victoria University, Ken completed his PhD in the high-temperature solid-state chemistry of clay minerals with the late Professor Duncan. This early work resulted in a key 1969 paper in *Nature* entitled *The Development of Electric Potentials in Clay Minerals and Alumina-Silica Systems* and set him on a career researching the fundamental chemistry, structures, properties, and thermal transformations of ceramic materials. Initially his interest centred on clay-based ceramics, but soon broadened to eventually include hydrous minerals, glasses, oxides, cements, catalysts, electroceramics, high-technology engineering oxides and composites, and, most recently, the carbothermal synthesis of non-oxide ceramics, notably nitrides and sialons.

After three years of post-doctoral experience on ceramic materials at the University of Sheffield (UK), he returned to New Zealand, joining the Physical Chemistry Section of the then DSIR Chemistry Division. Here his work was on the spontaneous ignition of coal, but within four years he was seconded for two years by the government of Iran to set up a ceramics laboratory and to train staff for a newly-

formed Materials and Energy Research Centre in the Aryamehr University of Technology, Tehran. Although he was recalled to New Zealand just before the 1978 revolution in Iran, he still retains contacts with his colleagues there, returning occasionally to lecture and advise on research projects. In 1976 he was awarded the degree of DSc from Victoria University for his contributions to high-temperature chemistry, becoming, at 33 years of age, the youngest person at that time to be thus honoured by VUW.

On returning to DSIR Chemistry Division, Ken took charge of the Physical Chemistry Section, forming it into a group specialising in solid-state chemistry, especially of ceramic materials. A visit to China and Japan in 1985 convinced him of the need to diversify New Zealand ceramic research from low-technology (clay-based) materials into advanced ceramics for engineering applications. The resulting fundamental research into electroceramics and carbothermal synthesis of sialon and nitride ceramics displaying improved mechanical hardness and toughness was continued by the ceramics group of the former DSIR (now a part of the Advanced Materials Technology group of Industrial Research Limited), which now enjoys international recognition as a world leader in the development of new sialons and sialon products. Many of the new ceramic products arising out of Ken's research (iron sand-based building materials, heat storage blocks, ceramic filters for municipal water supplies and non-oxide refractories for the aluminium smelting industry) have been commercialised, and are now being manufactured in New Zealand.

Ken has always strongly promoted the benefits of modern instrumental techniques to his research on ceramic materials. His earlier work exploited thermal analysis, Mössbauer and infrared spectroscopy, but for the last 15 years he has pioneered the use of solid-state nuclear magnetic resonance (NMR) spectroscopy with magic angle spinning (MAS NMR) to gain insights into the chemistry and physics of inorganic materials. In 1992 he spent 7 months as a Visiting Research Professor in the NMR laboratory of Professor Colin Fyfe at the University of British Columbia, developing ^{25}Mg NMR for studies of magnesium ceramics and minerals. His substantial contributions to solid-state NMR led in 2002 to the publication with Professor M.E. Smith of Warwick University of an authoritative text *Multinuclear Solid State NMR of Inorganic Materials*, published as Volume 6 of the Pergamon Materials Series.

Ken's most recent research interests include the development of new processes ("soft" chemistry and mechanochemistry) for more energy-efficient and ecologically friendly synthesis of advanced ceramic materials. Other interests include the synthesis of new nanoporous materials using mineral structures as templates, the synthesis, and properties of geopolymers and the development of new fibre-reinforced composites for aerospace applications. Much of this research, which relies heavily on solid-state NMR techniques, is carried out in collaboration with overseas universities and institutes, including the Tokyo Institute of Technology, the German Aerospace Centre in Cologne, the University of Oxford (where Ken recently spent two years as a James Cook

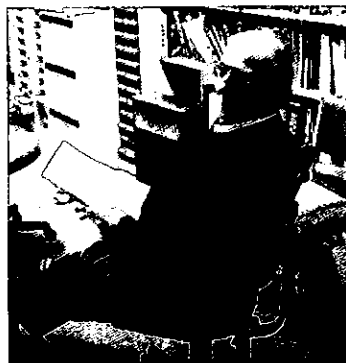
Research Fellow), Warwick and Exeter Universities, and the University of Hokkaido, where he has spent two periods as a Distinguished Visiting Academic. His research has resulted in the publication of more than 230 refereed papers in international journals.

Throughout his career, Ken has been the recipient of a number of awards and distinctions, notably a Royal Society of New Zealand James Cook Research Fellowship (1998-2000), a Royal Society Medal for Excellence in Science and Technology (1997), the ICI Medal of the New Zealand Institute of Chemistry for Excellence in Chemical Research (1990), the Shell Prize for Industrial and Applied Chemistry (1990), the Ministerial Award for Excellence in Technological Development (1989), and the Easterfield Medal of the Royal Institute of Chemistry (1976). He was elected to Fellowship of the New Zealand Institute of Chemistry (1983), the Royal Society of Chemistry (1979), and the Institute of Ceramics (1979).

In addition to his passion for scientific research and teaching, Ken is a keen musician, with a strong interest in music including light, orchestral, organ, and choral scenarios. He has held posts as organist in a number of large churches in New Zealand and overseas, the most recent being a 2-year period as organist and master of the choristers at an Oxford church. His other interests include gardening and keeping abreast of new developments in theology.

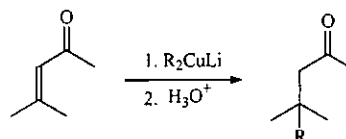
Rob Smith

The statement associated with the announcement of Professor Rob Smith's election FRSNZ was "... Professor Smith has demonstrated distinguished scholarship in organic chemistry, achieving notable successes in multi-disciplinary research. His work has led to mechanistic understanding of the conjugate addition reactions of organocopper species, leading to a new synthetic methodology of practical importance. In addition, his work in enantioselective organic synthesis has resulted in chiral biaryl diols of exceptional value. Further, in collaboration with Dr. Mike Murphy, Professor Smith designed and synthesised biologically active molecules with the potential for treating diseases of mitochondrial malfunction, such as Friedreich's ataxia, Huntington's disease and Parkinson's disease, a development which has led to clinical trials and commercialisation. His research in organic chemistry exhibits breadth, adaptability and imagination." Professor Smith gained his PhD in 1968 at the University of Otago studying natural products organic chemistry under the direction of Professor R. E. (Ted) Corbett. He carried out postdoctoral studies in the USA (T. A. Spencer, Dartmouth College; E. Wenkert, Indiana University), returning to New Zealand in 1971 to take up a position as lecturer in organic chemistry at Otago University. He has remained in the Chemistry Department there since that time, with various leave periods with research leaders

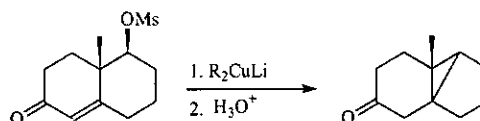


worldwide. In 2000 he was appointed to a personal professorship in Organic Chemistry. Professor Smith has been a member of the Royal Society of Chemistry (UK) and the NZIC since 1967. He has held various positions in the local NZIC branch including a period as a council delegate. He was elected a fellow of the NZIC in 1985.

Rob Smith's research is based on organic chemistry with the design, synthesis, and analysis of new molecules and methodologies being the consistent theme. On taking up his lectureship he felt that organic methodologies for creating new carbon-carbon bonds involving organometallic chemistry was developing into an exciting and attractive area for research. Organometallic compounds containing copper, *e.g.* organocuprates - R_2CuLi , were increasingly being used in organic synthesis, especially for conjugate addition reactions to unsaturated carbonyl compounds:



The mechanisms of these reactions were unclear and an extensive investigation undertaken by the Otago group occupied a considerable period of the 1980s. Some significant results were obtained especially using electrochemical simulations, molecules designed to trap transient intermediates, and stable isotope (^{13}C) labelled substrates in conjunction with low temperature nuclear magnetic resonance (NMR) measurements:

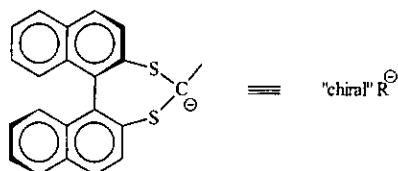


However, the complete mechanistic picture was not revealed and remains an unsolved problem to this day. "It is clear that these reactions do not proceed by any of the well-recognized processes in organic and organometallic chemistry" says Professor Smith "I was working with Hugh Felkin at the time he was entering the organometallic field following an illustrious career as a mechanistic organic chemist, and his view then was that the fundamental mechanistic basis of organometallic chemistry was at an equivalent stage of development to that of organic chemistry in 1920 and therefore there were many challenges left in the field. In hindsight that was a very prophetic comment." In addition to fundamental organocuprate studies, many useful synthetic sequences were developed during this period.

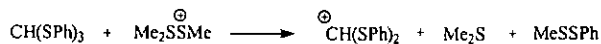
Efforts to modify the organic components of organometallic compounds for use in organic synthesis lead to an examination of the reactivity of thio-substituted carbanions. These compounds were the synthetic 'equivalents' of bulky alkyl anions:



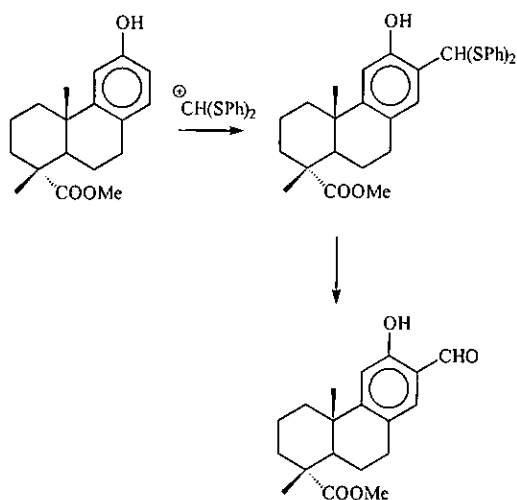
Further activity led to the development of a chiral alkyl anion equivalent:



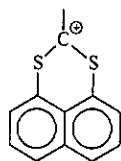
Electron poor carbon chemistry has also been investigated along with the electron rich carbanions associated with organometallic compounds. A chemospecific aromatic formylation was developed,



including examples using the New Zealand natural product podocarpic acid which can be isolated from rimu trees:



In addition, the preparation and examination of carbocations in constrained bonding arrangements were revealed. *viz.*

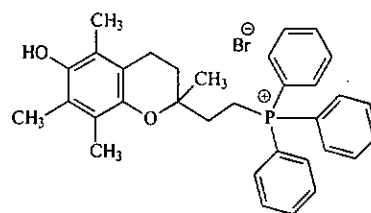


Application of the modern concepts of environmentally friendly chemical synthetic processes is currently being actively pursued with particular emphasis on organometallic and catalytic reactions. The approach adopted is to use the desirable properties of perfluoroalkylated chemicals to produce efficient reagents and catalysts that can be readily isolated and recovered using the distinctive liquid phase separation properties of perfluoroalkyl solvents.

A second, and rapidly expanding, area of research activity is in the application of chemistry to biological issues. This research direction arose from a collaboration with Drs. J P Leader and J J Bedford of the University of Otago Physiology Department and was based on the idea that high resolution, high sensitivity ^1H NMR could be used to assay various aqueous extracts for relatively simple but biologically significant molecules. The samples studied included extracts from crab leg muscle, rat cerebral matter, and possum kidneys. In addition, an understanding of the stabilizing effects of trimethylamine *N*-oxide and related compounds on proteins within cells subjected to stress have been undertaken based on ^1H and ^{31}P NMR measurements. Current work in this area involves the use of NMR for

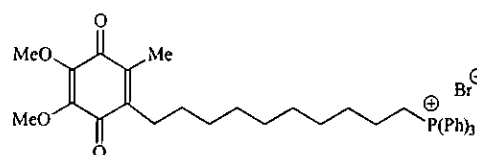
obtaining enzyme kinetic data and diffusion coefficients, which relate to the effective molecular volumes of proteins in typical intracellular solution environments.

Currently, the predominant area of chemistry research involving Professor Smith and co-workers is designing and preparing molecules targeted at mitochondria – the energy source of cells. This is a collaborative project with Dr. M P Murphy, a bioenergeticist, formerly of the Biochemistry Department at Otago, who now works in an MRC (UK) research institute. “He approached me for help to make a molecule that he was interested in. The fact that he was prepared to spend a summer in my lab personally carrying out the synthesis we designed certainly endeared him to me in the initial stages of our collaboration” comments Rob Smith. This joint research project, which has expanded considerably in recent times, is based on the feature that a functional moiety, appropriately tethered to a phosphonium salt, can be concentrated in the mitochondria by virtue of the electric gradient across the mitochondrial membrane. This enables substrates with biological potential to be effectively targeted to the mitochondria. Progress in this area has involved creating molecules targeted at mitochondria including derivatives of Vitamin E (mito VitE), Coenzyme Q (mito Q), enzyme mimics and spin traps.



Mito Vit E

While the basic impetus for the research was the pursuit of core knowledge about mitochondrial function and control, the demonstrated links between mitochondrial malfunction and several disease states inevitably created the opportunity to consider the newly created chemicals as potential pharmaceuticals.



mito Q

The selective delivery of drug candidates to the required site within the target species is a significant aspect of modern drug development and was cogently summarised previously in *Chemistry In New Zealand* by Bill Denny and Gordon Rewcastle from the Auckland Cancer Research Group [*Chem. in N.Z.*, 2002, 66(3), 22-25]. The Otago research has developed into a significant multidisciplinary effort and a commercialisation process of the more reactive targeted antioxidants is currently underway facilitated by a large Technology for Business Growth grant from the New Zealand Government in conjunction with a private New Zealand biotechnology company (Antipodean Biotechnology) directed by Dr. Ken Taylor. This program involves a combination of elements from Universities (Otago, Massey) Crown Research Institutes (IRL, ESR) and private companies (Antipodean Biotechnology,

Douglas Pharmaceuticals) and is aimed at ultimately undertaking a Phase I clinical drug trial within New Zealand. "I anticipate that our work in creating these designer molecules will develop considerably in the near future" says Professor Smith "however, at the end of the day, these projects rely on obtaining the target molecule in useful amounts so any synthesis must be viable in a reasonable timeframe".

NZIC Branch News

AUCKLAND

The Auckland Cancer Society Research Centre (ACSRC) Co-Director, **Professor Bruce Baguley**, was made an Officer of the New Zealand Order of Merit in the New Year Honours list, for his services to Cancer Research. Bruce has an MSc in Organic Chemistry, and a PhD in Cell Biology, and this combination of expertise has been of great benefit to anticancer drug development in the ACSRC over the last 30 years.

The ACSRC has also welcomed **Adrian Blaser** and **David Appleton** to its chemistry section. Adrian comes originally from Switzerland and has spent the last year working in the **Margaret Brimble** group in The University of Auckland Chemistry Department. David recently obtained his PhD with **Brent Copp** at Auckland, working on Marine Natural Products, and is temporarily in the ACSRC filling in for **Moana Tercel** who is on maternity leave.

On Thursday 20 March 2003 a reception was held at the Department of Chemistry of The University of Auckland to celebrate the opening of the new synthetic chemistry research laboratories. The laboratories have been refurbished to meet the high standards required for modern synthetic chemistry and will be used in research programs in organic, medicinal, inorganic, organometallic and sustainability chemistry.

CANTERBURY

The **Canterbury Branch** NZIC Prize for the best overall performance in 200-level Chemistry at the University has been awarded to **Rosalind Phillips**, a direct-entry student from Hastings. The Haydon Prize for the best 300-level performance went to **David Pearson**.

ESR

Rob Lake was one of the three signatories approved by IANZ in September as part of their accreditation of the ESR Christchurch Science Centre Laboratory for the analysis of genetically modified (GM) foods. This accreditation is the first in Australasia for this type of analysis, which employs the polymerase chain reaction to detect novel DNA present in GM ingredients in foods. The analyses being conducted by ESR are part of a New Zealand Food Safety Authority monitoring programme to support enforcement of the GM food labelling requirements.

Ian Shaw was one of the keynote speakers on *LIFE IS A RISKY BUSINESS - Is vaccination one of life's risks or benefits?* at the Vaccination in Tomorrows Society conference held at Anney in France in late February.

Margaret Leonard, a chemist turned microbiologist, has recently joined ESR from the engineering consulting firm of Golders Associates and is working on policy support for New Zealand's wastewater infrastructure. Is this another example of how "chemists can do anything"?

University of Canterbury

Congratulations to **Richard Payne** who has been awarded the prestigious Gates Scholarship for PhD studies at the University of Cambridge, to **Tim Heaton-Burgess**, BSc (Hons) (2002) who has been awarded a Lord Rutherford Memorial Research Fellowship to support PhD studies in the USA.

Third-year chemistry student **Estelle Whaiapu** has been awarded a University of Canterbury Blue for touch rugby. **Jared Panther** has been offered a Canterbury Scholarship, while **Kelly Anderson**, **Steven Aitken**, **Ben Perston**, and **Ramin Zibaseresht** were offered University of Canterbury PhD Scholarships.

The Fenwick Prize for best 4th year demonstrator went to **Meryn Bowen** and the Ralph Earle Prize for the best second year seminar went to **Jonno Hill**.

Richard Hartshorn and **Jan Wikaira** won University of Canterbury teaching scholarships to attend the RACI Chemical Education Division Conference in Melbourne last December. Richard also received a University of Canterbury Teaching Award at December's graduation ceremony.

New Postdoctoral Fellows have arrived in the Department. **Vaughan Langford**, who completed a PhD with **Bryce Williamson** then worked at the Universities of Geneva and Western Australia before taking a short appointment at Burnside High School, is working with **Murray McEwan** and **Colin Freeman**. He is working on the SIFT (or is that SYFT)/Supernose project. **Christian Narkowicz** is working with **Murray Munro** and **John Blunt** in the Marine Group. After graduating in chemistry from the University of Tasmania, he worked in industry and in several university departments, including Pharmacy (prostaglandins), Medicine (free radicals in cyclooxygenase activation, coronary vasodilation, hyperbaric oxygen therapy) and Physiology (teaching cardiovascular physiology). An industry project with Novartis Animal Health lured him back to marine natural products in 1998. **Florian Graichen** is working with **Andrew Abell** on the synthesis of uridine phosphorylase (UDPase) inhibitors. He studied chemistry at the University of Regensburg (Germany). During his PhD he worked in the group of **Professor Dr. A. Buschauer**, developing a method for the solid-phase synthesis of NPY Y1 antagonists.

Farewells - The Department was saddened by the death of **Emeritus Professor Cuth Wilkins** in November. Although long retired, Cuth, was regularly to be seen around the Department till his sickness became too much of a burden a couple of months before his death. Cuthbert John Wilkins was born in Christchurch in 1917 and raised

and educated in Christchurch, graduating from Canterbury University College with a BSc (1935) and MSc (1937). In those days one could not undertake PhD studies in New Zealand, so he set off for the UK, arriving just before the outbreak of the Second World War. He conducted and completed his PhD at Imperial College (London) before working for the Armament Research Division in the UK. He returned to Christchurch in 1945, taking up a position of lecturer at Canterbury University College. In 1964 he was appointed to the position of Professor of Inorganic Chemistry, which he held until his retirement in 1982. For many, that would be the end of one's research career, but Cuth remained active and productive in research for another 20 years. His last act in the Department was to submit a paper to the *American Mineralogist* on spectroscopic investigations of New Zealand greenstone. Over the years, Cuth supervised many BSc (Hons), MSc and PhD students, a surprisingly large proportion of whom have gone on to academic careers in New Zealand and overseas (a full obituary will be published in June).

After more than five years working with **Peter Steel**, **Dave McMorran** has accepted a position as a Senior Teaching Fellow in the Department of Chemistry at the University of Otago. His new job will involve coordinating the first year labs and tutorials, as well as the bridging course, summer school, and distance chemistry course. He will also be involved in developing the Department's outreach programme to schools. And as well as all that, there will be opportunities for him to do some research (if he can find the time). He will be sadly missed at Canterbury, not least by the undergraduates who gave him such good ERAU survey results.

Chris Fitchett completed his PhD studies with **Peter Steel** and took a postdoctoral position in Dublin in January. **Carl Otter** completed his postdoctoral period with **Richard Hartshorn** and has moved to a new position at Massey. **Yunjiang Feng** leaves the marine group for a job with the Auckland District Health Board. **Richard Phipps** has just completed his PhD and is starting with **Nigel Perry** at PERU in Dunedin for a short-term postdoctoral appointment.

Allison O'Brien is visiting the Department for the next five months working with **Greg Russell** on modelling of complex photopolymerisation behaviour. She has BS in chemical engineering from Cornell University having been raised in nearby Syracuse. She is currently pursuing a PhD in chemical engineering from the University of Colorado at Boulder. Her doctoral work, on the impact of oxygen on free-radical photopolymerisations, is being conducted under the supervision of **Professor Chris Bowman**.

Hot Papers - For the third time this year, a paper from the Department has been selected by the ChemWeb magazine *The Alchemist* as one of the week's two Hot Papers in Chemistry. This time it is "Photochemistry of concentrated sulfuric acid in the presence of SO_2 and $Fe(II)$, and implications for the cloud chemistry of Venus" authored by **G.A. Rowland**, **R. van Eldik**, and **L.F. Phillips** (*J. Photochem. Photobio. A: Chemistry*, 2002, 153, 1-10).

Blue Light Halloween Rage - On November 1 last year Blue Light held a Teenage Halloween Rage at the Riccarton Park Function Centre with the aim of entertaining the young

people of Canterbury in a safe environment and building a better relationship with the Police. Approximately 150 teenagers, including some from Cheviot and Oxford, attended the event. **Rebecca Hurrell**, **Jan Wikaira**, **Marie Squire** and **Bruce Clark** presented a pyrotechnic display with the theme *History of Halloween*. The night was a great success.



Above: Scenes from the Blue Light Halloween Rage.

Denis Hogan, **Michael Mautner**, and **Craig Tennant** have had their appointments as Adjunct Senior Fellows extended for a further three-year term.

VC's Awards for General Staff: **Michael Pearce** and **Sandy Ferguson** have each been given an award to extend their Northern Hemisphere trips to visit selected research laboratories and attend workshops.

2003 New Zealand Institute of Chemistry Conference (**Andrew Abell**, Conference Chair)

Approximately every two years the New Zealand Institute of Chemistry (NZIC) sponsors an international conference that provides a wealth of outstanding science in all aspects of chemistry. Topics covered include biological chemistry, synthesis, materials science, computational chemistry, spectroscopy, chemical technology, natural products, medicinal chemistry and much more. This year we are particularly fortunate in that the NZIC conference is to be held in Nelson, with its vineyards, arts and the world-renowned natural beauty of the Abel Tasman National Park. The conference is set for November 30 until December 4 (2003), a very good time to be in this part of the world.

The theme *Chemistry at the Interface* provides an opportunity for practising chemists from a range of backgrounds to observe first hand how the discipline is evolving and heading in the future. The programme will feature lectures from an outstanding, and growing, list of

international speakers, some of New Zealand's best chemists, and the recently established Centres of Research Excellence (CoRE) groups. There will be ample opportunity for involvement from all the branches of chemistry.

NZIC Conferences are always enjoyable and productive gatherings and you are warmly invited to interact with colleagues within this environment. Details can be accessed at <http://www.chem.canterbury.ac.nz/> Please mark November 30 until December 4, 2003 in your diaries.

MANAWATU

The November 2002 Annual General Meeting of the Manawatu Branch, elected the following committee:

Chair: **Carol Taylor** (Massey University)

Treasurer: **David Shillington** (UCOL)

Secretary: **Justin Bendall** (Fonterra Research Centre)

Branch Editor: **Andrew Brodie** (Massey University)

Student Rep.: **Andy Bent** (Massey University)

Committee: **Mike Boland** (Fonterra Research Centre), **Jeremy Dombroski** (HortResearch), **Barry Scott** (Merck Ltd), **Richard Haverkamp** (Massey University), **Geoff Jameson** (Massey University), **Grant Boston** (Fonterra Research Centre) and **David Harding** (Massey University).

