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IN NEW ZEALAND

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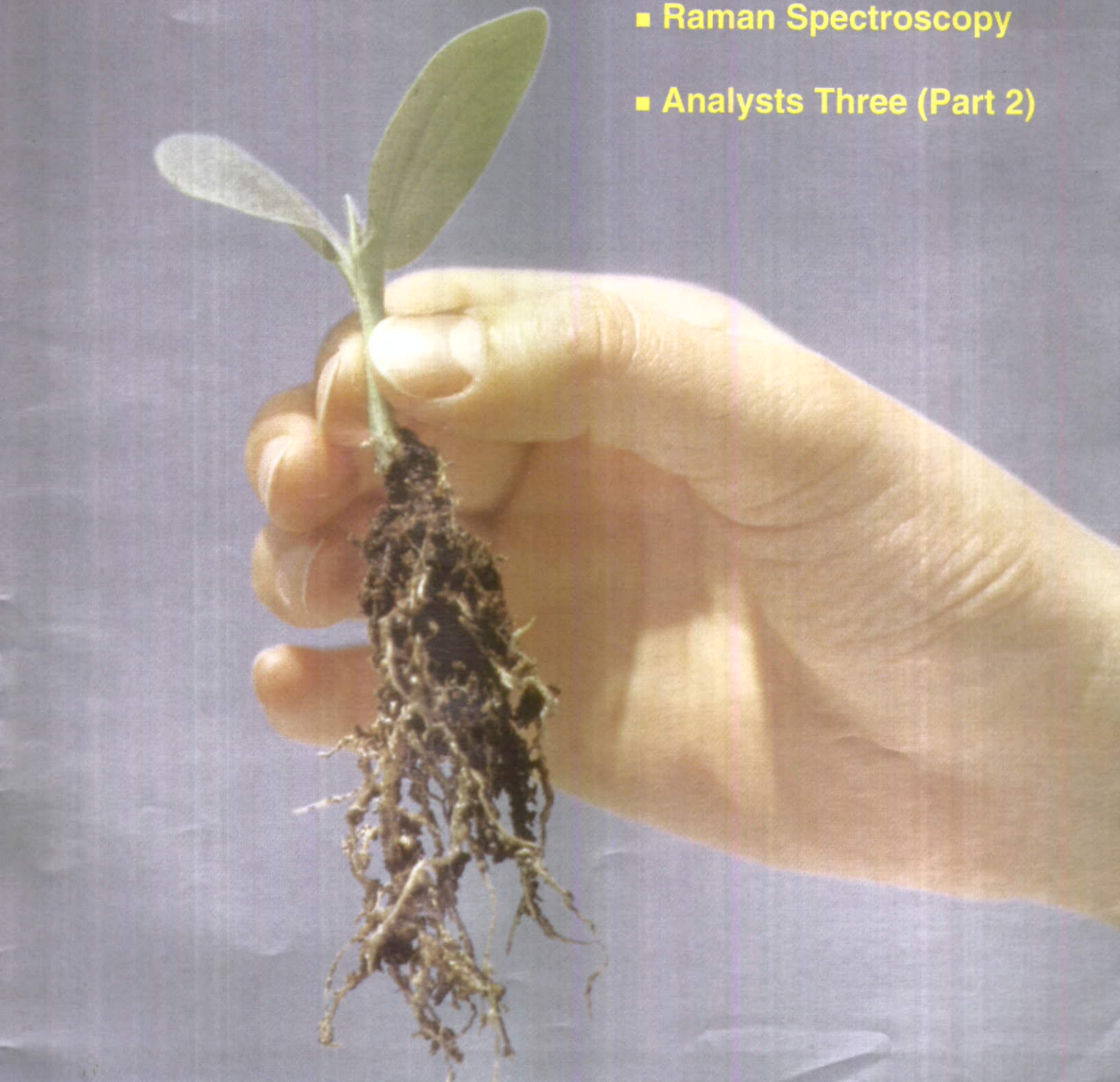

Chemistry IN NEW ZEALAND

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NZ Science Scene

FOREST RESEARCH CHANGES NAME TO SCION

The Crown Research Institute formerly known as Forest Research has announced that it will now be operating under the new trading name of "Scion". Chief Executive Dr Tom Richardson says that the name, Scion, speaks of inheritance and new growth, which is what the organisation's biomaterials strategy is all about - building on the legacy of the past to create a new kind of future.