Right: 2003 Manawatu Branch Chair, **Carol Taylor**

(Photo courtesy of *Massey News*)



The Annual General Meeting was preceded by dinner at Wharerata, the Massey University staff club and when the formal business was concluded, **James Wright**, The University of Auckland, addressed the branch on *Green Chemistry in the Pulp and Paper Industry – More than Pulp Fiction*. In his talk he described the contribution his research (in collaboration with **Terry Collins** at Carnegie Mellon University, and Forest Research Ltd) has made to the design of environmentally benign alternatives to replace existing, polluting, bleaching technologies in the pulp and paper industry in New Zealand. On November 19, **Robin Clarke**, University College London, delivered a lecture entitled *Pigment Identification by Spectroscopic Means – an Arts-Science Interface*. The lecture, which was attended by people from both science and arts, was a fascinating insight into the problem of finding solutions to the restoration, conservation, dating and authentication of manuscripts, ceramics and papyri in the art world.

The Manawatu Branch's *Chemical Education Trust* has made the following awards to high schools:

Hastings Girls' High School

\$450.00 molecular model kits, 2 conductivity cuvettes

Lindisfarne College

\$340.00 colorimeter probe plus cuvettes

Ponatahi Christian School

\$316.00 pH sensor, data logging software and magnetic stirrer

Queen Elizabeth College

\$447.75 electronic balance

Sacred Heart College (Napier)

\$190.00 portable pH meter

Taihape College

\$450.00 pH meter electrode and 2 pH meters

Taradale High School

\$450.00 demonstration molecular crystal structures

Tararua College

\$293.00 software (3 pkts)

Upper Hutt College

\$350.00 CD Polychem software

Wairarapa College

\$450.00 2 computer to TV set interfaces

The funds for the Trust are derived from the annual chemistry quiz run by the Branch.

Landcare

Benny Theng reports that he is again visiting the CRMD-CNRS-University of Orleans (France) for about 3 months. He is there to help edit and review the contributions to the *Handbook of Clay Science*. So far the editors have received 12 drafts of the estimated 32 chapters and subchapters. When he arrived in January there was snow on the ground that proved quite a shock to the system. Fortunately, the tiny studio apartment has central heating; and the weather has improved somewhat since then.

Massey University

About 25 chemistry academic staff, postdocs and graduate students travelled to Wellington for the 11th Annual Victoria-Massey Chemistry Graduate Seminar Day late last year. Massey was represented by **Amy Ballantyne**, **Sam Brodie**, **Kurt McBeth**, **Susan Habas**, **Adrian Chaplin**, **Chantelle Jones**, **Amy Keedwell** and **Daina Grant**. The energetic played a friendly soccer match at lunchtime and some stayed for dinner after the talks. Thanks to the chemists at Victoria for hosting a great event, **Amy Ballantyne** and **Geoff Jameson** who made sure the Massey group all got there and back safely. In February this year the Massey chemists held their Annual *Chemistry Research Symposium* (superbly organised by **Carol Taylor**) at which graduate students and postdoctoral fellows give short talks about their research. The topics covered a wide range – nanotubes to batteries, proteins to organic synthesis and phosphazenes to conducting polymers. Talks were well presented and it is noticeable how much students improve each year with practice and noting what others do to make their presentations interesting. The day finished with dinner together at the Southeastern Restaurant.

Pat Sullivan, Professor of Biochemistry and Head of the Institute of Molecular BioSciences, has been appointed to chair one of the twelve Moderation Panels – Medicine and Public Health – for the Government's new Performance-Based Research Fund.

Roger Lins has joined **David Harding** in the Centre for Separation Science. He comes from the University of Edinburgh, where he was a postdoctoral fellow with **Dr. S. L. Flitsch** and **Dr. N. J. Turner**. Previously he was at University of Loughborough and prior to this, he studied for his PhD with **David Larsen**, University of Otago. **Carl Otter**, has joined **Eric Ainscough** and **Andrew Brodie**, to work on their Marsden-funded project, New Metal-Rich Molecular Scaffolds. Carl is a graduate of the University of Bristol where he completed his PhD under the

supervision of **Professor Mike Ward** working on a project designing and preparing ligands for specific metal ion extraction. He then moved to the University of Canterbury with **Richard Hartshorn** to look at the photochemistry of cobalt polyamine complexes with a view to modelling a specific radical based enzyme process. **Amy Keedwell** and **Celia Webby** have been awarded Massey University Doctoral Fellowships to work with **Emily Parker**. **Krishanthi Jayasundera** has taken up a position as postdoctoral fellow with **Carol Taylor** to work on synthesizing a transition state analogue for the hydrolysis of zearalenone lactone. **Adrian Jull**, an assistant lecturer in chemistry, has started a PhD looking at the aspects of the chemistry of compounds from plants. Previous postdoctoral fellows in Carol's group have recently departed – **Renaud Hardré** to return to his native France and **Will Barker** to take up a position with ESR in Auckland. **Slavica Pavlinic** and **Michael Liu** have recently defended their PhD theses successfully. Slavica worked with **Tony Wright** and **Paul Buckley** and has moved to Hamilton and Michael's supervisor was **Simon Hall**. He now has a position in the Nanomaterials Research Centre.



Above: NRC members, **Huoguang Chen**, **Pawel Wagner**, **David Officer** and **Sanjeev Gambhir** at the recent AMN-1 Conference, Victoria University.

After a very successful funding year last year, the *Nanomaterials Research Centre* has recently welcomed several new staff members. There are now six post-doctoral fellows working there. The most recent to join the group are the husband and wife team **Pawel** and **Klaudia Wagner** from Poland, and **Mark Vigneswaran**, formerly of HortResearch (PN). Klaudia completed her PhD at the Institute of Physicochemistry and Technology of Polymers, Gliwice, Poland, in 2002 and has taken up her first postdoctoral position in **Dr. Simon Hall's** electrochemistry group working on electropolymerization and electrochemical investigation of conducting polymers. Pawel, a graduate of the Institute of Organic Chemistry and Technology, Silesian University of Technology, Gliwice, Poland, carried out the chemical synthesis of electroconductive polymers with **Professor Dirk Vanderzande** in Belgium in 2001 before returning to Poland as a Senior Researcher. Prior to coming to New Zealand and taking up a postdoctoral position with the Centre's head, **Professor David Officer**, in the field of organic synthesis, X-ray structures, and conducting polymers, he won a prestigious three-month fellowship at the Polish Academy of Sciences. **Mark Vigneswaran** joined the NRC as a postdoctoral fellow late in 2002 and is also working with **David Officer** synthesizing

compounds, which could be used as sensors and molecular wires. New PhD additions are **Fabio Lodato** who graduated from the University of Pisa. Fabio is working in the area of porphyrin array synthesis in order to obtain new materials for light harvesting devices. **Yvonne Ting** has just commenced a PhD on a MacDiarmid Institute scholarship in the area of electrospinning of nanofibres. Yvonne is a Victoria University of Wellington graduate. Joining the new PhD students are Research Technicians **Shannon Bullock** and **Amy Watson**. Shannon is currently working in the field of electroluminescence and is a Massey University MTech graduate in Chemical Technology, who has previously worked at AgResearch with the Biosensors group. Amy recently completed her MSc in organic synthesis with **Carol Taylor** at Massey University and is now synthesizing a variety of porphyrin and terthiophene starting materials.

Geoff Jameson reports that the *Microbes and Molecules* meeting in Christchurch – a joint meeting in December 2002 of the New Zealand Society for Biochemistry and Molecular Biology, the Microbiological Society and the New Zealand Society of Plant Physiology – featured some interesting visualisation of Ca^{2+} fluxes in plants using proteins tagged with aequorin, a protein from jellyfish, which on binding Ca^{2+} is stimulated to produce the blue light characteristic of some jellyfish. On a short-time scale of seconds and minutes oscillatory behaviour can be observed as cellular feedback loops overcorrect to a transient insult applied to the plant, such as brief exposure to ozone. There were several efforts to present molecules in a non-acronymic manner, including Geoff's ultra-high-resolution structure of manganese superoxide dismutase.

Geoff Jameson also attended the *Australian Synchrotron Workshop* in late January, in Melbourne, along with his former graduate student, **Julian Adams**, now a postdoctoral fellow at St. Vincent's Institute of Medical Research, Melbourne. Several other New Zealanders from IRL and The University of Auckland also attended to find out that the State of Victoria has committed additional resources (now \$A157.2m) to build a world-class third-generation facility. The State of Victoria sees long-term economic benefit to this very substantial investment. To bring 9 beamlines on line will cost an additional A\$50m; the source(s) of this funding is(are) unclear, but New Zealand should not lose this opportunity to invest in core research infrastructure, which will be closer to New Zealand than some parts of Australia. The beamlines under discussion include structural biology and ultra-small crystal small-molecule crystallography (2 beamlines), powder diffraction, small angle, wide-angle and surface X-ray scattering, X-ray lithography and imaging, X-ray microprobe and X-ray fluorescence and edge spectroscopies (XAS, XANES, EXAFS), UV, CD and IR spectroscopies. In addition to delegates from Australian universities, the State of Victoria Government and the private sector, there were specialists from various synchrotron facilities in Japan, the USA, the UK, and Switzerland. Various proposals for beamlines were presented and discussed – around 350 people attended.

In early February, **Geoff Jameson**, **Andrew Brodie**, **Eric Ainscough** and **Andreas Derwahl** attended the *RACI*

Inorganic Chemistry Division Meeting, in Melbourne, which featured several New Zealanders presenting keynote lectures. Supramolecular chemistry featured very strongly, along with chemistry of metal ions in biological systems, including various metal-based drugs. Among the excellent plenary lectures given, the ones which stood out were by **Makoto Fujito**, University of Tokyo (supramolecular chemistry), **Lucia Banci**, University of Florence (high-field NMR applied to unravelling the mechanism of copper homeostasis in cells), **Terry Collins**, Carnegie Mellon University (an impassioned well-reasoned plea for Green Chemistry concepts to become embedded in all aspects of chemistry) and **Thomas Rauchfuss**, University of Illinois (on hydrogenase models – contrary to some anthropomorphic beliefs, nature discovered organometallic chemistry of CO and CN⁻ and dithiolate ligands and metal-hydrides long before humans!).

OTAGO

Professor Bill Cooper from the Chemistry Centre for Marine Science at the University of North Carolina at Wilmington (US) arrived in early January to undertake a period of sabbatical leave with **Barrie Peake's** research group until early June. Bill is a leading expert on the photochemical production of reactive oxygen species (ROS) such as hydrogen peroxide, superoxide anion, singlet oxygen and the hydroxyl radical, and he will be looking at aspects of their production in a variety of local South island natural waters. He was awarded a William Evans Visiting Fellowship at the University of Otago and will be giving a postgraduate lecture course on radiation chemistry during his stay.

Dr. Henrik Kjaergaard (Department of Chemistry) has been awarded a prestigious Japan Society for the Promotion of Science Invitation Fellowship for Research in Japan. The Fellowship will allow him to travel to Japan to further his collaborative research with **Professor Masaaki Fuji** at the Institute for Molecular Sciences, Okazaki National Research Institute, in the area of theoretical modelling and double resonance spectroscopy of aromatic molecules and clusters.

A fourteen-strong contingent from the University of Otago attended IC-03, the conference in Melbourne of the Inorganic Chemistry Division of RACI. Almost one half of the Otago participants were postgraduate students, and postdoctoral fellows were also well represented. Lecture presentations at the conference were given by **Lyall Hanton**: *Using flexible multimodal ligands to influence coordination polymer architectures* and **Sarah Howell**: *Fundamental studies of solar energy materials: vibrational spectroscopy and ab initio studies of 1,10-phenanthroline and its complexes*. Sarah was one of six chosen from a field of ninety candidates to give a Stranks Award presentation. Ex-Otago student **Greg Halder**, now undertaking a PhD with **Cameron Kepert** at the University of Sydney, was another. Greg spoke about *Guest-dependent spin crossover in nanoporous molecular framework materials*, work which has recently been published in *Science*. Up to 45 different posters were displayed in morning sessions every day and this provided an excellent opportunity to present and discuss the work

on display. All the Otago participants agreed that it was a great conference.

Keith Gordon and **Tracey Clarke** attended the Intelligent Polymer Research Institute workshop on *Electronic Textiles and Fibres* in Wollongong presenting work on spectroscopy and computational chemistry of polythiophene systems. **Sarah Howell**, **Tracey Clarke** and **Keith Gordon** also attended the inaugural *Advanced Materials and Nanotechnology* (AMN-1) meeting in Wellington to celebrate the formation of MacDiamird Insititute. Keith gave a talk on organic light emitting diodes, Sarah presented a poster on excited state spectroscopy and computational studies of solar energy dyes, and Tracey presented a poster on the spectroscopy and computational chemistry of terthiophenes.

Dr. Amar Flood is currently visiting Otago to carry out some resonance Raman spectroscopy of dumbbell nanostructures synthesised with the **Stoddart** group at UCLA. Through the "efficiency" of the US immigration service and UCLA's visa department, Amar will be staying an extra two weeks to do some more work with the Gordon group.

WAIKATO

University News

The annual 'recruitment' BBQ for students was held on Wednesday 19th March, and followed by a talk from **Melanie Snow** (ESR Auckland) describing her work with forensic analysis of clandestine laboratories.

Nick Lloyd has completed his MSc and is returning to do his PhD on a Marsden-funded project looking at the bio-inorganic chemistry of aryl-arsenic compounds. **Sam Whitley** has also completed his MSc on mercury chemistry and is planning his OE. **Corry Decker** successfully completed her PhD oral examination and has been employed at the University of Waikato as the first-year tutor. In news of ex-students, **Scott McIndoe**, currently at the University of Cambridge, has accepted a lecturing position at University of Victoria, British Columbia.

Recently, **Dr. Graham Saunders** (Queens, University, Belfast) visited the Department and gave a talk entitled, *Organometallic Cp-P and Ar-P Complexes by C-F bond Cleavage*. **Walter Siebert** from the University of Heidelberg is due to visit in March.

Waikato Institute of Technology

The new intake of Diploma in Technology students has been good. The first graduates of this programme (launched in 2001) are now finding employment in food, environmental and medical laboratories. The one-week chromatography courses are still proving popular. Three courses will be run in 2003 that include an HPLC course starting on April 8. Gas chromatography courses run in the last weeks of November. *See report elsewhere in this issue.*

NIWA, Hamilton

The Storm Water and Transport (SWAT) workshop was held at NIWA in Hamilton in late November to 'showcase' NIWA's research in the Environmental Protection and Sustainable Cities SPO (FRST), and facilitate communication of research findings to end-users. **Craig Depree** gave two presentations, entitled: *Reducing the*

Toxicity of Organic Contaminants in Urban Streams II and Sediment PAHs: Distribution, Black Carbon and Potential Sources. The bioactives group (**Trevor Mathieson, Craig Depree, Greg Olsen and Michael Ahrens**) have recently acquired a new ThermoFinnigan LCMS system, which will be used facilitate the identification and structural elucidation of purified marine compounds. **Michael Ellwood** has recently participated in NIWAs FeCycle cruise. The cruise aim was to gain a better understanding of the cycling of iron in the upper ocean. The research took a multidisciplinary approach and involved a number of marine chemists and biologists from New Zealand and overseas institutes.

Fonterra Chemistry Laboratories

With the Fonterra merger behind us, the Chemistry Laboratories are now in exciting times, with one of the most significant changes happening right here in the Waikato Region. The Te Rapa site has now been designated to be the main site for all northern region chemistry testing from Northland to Edgumbe. Building extensions are rapidly progressing to allow for the enormous volumes of testing that will be conducted on site. Butter testing will be the first to move to Te Rapa Laboratory, with the rest of the products moving over the next two and a half years. Analytical Chemistry has three Chemists in the Waikato Region, **Mel Petersen, Jim Le Prou and Kitty Lee**. Our specialist micronutrients laboratory will remain at Waitoa, servicing testing for the nutritional products such as infant formula made on site. **Harvey Indyk** is the Scientist who has developed many of the specialised methods for the industry. Vitamin and mineral testing, alongside other micronutrients such as choline and biotin are performed at the Waitoa Laboratory which will soon take on specialist testing for all of Fonterra.

WELLINGTON

The 2003 Wellington Branch Committee is:

Chairman: **Neil Curtis**
Secretary: **Vacant**
Treasurer: **Alan Turner**
Committee: **Suzanne Boniface and Elizabeth Douch** (half-time each), **Kirsten Edgar and John Ryan** (half-time each), **Vince Gray, Brian Halton, Ted Harvey, Peter Northcote, Helen Palmer** + one to be nominated by **Graeme Gainsford** as his replacement.

It has just been announced that **NZIC President David Bibby** has accepted appointment as Pro-Vice-Chancellor and Dean of the Faculty of Science, and of Architecture and Design, at Victoria University and will take up his position on April 7.

November 6th saw an excellent presentation by **Dr. Neil McCallum** on *Science and the Evolution of Winemaking at the Dry River Winery*. Neil is no stranger to the Wellington Branch and his lecture on the work at the Hawkes Bay vineyard and the 'tasting' made an appropriate accompaniment to the Branch AGM. On November 20th **Professor Robin Clark** gave an RSC sponsored lecture entitled *Pigment Identification by Spectroscopic Means: An Arts/Science Interface*. Robin is a New Zealander who holds the Sir William Ramsay Professorship in Chemistry at University College, London. He is an FRS and an

Honorary FRSNZ. His work over many years has established him as a Raman spectroscopist *par excellence*. This multifaceted lecture described how Raman microscopy and other spectroscopic techniques permit the non-destructive characterisation of the pigments used to illuminate medieval manuscripts, paintings, ceramics, frescos, papyri and other artefacts. These critical studies have had a major international profile and are widely recognised for the insight that they give on the characterisation, restoration, conservation, authentication and dating of artefacts.

Dr. Gary Evans, of the Carbohydrate Research Group at Industrial Research Limited gave the first Branch Lecture for 2003. In mid-February he discussed, at IRL, *Immucillins: From Concept to Clinic*, a current project of the group. Workers at the Albert Einstein College of Medicine (US) have determined the structure of an enzyme essential and specific for the proliferation of human T-cells, and have modelled the substrate site and shape. The IRL group has designed and synthesized a new class of compounds, termed the *Immucillins*, which bind to the site and inhibit the enzyme. These molecules are extremely potent enzyme inhibitors, which selectively ameliorate T-cell proliferation in humans. The multi-step syntheses were outlined and strategies for producing variants described.

The Immucillins have been licensed to the US Biotech Company BioCryst Pharmaceuticals Inc. and are now in clinical trial for treatment of diseases caused by uncontrolled T-cell proliferation.

Victoria University

November visitors to the School included **Professors Mordecai Rabinovitz** (Hebrew University of Jerusalem) and **Robin Clark** (University College, London). Both gave lectures, Rabinovitz on *Unexpected s Bond Formation in Polycyclic Anions* (would you have believed that a conjugated polycycle can be taken through six oscillations from non-aromatic to aromatic) and *Raman Spectroscopy: Its Impact on Inorganic Chemistry and Materials Science* (Raman microscopes now allow for study of micrometre-sized particles of all kinds in forensic and materials science).

The Organic chemists at VUW have been thin on the ground over the summer. **Dr. Peter Northcote** returned from his period with the late **Professor John Faulkner** at the Scripps Oceanographic Institute in La Jolla California in mid-November, but his research and refresher leave period extended until February even though he has been active in the School. **Professor Brian Halton** left in late November to undergo coronary bypass surgery and recuperate (editing *Chemistry in New Zealand* amongst other things) while **Dr. John Hoberg** spent the vacation in the USA. No report on the inaugural AMN-1 conference to mark the opening of the MacDiarmid Institute was forthcoming.

Professor Neil Curtis is hospitalised having fallen and broken his ankle. He is expected to be incapacitated for at least 6 weeks.

Michael Richardson has completed his PhD studies under the supervision of **Drs. Johnston and Northcote**. His thesis was concerned with novel methods for the wet oxidation of industrial waste.

Black (White And Grey) Boxes Revealed

(Gas Chromatography Basic Course, November 2002)

The black box theory - where samples go in one end and magic numbers come out of the other - is more than familiar to the practising scientist. More often than not, instruments today are expensive items of equipment performing critical analyses. Users are often told not to fiddle with (or worse) break these instruments once they have been set-up on a bench. The pressures of high-throughput laboratories seldom allow the opportunity of dissecting an instrument and have it lie in pieces around the bench for a few days while analysts learn the principles of behind the instruments they are using. The Gas Chromatography Basic Course, held at the Waikato Institute of Technology, is an invaluable four-day course of hands-on opportunities to look under the 'bonnet' of some GCs and combine this with theory on quantitative and qualitative analyses.

Drs. Peter Robinson (Hill Laboratories Ltd, Hamilton) and George Zabkiewicz (Forest Research Institute, Rotorua) presented the 2002 course. Twenty-two participants came from around the country and from across a wide range of industries, including food, forensics, petrochemical, and research backgrounds. Their experiences ranged from very little to several years in gas chromatography.

The *Introduction* covered some of the basic theory behind gas chromatography - how a column works, peak identification, and the components of an instrument. This was followed by a practical introduction to some of the general GC equipment and instrumentation including different types of columns, syringe care, and trouble-shooting advice.

The bulk of the course focussed on a practical hands-on approach to learning. Small groups of two or three participants were given the opportunity to get their hands dirty right from the beginning. The GCs in the course ranged from the latest models to earlier, non-digital models from Shimadzu. They were presented in an *out of the box* state for the initial task of learning how to set up an instrument.

Our instructions were to *plumb them up to the gas lines, check the flow rates, and fire them up*, which sounded easy enough. However, being forewarned that the best way to learn about trouble-shooting is through personal experience gave much satisfaction. Experience quickly began to mount with cross-threaded joints, leaky connections, non-regulated gas flows ... and puzzling gas flow rates! Closer inspection of the internal workings of the particular instrument assigned to us eventually revealed creative plumbing left by previous users. Further creative plumbing of our own resulted in lighting the detector and obtaining our first analytical peak, namely of hexane (a cause for celebration!).

While some instruments were fully computer controlled, the ability to manually manipulate the system was an invaluable learning experience. For the beginner, the advantages in seeing the plumbing inside the instrument alongside instrument diagrams certainly helped in understanding how a system works.

The remainder of the course was based on lecture sessions presenting the theory behind the technique and this was followed by relevant practical sessions, where we could work on at our own pace. Topics covered areas such as instrument components including the various types of columns, detectors, and the types of recorders available and when, where, and how to use them. The practical sessions included how to evaluate system performance, and how to optimise column separation and detector performance. Also we investigated basic rules of thumb such as temperature dependency and retention data reporting.

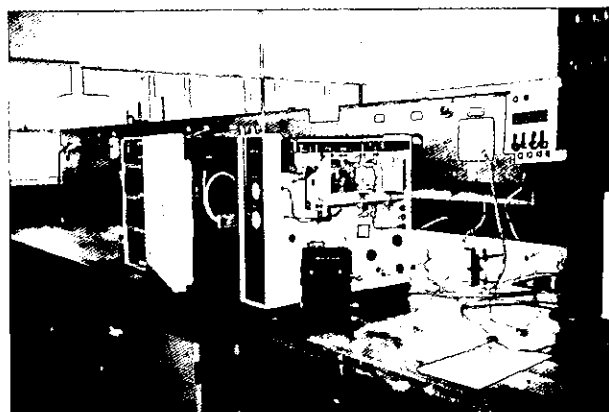
Both qualitative and quantitative analyses were covered as the principles behind identifying and quantifying compounds. Practical sessions included the interesting task of comparing the statistical errors involved between and within operators performing manual injections!

While the days were intensive, plenty of help was available along with lots of handy hints for the uninitiated (such as how to clean and unblock syringes). *GC rules of thumb* and trouble-shooting guides were provided. The course ended with a wrap-up session where we compared results of different systems and tried interpret results based on the components used on each instrument.

The Gas Chromatography Basic Course was a great opportunity to learn the principles behind operating GCs in a friendly, relaxed environment, and it revealed some of the mysteries behind the covers of the black box. It is thoroughly recommended for all levels of GC analysts.

This course is run by Dr. Peter Robinson (Hill Laboratories Ltd, Hamilton) and Dr George Zabkiewicz (Forest Research Institute, Rotorua) in conjunction with Waikato Institute of Technology under the umbrella of the New Zealand Chromatography Group (NZIC). Capillary GC courses and High Performance Liquid Chromatography courses are also run throughout the year. Inquires can be made to Fiona Buchanan, Department of Science and Technology, Waikato Institute of Technology, fiona.buchanan@wintec.ac.nz

The author was sent on the course by Fonterra, Te Rapa.



Above: Revealing the internal workings of the black box (GC).

ALAN WILLIAM MACKNEY (1913-2003)



Alan Mackney was born in New South Wales. He graduated from the University of Sydney with a BSc followed by an MSc in 1935. He was a demonstrator in Organic Chemistry at the University and after graduating he became a research assistant in the Division of Forest Products,

CSIRO. After five years in the CSIRO he joined Australian Newsprint Mills Ltd, which was, at that time, the sole newsprint manufacturer in Australasia.

In 1944, the NZ Forest Products' managing director, David Henry, recruited him to cross the Tasman to join his company as chief chemist. At that time the company was the largest in New Zealand. Alan recounts in his chapter on *Paper from Pinus radiata* in the NZIC book *New Zealand is Different* that his appointment letter from David Henry stated "we should push on with our pulp research as urgently as possible, and I was glad to learn that you were prepared to accept the position of chemist-in-charge of laboratory work associated with the above development. I feel, I hardly need stress how important your work would be to our Company in view of the very large holdings of forests which it owns and which have to be utilised".

Alan established small-scale trials of *Pinus radiata* pulping and paper making which resulted in confirmation that this tree species could be processed into acceptable paper. In fact, in 1945, when the war was still on, NZFP shipped some billets of *Pinus radiata* to the US and Alan, David Henry, and another colleague, island-hopped in planes to get to Savannah, Georgia, to run pilot-scale trials. These trials confirmed that the kraft pulping of *Pinus radiata* could yield strong packaging papers. This resulted in New Zealand reducing its paper imports and developing a large export industry. He stayed with NZ Forest Products and progressed through the ranks retiring in 1978 as the managing director. Thus, Alan played a crucial role in the development of a paper industry in New Zealand. This commercial opportunity led to the start up of pulping and paper making at Kinleith in 1953. This achievement was a notable new development for New Zealand.

Alan not only had a distinguished career in commerce but also in science management and planning. He was a member of the Liquid Fuels Trust Board (1978-86), the Atomic Energy Committee (1960-67), the Auckland University Council (1982-84), and in 1964 he was appointed to the National Research Advisory Council being chairman 1979-1986 until the Council was disestablished. In 1982, he was awarded the OBE for his services to forestry and the community.

He was an enthusiastic supporter of the NZIC and contributed in many ways including being Auckland Branch Chairman, Chairman of the Golden Jubilee Conference committee, inaugural chairman of the Chemical Education Trust, and most notably Institute

President in 1984-85. His services to the Institute were recognised when he became an Honorary Fellow in 1978.

His commercial interests extended beyond his own company. He became a Director of several other companies including Hume Industries, Spiral Welded Pipes Ltd, Horticultural Industries Ltd, and Burns Philip (NZ) Ltd. He was one of the few scientists who joined senior company management and who made their mark through technology, economic, and management inputs.

Alan also had personal interests, which included Rotary in which he became President of the Penrose Rotary Club and was made a Paul Harris Fellow of Rotary in 1990. His recreations included gardening, fishing, and golf.

I have many fond memories of Alan especially when he was Chairman of the NRAC and one of the Institute's Vice-Presidents. As President of the NZIC in 1982-83, I was involved in the establishment and organisation of the First Pacific Chemical Congress [PacChem] in Honolulu. Alan and I represented the Institute at the various functions at the Congress. I recall he became interested in tropical plant production and asked me to accompany him to see propagation and cultivation of *Spathiphyllum* cultivars near Honolulu. Alan was interested in this indoors-ornamental plant as a new product in New Zealand. Twenty years ago this plant was rarely seen here. Now it is a popular and spectacular indoor plant with its shiny green leaves and white to cream flowers.

At the same Congress, Alan advised my wife, Sue, who was the Executive Officer for two of the NRAC advisory committees, that the Minister of Science, the Hon. Bob Tizard, intended to run a national Science and Technology Conference in Wellington in six-months time and he wanted Sue to organise it. Alan was sympathetic re the short time frame and offered to help in any way. Sue remembers him as a firm chairman who had gentle but decisive manners in bringing long winded speakers to a conclusion, in being a persuasive voice for science at a time when science funding was under threat, and a Chairman who carefully did his homework. At that time science organisations required NRAC approval for staff increases and the Chairman was not easily hoodwinked by individuals or groups seeking additional resources.

Some members will remember cuts in overtime for staff at a time when overtime was essential for research especially that which involved field experiments. I recall being the most highly paid temporary shepherd at Ruakura when a long-term sheep experiment was threatened with closure because of bans on overtime! Alan was able to persuade the Minister that research needed better support and to his credit the Minister was able to restore the cuts. Alan was disappointed that the NRAC was disestablished as he perceived it as having a necessary and significant role in advising Government on research priorities and funding.

He is survived by his four daughters, his wife Phyllis having pre-deceased him.

Doug Wright

RON BERNERS HALL

(5 July 1931 - 8 September 2002)



Ron Hall, who had a long career as an industrial chemist and technical and production manager with New Zealand Forest Products Limited (NZFP), died in Auckland last September.

He was born in Canvastown, Marlborough, and attended schools near the family farm. His parents later moved to the Horowhenua and he attended Wanganui Collegiate. He developed an interest in chemistry there and went on to Victoria University to complete BSc and MSc degrees.

Ron joined NZFP in 1953. It was an exciting time in the company for as well as having the wallboard operations at Penrose, the large pulp and paper mills at Kinleith were started up. At first Ron worked on the quality control and product specifications of Penrose products. He then had a few years in research from which an early publication was on the extraction of turpentine from pine chips during the pulping process. That work led to a successful industrial venture in the 1980s at Mt Maunganui, where turpentine is fractionated into a wide variety of useful products. He made particle board in the laboratory long before the company began commercial production, and extracted the tannins from pine bark. The company started a process to use these tannins as a water resistant adhesive, but it didn't prosper.

In 1959 Ron was appointed Works Chemist at Penrose Industries. He had a small team working with production staff on quality control, process control and improvement, and testing effluents and boiler waters. By the late 1960s the plant was making wallboards, multi-wall bags, moulded waste paper products and plastic-coated papers.

CHEM ED 2003

Bringing Chemistry to Life

Chem Ed 2003 - the biennial conference for chemistry educators is to be held in Wellington from 6 to 9 July this year. The theme is *Bringing Chemistry to Life* and the conference programme will focus on creative and innovative ways to inspire teaching and learning chemistry. Alongside this will be opportunities to learn about the latest cutting-edge research and development happening within and around Wellington.

Three overseas speakers have been invited. **John Holman** (Professor of Chemical Education and Director of the Science Curriculum and Chemical Industry Education Centres, University of York, UK) will focus on *Chemical Literacy For All* and the issue of reconciling the needs of future citizens who need grounding in scientific literacy with those of future specialists who need a basis on which

In 1969 Ron was appointed Wallboard Production Manager. He had a workforce and foremen managing an operation that ran around the clock 7 days a week. There were callouts when there were fires and production problems, and he had to carry the workforce with him in introducing improvements. It was Ron who traced the spontaneous combustion of stacked insulating board to the higher percentage in the chip supply of a more resinous pine than radiata.

With some other changes in the company Ron was appointed General Manager of the Technical Division in 1979. At that time it was the largest industrial research department in the country and Ron had a staff of engineers and chemists, including seven PhDs, reporting to him. It was this team that developed an economical and environmentally friendly bleach sequence for a major expansion at Kinleith. In 1988 he left the company when it lost its way and within a few years had ceased to exist. He worked as a consultant on wallboard operations and quality standardisation for a number of years.

Ron was a Fellow of NZIC and a member, and for a time, Vice-President of the Australasian Technical Association of the Pulp and Paper Industry, APPITA. He served for five years in the 1980s as the editor of *Chemistry In New Zealand*. He loved science, read many scientific publications, and applied his chemical knowledge to become a creative potter. Above all he was a thoroughly decent and good person always ready to discuss a topical issue with his friends.

He is survived by his wife Jane, to whom he was married for 45 years, and their four sons one of whom, Simon, is following in his father's footsteps in Massey University's Chemistry Department.

Ashley Wilson

they can build further scientific study. **Vanessa Kind**, (principal of an International School in Norway and a Teacher Fellow for the Royal Society of Chemistry) will speak on *Understanding and Teaching Chemistry in Context*. She will draw on her research on student misconceptions and misunderstandings, which often hinder their learning in chemistry and give the impression of a subject that is "too hard". **Debbie Corrigan**, a Senior Lecturer in Chemistry Education (Monash University, Melbourne) has an interest in real life contexts for teaching chemistry as well as developing links between industry and education. Her focus at conference will be *What Counts as Chemistry of Worth*.

The conference programme includes the opportunity to visit local centres of research and chemical industry, talks from local chemists (many of whom are involved in ground breaking research), and workshops where ideas can be shared and explored in small groups.

Contact: Internet: <http://www.vuw.ac.nz/chemed2003>
Email: chemed2003@vuw.ac.nz

Towards A Link Between Theory And Practice In Chemical Education[†]

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[†]A publication from the NZIC Chemical Education Special Interest Group

Introduction

In recent years there has been a huge research effort investigating aspects of the teaching and learning of science and chemistry. There now are a number of journals and dedicated conferences and symposia addressing all aspects of education as researchers and groups of researchers attempt to carve out a niche area in this huge domain of research. However, experience suggests that almost all such reports are aimed at education researchers rather than at practitioners, that is the teachers of chemistry and science. In the view of the authors this raises serious questions as to how we might pass on the lessons learned from education research to the teaching community. Certainly there are a few journals that ostensibly seek to achieve such an aim - *University Chemistry Education*, *Chemical Education: Research and Practice in Europe*, *Education in Chemistry*, the *Australian Science Teachers' Journal*, and the *Journal of Chemical Education* (and indeed this *Journal*). However, close examination of the content of such journals suggests that these periodicals are often producing articles consisting of teaching tips, or descriptions/assertions of 'what I found to work in my classroom' rather than drawing on the immense body of research in science education. It seems to us that while some do indeed report research-informed studies based on sound, rigorous research in education, e.g., *Australian Science Teachers' Journal*, these periodicals speak mainly to secondary school educators and so are of limited value to tertiary chemistry teachers.

In this article we attempt to address this issue, and begin by summarising the main findings in the chemistry and science education literature, and use a case study of some of our own work for the basis of some suggestions as to how the link between theory of education research and practice of chemistry education might be enhanced.

Education Research

Much of science and chemical education research has been concerned with teaching and learning at the elementary and secondary school levels with much less work reported on learning at the tertiary level. In addition the tertiary research that is reported is concerned with undergraduate teaching in chemistry.^{1,2}

There has long been a debate in the science education literature about the purpose of science education: to produce specialists for careers in scientific professions, or to educate the general population, e.g., to make individuals more informed about such controversial issues as cloning, genetic engineering, use and abuse of pesticides, global warming,

etc. At first sight this might seem a trivial issue at the tertiary level since students surely come to university to become specialists in a given discipline? But what about chemistry majors and non-majors? Some issues of interest and concern are the differing roles chemistry has in students' degrees and programmes, issues of national concern - such as the falling numbers in science as nations attempt to develop a knowledge economy, and the academic ability of new entrant tertiary students. One might expect the general academic ability to be higher than secondary school given the entry and selection criteria, but many academics believe that today's students are seriously under prepared compared with the past. Rheingold, for example, expresses considerable dismay about his students' ability in recent years.³

The learning environment at tertiary level, especially at the advanced tertiary level, is different in important ways from that of lower levels. The content of tertiary science and chemistry is clearly very different to that taught at secondary school. For example, there is much greater use of models (whether or not they are explicitly presented as such), more complex mathematical models, and use of mathematics generally at the tertiary level.⁴ To illustrate, there are teaching models for chemical bonding, e.g., the octet rule, etc., that are widely used and consensually agreed in their nature, but they do not represent the 'consensual scientific model' for bonding in chemical substances. Also, it is common for chemists to use multiple models like the octet rule and molecular orbital theory and to swap between such models as appropriate. Experienced chemists can do this easily and at the same time remain fully aware that all of these models possess limitations: they still use such models, because they 'work', i.e., they are useful in certain well-defined circumstances. The ligand field theory is a good example of a model that is theoretically flawed, has a number well known limitations, and yet is still used by chemists. Another issue at the tertiary level is what to teach in a given course, and this is an issue that will probably become more problematic, especially given that tertiary teaching is supposedly informed by individual staff or faculty's research expertise, although some researchers have claimed this link is an 'enduring myth'.^{5,6}

Chemistry Teaching and New Ideas About How Students Learn

If we were to summarize the huge body of educational research, it would be that knowledge is created in the mind of the student, that the context of the learning such as prior knowledge, and that prior learning experiences of students

are important. We have written about this elsewhere and there is an extensive literature on the subject.⁷ This notion is derived from the theory of learning loosely called constructivism which has many variants, but for the sake of convenience we use the singular here. It is worthwhile to note at this point that there is considerable disagreement in the education literature⁸⁻¹⁰ about aspects of educational theories of learning such as constructivism but there is general agreement that the knowledge of an individual represents a mental construct. A major outcome of constructivist-based research is the alternative conceptions or misconceptions movement which has it that student naïve ideas are logical to them, and we are best to develop an understanding of students' prior knowledge, and use teaching strategies that build upon the students' prior knowledge.⁷⁻⁹

What does educational research and thinking based on this research mean for teaching chemistry at the tertiary level in purely practical terms? Acceptance of current educational beliefs about the nature of truth and the means of learning results in a different view of how one would go about the teaching of chemistry, or indeed other discipline.¹⁰⁻¹³ Inherent in such an approach to learning is a shift away from the conventional teaching style based on a view of learning in which science is seen as a body of knowledge that can be transmitted to the learner. From a conventional teaching point of view, students are seen to possess little, if any, prior knowledge of the concepts that they are required to learn, particularly for abstract scientific concepts.¹⁴ Modern education researchers, in contrast, think that teachers should attempt to foster active learning, and guide learners by using a process of peer- and teacher-facilitated learning.^{8,14-18}

In contrast, it is not at all trivial to decide how to implement new theories of learning in the classroom or lecture theatre, even assuming one believes them to be of value. To put this issue into perspective, consider a common difficulty encountered in the teaching of school and introductory tertiary level science. Millar's comments:¹⁷

For good, understandable pedagogical reasons, constructivist science educationalists...acknowledge that science as a school subject poses a formidable challenge to the teacher in maintaining the involvement of many pupils simply because the science covered at school is, almost entirely, a consensually agreed body of knowledge. There is, therefore, a limited value in children taking away from science lessons ideas that diverge radically from the accepted ones. This means that science can come to look like the transmission of a body of knowledge that cannot be challenged by the learner, and whose learning leaves little scope for the creative involvement of the learner.

So, instructors wanting to teach from a constructivist view of learning are faced with a dilemma: what is the point in trying to teach by 'negotiation' something that is so well agreed upon by teachers and scientists that it may as well be a fact!

The danger with constructivist-based teaching approaches as suggested here, is that teachers are seemingly obligated

to treat highly verified scientific theories as if they are tentative, purely because they can never be totally 'proven'. However, Kragh¹⁹ points out that even though a scientist is not divorced from his or her observations, this does not make scientific conclusions tentative. From a practical teaching point of view, such a 'soft' stance may introduce inappropriate uncertainty about scientific theories or findings. In reality, the validity of well-established scientific theories is based on a huge body of data and for any teacher to suggest that such scientific knowledge is tentative is misleading. As Harding and Hare²⁰ comment: "It is certainly not so tentative that a student can come along with a little knowledge about the subject and only one piece of evidence, and make valid decisions about it". Science is made from creative acts performed by fallible humans, and it is true that careful, controlled procedures do not necessarily yield general conclusions, and that conclusions depend on how the evidence is interpreted. However, the more evidence supporting a conclusion (especially evidence from a variety of sources), the more confidence one can have in the results.²¹ This surely is standard science that all chemistry lecturers are happy about. The validity of scientific conclusions is based on evidence – paying particular attention to how it was generated – but not expressing undue concerns as to how we could ever prove something to be incontrovertibly correct.¹⁴

Following on from this argument, much criticism of new theories of learning has centred on the status given to students' views in the classroom, what some authors have even termed 'childrens' science'.²² But Jenkins²³ asserts, "Students' ideas about natural phenomena are too glibly described as theories" and Matthews²⁴ likewise argues: "Why must learners construct for themselves the ideas of potential energy, mutation, linear inertia, photosynthesis, valency, and so on? Why not explain these ideas to students, and do it in such a way that they understand them?" To us this is an important and reasonable question. We do think there is merit in thinking about new ways of learning, and illustrate below with an example from our own work.

Students' Mental Models of Chemical Bonding

The work presented below is part of a study of students' mental models for chemical bonding. The details of this study have been published in the science education literature, naturally!²⁵⁻²⁷ Here we provide an overview of the main findings of which two aspects of the study are, we think, of particular relevance to this discussion. First, is the fact that the student participants in this study held very simple views of chemical bonding. They were interviewed and asked to tell the interviewer what the bonding would be like in a series of samples shown to them (sodium chloride, steel wool, molecular iodine, etc.). The descriptions of their models were probed with follow-up questions, and we also used a series of focus cards - cards that depicted model use in some way, e.g., malleability of metals, conductivity of molten salts, etc.

The study found that students from three academic levels prefer really very simple mental models for chemical bonding for all classes of substances, i.e., metallic, ionic and covalent, an example of a response which is shown in Figure 1.

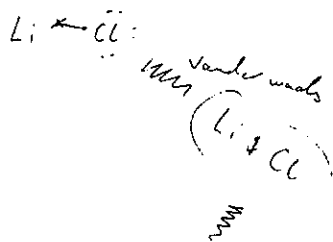


Figure 1. The bonding in lithium chloride according to a student participant in the study.

The more advanced level students did provide a little more detail in their descriptions, probably because of their more extensive learning experiences. The findings of this study are consistent with those of other studies involving abstract chemistry concepts such as atomic structure for which senior secondary school students showed a preference for realistic-looking, e.g., space-filling, models of atoms and molecular species.²⁸⁻³⁰ What is of particular interest and importance (and perhaps some concern) is that even the advanced level-students, including PhD students, retained similar strong images of simple models like the sea of electrons and octet rule. This is really very surprising given the vast differences in complexity between models like the octet rule and advanced-level molecular orbital theory – the latter including conceptually challenging content like group theory.

Clearly one has to be cautious about generalising the findings from a single study, but the findings from this study allow us to think more deeply about the teaching of such topics. For example, the findings suggest that these

students prefer simple models and relate to more abstract models only in the context of tests or examinations. This conclusion is similar to other reports in literature – albeit for secondary school students and undergraduates.^{28,31-34} The fact that the senior tertiary level students in our work clung to these models even when they broke down is cause for concern. For example, lecturers might well have expected their students to choose, or more quickly adopt, at least some of sophisticated mental models for chemical bonding that possess more explanatory power. It is important to realize that the interviews used did include a number of probes in which the simple models were in fact inadequate, e.g., the structure of aromatics like benzene.

It might not seem that surprising that students prefer simple models – indeed some researchers argue that for students to like and use simple views of models is as one would expect, but it is odd that there were a large number of alternative conceptions revealed in the study (Table 1).

The interview data for our study revealed also prevalent alternative conceptions for chemical bonding across three levels of learning (ref. 26 provides a detailed description of the data presented in Table 1). In addition to some common alternative conceptions previously reported in the literature (at the secondary level), such as misunderstandings about intermolecular forces and molecularity of continuous lattices, the inquiry found a surprising number of alternative conceptions about even very simple ideas (in the context of tertiary chemistry education at least) like ion size and shape. As many as 20 alternative conceptions were revealed in the study, the most common being belief that continuous ionic or metallic lattices were molecular in nature, and confusion over ionic

Alternative Conception 1 <i>Metallic bond is weak bonding</i>	Alternative Conception 11 <i>Metallic lattices contain neutral atoms</i>
Alternative Conception 2 <i>Intramolecular covalent bonding is weak bonding</i>	Alternative Conception 12 <i>Electronegativity comprises attraction for a single electron</i>
Alternative Conception 3 <i>Ionic bonding is weak bonding</i>	Alternative Conception 13 <i>Molecular iodine is metallic in nature</i>
Alternative Conception 4 <i>Continuous metallic or ionic lattices are molecular in nature</i>	Alternative Conception 14 <i>Ionic bonding comprises sharing of electrons</i>
Alternative Conception 5 <i>The bonding in metals and ionic compounds involves intermolecular bonding</i>	Alternative Conception 15 <i>Ionic and metallic bonding contain an element of directionality</i>
Alternative Conception 6 <i>The ionic radius of the sodium ion is greater than the chloride ion</i>	Alternative Conception 16 <i>Ions in close-packed metal lattices possess other than eight nearest neighbours</i>
Alternative Conception 7 <i>The ionic radius of the lithium ion is greater than the sodium ion</i>	Alternative Conception 17 <i>Metal to non-metal bonding in alloys is electrostatic in nature</i>
Alternative Conception 8 <i>Polar covalent compounds contain charged species</i>	Alternative Conception 18 <i>Ionic shape and packing is influenced by pressure</i>
Alternative Conception 9 <i>Molecular iodine contains I minus ions</i>	Alternative Conception 19 <i>Intermolecular forces are influenced by gravity</i>
Alternative Conception 10 <i>The charged species in metallic lattices are nuclei rather than ions</i>	Alternative Conception 20 <i>Glass is an ionic crystalline substance</i>

Table 1. Student alternative conceptions identified in the present study.

size and charge. For example, many students apparently believed molecular iodine, I_2 , contained charged species and that the radius of the sodium ion is larger than the chloride ion. It is surprising that undergraduate and postgraduate students, especially given their good academic records, held such alternative conceptions. Again one has to be careful about interpreting such data. For example, the ideas discussed were related to content that these participants studied some time ago and some misunderstanding we have chosen to call 'alternative conceptions' may only appear to be misunderstandings but are, in fact, indicative of inability to recall content from past instruction. Nonetheless, these data do suggest that at least some of the problems identified in the science education literature for student misunderstandings at secondary school and entry-level tertiary study are present at advanced levels.

Teaching Based on Educational Research

Our own work and the enormous number of studies into students' understanding of abstract scientific conceptions suggest that conventional transmissive teaching is not without problems.³⁵ To us it seems too simplistic to ascribe misconceptions of the extent reported in the science education literature on poor teaching, weak students, or lack of attention by students in lectures or classrooms.

Kettle, a highly experienced chemist and tertiary chemistry educator, agrees³⁶ that tertiary chemistry teachers need "better in-depth insight into student understanding, learning and difficulties". This is in accord with our own research-based classroom-based practice. We think that chemistry educators should employ the most appropriate research-based teaching approaches appropriate to their educational context without buying into metaphysical debates that are more representative of religious fundamentalism!^{10,37,38} It is our belief that tertiary educators need to be aware of ideas and issues such as we have described here, since these ideas can provide clues as to why students hold views that are in disagreement with desired teaching outcomes. These we think can help us as teachers to think about better ways to teach the complex subjects in chemistry at the tertiary level.

So what teaching style and approaches do we use in our classrooms, and how have new ideas, and our own research in education about how students learn, informed our teaching practice? First, we think that you can teach factual material, *i.e.*, consensually agreed material, by conventional transmissive means and we believe that there is little to be gained by changing this teaching approach. We can see little point in trying to elicit prior knowledge or negotiate understanding of substantial parts of tertiary chemistry, like organic functional group chemistry and descriptive inorganic chemistry, *e.g.*, common properties of main-group elements. However, in our minds, the teaching of abstract conceptions such as atomic structure and chemical bonding is another matter entirely. This, we believe, is

enhanced by a different pedagogy. For example, tutorial classes are small, are less concerned with content and more concerned with understanding, hence they are geared towards more interactive strategies such as those described in this paper. Specific teaching tools we have used include probing for students' prior knowledge and probing of their understanding using tools like *Prediction-Observation-Explanation* (POE)^{a,39} and the use of concept maps.^{b,39} We also have found that POE works well even in large lecture settings. Likewise, we have found success with the use of interactive group work, off-site learning experiences, and more student-driven activities such as case studies of local industries.⁴⁰ All of these activities challenge the student and make the chemical concepts more real and relevant to our students.

Making a Link Between Research and Teaching: The Way Forward

How then can we make the link between these parallel universes of education research and chemistry teaching? In keeping with the new theories of learning, we illustrate our views with an analogy! Imagine two parallel streams of thinking, one being research in education the other chemistry teaching. It is our contention here that they are happily (or maybe unhappily) tracking along in parallel, barely aware of each other (Figure 2). They may be travelling in the same direction, *e.g.*, both concerned with how to improve student learning, or in opposite directions, *e.g.*, one concerned with improving teaching and the other concerned only with research, be it in education or chemistry. A slight deviation in tracking on either party's part will lead either to conflict, or to forging ahead together.