The Research Institute has extended its expertise in forestry and wood science to facilitate the development of new biomaterials made from renewable plant resources, that can be used as alternatives to non-renewable products. The organisation officially launched their Biomaterial Futures strategy in 2003, and biomaterial research capability at Scion has been strengthened by investment in new staff, new partnerships and specialised equipment.

JAMES COOK RESEARCH FELLOWSHIPS: CALL FOR APPLICATIONS

The James Cook Research Fellowships are administered by the Royal Society of New Zealand on behalf of the Government. They are awarded to researchers who are recognised leaders in their respective fields, have the requisite qualifications and experience, and are able to demonstrate that they have achieved national and international recognition in their area of scientific or technological research.

Applications are now being sought in the following two research categories:

Physical Sciences, and Engineering Sciences and Technologies. The primary intention for the award of Fellowships is the recognition of sustained excellence in research. The normal term of a Fellowship is two years and the stipend offered for those awarded in this round will be $110,000 including GST per year. This increased stipend will hopefully make tenure overseas for all or part of the Fellowship more viable. Reimbursement of relevant expenses to a maximum of $10,000 annually will also be offered. Those appointed will be required to take up their Fellowships by March 2006.

Eligibility: New Zealand citizens or permanent residents. Host Institution: Fellowships will be tenable in a location and institution of the applicant's choosing, whether in New Zealand or overseas. Closing date for application: 1 September 2005. For further information, please contact: Executive Officer - Awards (awards@rsnz.org) or see <http://www.rsnz.org/awards/james_cook/index.php>.

2005 MEDALS AND AWARDS: CALL FOR NOMINATIONS

The following suite of medals and awards is being offered in 2005 by the Academy Council of the Royal Society of New Zealand.

Hector Medal - Mathematical and information sciences. ***Te Rangi Hiroa Medal*** - Social and economic policy and development. ***R. J. Scott Medal*** - technologies associated with biological, food, natural products processing and medical practice technologies. ***Hamilton Memorial Prize*** for beginners in scientific or technological research in New Zealand. ***Hatherton Award*** for the best scientific paper by a PhD student at any New Zealand university in physical sciences, earth sciences and mathematical and information sciences.

The closing date for applications and nominations is Friday, 5 August 2005. Electronic copies of the information and application forms are available from awards@rsnz.org or on http://www.rsnz.org/awards/academy_awards/forms.php

ASSOCIATION OF UNIVERSITY STAFF ASSESSES CHANGES FOR PBRF

The Association of University Staff (AUS) has commented on the recent review of the Performance Based Research Fund, which recommends 128 changes for next year. One recommendation is that the next round be a partial one with voluntary participation, that there be new categories for new and emerging researchers and that the unit of assessment be reviewed after 2006. AUS President, Professor Nigel Haworth welcomed the proposed changes as sensible improvements. A total of $163.5 M (excluding GST), almost $9 M of which is new money, will be allocated via PBRF in 2005/06, increasing to a total of $194 M in 2008/09. The Tertiary Education Commission is currently finalising the appointment of panelists for the twelve Peer Review Panels for the 2006 Quality Evaluation. See the report at <http://www.tec.govt.nz/downloads/a2z_publications/pbrf-sector-reference-group-report.pdf>.

NEW FRST OPPORTUNITIES FOR COLLABORATIVE RESEARCH

New opportunities to support collaborative research ventures which promise high commercial gains will be available from July 2005 through the Foundation for Research, Science and Technology. An extra $16.214 million over four years was allocated in the Budget to expand research consortia, which are industry-led, collaborative ventures. The Foundation will be calling for new consortia proposals shortly.

Additional Budget funding was also allocated to support unprecedented growth in demand for the Technology for Business Growth (TBG) scheme. An extra $40.96 million is being injected into the Technology New Zealand suite of investment schemes, including TBG, over the next four years. TBGs provide up to 50% of the cost of a research project with companies required to provide the rest.