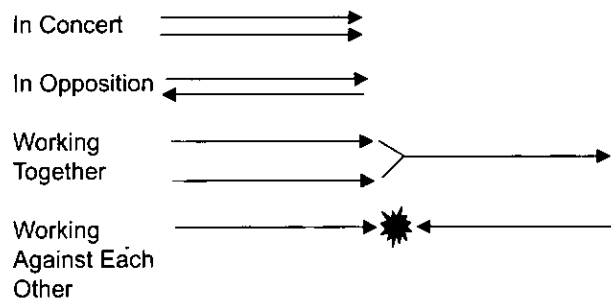


Figure 2. Parallel universes: Education research and chemistry teaching.

It is of course imprudent to take an analogy too far, but the diagram suggests that a small deviation in pathway could bring these disparate universes together. If one accepts our analogy, how might this 'bringing together' be achieved? We see several means, the first of which is our belief that the initiative must lie with education researchers and chemistry lecturers involved in education research, since it is clearly their role to inform the practice of teaching and learning. We see a real need for collaborative research efforts, particularly action research^c much along the line of the special edition in the education periodical *Research*

^a Where a teacher describes an experiment or class demonstration, asks the students to *predict* the outcome, conducts the experiment, and then asks students to *observe* this and then to *explain* or reconcile this with what actually happened. This works particularly well when the outcome is not obvious. A nice example is one the first author (Coll) uses in a chemical technology class in which a rubber band is stretched with lead sinker and heated, the students expect it to lengthen, whereas in fact it shrinks.

^b Students are asked to write down all they know about a given concept and then asked to link ideas together using descriptions or linking phrases.

^c Action research is research that typically involves an intervention or change, *e.g.*, a change of teaching approach, and typically evaluation (or at least reflection) of the effect of that intervention. It is a common tool for teacher-researchers (often working together with university researchers). Action research seeks to bridge the gap between theory and practice in education and such projects are driven by a desire to improve practice.

in *Science Education*.⁴¹ This special edition reports on 'science teachers as researchers' in an Australian context. Atweh⁴² argues that this research paradigm, by its very nature, offers a means of bridging the gap between research concerns and problems of the reality of the classroom. Put simply, action research is research that is conducted by the teacher in his or her classroom in order to improve. However, action research is not without its problems. Teachers' time, work practices, and initial training impose constraints on their involvement in research activities, and Gitlin and Gore⁴³ warn that unless these factors are taken into account little progress is likely to be made in terms of improving practice. However, if conducted effectively, action research can be extremely empowering for teachers. When seeking solutions to problems identified by teachers it gives them a sense of ownership of these solutions and the knowledge generated through their action research projects.

This we agree is a useful strategy, but the research findings – no doubt of interest to those in the science education community – also need to be published in periodicals that chemistry teachers are likely to read. This attitude has formed the basis of this paper. The authors hope that the tertiary education community find it useful and would welcome suggestions and expressions of interest in joint collaborative research projects.

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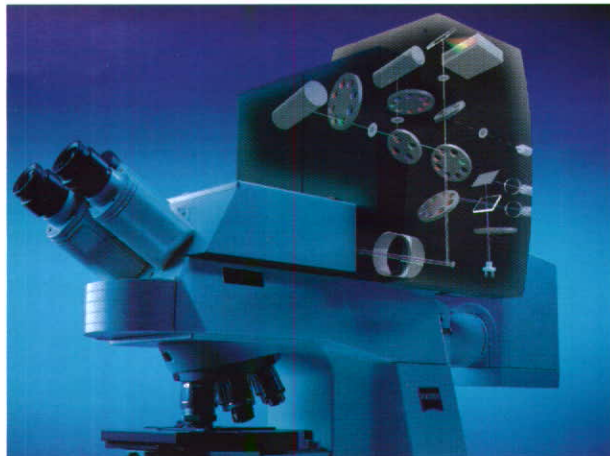
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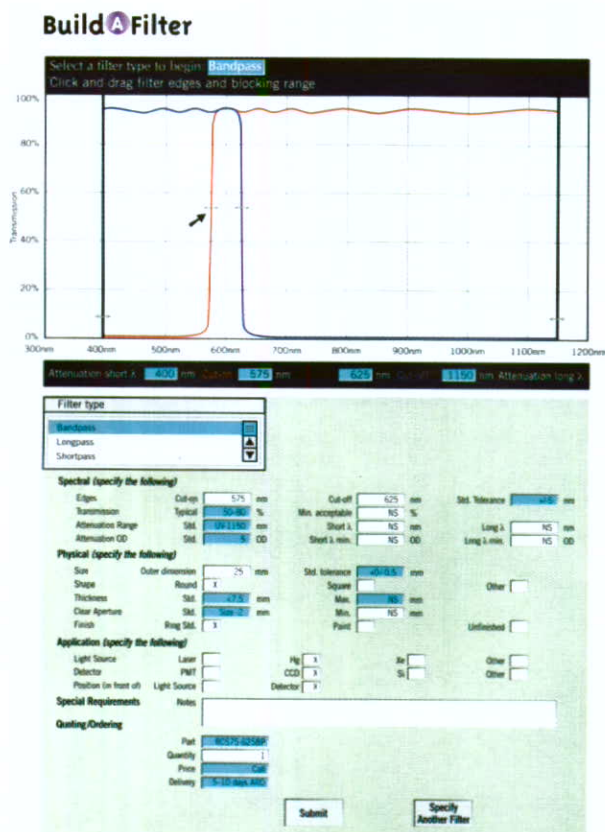
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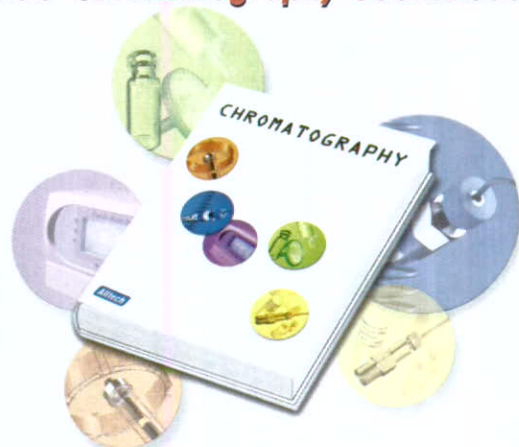
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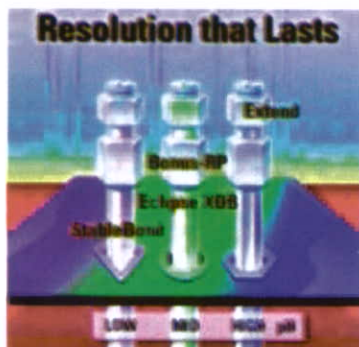
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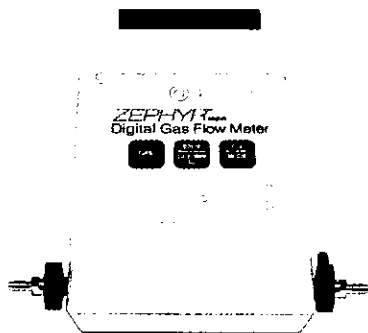
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EXPLORING INNOVATION

Hon. Pete Hodgson, Minister of Research, Science & Technology

Fifth Richard Dean Batt Memorial Lecture

delivered at Massey University, Palmerston North
12 September 2002

Foreword

The R. D. Batt Memorial Lecture, which was established in 1994 in memory of the Foundation Professor of Biochemistry, Richard Dean Batt, has become an important event in the life of Massey University. The first 4 lectures were on a variety of topics:

The Next 30 Years – Problems and Partnerships, Mr Hugh Williams Q.C., Chancellor of Massey University (1994),

The Future of Science and Technology in New Zealand, Hon. Simon Upton, Minister of Science and Technology (1996),

The Biological Revolution, Dr James Watson, Chief Executive, Genesis Research and Development Corporation Ltd (1998),

The Cost of Knowledge, George Petersen, Emeritus Professor of Biochemistry at the University of Otago (2000),

The Fifth Lecture, *Exploring Innovation*, was delivered by the Hon. Pete Hodgson, Minister of Research, Science and Technology. This lecture provides a timely review of research and development in New Zealand; our strengths, the gaps and the challenges ahead. Innovation is essential for our prosperity. Mr Hodgson has identified some key issues for reflection and action.

The lecture has been also being published in *NZ BioScience* 12 No.4 (November 2002).

It is also available at:
http://imbs.massey.ac.nz/HTML/dean_batt5.html.

of a motorcycle, the excitement of stage three biochemistry lectures as their clinical relevance started to become apparent to me.

I remember a short, sometimes stern, sometimes aloof man who seemed to be preoccupied only with imparting understanding. But I also remember a man who, despite huge class sizes, allowed his pastoral care for his students to show through. I saw the same thing in his wife too. She taught me neurophysiology and imbued me with the magic of the work of Eccles under whom she had studied. Her name was Dr Batt, and she didn't have a nickname. Dr Batt spoke often and glowingly of Professor Batt. But then she would.

Dickie Batt was an unforgettable man, one of those teachers whose image and voice I can recall at will. This is despite the fact that I studied biochemistry only because I chose veterinary science and biochemistry was on the list. Neurophysiology for that matter too. I was therefore a conscripted student rather than one who wanted to become a biochemist, but both Batts contributed enormously to my eventual love of their respective subjects and of biological sciences in general.

Many years later, as a Parliamentarian, it was Professor Batt I turned to for advice on liquor laws. I would ring him and talk to him. Always he maintained his painstaking accuracy. Always he chose his caveats with care and without unnecessary extra syllables. As I tested my political conclusions he would colour those conclusions with precisely chosen shading.

You will understand therefore why I feel honoured to give the 2002 memorial lecture and why I accepted without a second thought.

I've called this talk exploring New Zealand's innovation system.

I have already introduced jargon – New Zealand's innovation system. Why do I use it and what does it comprise?

I use it because I think a narrower concentration on the role of science in an economy or society will no longer do. I use it because in recent years a consensus has begun building in New Zealand that our future depends on the creation and creative deployment of knowledge and that all parts of our society are affected by that finding. I use it because it helps convey attitude changes that are under way in New Zealand and that need to quicken.

As you might expect I remember Professor Batt well. Behind his back we called him Dickie Batt and it approximated both a term of endearment and a term of respect.

I remember his alcohol experimentations well though regrettably I never myself partook of the vodka. I remember the discovery of microorganisms in the gearbox

What is an innovation system? There is no textbook answer. Every player wins a prize. But for me it is the aggregation of those things that contribute to a nation's ability to create or discover valuable knowledge and to deploy it widely, accurately and quickly.

Of course research, science and technology are at the heart of a good innovation system. They are the important wellsprings. So is our education system. These are obvious statements.

Less obvious is our ability to define, protect, value and congregate portfolios of intellectual property, and to see it as a new form of capital. How good are our patent attorneys or our regulatory structures in this regard? How good are we at licensing IP, at defending IP, at keeping secrets?

Our immigration system plays a role, given that the movement of talented people across jurisdictions is becoming more and more fluid. Each nation is competing for talent.

Our ability to look outward is a feature of an innovation system. How good are our government and institutions at interacting with other nations or institutions? How good are our businesses? How easily and how well do we form international strategic alliances, given the inexorable move to a more and more globalised, integrated economic and social future?

A good innovation system is concerned also with the core state sector. How nimble and responsive is a Government? How good are politicians or state servants at facilitating? What amount and quality of regulation is the right amount and quality?

How good are the nation's capital markets, its fibre optic infrastructure or its attention to career structures? What strategic attention is paid to the creative arts, to design, to engineering? How well are the science and society linkages drawn and nourished? How good is the nation's collective futurewatch capacity? What is the state and status of basic research? What is the state and status of public good research?

These things are collectively a nation's innovation system and they are the things I wish to explore.

Before I begin I want to do two other things. I want to comment on the quality of New Zealand science, and I want to comment on Simon Upton's R.D. Batt memorial lecture of six years ago.

First our science. We should remind ourselves that we are uniquely strong in many areas. Our mammalian reproductive sciences are world class, as are our mammalian genomics, earthquake engineering, some aspects of climate modelling, plant gene technologies, plant breeding, various frontiers of bioactives research, aspects of diabetes or asthma research, and much besides.

Kiwifruit is our story. Earthquake and volcano monitoring is our story. Much of Polynesian research is, of course, our research. We invented the jet boat, pinus radiata

cropping and we have good biosecurity research. We domesticated the green lipped mussel, produced the Bose-Einstein condensate, progressed ozone research. We can bring endangered species back from the brink, and we know a lot about a lot of proteins.

Our science is done efficiently, it enjoys good bibliometric evaluation, it is comparatively collaborative across institutions, countries and disciplines. It is of reliably good quality.

I'm saying this to set the scene. There is much that this country must do. Raising the average quality of our science is not at the top of anyone's list. The quality is already good, even if good can never be good enough.

Now to Simon Upton's lecture six years ago. Simon was approaching the end of a six-year spell as science minister, though he continued the ownership role for Crown Research Institutes for a further three years.

I want to offer some comment on Simon's address, or more accurately on the times in which he made that address. But I want to put on record first my view that he was a very good minister of science, and as effective as he could have been under the circumstances. In short, if Simon were minister now, he would be thriving.

His address was of course erudite. It was well structured, well argued and well worth the read.

But it was repeatedly defensive. He repeatedly defended taxpayer expenditure on science against those who, in his mind, would oppose it. He mourned the fact that not enough people thought science important.

Much of his address was about Crown Research Institutes. He spelt out his aims and hopes for CRIs and urged his successor not to undertake another round of restructuring in response to his. He defended Crown Research Institutes against those who would take dividends from them, and he railed against those who would interrupt CRIs as they made necessary adjustments to their assets and campuses and ways of doing things. He explained non-specific output funding and the theory of purchaser failure and he defended the creation of the Marsden Fund.

Throughout he drew on the work of his favourite economic philosopher, Friedrich von Hayek, as he sought to explain clearly why a liberal market thinker like himself should be so strongly in favour of ample public sector funding of science, especially funding which might give serendipity a chance. It is, as I said, well worth the read. Most of Simon's lectures are.

But it was not an optimistic speech.

New Zealand science was emerging from earlier indifference and recent restructuring. Simon Upton was right to establish CRIs, he was right to establish the Marsden Fund, and he was right to give universities access to what was then called the Public Good Science Fund. He had good reason to be optimistic.

But it was not an optimistic speech because science was still struggling to secure its rightful place in the minds of the policy elite in Wellington.

How things have changed, or at least how they have started to change.

The CRIs are now ten years old and thriving. They haven't been restructured by me, nor will they be.

I did take \$50 million off their balance sheets. This got doubled to \$100 million and became the New Zealand Venture Investment Fund, which will ultimately be multiplied up into about \$300 million of venture capital. It will start to hit the New Zealand innovation system in a few weeks.

There were two reasons to do that. One is that CRIs were awash with cash. One company had even invested in Government bonds – hardly leading-edge stuff. The second is that I have a Finance Minister and a Government as committed to science as I am. The \$50 million was bulked up to \$300 million and retained in the innovation system. Simon's Finance Minister would have wished to retire debt or lower taxes.

The Marsden Fund has more than trebled since Simon's speech, and a new basic research fund called the New Economy Research Fund is even larger. Basic research funding, and those two funds, made it into the Speech from the Throne last month, which outlines the Government's agenda for the Parliamentary term. That's always a good sign.

The point is that the mood of this country has changed. Research and Development is being viewed less as a cost and more as an investment. The idea of a knowledge economy is taking root, even if people dislike the term. The role of innovation is understood by those who matter – a quick comparative read of the 1999 and 2002 Treasury briefings to the incoming Government is arguably a case in point.

I must not of course overstate this change. We have after all just been through an election in which a heated debate on genetic engineering played a prominent part, but even here I can reasonably claim that it is the first election in our nation's history that was fought in part over science. The science and society debate is alive.

In all, I stand here optimistically.

Does that mean that New Zealand's innovation system is in good shape, that we need do no more than maintain and upgrade it from time to time?

No it does not. Our innovation system has serious shortcomings. I am optimistic that we can address them, but they are serious nonetheless. I would like to explore our innovation system from four different perspectives, or through four lenses.

As I do I ask you to think through what role your university, your department, your research team, or you can play to

help address the shortcomings I am about to explore.

The Government has been building a partnership with New Zealand's research community these past few years. It has many dimensions. It has a lot of potential. It is a work in progress.

We want to enable you to deliver more benefit for New Zealand. So as I wander through this address, think how your lot and my lot might make better progress on the issues we face. Consider how we might advance this partnership and make it hum.

Now to the first of the lenses I want to look through. Money.

After the endless international comparisons are made, one fact stands out above all others. It is that although public funding of research and development in New Zealand is close to the Western World average, private sector funding is closer to a quarter or a third of the Western World average. If it were equal to the Western World average, New Zealand would be spending an extra one billion dollars on R&D. We call that gap the missing billion.

Think through what the research community might do to help mobilise the missing billion. It is a big issue and it belongs to all of us. But first, why does it exist?

The first reason is that we are a primary production economy, rather than one that makes pharmaceuticals and aeroplanes. Around the world farming, forestry, and the like spend relatively modest amounts on R&D.

The second is that ours is a small business economy — and corporate size matters in the creation and defence of R&D budgets.

The third is that, though New Zealand attitudes to research and development are changing, they have not changed nearly enough. Companies are still taking an excessively short-term approach and R&D is an easy short-term target.

Low private sector R&D investment is both a cause and a symptom of our stage of economic development. Low R&D expenditure is what you expect from a primary production nation, and it is the reason we remain a primary production nation.

I do not forget that our excellent primary industries are what have made us a developed nation at all. We still post exceptional productivity increases, and part of our future is undoubtedly what some label the gourmet economy. But while primary production might underpin our economy, it is by no means sufficient.

What to do?

"Tax cuts" chorus some, ignoring how costly and blunt an instrument that is. Even so, I freely acknowledge the psychological impact of such policies and I freely acknowledge that Government should continue to actively explore the potential for gains through taxation changes.

That is why we now allow full expensing of all R&D costs in the year in which they were incurred.

“Measure R&D properly”, chorus others, and probably rightly. Measuring private sector investment in R&D accurately has proved something of an adventure. We will have better data soon. Will it reveal that the missing billion has been there all along? I very much doubt it.

A more useful answer might be labelled “industry policy”, something New Zealand all but abandoned during the nineties. More venture capital, more incubation and more attention to business formation, business growth and so on.

Here we are making useful progress.

Technology New Zealand, a grants to business facility, has had its budget doubled. Venture capital funding is forming quickly, though off a low base. We have more than a dozen business incubators, when three years ago there was only one. A new organ of Government, Industry New Zealand, has been formed, has found its feet and delivers most of the Government’s industry policy. It has a suite of industry development programmes and progress in recent times has been startling. In May a new form of R&D funding, consortium funding, got under way. The Government funds up to 50% of new and additional private sector investment into R&D, ranging from low risk to high risk. It has all gone, already.

So, if the lens is money, then the key issue, but by no means the only one, is to increase private sector funding of R&D and the role the Government might play in assisting that. We increased R&D funding by 18% in our first term and a useful chunk of that went into leveraging extra R&D investment from industry.

Or we could pick up another lens through which to view our innovation system – not money, but regulation. Here the news is mixed.

By international standards New Zealand’s regulatory system allows businesses to form or die easily. That is important. It is one of the reasons this country tops the international Global Entrepreneurship Monitor.

Deregulation can help. So can low compliance costs. The New Zealand Companies register, for example, now costs \$70 instead of an earlier \$200, takes thirty minutes not two weeks, can be searched anytime instead of during office hours and employs 20 people, not 70. Good, nimble, responsive Government.

Regulation can help. High environmental standards, which we have, force New Zealand companies to deploy cleaner technologies, or to invent them. Should they be exporters, they will clear the standards of other countries readily.

Let’s take a look at a university favourite, the Environmental Risk Management Authority. The Royal Commission found that high risk applications were subject to a precautionary, transparent and participatory process

that they deemed to be in good shape. But they found low risk applications to be over-regulated, costly and time wasting. That needs to be fixed.

We also have unfinished work on plant variety rights and patents. Here the regulatory framework is out of date, and harming innovation. Note also that we have no bioprospecting policy in this country, at all. We need one.

If one takes a broader view of regulation one bumps into contestable funding rounds, arguments around peer review, the debate about compliance costs for science and the role of evaluation of research. Here, surely, we must deploy a variety of techniques.

On the one hand, we have contestable processes regulated by peer review for investigator initiated research. On the other hand we have negotiation followed by evaluation when the taxpayer and industry are forming a consortium to fund an agreed portfolio of research. In general and on average my preference is to soften the contestability element a notch or two.

An emerging debate is how to evaluate the new performance-based tertiary research fund that is being split out of the EFTS funding model Simon Upton was so scathing about, six long years ago.

The EFTS model was, of course, hugely successful in achieving the aim of lifting tertiary participation rates, which are now amongst the highest in the world. But Steve Maharey saw the side effects of that policy — including the inefficiencies of duplication and growing uncertainty over the quality and quantity of teaching research — and acted accordingly. That is a topic for another speech, but its relevance here is that performance-based research requires an evaluation framework. That debate, essentially a regulatory debate, is upon us.

Let me put down that lens and pick up another. Not money. Not regulation. People.

An innovation system is self-evidently centred on and dependent upon people. How well does our innovation system stack up in this respect?

Here we can choose to travel quite well worn ground. The received wisdom might go something like: “too few scientists, too few science students, high tertiary education costs, not enough recognition of the research community,” and so on. That is a pessimistic analysis, but not necessarily a wrong one. There are, no doubt, many elements of truth in it.

The more optimistic analysis is also well travelled. It asserts that New Zealanders are well educated on average, and that education, combined with New Zealand’s geography, history and culture, produces people who think outside the square, pride themselves on a ‘can do’ attitude, display ingenuity and are not hide-bound by the traditions of other nations. This analysis often invokes Hillary’s line “we’ve knocked the bastard off” or Rutherford’s “we have no money gentlemen, so we shall have to think”.

I want to travel less worn ground. When I think of the role of people in the innovation system I am inclined to think of people on the move. Those who are clever and well qualified are even more mobile than before. New Zealanders leave and return, or not. Non-New Zealanders arrive and stay, or not. The phenomenon of a highly skilled, highly mobile, global workforce is growing and is likely to become permanent, as the global movement of capital has already become.

This third analysis means that immigration policy becomes very important.

Over the last year or two the New Zealand immigration service has altered its approach, becoming not just a gate keeper but also a recruitment agency. In a variety of ways, New Zealand actively encourages well-qualified people to immigrate to New Zealand to work. Accredited businesses now enjoy the ability to recruit staff directly, so long as they have a permanent job for them paying over \$45,000 a year.

Every Western nation is joining this quest for talent, as ageing progressively turns demographic profiles from upward triangles to inverted triangles. The New Zealand inversion lags other countries to a degree, courtesy of Polynesian demography.

By the way, as our population becomes more Polynesian, the case for greater Maori involvement in science becomes greater. Maori in my view, think differently. Maori have a different knowledge set, including some very old knowledge. For those reasons, and because it gives effect to the Treaty partnership, we have created a still small line item in the budget called Maori Knowledge and Development. I'll say no more on it today, except watch this space.

We can and should view the kiwi expat community differently. The best part of a million kiwis live offshore and many are in a position to contribute to the New Zealand innovation system.

An example of this is the Kiwi Expat Association, or KEA, which now has chapters in several world centres. I attended the opening of the first of them earlier this year on the Berkeley campus. About 100 kiwi expats in the Silicon Valley area gathered for the day to gain an update on their country of origin. They are mostly in business or academia. All of them are keen to help New Zealand or New Zealanders, a few want to come home and many wish to make money.

KEA is essentially a private sector initiative that arose from last year's knowledge wave conference. A supporting policy initiative from Industry New Zealand finances the movement of expats back to New Zealand for a sabbatical, typically with a New Zealand business.

New Zealand has started to learn that talent, here and abroad, matters. A question to leave you with is: What can the research community do to augment these policy initiatives and maximise their benefit?

Which leads me nicely to my fourth lens. Not money, regulation or people but interactivity. This idea attracts its fair share of synonyms. Interconnectivity, strategic alliances, global connectivity, interdependence and so on.

The essential idea is well understood. It is that a good innovation system depends on many different relationships. The thicker that web of relationships, the more chaotic it is, the better. The classic linear analysis of an idea making its way from basic research to applied research to pre-commercial development and successful entry into a grateful global market is mostly fantasy.

In practice, innovation is most likely to flourish where scientists and entrepreneurs mingle to the point where the distinctions are lost. Where academics flick in and out of commerce, or for that matter the policy arena. Where clever people look back on a career so eclectic and varied that describing it to a stranger becomes a burden. Where venture capitalists, technologists, marketers, designers and lawmakers live and work amongst each other.

Michael Porter has given this idea extensive academic analysis. This is cluster development, of course, and it is a favourite with Labour politicians because a functional cluster is economically very powerful and very resilient. Bits of it can die and be reabsorbed into the whole.

The level of interdependence in a cluster puts paid to the pure competitive model of business. People must cooperate at home in order to compete abroad. The king of the world's clusters, Silicon Valley, has been the subject of a number of books exploring its success, sometimes in the language of ecology. A linear model or a model that analyses inputs separately doesn't seem to work. An ecological analysis seems to make more sense.

In the New Zealand context interactivity is working both well and badly. The Fitzherbert science campus is a good example of university, crown research institute and research association collaboration and it is decades old. It collaborates well with primary industries but poorly beyond that.

Indeed there are few manifestations of the gourmet economy or of the modern biotechnology sector in the Manawatu. This is a cluster that has a good base and not yet a lot else. Some recent local initiatives are setting out to change that.

A number of recent Government policies have been designed, at least in part, to promote interactivity. Consortium research funding, which I have already touched on, uses money to forge and co-fund a research strategy in an industry sector. Centres of research excellence, though predicated primarily on excellence, also promote linkages between institutions. Applicants who were not well linked to other institutions did not succeed.

At this point I should pause and congratulate Massey on its success in that programme, with the Allan Wilson Centre opened just a couple of hours ago, and note also that both Ted Baker and Paul Callaghan hail from these parts.

Cluster development is now a function of Industry New Zealand and export network development a function of Trade New Zealand. Integration here and there is becoming a watchword, again, and at our place we seek to do the same, under the moniker of “whole of Government”.

International interactivity is harder. We are a small and distant nation and still that is a factor that counts against us, notwithstanding notices of the death of distance, occasioned by the Internet. A New Zealand scientist must be more outward-looking than an American or European one. So must a New Zealand institution, a New Zealand enterprise, the New Zealand Government. That is why New Zealanders have a high passport ownership. That is why over a third of our economy is in the export sector.

Yet the number of large exporters is disturbingly low. A Boeing 737 would seat all the chief executives of export companies of any size. Moreover, with important exceptions, New Zealand businesses are not noticeably linked with overseas marketing networks, owners, sister companies or R&D capability. The global web is, for us, still insufficiently woven.

Where does the research community sit in all this, given it is amongst the most globally connected of all New Zealanders? Where can you use your connections to better connect not just yourselves, but others including business?

This relates to another shortcoming in our innovation system, that of foreign direct investment. It is not that we have low levels of overseas ownership. Our poor savings record has seen to that over the decades, and continues to do so. But most foreign investment is in existing enterprises — utilities, for example — rather than in growth industries that use and develop New Zealand skill. There are some excellent exceptions — the joint venture between Ericsson and Synergy is often quoted — but the problem is I can name most of them.

Slowly that is changing. An increasing number of overseas investors are active in New Zealand. They are investing in biotechnology, information technology and manufacturing. Yacht makers, pharmaceutical companies or multi media companies are developing in partnership with home-grown capability.

New Zealand’s future does not lie in the Irish or Singaporean approach of joining the international bidding war to induce businesses to relocate. We do not have the right global location to induce a Viagra factory to a greenfield nearby, nor frankly the money to compete with the incentives other nations are prepared to offer. Besides which, easy come, easy go, as Britain has discovered to its cost.

New Zealand needs a foreign direct investment strategy and capability. We are quietly building one. It is called Investment New Zealand and it is putting runs on the board. Its activity and funding must grow.

None of this is to downplay foreign portfolio investment or investment in existing industries. In forestry processing,

for example, increased foreign investment is becoming urgent. Such investment is job rich. It is not however transformational.

Moreover, the next time the Manawatu creates a Glaxo, we should take care to retain the intellectual property here as a magnet for other investors, even if the budding company must move part of its operations offshore.

I have one more thing to say under this heading of interactivity or global connectivity. It is that we sell ourselves short on the way we brand ourselves as a nation.

The preoccupation with a clean, green image is not enough. It is a powerful idea for a nation that exports food and imports tourists. But it is hardly innovative. A better one liner would be ‘clean and green and on to it’. A nation that can produce three Nobel Prize winners in a century from a modest population base, make ‘The Lord of the Rings’, win and defend the Americas Cup with boat design and technology second to none, should project itself differently.

We have started. The taxpayer threw a party at the Beverly Hills Hotel two days before the Academy Awards last March and invited Hollywood to come. They did. They were impressed with the skill and technology available here. More film-making is coming our way. The day after the awards we paid for full page adverts in several large newspapers in the US and elsewhere which read ‘best supporting country’. Innovation has become a pretty broad idea. I wonder whether Dickie Batt would have approved.

Let’s pause and see where we have got to so far.

I have described what, for me, an innovation system is and I have described it broadly, even if I have left out important contributions such as the creative arts or physical infrastructure or savings policy or macro-economic underpinnings.

I have explored the New Zealand innovation system through four lenses — money, regulation, people and interactivity. I’ve noted that my mood is more optimistic than I judge my predecessor Simon Upton’s to have been six years ago.

This analysis of the strengths and weaknesses of the New Zealand innovation system is not new. But it is not very old either. It was an uncommon analysis even two years ago.

Since then what gets called a national conversation has been underway. The Science and Innovation Council took part. So did the Knowledge Wave conference, various consultants hired by Government, and quite a few Government agencies. So did business, academia and the community.

To cut a long story short, the result of this for us, the Government, was a strategic statement called ‘Growing an Innovative New Zealand’, with which the Prime Minister began Parliament in February this year. This

document informed this year's budget and this year's Speech from the Throne. It pervades Government thinking. Some of you will be familiar with it, some not. But all of you will have a sense of the policy direction our nation is following, or will have helped shape it.

Why does growing an innovative New Zealand matter?

If I were an economist my answer would be that wealth creation is good and that the main driver of wealth creation is an increase in total factor productivity and that the main driver of that increase, these days, is innovation.

I suspect the economist's answer, though dull, will do.

If we latch onto it, we can readily dredge up periods of human history when the economist's increases in total factory productivity had other origins. Like the advent of property law, the French Revolution, railways, the widespread availability of secondary education, you name it.

The current chapter in the story of New Zealand's productivity began during the eighties, I reckon, when people started to think about a knowledge economy and how it might differ from a goods economy or an economy based on efficiently using natural resources.

The first findings were obvious. Research and Development mattered, education mattered, intellectual capital or property mattered. As our understanding grew we discovered cluster development, why the so-called law of diminishing returns may not be a law after all, and the importance of global linkages.

By the nineties the mood had started to catch on in universities, Crown Research Institutes, some local bodies and some businesses. I know because it had started to catch on with my colleagues too. And me.

I entered Parliament in 1990 and was promptly thrust the science portfolio as an Opposition backbencher. I spent every Friday for a year visiting New Zealand's research facilities and I read avidly.

At the end of 1991, I went to my leader Mike Moore and declared that, while I loved the science portfolio, I couldn't understand it. I had found too many ambiguities, and the international policy literature was too contradictory and changing very quickly. Mike Moore's advice was, unsurprisingly, a one-liner. He said, "If you don't understand something, you must write a book about it".

So over the next few months I did. It is unpublished, and it is unpublishable. But it certainly helped me sort out my thoughts and I have followed the science and innovation debate ever since.

Through the nineties the Government however, didn't get it. They thought the nation needed more deregulation, privatisation, cost cutting, structural reform, price stability and tax cuts. They held that Government had no business in business. They saw no role for a modern Government as a leader, facilitator, partner, broker. They didn't grasp the importance of R&D, or of innovation.

Simon Upton, and later Maurice Williamson, did. They sang lonely songs. They were in concert with the US, the UK, Finland, Singapore, Canada, Australia, Israel, Ireland and Denmark. But they sang discordantly within their own Cabinet. By the end of the nineties, the government of the day was travelling determinedly down a cul-de-sac, and then they reached the end.

So as far as the current New Zealand Government is concerned, we have entered this new era of development, based on innovation, later than we might have. To an extent we have some catching up to do. On the other hand we can learn from the mistakes of others, and we are doing so.

I've already touched on some areas where the present Government has moved in its first term. But how does the immediate future or medium term future look?

Before this crystal ball gazing begins, I need to drop a couple of caveats into the mix, a little defensively.

The first is that the Government will not be swayed from fiscal prudence. Too many of us still remember Mr Muldoon. We will run surpluses over the business cycle, not deficits.

The second is to repeat that the New Zealand innovation system belongs to New Zealand, not to the New Zealand Government. That is, institutions, companies and individuals have a role to play, a risk to take and an opportunity to secure. Indeed an innovation system in which the Government looms large usually doesn't work, except perhaps in cultures very different to ours such as Singapore.

So, money doesn't grow on trees, and partnerships across society and the economy are very, very important. Given my assertion that things have changed markedly since Simon Upton gave this lecture six years ago, what might the changes be in the next six years? Where will society, commerce, the Government, research institutes be at? How will our place in the world have changed, our social attitudes, our economic performance, our environment?

The beginning of this period is easy to describe. Existing policies such as the performance-based research fund will be implemented, along with the rest of the tertiary education reform package. So too, to give another example, will Trade New Zealand's beach-head programme, enabling New Zealand exporters entering new markets to share office facilities provided by the state as they settle in to build their contacts and markets.

The Government has no shortage of implementation ahead of it. Ditto universities as they manage the risks and opportunities of reform, CRIs as they implement some exciting business plans, and numerous rapidly growing businesses as they follow their own plans for exporting, listing, merging or whatever it is to be.

I think the mix of financial instruments available here will change as New Zealanders explore the further use of stock

options, or venture capital, or as superannuation funds in New Zealand finally click to the importance of investing in the private equity market. I think our stock exchange, currently performing well, will offer up new products or refine existing ones.

The three focus sectors in the Growth and Innovation Framework — biotechnology, information and communications technology and the creative industries — will have all doubled in size in six years. That represents only 15% growth a year, which feels to me eminently achievable. However the indirect effects of growth in those sectors on the rest of the economy — of biotechnology on our primary industries for example — will be even greater, though harder to measure.

The Kyoto Protocol will have come into effect six years from now, bringing with it a new wave of innovation. Some of that will be imported — hybrid cars will do as an example. Some of it will be homegrown and exported — ruminant methane mitigation practices and technologies, perhaps.

We will, I predict, have a biopharmaceutical industry in New Zealand, or partly in New Zealand, in about six years. Whether it will arise from Genesis or IRL or Auckland or AgResearch or Otago I can't know. But I don't doubt it is coming.

Government expenditure on R&D will have risen, and within that, expenditure on basic R&D will have risen faster. But private sector expenditure will have risen faster still, prompted in part by a range of Government policies and in larger part by further attitude changes and further economic transformation. As a percentage of total Government expenditure, or as a percentage of GDP, research and development investment will be up, or up a lot.

We will still be a small and distant nation, but we will have a lot of international alliances in six years that we don't have now. Some of them will be in the private sector, along the lines of the Ericsson-Synergy model I mentioned earlier. Some will be at the institutional or even national level. We may have implemented our own version of what is called BIRD, or bilateral investment in R&D, by which Israeli and American businesses partner their research. We may have formal and deep state-to-state links of consequence — with Queensland in biotechnology, for example.

Some of our primary industries will look very different, as we install traceability technology or as we secure the value of what, today, we call waste. I am thinking of real examples such as a fining agent made from hoki skins, adhesives made from tree bark, and all the bioactives and biomaterial opportunities we are currently researching.

But there are some words of caution to sound, too.

The first is that we must resist the temptation to ape other nations. We can lift public policy ideas from them — and I should acknowledge and thank Israel, Singapore, Korea,

Canada, Australia, Britain and the US, amongst others — but we must adapt ideas for New Zealand. Copying doesn't work.

The second is that we must guard against fake success. The dotcom experience tells us that, as does the start-up fever that has swept some countries, stripping students and academics alike from institutions as it passes through. A little start-up fever is a good thing. A lot of it will prospectively end in tears.

The third caution is that science and society issues are upon us. Whether it is the GE debate or concern about electromagnetic radiation or the ethics of stem cell research, science is nestled in society and in a contemporary value system. Scientists and technologists have a role in society to listen, to explain and to listen again. A risk management analysis is a hard thing to explain, yet it is often the best tool we have. Good science communication is so important. So is an ethical framework that will withstand scrutiny.

New technologies are arriving quickly. They will test our value system and our values or cultures will test science. Some science will be rejected in New Zealand. Nuclear fission. Human cloning. The issue is how we debate and decide those things. The Royal Commission was a good example of good process. The election campaign was a shocking example.

It is time to draw this exploration to a close.

As I do, I want to acknowledge that I have left a lot of science out of my discussion on innovation. Environmental science, social science, and straight academic scholarship. I regret that.

Nor have I spoken of career structures, of scholarships provision, or of women in science. I haven't dwelt on science promotion, or the costs of a science education, or sustainable development. I've defined innovation broadly but have then explored some, not all, of its many facets.

Given another hour or so I might make a reasonable fist of those issues. But my time is up, so I acknowledge them as unfinished business.

Being Minister of Research, Science and Technology is a privilege. I enjoy the company and debate of fine minds. I watch new knowledge being created. I experience the excitement of new ideas or paradigms unfolding. I enjoy playing my part in making our innovation system function better and better and I'm lucky to be part of a Government that has growth through innovation at the heart of its thinking. I am very committed to my work.

I feel very optimistic about our small country's innovation system.

If Dickie Batt were here I think he would, in his own carefully constrained way, agree.

Patent Proze

by Jane Calvert and Helen Palmer

BIOPROSPECTING

“Who owns the cactus that kills hunger pains for Kalahari hunters?” Questions like this are being raised on a regular basis throughout the world given the increasing value that is placed on traditional/indigenous knowledge. An important concern of indigenous peoples is that their traditional knowledge of natural resources is being exploited.

The recent release of a discussion paper on bioprospecting in New Zealand raises several issues at a local level. The purpose of the discussion paper is to guide further consideration of bioprospecting policy. The full discussion paper can be viewed at www.med.govt.nz.

Bioprospecting issues must be considered against quite a complex background.

New Zealand has ratified to the United Nations agreement of the Convention on Biological Diversity (CBD). The CBD is known as an environmental treaty. Article 1 of the CBD states:

“The objects of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.”

Essentially, the CBD does not impose any obligation on its members to award intellectual property rights for cultural or indigenous knowledge to its indigenous peoples. Rather, the focus is on the collective sharing of traditional knowledge or folklore.

New Zealand is also a member of the World Trade Organisation TRIPS (Trade Related aspects of Intellectual Property) agreement, which sets in place international legal obligations for its members. TRIPS states that “intellectual property rights are private rights”. There is recognition at an international level that the objectives of the CBD and the TRIPS agreement are not aligned.

On top of this, consideration must also be given in New Zealand to the principles of the Treaty of Waitangi and the WAI 262 claim, a part of which relates to indigenous flora and fauna. The WAI 262 claim was lodged in 1991. The claim encompasses Maori culture and intellectual property rights and ownership claims by Maori to indigenous resources and species. The Royal Commission of Inquiry into Genetic Modification considered the WAI 262 claim and the indigenous issues in detail. Submissions were heard from several parties. It was clear from the submissions that there was a clash between the private economic rights that one can achieve through the existing intellectual property regimes and the collective cultural/indigenous rights in respect of traditional knowledge.

The balancing of all these competing aspects in developing a workable bioprospecting policy will be difficult and ambitious.

Furthermore, bioprospecting is happening in New Zealand and has been for some time. Is this a case of the Government trying to rein in the horse after it has already bolted?

A reminder: if you have any queries regarding patents, or indeed any form of intellectual property, please direct them to:

Patent Proze
Baldwin Shelston Waters
P. O. Box 852
Wellington
Email: email@bsw.com



Jane Calvert

Jane Calvert and Helen Palmer of Baldwin Shelston Waters specialise in chemistry and biotechnology patents. Jane is a patent attorney and solicitor. She joined BSW after completing a PhD in chemistry at the University of Canterbury in 1994. Helen joined BSW in 2000. She has a PhD in chemistry from The University of Auckland, and has had postdoctoral research experience in the USA and New Zealand.



Helen Palmer

Maurice Wilkins

- Achievements Celebrated

This year marks the golden jubilee of the publication of the helical structure of DNA for which Pongaroa-born Maurice Wilkins, now 86, was jointly awarded the Nobel Prize for Medicine or Physiology with Watson and Crick. The Royal Society has organised a variety of events to celebrate the occasion and *Chemistry in New Zealand* marks this jubilee with commentary on the Wilkins plaques and memorials, and an article on Wilkins by Wellington member, Vincent Gray who studied in Cambridge from 1939.

B. Halton (Ed.)

Plaque Unveiled In Kelburn

The achievements of Maurice Wilkins, the scientist who was jointly awarded the 1962 Nobel Prize in Physiology or Medicine for his role in the discovery of DNA, were marked at the site of his boyhood home in Wellington on Tuesday February 11, 2003 to celebrate the golden anniversary of the discovery.

Professor Wilkins shared the Nobel Prize with Francis Crick and James Watson. A plaque (transcript below) and double helix sculpture to honour Professor Wilkins, who considers himself as a New Zealander despite living in the United Kingdom since the early 1920s, was unveiled by three visiting fellow Nobel Laureates. Professor Alan MacDiarmid (Wellington-born and educated at Victoria University) was joined by fellow winners of the 2000 Nobel Prize in Chemistry Professors Hideki Shirakawa and Alan Heeger for the unveiling outside Victoria University's Murphy Building. The Murphy Building is built on the site of 30 Kelburn Parade, which was the family home of Wilkins.

The Nobel laureates were in Wellington for the first conference on Advanced Materials and Nanotechnology (AMN-1), organised by the Victoria University MacDiarmid Institute for Advanced Materials and Nanotechnology.

Professor Wilkins, who was not present for the unveiling, said, "It gives me great satisfaction that my life at Kelburn Parade as a boy is being celebrated in this way."

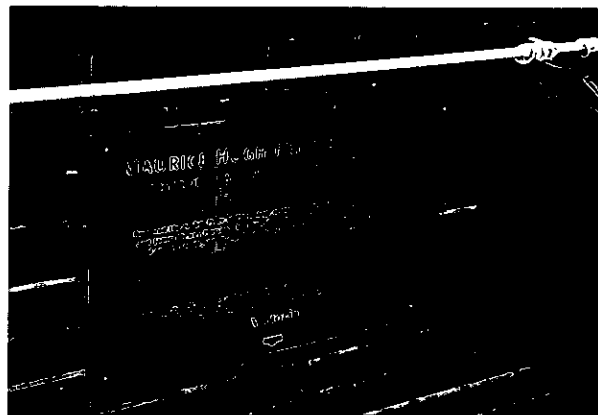
Professor Stuart McCutcheon, Vice-Chancellor of Victoria University said, "This is a golden moment in celebrating science. I hope that the commemorative plaque will come to be recognised as a national monument to the achievements of Professor Maurice Wilkins".

"The University is delighted to have this inspirational link to Maurice Wilkins and his outstanding achievement. Along with the University's close relationship with Alan MacDiarmid, and our extensive research networks, the plaque cements staff and student ties to the international science network."

Poet Chris Orsman, the VUW 2002 Writer in Residence, read for the first time in New Zealand, *Making Waves*, the poem commissioned by RSNZ to celebrate Wilkins.

The Hon. Pete Hodgson, joined the Nobel Laureates at the unveiling celebration together with members of the Science and University communities, the Kelburn Residents Association, Wellington Mayor Kerry Prendergast, and children from Kelburn Normal School who released 50 balloons to represent the golden anniversary of the discovery of DNA.

The event fits into a year-long programme organised by RSNZ to mark the 50th anniversary of the discovery of the structure of DNA. More details are available from Glenda Lewis (RSNZ): (04) 470 5758 or 025 210 0997.



Above: The plaque at the site of the former 30 Kelburn Parade (Photo courtesy of Image Services, Victoria University).



Above: Maurice Wilkins with HRH Princess Anne and James Watson (background) at the opening of the Franklin-Wilkins Building, Kings College, London, March 2000.



Left: One of the original DNA models built by Maurice Wilkins in 1953. **Right:** Rosalind Franklin's famous X-ray diffraction photo (Photo 51) of the B form of DNA.

The Plaque At 30 Kelburn Place

Maurice Hugh Frederick Wilkins

1962 Nobel Laureate in Physiology or Medicine, born Pongaroa, 1916, lived here at 30 Kelburn Parade as a boy, received the Nobel Prize in Physiology or Medicine with Francis Harry Compton Crick and James Dewey Watson, "for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material".

In 1945 Maurice Wilkins decided to study the molecular structure of genes. In 1947 he began studying genes in living cells, DNA, and viruses using new types of optical microscopes. In 1950 he concentrated on X-ray diffraction of DNA with Raymond Gosling and Alexander Stokes, and they discovered that DNA was helical. In January 1951 Rosalind E. Franklin (1920-1958) joined the work at King's College, followed by Herbert Wilson in September 1952, and their work considerably aided the X-ray studies. In April 1953 *Nature* published the Watson Crick model of DNA. The crystallographic data supporting the model appeared in the same issue in two separate papers by Rosalind Franklin and Maurice Wilkins.

To commemorate the 50th anniversary of the publication of the discovery, this plaque was unveiled on 11 February 2003 by the Nobel Laureates in Chemistry who together discovered and developed conductive polymers:

Professor Alan J Heeger
Professor Alan G MacDiarmid (Victoria University of Wellington alumnus)
Professor Hideki Shirakawa



Above: 2000 Chemistry Nobel Laureates (L-R): Alan Heeger, Alan MacDiarmid, and Hideki Shirakawa after unveiling the helix memorial at the former 30 Kelburn Parade (Photo courtesy of Image Services, Victoria University).

Plaque At Pongaroa, East Of Pahiatua

The plaque unveiled in Pongaroa in 2001 reads:

Maurice Hugh Frederick Wilkins

Maurice was born in Pongaroa in 1916, son of our local doctor, Edgar Wilkins and his wife Eveline. In 1940 he received his physics doctorate from the University of Birmingham. During World War II he worked on radar and the atom bomb but afterwards became a strong campaigner against nuclear warfare and switched to the new science of biophysics.

At King's College, University of London, he and colleague Rosalind Franklin studied the structure of deoxyribonucleic acid (DNA) using X-ray diffraction techniques. Their discovery of what appeared to be a double helix enabled Francis Crick and James Watson to deduce a structure for the molecule.

Wilkins, Crick and Watson were awarded the 1962 Nobel Prize in Physiology and Medicine for this work.

The citizens of Pongaroa placed this monument here with assistance from: Royal Society of NZ; College of Sciences, Massey University; horizons.mw and others.

17 March 2001



Above: The Wilkins monument at Pongaroa (Photo courtesy of Vincent Gray).

Maurice Wilkins And The Double Helix*

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*This article is based upon a lecture delivered to the NZIC Wellington Branch on June 13, 2001.

Three papers appeared on April 25, 1953 in *Nature* announcing the discovery of the molecular structure of deoxyribose nucleic acid (DNA), the chemical substance responsible for heredity. Three of the four principal authors, Maurice Wilkins, James Watson, and Francis Crick were awarded the Nobel Prize for Physiology or Medicine for this discovery in 1962; Rosalind Franklin, the fourth major contributor, had died in 1958.

This year marks the 50th anniversary of this discovery, and it is appropriate that we should celebrate it, and particularly the contribution made by Maurice Wilkins who was born in New Zealand. It is a matter of pride to tiny New Zealand that of the many scientific discoveries of the twentieth century, possibly the two most important, the structure of the atom, and the molecular basis of biological action, both involved its former citizens. It has to be admitted, however, that both discoveries actually took place elsewhere, in Britain.

Maurice Francis Hugh Wilkins was born in the tiny Wairarapa town of Pongaroa on December 15, 1916 and his baptism was recorded at St John's Church of Pongaroa on 15 February 1917. Wilkins, left Pongaroa with his parents for Wellington when he was three months' old, and he left New Zealand for good in 1922 at age six and a half years and has never returned.