Other Budget allocations would fuel the Foundation's drive to build international connectedness. An additional $14.72 million over four years for the Technology for Industry Fellowships (TIF) scheme will allow New Zealand firms to send staff overseas to gain knowledge or bring highly qualified people from offshore to New Zealand, to work in firms helping them solve technical and innovation problems. The International Investment Opportunities Fund, managed by the Foundation, has also been boosted by $17.068 million over the next few years, with new applications to be called for in July 2005.

APPLICATIONS FOR NEW ZEALAND ENGINEERING EXCELLENCE AWARDS

Could you be the 2005 New Zealand Engineer of the year? Or has your team run the best engineering project? If you think so, time is running out to apply for the inaugural New Zealand Engineering Excellence Awards (NZEEA). Entries close Friday, 1 July 2005.

The awards have been initiated by New Zealand's engineering profession to highlight the key roles engineers and their organisations play in addressing national goals through innovation, entrepreneurship and development of infrastructure that meets community needs.

The event is staged by a consortium of four partner organisations: Centre for Advanced Engineering (CAE), INGENIUM (Association of Local Government Engineering New Zealand Incorporated), Electricity Engineers' Association of NZ (EEA) and the Institution of Professional Engineers New Zealand (IPENZ). Contributing organisations include: New Zealand Water and Waste Association (NZWWA) and the IPENZ Foundation.

A black-tie awards dinner will be held at the Duxton Hotel in Wellington on 23 November 2005 to present the awards recognising people and activities at the pinnacle of engineering excellence.

Tel: (04) 4748987 for more information or see the website: <http://www.nzeeawards.org.nz/>.

2005 AVENTIS PRIZES FOR SCIENCE BOOKS

Journalist and science writer Philip Ball has won the Aventis Prizes for Science Books General Prize, with his book "Critical Mass: How One Thing Leads to Another". The Aventis Prizes are the world's most prestigious awards for popular science writing.

The shortlisted books for the General Prize 2005 were:

Critical Mass: How One Thing Leads to Another, Philip Ball (William Heinemann) The Ancestor's Tale, Richard Dawkins (Weidenfeld & Nicholson) Why Life Speeds Up As You Get Older, Douwe Draaisma (Cambridge University Press) Matters of Substance: Drugs and why everyone's a user, Griffith Edwards (Penguin, Allen Lane) The Earth: An Intimate History, Richard Fortey (Harper Collins) The Human Mind, Robert Winston (Bantam Press/ Transworld Publishers).

The Prizes are managed by the Royal Society, the UK National Academy Of Science and generously supported by the Aventis Foundation, a German charitable trust established by a predecessor of Sanofi-Aventis, a world leader in pharmaceuticals.

For more information on the Aventis Prizes for Science Books please visit the website at <http://www.aventisprizes.com>.

YOUNG NEW ZEALANDERS TO MEET WITH NOBEL PRIZE WINNERS

For the first time, young New Zealand scientists are to attend the annual meeting of Nobel Prize winners in Lindau, Germany. The meeting, to be held late in June 2005, will be attended by more than fifty Nobel Prize winners, including New Zealand Nobel Laureate, Professor Alan MacDiarmid. The annual meetings began in 1951 when Nobel laureates first came together with young scientists to network and exchange ideas.

The New Zealanders attending were chosen by the Royal Society of New Zealand and will join up with 600 other specially-selected students from Europe, North America, and Asia for the four-day programme.

The New Zealanders attending are: Kaa-Sandra Chee who is doing a PhD in Biomedical Science at The University of Auckland; Peter Mace from the Biochemistry Department at University of Otago; and Shelley Scott from the University of Canterbury Physics and Astronomy Department.

HAMILTON SCIENTIST WINS AWARD FOR TOP AGRICULTURAL COMMUNICATOR

A Hamilton scientist who is widely known for his ability at putting science into plain English has won this year's Landcorp Agricultural Communicator of the Year.