On Saturday March 16th 2001, local historian Bernadine Meech unveiled a monument in Pongaroa to honour Maurice Wilkins and the discovery of the double helix, and to mark his birthplace with a commemorative plaque. Funding for the monument came from a variety of sources including RSNZ and the NZIC Wellington Branch. Wilkins is still alive, now aged 86, but is sufficiently active to have provided a speech for the occasion and to give an interview with the Kim Hill radio show the following Monday.

To celebrate the 50th anniversary of the discovery of the structure of DNA this year, the Royal Society of New Zealand arranged a programme of events. A portrait of Maurice Wilkins, commissioned by the Royal Society of New Zealand in association with the New Zealand Portrait Gallery, was unveiled at a ceremony to honour the contribution of Maurice Wilkins at Government House, Wellington, on March 10th. The pre-eminent New Zealand artist Juliet Kac, who currently lives in Brighton, painted the portrait. This ceremony follows a similar event that took place in London on November 26 last.

Wilkins' father, Dr. Edgar Henry Wilkins and his wife, Eveline Constance Jane (née Whitaker) were born in Dublin, Ireland, and came to New Zealand in 1913 on the *Ruahine*. Dr. Wilkins practised medicine in Petone, where their daughter Eithne was born. He then accepted a post with the Pongaroa Medical Association, which also involved "commuting" by an unreliable car to Pahiatua.

Edgar Wilkins' letters to his mother in Dublin from these periods are held in the National Library of New Zealand.

In March 1917 Edgar Wilkins was appointed Director of School Medicine with the New Zealand Health Department in Wellington and the family moved to 30 Kelburn Parade, now a part of the Victoria University campus. Six years later, in 1923, the family left for London because Dr Wilkins decided to study for a Diploma of Public Health at King's College, London, the same college where his son later worked on DNA. He then secured a position with the School Medical Service in Birmingham, remaining there for rest of his life. Maurice was educated in Birmingham and attended King Edward's School. He went to St John's College, Cambridge, to study physics, and graduated in 1938, the year following the death from septicaemia of Ernest Rutherford, his Professor.

Returning to Birmingham, Wilkins became a PhD student of Dr. John Randall at Birmingham University. Randall is a name not familiar to many, yet almost every kitchen houses Randall's greatest achievement, his invention, in 1940, of the cavity magnetron valve for generating radio waves. This device helped to win the Battle of Britain, as it was the essential tool of radar and it is the heart and soul of every microwave oven. It obtained a knighthood for Randall. Wilkins gained his PhD in 1940 for a study of the thermal stability of trapped electrons on phosphors and on the theory of phosphorescence, work that was used to improve cathode ray tube screens for radar, features which are still used in TV sets and computer monitors.

In the same year at the same university (Birmingham) Otto Frisch and Rudolph Peierls carried out their crucial calculation of the possible size of an atomic bomb made from pure ²³⁵U. They concluded that it could be only a few kilograms. The Germans never knew of this important discovery and failed to develop an atom bomb as a result. After Churchill was informed that an atom bomb was possible, Wilkins joined Mark Oliphant, the Australian physicist, to work on the separation of uranium isotopes and, in 1943, the group moved from Birmingham to Berkeley, California, as part of the US atom bomb programme under J. R. Oppenheimer.

In 1945 following the end of the war, Wilkins returned to Britain. He was disgusted at the dropping of the atom bombs on Japan in 1945 and he elected to have nothing further to do with atomic weapons. He became a lifelong opponent of nuclear weapons, becoming for several years President of the British Society for Social Responsibility in Science.

He took a post as a lecturer in physics at St Andrews University, Scotland, again under J. T. Randall, who was now the Professor of Physics. Randall was asked to head



Left: A younger Wilkins.

a biophysics research unit at King's College, London, with a very wide brief. Wilkins applied to join him, and was accepted. In 1946, King's College was something of a mess as it had been bombed during the war, but Wilkins, now aged 30, embraced the newly established scientific

discipline of biophysics by tackling a variety of projects that included studies on the properties of tobacco mosaic virus and ram's sperm.

It appears that Wilkins, like many scientists of the day, was greatly impressed by Schrödinger's book *What is Life*, which is currently available *in toto* on the Internet. Erwin Schrödinger (1887-1961) founded wave mechanics and supplied the fundamental equation of quantum mechanics, for which he shared the Nobel Prize for Physics in 1933 with Paul Dirac. In the book Schrödinger states:

"The code-script for the entire pattern of an organism's future development and functioning is contained within the chromosomes which lie within the nucleus of the fertilised egg. There are always two sets of chromosomes. In humans there are two sets of twenty four. One half of each pair is from the mother and the other half from the father. Growth of an organism occurs through the process of cell division, or "meiosis". It takes between 50 and 60 cycles of cell division to produce the number of cells in a grown man."

Proteins are by far the most important biological chemicals, as they provide the main structural and functioning components of all organisms, many enzymes, and other chemicals which control living systems. They all consist of polymers of some twenty amino acids, joined together in many different ways. They were widely regarded as the most likely solution to the puzzle of heredity posed by Schrödinger.

Nucleic acids were amongst the last group of biological chemicals to be discovered, by the Swiss biochemist Friedrich Miescher in 1869 working in Tübingen, Germany. He extracted a chemical from pus (obtained from used bandages) and found that it was not a protein, but contained phosphorus. He called it nuclein, as it was evidently present in the nucleus of cells. He had great difficulty publishing his results, as its very existence seemed unlikely to those who believed that proteins were the only biological molecules. Subsequent work confirmed his results and showed that this *nuclein* contained, besides phosphate, a sugar (ribose or deoxyribose) and a set of four bases. As it was slightly acidic it was called nucleic acid. There are two principal nucleic acids: deoxyribose nucleic acid (DNA) contains the bases adenine (A), cytosine (C), guanine (G), and thymine (T), while ribose nucleic acid (RNA) has A, C and T, but guanine (G) is replaced by uracil (U).

As long ago as 1884 the zoologist Hertwig pointed out that since DNA came from the cell nucleus it must surely

be the material responsible for heredity. Yet for 70 years this likelihood was ignored. Everybody assumed the hereditary substance must be a protein because DNA seemed to be so simple, and proteins seemed to be more complicated and, therefore, more likely to be involved with the complex processes of heredity.

After many years of confusion, in 1944 a team led by Oswald Avery (1877-1955) of the Rockefeller Institute, New York, proved that DNA was the hereditary substance, at least for the pneumonia bacillus. They extended a 1928 experiment of the British bacteriologist Fred Griffith who had shown that killed deadly pneumonia bacilli could activate live benign bacilli and transform them into the deadly form, and so kill mice. Avery managed to isolate the chemical that did it and to show that it was DNA, and not a protein.

Maurice Wilkins had a great stroke of luck in 1950. As he recounted in his March 2001 radio interview with Kim Hill, a junior member of the laboratory team attended a conference in London where he met a co-worker of Avery who convinced him that DNA might be the hereditary substance. Wilkins accepted his colleague's enthusiasm and switched his interests to this most vital molecule, which at that time was little studied by others. He obtained a sample of pure DNA from Professor Rudolph Signer of Bern, Switzerland, at a meeting of the Faraday Society in London in May 1950. He found that fibres could be drawn from this sample that showed a high degree of crystallinity, so he made some X-ray diffraction photographs of these fibres using an old X-ray machine in the basement of Kings College, with the help of Raymond Gosling, his PhD student.

The solution to the problem of the structure and function of DNA depended to a considerable extent on the technique of X-ray diffraction. The founder of this technique was William Lawrence Bragg (1890-1971). He was born in Adelaide, Australia where his father was Professor of Physics. In 1912, at Leeds, where his father was again the Professor, he was examining some results of Max von Laue concerning the action of X-rays on crystals. He concluded that the atoms in the crystals diffracted the X-rays to give a pattern of spots on a receiving photographic plate and that these could be used to work out the positions of the atoms in the crystal. The process is exactly similar to diffraction of visible light which we encounter regularly in our daily lives. W. L. (later Sir Lawrence) Bragg together with his father W.H. (Sir William) Bragg won the Nobel Prize for Physics for this discovery in 1915. W. L. Bragg was at that time serving in the army in Flanders, and, at age 25, is still the youngest person ever to be awarded a Nobel Prize.



Above: Maurice Wilkins at the inauguration of the new Wilkins/Franklin science laboratory at King's College, London.

The two Braggs agreed to split their interests. The father studied organic compounds at the Royal Institution, London, and the son studied inorganic compounds at Manchester University where he applied his technique to the structure of minerals. In 1938, after the death of Ernest Rutherford, he was appointed Cavendish Professor of Physics at Cambridge University. He thus presided over the discovery of the structure of DNA and actively participated in the researches of Perutz and his team, including those of Watson and Crick.

The elder Bragg, while at the Royal Institution had several important pupils. W. T. (Bill) Astbury (1898-1961) became Lecturer (eventually Professor) in Textile Physics at Leeds University. He applied the X-ray diffraction technique to biological fibres and made the first X-ray photograph of a fibre of DNA in 1938. The work of Watson and Crick in 1950 began with this photograph. It is ironic that one of Astbury's students made an improved photograph of DNA in 1952 similar to the one that confirmed the structure of Watson and Crick, but it was never published.

John Desmond Bernal (1901-1971) was another protégé of W. H. Bragg. He was an Irishman from Stonyhurst, a Catholic College. He went to Emmanuel College, Cambridge, to study physics, and he worked under W. H. Bragg at the Royal Institution for several years before being appointed as lecturer in crystallography at the Cavendish Laboratory, Cambridge, in 1934 under Rutherford. Between 1934 and 1937 he established an X-ray crystallography unit where he developed many of the techniques for interpreting X-ray diffraction photographs, and he studied several biological fibres.

He was the prototype mad scientist. He had a flock of flowing hair and a continuous flow of conversation. He was a Marxist and a Communist, sat on innumerable peace committees, and was involved in many political campaigns. In 1939 he founded *The Science of Science* with his "Social Function of Science" and he wrote a monumental *History of Science*. He was a womaniser and a Bohemian. I remember once attending a meeting in his spare bedroom in London, where, above the bed on the ceiling, was an original painting by Picasso. He could never be made a Professor or College Fellow in Cambridge. On one of the occasions when he applied, an elderly Fellow purportedly said "A man with hair like that cannot be *sound*". It is ironic that he left Cambridge in the year that Rutherford died. Bernal subsequently presided over molecular biology research from 1937-1968 at Birkbeck College, London.

Linus Pauling (1901-1994) got his PhD in physical chemistry at the California Institute of Technology in 1925. He devoted his early career to the study of chemical structure and bonding and his 1939 textbook *The Nature of the Chemical Bond* was the "Bible" of physical chemists in my day - it still packs a punch despite its neglect of the currently favoured molecular orbital theory. This book provided the basis for Watson and Crick's attempts to build a structure for DNA in 1953. Pauling had proposed the α -helix structure for proteins in December 1950 and produced a structure for DNA in 1953, which whilst wrong, was sufficiently close to inspire Watson and Crick towards the correct solution.

When I went to Emmanuel College to study chemistry in 1939 (thanks to a scholarship for which the examiner was C.P. Snow) I was told to choose two other subjects for my first two years to avoid too great a specialisation. Physics was obvious, but mathematics was only half a subject, and so I chose what appeared to be the soft option, *mineralogy*. And so it was that I found myself at the cutting edge of science, the crystallography class, but without its recently departed Head, Bernal.

After completing my degree I joined the Colloid Science Department under Professor E. K. Rideal, where I became involved in the war effort with the study of incendiary bombs and flame-thrower fuels. I used the work to obtain a PhD in 1946, and then found I had to depart to make room for all those who were returning from the war.

Max Perutz was an Austrian Jewish refugee who arrived in Cambridge in 1936. He became obsessed with discovering the structure of haemoglobin, the blood protein. I had attended several of his progress lectures, and it was obvious that given the technology of the time, he was getting nowhere, something that Francis Crick told him when he joined the laboratory in 1949. I asked Perutz whether he needed an assistant as I did not particularly want to leave Cambridge. He did need an assistant but there was no money, so we parted. A few months' later, John Kendrew came along with some scholarship money and became his PhD student and assistant. Together they won the Nobel Prize for Chemistry in 1962 for their studies on the structure of proteins. Perutz became chief assistant to Professor Bragg, and the UK Medical Research Council eventually financed the X-ray work on proteins.

Francis Crick was born in Northampton (UK) in 1916 and it is a strange coincidence that his mother's maiden name was Wilkins. He studied Physics at University College, London, and worked for the Admiralty during the war on radar and magnetic mines, where he met Maurice Wilkins. Crick, too, was inspired by Schrodinger's *What is Life* and he eventually managed, in 1949, to study X-rays and proteins for a PhD under Max Perutz (at Cambridge) on a Medical Research Grant.

James Dewey Watson was born in 1928 in Chicago (USA) and studied at the University of Indiana under the pioneering biophysicists Max Delbrück and Salvador Luria who convinced him that the secret of biological function was to be found with DNA. He was awarded a grant to study in Copenhagen, and while there, attended a conference in Italy where he met Maurice Wilkins who displayed his first X-ray picture of DNA. Watson determined to transfer to Britain and, meeting Francis Crick found the scientific soul mate he needed. The US authorities at first refused to transfer his grant, as his job at the Cavendish Laboratory was to study proteins. Watson and Crick, with little background experience, had become inspired to seek a possible structure for DNA, at first in secret, using Pauling's book as their base.

So let us return to Maurice Wilkins who at King's College, London, in 1946 had obtained his first X-ray photograph of DNA before the old X-ray machine gave up the ghost. Wilkins realised that he knew very little about X-rays, and

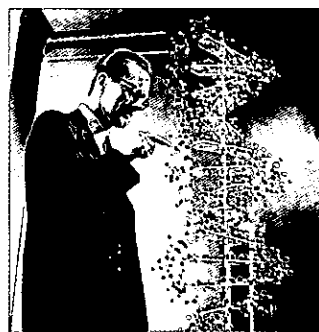
he needed modern equipment, so the word went out for an X-ray expert to join him.

Rosalind Franklin (1920-1958) was born in London and went to St Paul's School, close to the boys' school that I attended in Hammersmith. She went to Newnham College, Cambridge, in 1938 to study chemistry, and she studied the same courses I did, one year ahead of me. This included the crystallography class and she may have overlapped with Bernal. There were few girls studying chemistry, so I was vaguely aware of her as an attractive, but rather imperious young woman that I did not meet at the time. She started a PhD with Professor Ronald Norrish in Physical Chemistry but, because of serious disagreements with her supervisor, abandoned Cambridge and obtained her PhD instead from the British Coal Utilisation Research Association in Manchester, for pioneering work on the density of coal, and the X-ray structure of carbons (various carbonised substances including coals).

Rosalind Franklin then decided to see the world, and in 1947 took a post with Professor Mathieu to further her work on X-rays and carbons in Paris at the State Services Laboratory. In September 1947 I went to Paris myself, working at the Institut Pasteur on flow birefringent properties of gelatin. I met Rosalind at a dance and subsequently had dinner at her flat, and spent a day in the Compiègne forest with her. She was a pleasant, friendly, unassuming person, dedicated to science. She thoroughly enjoyed life in Paris and spoke excellent French but I saw little more of Rosalind, except at a subsequent scientific meeting in Britain.

After three years (1950) Rosalind's family wanted her to return to Britain. She heard that they wanted an X-ray expert at King's College, London, and she got the job. She was told at a meeting with the Professor (Randall) that she was to work on proteins but he then changed his mind and put her to work on of the structure of DNA. She was an experienced research worker with many publications, and she assumed that she would be in charge of the project. Wilkins was not present at the interview, and he subsequently believed that she was merely his assistant. As a result they became estranged, to the level of hardly being on speaking terms. Randall must be held partly to blame as he seems to have done little to set matters straight. Franklin set about acquiring decent X-ray equipment through Bernal at Birkbeck College, and Wilkins gave her the sample of DNA obtained from Signer in 1950, expecting to carry out his own studies on another sample he had received from Erwin Chargaff, which ultimately proved disappointing.

Rosalind Franklin was a thorough, systematic worker who did not like to be railroaded into premature conclusions or publication. She was reluctant to release her X-ray pictures to Wilkins, or to Watson and Crick, until she had made a thorough analysis of what they meant. Watson and Crick took an alternative approach. They built structures that at first were ridiculous partly because of their own ignorance. It is understandable that Franklin found Watson and Crick irritating, particularly because what they were doing was not supposed to be their job anyway; Pauling's proposed structure was also ridiculous but was still published. An incident recorded in *The Double Helix* when she got mad



Above: Wilkins and DNA model.

at Watson is now attributed to the fact that Pauling's results were sent privately, via his son, to Watson, whereas Rosalind, who had asked for them, had not yet seen them.

For some time Franklin believed that the structure of DNA might not be helical at all, but this

changed when she found that there was a second form of DNA (Type B) containing extra water, which definitely was helical. Watson and Crick received sufficient hints from her work, plus the realisation, from Chargaff himself, that there were equal amounts of A and T, and G and C bases to build a structure that explained how the molecule could transmit genetic information and reproduce itself.

Rosalind Franklin by this time had had enough unpleasantness at Kings and arranged to join Bernal at Birkbeck. She packed her things and gave her best DNA photo to Wilkins. Watson and Crick happened to notice it during a visit. They realised that it confirmed their double helix structure, which must therefore be right. They all met and agreed to submit three letters to *Nature* announcing the discovery. These were published on 25 April 1953 by Watson and Crick, Wilkins, Stokes and Wilson, and Franklin and Gosling.

Franklin spent several more years at Birkbeck on studies of plant viruses and on the poliovirus. She died of ovarian cancer in 1958 aged only 37; undoubtedly this resulted from exposure to X-rays. She spent her last convalescence with the Cricks who by this time had become firm friends.

The Nobel Prize for Physiology or Medicine was awarded to Watson, Crick, and Wilkins in 1962, the same year that Perutz and Kendrew got the Prize for Chemistry. In addition, 1962 saw the Nobel Peace Prize awarded to Linus Pauling another major campaigner for peace and nuclear disarmament who was, for a while, denied a passport by the US authorities. There has been a suggestion that his Nobel Prize for Chemistry in 1952 was partly inspired by the desire of the Nobel Committee to snub the US Government of the time. Whilst one of three individuals to have received two such prizes, he is the only person to be awarded two independent prizes alone.

In 1962 W. L. (Sir Lawrence) Bragg was the senior member of the Nobel Committee and had considerable influence. Apparently he was responsible for persuading the committee to change from a single recipient to a maximum of three. According to Judson, he advocated that the Physiology or Medicine prize in 1962 should go to Watson, Crick, and Dorothy Crowfoot Hodgkin. So Maurice Wilkins can consider himself lucky to have had other influential friends on the committee; Hodgkin received her Prize for Chemistry in 1964.

There can be little doubt that Franklin would have been personally honoured in some form had she lived. It has been remarked that if she had had a collaborator it was likely she would have found the structure first. But perhaps



Left: Nobel Prize Winners 1962 (left to right): Wilkins, Perutz, Crick, Steinbeck, Watson, Kendrew.

her real collaborator, whether either of them knew it, was James Watson. Wilkins recently opened the new “Wilkins/Franklin” laboratory at Kings College, London, an example of a posthumous honour for Franklin. When she died her chief collaborator at Birkbeck was Aaron Klug who received the Nobel Prize for Chemistry in 1984; had Franklin been around, she could have shared it with him.

James Watson published *The Double Helix* in 1968 as a frank and amusing one-sided account of this discovery. It is still a best seller. At the time almost everybody concerned, including Crick and Wilkins, condemned it as unfair. Bragg wrote a foreword but made excuses for its deficiencies. Crick said it should be viewed “not really as history, but as a fragment of Jim’s autobiography”. They never collaborated again. Watson recently has written a sequel to his Cambridge adventures, which has received hostile reviews.

Watson’s treatment of Franklin in particular has been criticised. He wrote that she “might have been quite stunning had she taken even a mild interest in her clothes. This she did not. There was never lipstick to contrast with her straight black hair, while at the age of thirty-one her dresses showed all the imagination of English bluestocking adolescents”. This statement is simply not true. Rosalind Franklin did not go in for high fashion, make-up and jewellery, but she was neat, well dressed and attractive. One is bound to speculate that the little whippersnapper, Watson, eight years her junior, homing in on her scientific territory, made a pass at her and was rebuffed unmercifully.

Watson tried to make amends later in the book, perhaps under goading from Bragg, “Since my initial impressions of her were often wrong I want to say something here about her achievements We both came to appreciate her personal honesty and generosity...”. Much has been made of Watson’s unfortunate remarks. Ann Sayre, a friend of Franklin’s, wrote a biography that over-exaggerated and claimed anti-feminine discrimination. There is some truth in this, but Rosalind Franklin held her own, both socially and scientifically, and was generally treated as an equal in the scientific community, and at her work. The recent biography by Brenda Maddox does much to set matters straight. Wilkins has also been criticised for showing Franklin’s X-ray photograph to Watson and Crick without her permission. It seems likely that this was never done purposely, and that Franklin herself never resented it since it led to the resolution of the double helix structure which all of them desired.

Francis Crick has been the leader in the subsequent work of teasing out the details of the genetic code, involving

messenger RNA and transfer RNA. He has also published interesting work on the function of the brain.

James Watson has been relatively inactive scientifically, with only one published paper since 1962. He wrote an important textbook *The Molecular Biology of the Gene* and has been in charge of the human genome project that was recently completed.

Maurice Wilkins spent a number of years on projects following up and confirming the DNA discovery, but spent much of his latter years teaching, and campaigning against nuclear weapons and for social responsibility in science. He is currently working on his own autobiography entitled *The Third Man*.

Are there any lessons to be drawn? This discovery was a genuine team effort and all four major players made vital contributions however dysfunctional they may appear. All science involves many people and many connections. As Wilkins said in his radio interview, they just had the luck to be there when the last stone was added to the pyramid.

In his book Watson says, “a goodly number of scientists are not only narrow minded and dull, but also just stupid”. Maybe they are just like the rest of us.....

Should you disobey your research supervisor and work on a completely different project? Should you rush in where angels fear to tread? Only if it works! The main lesson surely is that science can only progress by multiple inputs and arguments, by fresh thinking and bold approaches, as well as by the often tedious and detailed work.

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Contaminated Horticultural Land In The Auckland Region: An Historic Legacy

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Abstract: New Zealand has a long history of intensive horticulture. Many of the green fields areas designated for development throughout New Zealand have been used extensively for horticulture. Forty-eight soil samples were collected from five horticultural land uses (glasshouses, market gardens, orchards, vineyards and multi-use) in the Auckland region. The samples were analysed for acidic herbicides, organonitrogen, organophosphorus and organochlorine pesticides as well as trace elements. The contaminants most frequently detected at the highest concentrations in cropping areas sampled were total DDT (the sum of all isomers of DDT and its degradation products DDE and DDD), copper, dieldrin, arsenic and lead. Levels of these contaminants in cropping soils on some properties exceeded conservative New Zealand and international guidelines for the protection of human health and/or ecological receptors. Approximately 70% of properties developed prior to 1975 (n=35) sampled in this survey exceed at least one trigger level. The results from this survey indicate that historic horticultural practices including the use of agrichemicals have resulted in elevated levels of contaminants in some cropping soils. These elevated levels of contaminants have the potential to impact on the suitability of horticultural land in its current state for residential development.

Horticulturalists were allowed to use limited quantities of DDT and dieldrin under permit from 1970, and persistent organochlorine pesticides were deregistered³ only in 1989. Arsenic-based pesticides and herbicides were phased out⁴ during the 1970s. Although their use may be decreasing,⁵ copper-based formulations are still registered and are widely used in New Zealand.⁶

Crop	Lime	Copper	Sulfur	Lead arsenate	DDT
Pip fruit	✓	✓	✓	✓	✓
Stone fruit		✓	✓		
Citrus		✓	✓	✓	✓
Grapevines		✓	✓		✓
Berry fruit		✓	✓	✓	✓
Strawberries		✓			
Vegetables	✓	✓	✓	✓	✓

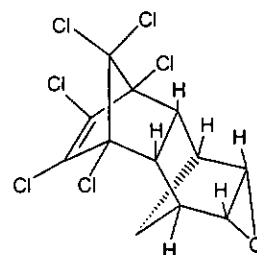
Table 1. Use of selected horticultural chemicals in 1956, as indicated by spray schedules – see reference 1.

Soil contamination from historic agrichemical use may pose risks to human health and the environment when horticultural properties are developed for residential subdivisions. Soil and settled dust can be significant sources of human exposure to contaminants through ingestion, dermal contact, and inhalation.⁷ Young children are particularly susceptible to soil contaminants due to their size, their stage of development, and their behaviour patterns.⁸ Typically they ingest more soil due to their hand to mouth behaviour and some children may even deliberately ingest up to 5 g of soil per day⁹ – a pica child.

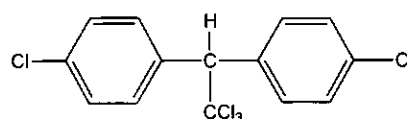
Introduction

Horticultural properties historically have been located on the fringes of our cities. Throughout New Zealand there is increasing pressure on this land for so called “green fields” development. For example, many of the green field areas designated for residential development in the Auckland Regional Growth Strategy¹ either have been used or currently are being used for intensive horticulture. Prior to the commencement of this project there existed only limited data on the types and levels of contaminants present in soil on the horticultural properties of New Zealand that had resulted from the recommended routine uses of agricultural chemicals.

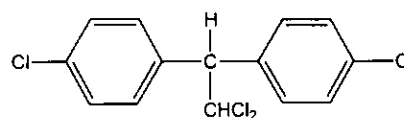
Until the mid 1970s, a range of persistent organochlorine, e.g. 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane (DDT) and dieldrin, and metal-based pesticides, e.g. lead arsenate and mercury-based compounds, were extensively used on horticultural crops in New Zealand. Spray schedules were recommended by growers’ advisory groups, marketing boards, and chemical supply companies; the Ministry of Agriculture and Fisheries also provided an advisory service. Typical spray schedules for 1956 as provided by Atkinson *et al.*² are summarised in Table 1.



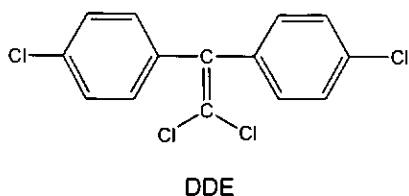
Dieldrin



DDT



DDD



Edible plants may take up selected contaminants from soil thereby creating a further potential human exposure route that must be considered when setting soil guidelines for residential subdivisions.¹⁰ Uptake by grazing animals also needs to be considered when assessing exposure routes for lifestyle blocks. The earthworks associated with subdividing land may result in contaminated soil entering waterways as well as generating contaminated dust. Contaminated soil may also be tracked into houses during construction and earthworks.

A research project to measure the levels of residual contamination on horticultural properties in three regions of New Zealand, namely Auckland, Waikato, and Tasman District, is underway and an evaluation of the significance of any residual contamination using New Zealand and international guidelines for the contaminants in soil is to be made. Results for the Auckland region are presented below.

Methodology

Soil samples were collected from cropping areas on 43 active or former horticultural properties in the Auckland region. The land use categories sampled were glasshouses, market gardens, multi-use, orchards, and vineyards. The land use duration categories were recent (<10 years cropping), long-term (>20 years cropping), and historic (>10 years inactive). Properties were also identified as developed for horticultural use prior to, or after 1975.

Soil samples were collected to a nominal depth of 7.5 cm using a stainless steel foot corer. This sampling depth was chosen as it represents the immediate surface layer that a future user of the site, e.g. a child, would be exposed to as well as the material that could potentially enter an adjacent waterway.¹¹ The Public Health Commission recommended that preliminary sampling to determine soil contamination of a potentially contaminated site should be carried out to a nominal depth of 5-10 cm.¹² A "Z" sampling pattern as shown in Figure 1 was used to collect one aggregate sample per hectare from the cropping area and care was taken to avoid potential hotspots, e.g. spray sheds and farm dumps. Up to four hectares were sampled within the cropping area on each property and the aggregate samples composited. Composite samples were prepared according to the detailed guidelines in Australian Standard AS 4482.1-1997 for non-volatile and semi-volatile compounds.¹³

Only eight hotspots were identified and sampled as part of the survey. Suspected hotspots on a given property were sampled last and all equipment was thoroughly cleaned between taking samples. To ensure adequate material for analysis, each hotspot sample consisted of 10 soil cores. On two of the properties (an orchard and a vineyard) the area around the spray shed contained a thin layer of soil over the top of gravel; a stainless steel trowel was used to collect these samples and the approximate sampling depth was 10-20 mm.

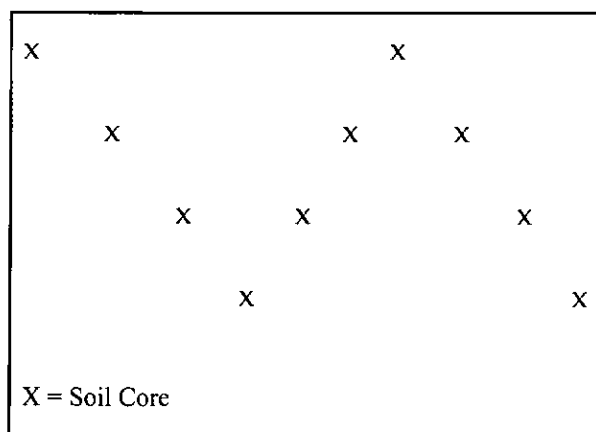


Figure 1. "Z" sampling pattern used on cropping areas - each aggregate sample contained 10 soil cores collected from an area \leq one hectare.

The soil samples were analysed by an IANZ accredited laboratory for a multi-pesticide and -herbicide residue screen, viz. organochlorine, organonitrogen and organophosphorus pesticides (181 compounds), 17 acidic herbicides, and 15 trace elements. Duplicate samples, a certified reference material (trace elements) and sampling equipment rinsate blanks were also submitted for analysis. Prior to analysis each soil sample was mechanically homogenised and a representative sub-sample dried in a dedicated oven for 5 days at 30 °C to \leq 8% moisture content.

Acidic Herbicides in Soil

The acidic herbicides were extracted from field-moist soil samples by accelerated solvent extraction with (dichloromethane and acetone), GPC cleanup and methylation to give a volatile ester for GC-MS analysis with an internal standard calibration. A procedural blank was included with each batch of samples. Samples were spiked with 0.05 mg kg⁻¹ equivalent 2,4,6-tribromophenol and/or 2,3,6-trichlorophenylacetic acid as system monitoring compounds. Three field moist blind duplicates were submitted to the laboratory for the multi-acidic herbicide screen; acidic herbicides were not detected in any of the cropping area samples or field duplicates.

Multi-residue Pesticide Analysis

Fully homogenised field moist soil samples were submitted to a registered commercial analytical laboratory (Hill Laboratories, Hamilton, New Zealand) for a multi-residue pesticide screen covering 181 organophosphorus, organonitrogen and organochlorine pesticides. Briefly, these samples were extracted with ethyl acetate under sonication, the extracts subjected to GPC or SPE cleanup and then analysed by GC-ECD/NPD using internal standard calibration with GC-MS confirmation. A procedural reagent blank was included with each batch of samples. Matrix spike recovery experiments were also undertaken and typical recoveries for DDT and its degradation products ranged from 61 to 108%.

Trace Element Analysis

Trace elements were determined using USEPA Method 200.2 Total Recoverable Metals. The extracts were diluted and determined by ICP-MS. Three blind duplicate and one certified reference material (CW 7401 Soil, National Research Centre for CRMs, China) samples were also submitted for trace element analysis. The trace element

results for the three blind duplicates were within 20% excepting those trace elements with concentrations close to the detection limit.

Results and Discussion

The contaminants most frequently detected at the highest concentrations in cropping areas sampled as part of this survey were the sum of the DDT isomers and its degradation products DDE and DDD (Σ DDT), dieldrin, arsenic, copper, and lead. Σ DDT and dieldrin were only detected on properties developed prior to 1975 whereas copper was the main contaminant of concern for properties developed after 1975. Levels of Σ DDT, dieldrin, arsenic, copper and lead in cropping areas frequently exceeded baseline levels for soils in the Auckland region (see Table II).^{2,14}

Acidic herbicides were not detected and generally only low levels (<1 mg kg⁻¹) of organonitrogen and organophosphorus compounds were found in cropping areas. These findings are in agreement with the results of similar surveys carried out in New South Wales¹⁵ and Canada.¹⁶ The few cases where organophosphorus and organonitrogen residues were detected were most probably due to recent use.

With the exception of copper, none of the other modern pesticides that were assayed appear to be accumulating in cropping area soils. However, in saying this it should be noted that some specific classes of modern pesticides have not yet been assessed, due to the unavailability of cost-effective commercial analytical facilities for their

measurement. These include the bipyridyls paraquat and diquat, the dithiocarbamates Mancozeb, Maneb, Metiram, Propineb, Thiram and Ziram, and the phosphonyls (glyphosate, glufosinate-ammonium).¹⁷ Dithiocarbamates and phosphonyls are known to break down fairly rapidly in soil, although it is likely that the former class will leave behind residual zinc or manganese 'metal payload' upon degradation. In particular, levels of accumulated zinc may be a problem in soils where zinc-based dithiocarbamates have been used extensively. In the case of the bipyridyls, recent modelling studies¹⁸ suggest that Paraquat and Diquat do have the potential to accumulate on soils where they have been routinely used.

Eight potential hotspots from seven properties as described in Table III were sampled and selected analytical results are summarised in Table IV. Sample G contained paint flakes so it is likely that the elevated levels of lead and zinc are from pigments in the paint; no separate analyses of the flakes were undertaken. The results from the two long-term spray sheds and the outside of the glasshouse are of particular concern as the elevated levels of copper and lead may be acutely toxic to the pica child who deliberately ingests large amounts of soil.

Comparison with trigger levels

Conservative trigger levels were selected to put the cropping soil data from this survey into context. These trigger levels are envisaged as an initial 'Tier I' screening tool, *viz.* is there an issue that warrants further investigation?, and they are generic rather than site specific.

Contaminant	Baseline for the Auckland region				
	Range	Median	Range	Median	Source
Σ DDT ^a	<0.03-289	0.2	0.002-0.075	-	^b
Dieldrin	<0.005-0.56	<0.005	0.0002-0.042	0.0007	^b
Arsenic	<2-34	7	0.4-11	4.7	^c
Copper	7-490	58	1-45	9.8	^c
Lead	2.7-1250	32	<1.5-65	12.7	^c
Zinc	9-510	53	9-180	52	^c

^aSum of isomers of DDT, DDE and DDD. ^bAmbient concentrations of organochlorines in metropolitan Auckland soils (see ref. 3).

^cBaseline trace element concentrations in non-volcanic Auckland soils (see ref. 14).

Table II. Summary of soil analyses for contaminants most frequently detected at the highest concentrations in cropping areas in mg kg⁻¹ dry weight.

Sample code	Property type	Land use duration	Hotspot description
A	Glasshouse	Long-term	Compost disposal area
B	Multi-use	Long-term	Boiler ash disposal area
C	Multi-use	Long-term	Concrete storage pad
D	Vineyard	Recent	Spray shed
E	Vineyard	Long-term	Spray shed
F	Orchard	Long-term	Spray shed
G	Glasshouse	Long-term	Bare soil around the outside of a grape glasshouse
H	Orchard	Historic	Possible location of a spill from stationary spray system

Table III. Description of potential hotspots sampled in the survey.

Sample	Arsenic	Copper	Lead	Mercury	Tin	Zinc	ΣDDT
A	59	46	11	<0.1	1	86	0.05
B	22	94	191	<0.1	1	117	^b
C	11	74	208	<0.1	2	273	<0.03
D	4	41	26	<0.1	<1	131	<0.03
E	24	917	159	18.8	12	433	270
F	11	11800	86	0.1	14	1050	10.2
G	13	375	2000	0.2	7	671	74.8
H	3	85	86	<0.1	1	44	0.43
Cropping soils	<2-34	7-490	2.7-1250	<0.1-0.4	<1-8	9-510	<0.03-289

^aUnits are mg kg⁻¹ dry weight. ^bNot assayed for pesticides. ^cThe range for cropping soils is included for comparison.

Table IV. Trace element results for potential hotspots on selected horticultural properties in the Auckland region.^a

Exceeding any one trigger level indicates that further data assessment needs to be undertaken, including (if necessary) further sampling and analysis, but it does not (and must not be assumed to) indicate that there is necessarily a risk to human health for people living and/or working on the site. Such an assessment can only be made on a site-specific basis upon consideration of all of the pathways operating at the site.

The conservative trigger levels of Table V were selected to protect human health under the most sensitive land use scenario, which is considered to be lifestyle blocks with 50% produce (fruit and vegetable) ingestion.^{10,19-21} Where available New Zealand risk-based guidelines were chosen for arsenic and copper. In the absence of New Zealand risk-based guidelines (ΣDDT, dieldrin, lead and zinc) trigger levels were selected from overseas sources according to the procedures outlined in the draft document Contaminated Sites Guidelines No 2.¹⁹ This hierarchy gives preference to guidelines that employ risk assessment or deviation from acceptance criteria similar to those adopted in New Zealand. The hierarchy also states "where several acceptance criteria values are available, the most conservative acceptance criteria should be used on consideration of all current and likely future users of the environmental medium under evaluation".

Arsenic, copper, lead, ΣDDT, dieldrin and zinc levels in all soil samples collected from cropping areas exceeded the trigger levels on at least one property as shown in Table

Contaminant	Trigger Level	Source
Arsenic	30	^a
Copper	80	^a
ΣDDT	0.7	^b
Dieldrin	0.3	^c
Lead	70	^b
Zinc	200	^b

^aHealth and Environmental Guidelines for Selected Timber Treatment Chemicals for residential settings with 50% produce ingestion see reference 10. ^bEnvironmental Quality Guidelines for agricultural land use from the Canadian Council of Ministers for the Environment – see reference 20. ^cUSEPA Region 9 Preliminary Remediation Goals – Residential soils adjusted for a one in 100,000 cancer risk – see reference 21.

Table V. Trigger levels for contaminants in soil in mg kg⁻¹ dry weight.

VI. Copper and ΣDDT were the two trigger levels most frequently exceeded. Overall, 70% of properties (n=35) developed prior to 1975 sampled in this survey exceeded at least one of the trigger levels for soil in a cropping area. None of the properties exceeded six trigger levels, 31% exceeded one trigger level, and only 9% exceeded four trigger levels.

Approximately 45% of the historic properties sampled (n=11), *i.e.* cropping areas that had reverted to pasture, had soil contaminant levels equal to or exceeding the trigger levels. This is an issue for future land management because limited record keeping means that historic cropping areas are the least likely to be readily identified without soil testing.

Conclusions

The levels of contaminants found in Auckland cropping area soils are comparable to those found overseas for similar land uses. The levels of arsenic, copper, lead, ΣDDT, and dieldrin measured in cropping area soils on some properties exceeded conservative guidelines for the protection of human health and the environment. ΣDDT and dieldrin were only detected on properties developed prior to 1975 while copper was the main contaminant of concern for properties developed after 1975. These findings are consistent with the registration and recorded use of organochlorine and copper-based pesticides in New Zealand.

The results from this survey indicate that the routine historic use of agrichemicals has resulted in elevated levels of contaminants in cropping area soils on a large proportion of properties developed prior to 1975. It is likely that cropping soils in other regions of New Zealand will also contain elevated levels of contaminants. These contaminants will impact on the suitability of such land in its current state for residential development. Moreover, the results presented here argue for regional and national policies (including appropriate guidelines) to be developed for the management of contaminated horticultural land in New Zealand.

Acknowledgements

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	Orchards (n=12)	Glasshouses (n=8)	Vineyards (n=11)	Market Gardens (n=8)	Multi-use (n=4)	Properties (%) (n=43)
Number of properties exceeding guideline values						
Arsenic	2	0	0	0	0	5
Copper	7	2	6	1	1	40
ΣDDT	6	5	4	1	0	37
Dieldrin	0	0	0	2	1	7
Lead	5	2	2	0	0	21
Zinc	1	1	0	0	0	5

Table VI. Number (n) of horticultural properties with agrichemical residue levels in all cropping area soils equal to or exceeding the selected trigger level (the overall figure is presented as a percentage).

The survey was undertaken with assistance from Regional Public Health, Auckland District Health Board. Parts of the work presented in this paper were previously presented at the 2003 WMINZ conference.

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Update

Biominerals

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Biomaterials have long fascinated humans not only for their everyday usefulness but their seemingly simple complexity. Recently scientists have begun to look to them as the possible foundations for the next revolution in materials production. Such research carries the aim of being able to synthesise inorganic-organic composites with controllable physicochemical properties.

When one considers what a biomaterial is, likely the first thing that comes to mind is bone. While bones are a very important example of a biomaterial they comprise only a small subsection of the class. Other members include polymer films, e.g. skin and nails, protein fibres, e.g. silk and hair, and signalling devices such as magnetic and gravity receptors. Each of these examples can be synthesised by a single living system with the organism exerting incredibly high control over all steps in the mechanism.

The smaller subclass of biominerals are produced by organisms that use a vast array of chemical compositions, matching the diversity found in their mineral cousins. Here, however, there is a slight twist: the minerals deposited by organisms have quite distinct physical properties when compared with a mineral of near identical chemical composition. The way in which the organism deposits the biomineral imparts enhanced properties to the final material. For example, paua deposit calcium carbonate primarily in the form of aragonite. However *nacre* or 'mother-of-pearl' has a tensile strength approximately 1000 times greater than that of the mineral aragonite. The problem that we scientists face is understanding how such enhancement comes about.

One distinguishing feature of biominerals is that they are hierarchical, *i.e.* they have a structure (or order) over different length scales, when compared with minerals whose morphology most often resembles its underlying symmetry. The construction of the biomineral places great importance on this hierarchy. We can take as an example of a hierarchical structure a sea urchin spine, whose general shape and form is similar to a pin. This then is one level of structure. Upon taking a closer look we see that in cross-section the form of the spine is comparable to a wagon wheel, but one can continue to look at the spine at higher levels of magnification until one comes to the packing of the calcium and carbonate ions in the crystal's unit cell. In general, a sea urchin spine will have at least five levels of hierarchy and it is this hierarchical structure that is believed to be the source of the enhanced physical properties observed.

In addition to hierarchical structure many biominerals are composite materials. The presence of an organic component in the final material can help to define the response of the material to external stimuli. The forms in which the organic molecules are present vary significantly

from being the dominant matrix in bone to films acting almost as a 'mortar' to the inorganic 'brick' in nacre, and as a defect in the crystal packing in sea urchin spines. In other systems the organic molecules are not physically incorporated into the growing mineral, but they influence the way that the inorganic material is deposited, such as in enamel nucleation and growth.

It is the combination of hierarchical structure with organic influence (and/or uptake during the nucleation and synthesis) that defines the final physicochemical properties of the biomineral and it is precisely this combination of factors that scientists presently are trying to understand.

From a medical perspective, the advantages of understanding not only the process of how biomaterials are deposited but also their function, reactivity, specificity, and molecular interactions – in short their mechanism of formation and resulting physicochemical properties – are obvious. Skin grafts, hair replacement, implants, bone and joint replacements are things that many of us may face or have at least contemplated. Despite the significant improvements in understanding these areas we are still unable to synthesise anything that truly resembles bone or skin, but the desire to do this has not stopped a multi billion-dollar industry in America alone from trying.

From a non-medical perspective, the fabrications of materials in the laboratory that have physicochemical (or merely physical) properties comparable to those of biominerals have the potential to be the next revolution in materials science advancement. The reawakening of this area stems from a new willingness of scientists in general to work on projects that require expertise from a number of different disciplines. In the case of gaining an understanding of how a biomineral is formed, developmental biologists, biochemists, chemists, engineers, physicists and the newest species – the materials scientist, are now working together. This new interdisciplinary environment has meant that the past decade has seen the beginnings of many new classes of materials.

How does one begin to understand now biominerals are synthesised? Organisms use a wide range of chemical functionalities to synthesise their biominerals and this automatically extends the possible mechanistic steps used during their formation. The nucleation and growth of biominerals range from control of the crystallographic alignment both in the deposition of individual crystals and in the subsequent positioning of several crystals. Examples lie in magnetic receptors used by whales to navigate using the Earth's magnetic field to the three-dimensional porous structure of bone. When these various factors are taken into consideration one has a system that rapidly becomes very complex and begs the questions – can

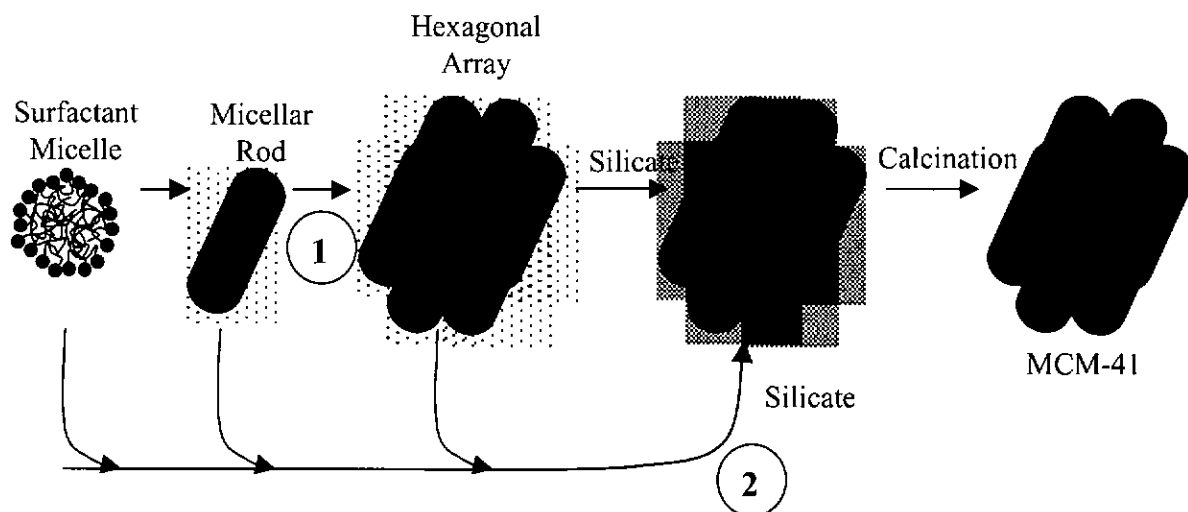


Figure 1. Schematic of the proposed mechanistic pathways for MCM-41 synthesis: (1) liquid crystal phase initiated, and (2) silicate anion initiated. Reprinted with permission from reference 2: *J. Am. Chem. Soc.*, 1992, 114, 10834. Copyright © (1992) American Chemical Society.

biomineralisation be broken down into a series of mechanistic steps? If so, are organisms able to manipulate these processes to build their final material? Does the formation of each individual biomineral have its own unique mechanism? Will the synthetic scientist ever be able to exert the level of control required to produce analogues in sizes that will actually be useful? – Or are we all just wasting our time?

Bearing all this in mind, how does the chemist proceed to generating new materials with properties reminiscent of biominerals? Such a question must also be coupled with the added degree of difficulty of wanting to understand the underlying intermolecular interactions that control the physicochemical properties and hierarchical structure of the final material. To answer these questions research has evolved along two quite distinct paths – the study of inorganic-organic composites, and the growth of inorganic materials in the presence of protein extracted from a biomineral.

The biggest jump forward in the synthesis of hierarchical inorganic-organic composites came in 1992 when a team of researchers from The Mobil Corporation showed that a material based on silica, having a pore network with hexagonal symmetry, could be prepared using a template formed via surfactant self-assembly.¹ The material, named MCM-41 (Mobil Corporation Molecule # 41), sparked an explosion in the field. The type of growth recorded arises

from a combination of specific molecular interactions and a matrix effect. The molecular interactions are between the inorganic precursor and added surfactant while self-assembly of the organic molecules into a pre-determined matrix imparts both fixed orientation and confinement effects on the initial nucleation and subsequent growth of the inorganic material. With the concentration of surfactant used self-assembly into the observed hexagonal matrix would not normally occur, but mutual association of the silicate precursors with the head group of the surfactants led to the hexagonal phase. Such an association ensures that the silicate precursors are ideally aligned and suitably spaced for the subsequent hydrolysis and condensation steps of polymerisation that follow. After the polymerisation the surfactant can be removed by burning (calcinations) leaving a purely inorganic material that has hexagonally symmetric pores. The size of the pores is controlled from the length of the hydrocarbon chain in the surfactant. Figure 1 shows a schematic of the proposed mechanism for formation of MCM-41 put forward by the Mobil group² while Figure 2 shows transmission³ and scanning⁴ electron micrographs of samples of MCM-41 materials. MCM-41 has characteristics similar to zeolites and biominerals. They have extraordinarily large surface areas of about $700 \text{ m}^2 \text{ g}^{-1}$ and hierarchical structure in the form of hexagonally oriented pores in the nanometre range and amorphous silica in the Ångstrom range.

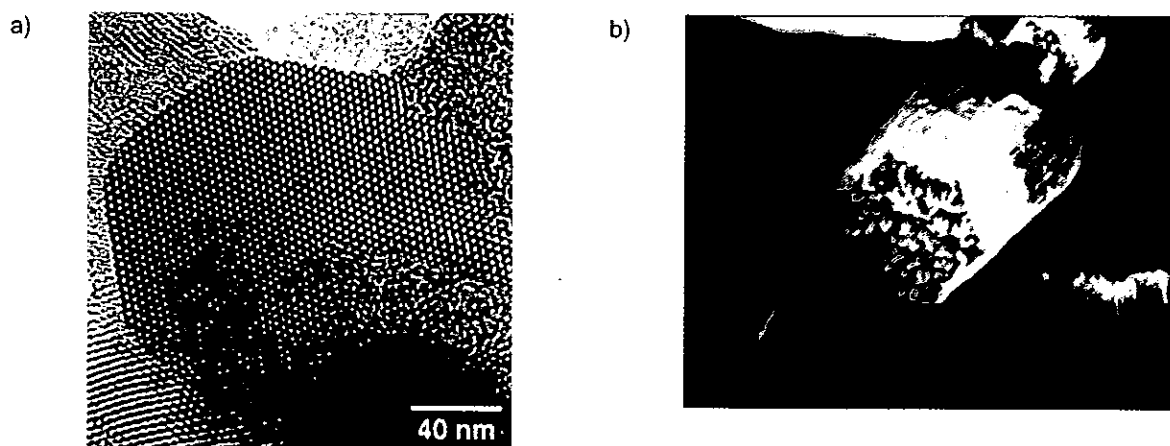


Figure 2. (a) Transmission and (b) scanning electron micrographs of MCM-41 obtained from the web. Taken from References 3 and 4, respectively.

A quick literature search shows that more than 2500 research articles have been written in the intervening years on MCM-41 alone. These materials, studied in their own right, have also been used to synthesise nanowires made from copper and nickel,⁵ as templates in the synthesis of polymeric networks (for example *N*-vinylcarbazole and vinyl ethers⁶) and as catalysts in the preparation of complex organic and inorganic molecules, such as chiral dioxomolybdenum(VI) complexes.⁷ In addition to the work focussing purely on MCM-41, silicates with other symmetries have been prepared¹ including some samples that have the ability to be moulded and grown to several centimetres in size.⁸ This ability marks a significant advantage as most of the MCM-41-like materials form only as coarse powders, which limits their further use. Further recent advances have included the preparation of thin films of these materials with good alignment of pores and cavities.⁹ Although much of the work has looked at silicates their chemistry is limited. Consequently, many other inorganic precursors have been used with the aim of maintaining the overall physical characteristics of the synthesised silicates, but with different chemical properties. In theory, this should allow materials to be prepared with both controllable physical and chemical properties.

Some of the final materials that have been prepared include oxides of titanium, antimony, tungsten, aluminium, zinc and lead.^{10,11} None of these inorganic materials have been prepared with the diversity of symmetries seen in the silicate systems. This is due, in part, to changes in the intermolecular interactions between the inorganic precursors and the head groups of the surfactant molecules that occur when the precursor is changed. This shift to the controlling intermolecular interactions, whilst perhaps subtle, can be enough to completely alter the symmetry of the self-assembled form of the system and therefore of the final inorganic material. Hence, for every different precursor used, manipulation of the system is required with respect to the surfactant used to ensure that the molecular interactions between the surfactant and the precursor are balanced so that the appropriate self-assembled form can be achieved. At present this is accomplished predominantly through trial and error.

From the perspectives of extending the catalytic properties of zeolites, providing new reaction environments for the controlled synthesis of, for example, chiral compounds, as well as preparing new molecular sieves for the separation of higher molecular weight molecules, the synthesis of this new class of template-mediated growth has been of considerable consequence. However, we are still unable to prepare materials that have higher hierarchical order that can be moulded and manipulated at will, and that have readily controllable physicochemical properties. In order to achieve this many other methods are being investigated from a purely chemical/materials synthetic perspective. Another outlook may also be applied to solving this problem, one that turns to the organisms themselves to learn how gross morphology may be controlled primarily through specific molecular interactions.

Many different biominerals have been the focus of attention to gain an understanding of the mechanism of¹² biomineralisation and replication of the biomineral *in vitro*.

For some of these systems considerable knowledge now exists on how the organisms control the crystal nucleation and growth, but replication is still difficult to achieve.

The most primitive biomineral is magnetite [Fe(II)Fe(III)O₄] and the formation of biominerals may well trace their roots to matrices developed by magnetic bacteria in eukaryotes, *viz.* cells with a nucleus, for the deposition of magnetite.¹² Figure 3 shows an example of chains of magnetite used by the organism for the detection of and interaction with magnetic fields.¹³ Here the size and alignment of each magnetite single crystal is controlled by the matrices but individual crystal morphology is unaltered compared to the mineral analogue.

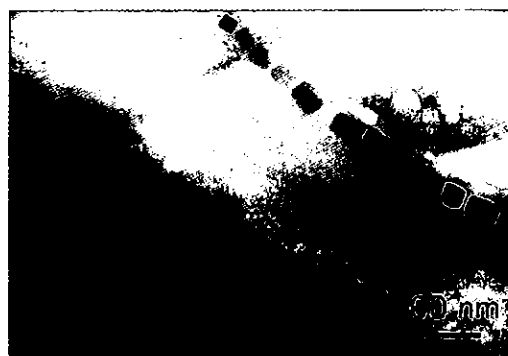


Figure 3. Transmission electron micrograph of magnetite magnetosome chains within cell walls of MV-1 magnetotactic bacteria (Taken from the internet – see Reference 14).

Taking the idea of specific crystallographic alignment of individual crystals further we can look at the example of biomineralisation in paua. The biomineral used here is calcium carbonate in the form of both aragonite and calcite. The final paua shell is made from aragonite plates, the size of which is extremely uniform, all aligned along their *c*-axis and intercalated with a porous organic matrix. This brick-like lattice¹⁴ is shown in Figure 4. This ensemble is then encased in a calcite shell.

The growth of nacre in paua may be studied by placing a substrate between the animal and the already deposited shell. The paua continues to secrete and grow shell directly onto the new substrate. In this way “flat pearls” are readily produced. Production of synthetic nacre, *i.e.* *in vitro* growth, is not so easy. From these growth studies it is known that the final form of the calcium carbonate depends on both the organic film that is intercalated between the aragonite plates, and a series of proteins that turn the growth of both aragonite and calcite on and off, through specific intermolecular interactions.¹⁵⁻¹⁷ Structural information on the individual proteins has not been obtained and determination of the overall mechanism for nacre deposition, or even the individual mode of operation of the protein, remains unknown. However, such information will allow insight into the fundamental interactions controlling crystal polymorph, size, and orientation that will lead to advances in *in vitro* growth studies.

The example of paua shell shows how control of crystallographic alignment may be achieved over a large length scale for thousands of individual crystals. Within the nacre biomineral, individual crystals maintain the symmetry and form of the inorganic mineral. In general, plates are hexagonal with clear faceting. Many organisms,

however, deposit biominerals that visibly lose all semblance to their mineral cousins.

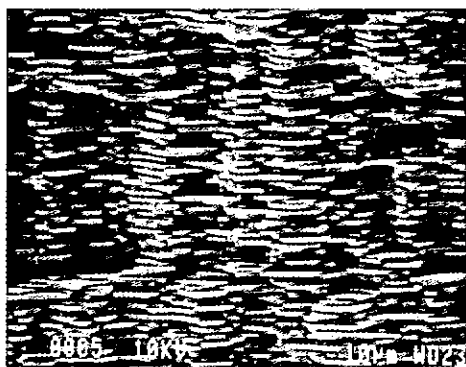


Figure 4. Scanning electron micrograph of aragonite (calcium carbonate) plates that constitute the main building blocks of the paua shell (Taken from the internet – see Ref. 15).

One such example is the deposition of calcite by sea urchins. In Figure 5 the calcite of the sea urchin spine shows a high level of hierarchy, smooth well-rounded features with no faceting and a high degree of symmetry. It is this form of growth that is the ultimate goal of scientists working in this area. In many ways, however, the least amount of usable knowledge exists with regard to the formation of such advanced hierarchical growth. Over 40 proteins are occluded into the growing inorganic matrix of the sea urchin¹⁸ in addition to up to 10% magnesium. Despite the complexity of this system hierarchical calcite has been synthesised from a growth solution containing proteins extracted from sea urchin spines. Understanding the molecular interactions at play during the nucleation and growth of these crystals will allow for simpler model systems to be devised, which will result in the formation of materials with similar morphologies.

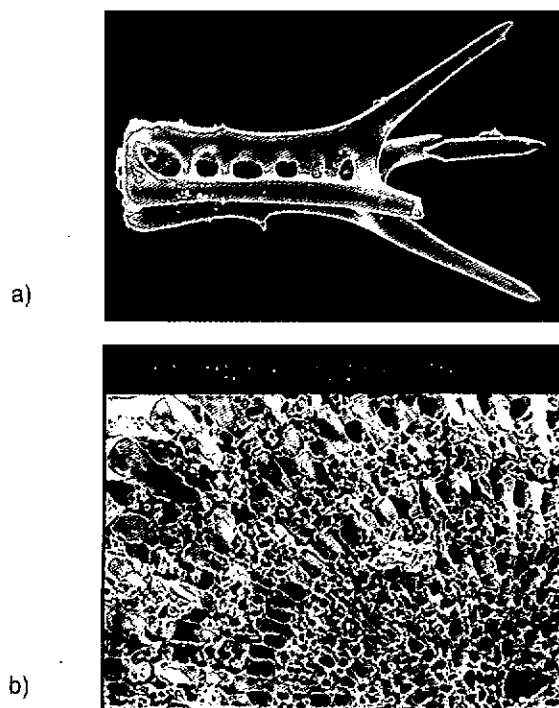


Figure 5. Scanning electron micrographs of (a) a juvenile and (b) an adult sea urchin spine taken from Reference 19.

The combination of studying biomineralisation and the formation of inorganic-organic synthetic composites will

give scientists the ability to generate materials with controllable physicochemical properties that can be grown to any desired specification. However, for the moment we must content ourselves with the joy of the chase.

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Yacón – A New Zealand Seasonal Variation And Storage Trial

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Introduction

Yacón, *Smallanthus sonchifolius*,¹ in the family Asteraceae, is a native crop of the South American Andes that is grown principally for its edible underground storage organs,² and has been cultivated (particularly in Peru, Bolivia, north-western Argentina and Ecuador) for more than a thousand years.^{3,4} Cultural changes in the last century have caused a decline in the cultivation of yacón in South America but the crop has recently received interest in the areas of carbohydrate chemistry and preservation of species diversity.^{3,5,6}

Yacón is an herbaceous plant with aerial stems 70-250 cm in height. The stems are green and purple and are covered with white hairs. The leaves are triangular-ovate and of the sunflower type - see Figure 1. The yellow flower is relatively small and flowering occurs in the autumn after some six months growth; the plant does not often set viable seed. The underground parts (Figure 2) comprise a plant crown that consists of a tight mass of enlarged, meristematic buds known as turiones, cylindrical roots, and swollen storage roots. Most storage roots weigh 100-500 g, but roots of 1 kg are common and roots of 2 kg have been reported.^{2,7-10}



Figure 1: Yacón - *Smallanthus sonchifolius*.



Figure 2: Underground parts of yacón.

Storage Carbohydrates of Yacón

Like other members of the Asteraceae, the storage carbohydrates in yacón are of the inulin type rather than starch. Inulin is a polysaccharide formed by successive additions of β -D-fructofuranosyl units in (1 \rightarrow 2)-linkages to sucrose (Figure 3). An oligosaccharide of the inulin type is commonly known as a fructooligosaccharide (FOS) and exhibits prebiotic qualities. Prebiotics pass undigested through the small intestine of the host animal to the colon, where they are selectively fermented by bacteria beneficial to the host.¹¹ Thus a considerable market exists for FOS

especially in Japan and Europe. Commercially, FOS may be derived by enzymic treatment of sucrose but it may also be obtained by hydrolysis or fractionation of inulin from Jerusalem artichoke (*Helianthus tuberosus*) and chicory (*Cichorium intybus*), which are also members of the Asteraceae.¹² Studies of yacón storage carbohydrates have shown them to be principally FOS rather than inulin.^{7,10} Yacón thus represents a potential, commercial source of FOS for which minimal processing is required.

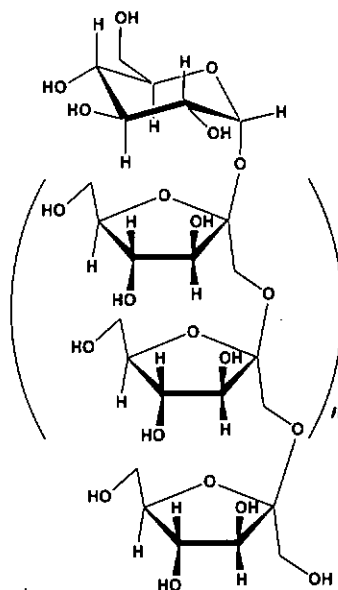


Figure 3. Structure of inulin ($n > 7$).

Edelman and Jefford¹³ have described the mechanism for the metabolism of fructans in higher plants. This permits very rapid changes in the size and number of molecules and hence a change in osmotic potential. During periods of low temperature or drought, rapid depolymerisation of fructan occurs to increase osmotic potential and prevent dehydration. Seasonal variations in the degree of polymerisation occur in yacón¹⁴ as well as in Jerusalem artichoke.¹⁵ In the trial described by Fukai *et al.*¹⁴ the aerial parts were damaged by typhoon winds in late summer and then they re-grew. This may have affected the outcome of the trial. Additionally, changes in degree of polymerisation may occur during post-harvest storage as such changes have been observed for Jerusalem artichoke,¹⁶⁻¹⁸ chicory¹⁹⁻²² and yacón.²³

In addition to the functional food role of yacón storage roots, the plant has other potential, commercial possibilities. A water extract of the leaves has demonstrated a hypoglycaemic effect in diabetes-induced rats²⁴ and an anti-diabetic agent containing sesquiterpenes has been claimed;²⁵ in Brazil and Japan the foliage is valued for preparation of an herbal tea.³

Yacón in New Zealand

Background

Yacón was first introduced to New Zealand about twenty years ago.²⁶ Until recently it remained a garden curiosity although small-scale production in both the North and South Island was reported⁸ in 1993, and a small field trial was carried out by Crop and Food at Invermay. Recently, more extensive trials have been undertaken in the Waikato and Pukekohe regions, with a view to commercialising the production of yacón for domestic and export markets. In fact, New Zealand introduced yacón to the Czech Republic and Japan, and thence to Korea and Brazil.³

Seasonal Variations Trial (2001-2002)

A trial was commenced in 2001 to determine the appropriate time to harvest yacón storage roots for optimum FOS. In this trial, the storage roots were sampled every 25 days commencing 5 months after planting, which occurred in October 2001. Four replicates were collected and each replicate consisted of two storage roots from each of two plants. Only roots in excess of 250 g fresh weight were selected. Roots were extracted, in triplicate, using the method described by Jaime *et al.*²⁷ for determination of total fructan and FOS in onion tissue. The extracted material was analysed by HPLC using Shodex KS801 and KS802 columns in series with water as eluant at 1 mL/min at 50 °C. Detection was by refractive index.

A typical HPLC chromatogram of a mature storage root from the 2000-2001 trial is shown in Figure 4. This root was deep frozen before freeze-drying and extraction. The unlabelled peak at 9.3 min in Figure 4 shows UV absorption presumed consistent with the presence of, *inter alia*, phenolic materials. The presence of phenolics was inferred from the darkening of the fresh storage root material upon maceration. Antioxidants including tricaffeoylaldaric acid have been isolated from yacón storage roots.^{28,29}

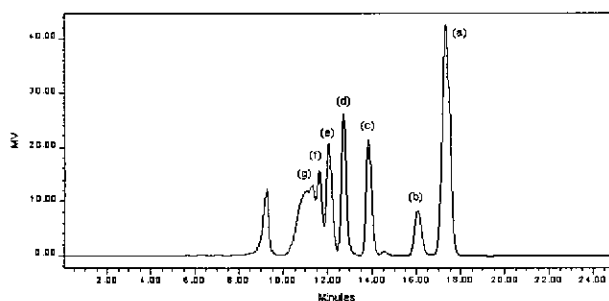


Figure 4. HPLC chromatogram of an extract of a mature yacón storage root showing (a) fructose, (b) glucose, (c) sucrose, (d) 1-kestose, (e) nystose, (f) kestapentaose, and (g) fructooligosaccharides dp > 6. The analysis conditions are as described in the text.

Figure 5 shows an HPLC chromatogram of the extract from a storage root after 5-months growth. The relatively large quantities of lower degree of polymerisation (dp) FOS, including 1-kestose, and of glucose in the immature root indicates that FOS are being synthesised. In contrast the larger quantities of fructose in the mature root indicate that some depolymerisation has occurred, probably as a result of the onset of cooler climatic conditions.

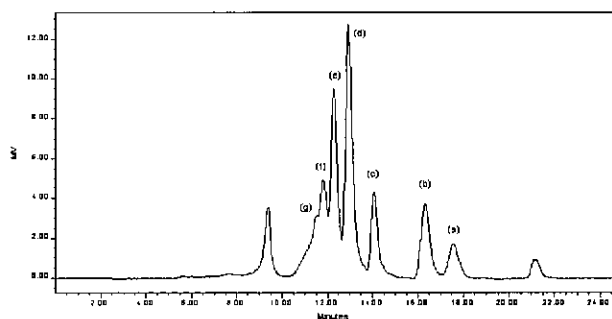


Figure 5. HPLC chromatogram of immature (5 month) yacón storage root; (a)-(g) are as described for Figure 4. The peak at 21.4 min is residual ethanol and analysis conditions are as described in the text.

Results for the seasonal variation trial are shown in Figure 6. Total extractable carbohydrate content varied from 76 to 83% composition on a dry matter basis (DMB). Dry matter, total extractable carbohydrates, and FOS showed a maximum on May 25 (7 months after planting), at which time flowering had occurred. The plants were the same age as those observed by Fukai *et al.*¹⁴ in an equivalent study in the Northern Hemisphere where a typhoon damaged the aerial portions of the plant after 4 months growth, but did not kill the plant. Their study continued as the plant regrew, though the results were likely affected by the severe damage incurred. In this study the planting took place one month earlier (October) compared with the Northern Hemisphere, *viz.* May,¹⁴ but the similarity recorded is remarkable considering the typhoon damage.¹⁴

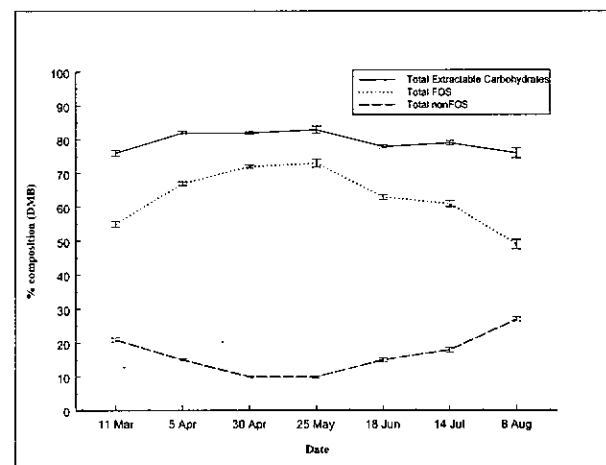


Figure 6. Seasonal variation in total extractable carbohydrates, total fructooligosaccharides (FOS) and combined total of glucose, fructose and sucrose (non-FOS).

As expected, regression analysis showed that there was a strong, negative, linear correlation ($R^2 = 0.85$) between total FOS content and total combined content of glucose, fructose and sucrose.¹³

Storage Trials 2002

Storage trials commenced in August using material sampled 10 months after planting. It is apparent from the seasonal variation trial, that this was not the optimum time for harvest to maximise FOS content. When the trial commenced, samples were stored at two temperatures, namely 10 °C and 5 °C. Before the trial commenced, storage roots were examined carefully to ensure that they were undamaged, clean and dry. By the end of the first week of the trial, the roots, which were stored at the lower temperature, showed extensive splitting and by week 4

the majority were decomposed. Cisneros-Zevallos *et al.*³⁰ were able to complete a trial of 90 days at 4 °C with 17, 21 and 27% decrease in FOS, respectively, for different accessions. In contrast, Asami *et al.*²³ observed a 33% decrease in FOS after only two weeks storage at 5 °C. It is possible that both the accession and the time of harvesting affect storage behaviour at lower temperatures.

The results for the 10 °C trial are shown in Figure 7. For the first week, FOS levels remained stable but after 2 weeks there was a 16% decrease in FOS content, and at 4 weeks the decrease was 23%. These results fall between the 25 °C and 4 °C storage trials of Cisneros-Zevallos.³⁰

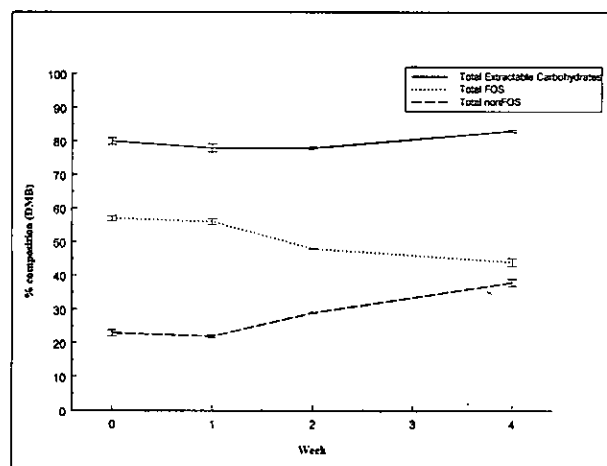


Figure 7. Results of storage trial at 10 °C for total extractable carbohydrates, total fructooligosaccharides (FOS), and combined total of glucose, fructose, and sucrose (non-FOS).

Conclusions

Yacón has been successfully grown in New Zealand and the level of FOS was found optimal 7 months after planting. As expected,¹³ there is a negative correlation between the FOS content and the mono/disaccharide content. The results of storage trials show disparity with the literature,^{23,30} which however, also shows inconsistencies. In this study, storage at 10 °C retained FOS levels for 1 week without loss, while after 4 weeks there was a decrease of 23%.

Acknowledgement

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Contact: gill.sutherland@rsnz.org

30 November-4 December 2003

2003 New Zealand Institute Of Chemistry Conference
Rutherford Hotel, Nelson, New Zealand
Contact: Dr Andrew Abell
Department of Chemistry, University of Canterbury
Private Bag 4800 Christchurch
a.abell@chem.canterbury.ac.nz

1-5 December 2003

3rd International Wildlife Management Conference
Christchurch, New Zealand
www.conference.canterbury.nz/wildlife2003

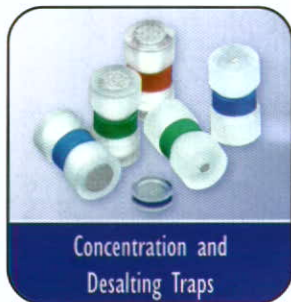
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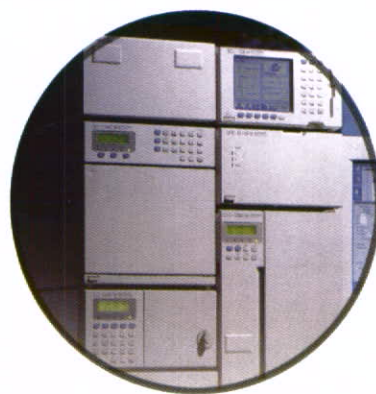
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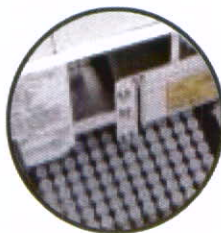
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