Dr Douglas Edmeades, now an independent science consultant, was previously AgResearch's national science leader and has written over 100 scientific papers. His commitment to the rural sector has been recognized with the awarding this week of the top award for agricultural communicators, The Landcorp Agricultural Communicator of the Year.

The Award, administered by the New Zealand Guild of Agricultural Journalists and Communicators, is in

its 19th year. It recognises excellence in communicating agricultural issues, events or information, and is judged by a nationwide panel of ten independent judges.

Regarded as the premier award for agricultural communicators, it is also the most valuable prize on offer. Landcorp, which has sponsored the Award since its establishment, now provides a prize of $2500, which is part of a funding packing of $7500 in sponsorship for the Guild. The additional funding assists with administration costs, including the Award dinner.

FRST NEW SCIENCE WRITER AWARD WINNER

A Christchurch-based freelance journalist whose portfolio of articles included stories published in The Antarctic Sun, a publication of the National Science Foundation published from McMurdo Station in Antarctica, is the 2005 winner of the FRST New Science Journalist of the Year Award.

Kris Herbert has been a journalist for 14 years, covering a range of different topics, including fashion, business, health and travel, and working as a staff reporter, sub-editor, production editor and senior writer for various Christchurch-based publishing companies.

This is the second year that the Foundation for Research, Science and Technology (FRST) has sponsored this award, which is open to people with a lively interest in writing or broadcasting about science who are new to science journalism. The award is sponsored in association with the New Zealand Guild of Agricultural Journalists and Communicators with a prize of $1000 worth of travel, to one or more science-related occasions.

The winner of the FRST New Science Journalist of the Year Award was announced at Hamilton at an awards night organized by the NZ Guild of Agricultural Journalists. Unfortunately Kris Herbert was not able to attend - she is currently in the United States, researching material for a commissioned travel article and identifying future science articles.

MORE FULBRIGHTS

Fulbright New Zealand has received a $2.7 million funding boost through the Ministry of Research Science and Technology which doubles the number of awards available for New Zealanders to carry out post-graduate study in the US. Ten of these awards are specifically for IT, creative industries and biotechnology, another one is in natural disaster research and another in entrepreneurship (valued at US $100,000). The remaining eight awards are open to applicants in any field of study. The awards are valued at US $25,000 plus return travel. The closing date for applications is 1 October 2005. Visit <http://www.fulbright.org.nz> for further information.

FUNDING CATEGORY REVIEW COMPLETED

The Tertiary Education Commission (TEC) has released the report of the Funding Category Review (FCR) Project Group which has been identifying potential funding anomalies in the student component funding system for tertiary education organisations (TEOs). The report is the result of substantial work by a cross-section of representatives from the tertiary sector as well as personnel from TEC and the Ministry of Education. The FCR Project Group report says that student component funding is based on classifying individual courses, and in some cases programmes, into one of thirty-nine defined classifications based primarily on the predominant subject matter. However, since the introduction of the current funding regime, it says, the resourcing requirements for providing different types of courses and the demands for subjects and disciplines have changed considerably.

The methodology used in the FCR included a comparison of the revenue and costs for each area under investigation within each TEO against the revenue and costs for the respective TEO as a whole.

Included among the findings are that the weighted average income-to-cost ratio for natural and physical sciences is 9 percent lower than the whole-of-TEO averages, while the differential in optical sciences is 15 percent. It also shows there is evidence that undergraduate course funding cross-subsidises taught postgraduate courses which, in turn, cost 119 percent more to run than undergraduate courses.

Any decision on whether to adjust funding rates will be made by the Government after taking into account the content of the report alongside other policy initiatives. $132.7 million from Budget 2005 and previous budgets has been allocated to increase funding rates in "strategically relevant areas" as part of the FCR. These include natural and physical sciences, trades and technical, agriculture and horticulture, optical science and osteopathy. The full report and findings can be found at: <http://www.tec.govt.nz/funding/ttf/keypolicydevelopments/fund_cat_review.htm>.

FUNDING PRIORITIES TO CHANGE

The Minister of Education, Trevor Mallard, has told tertiary education institutions that those who have not exploited 5.1 community education will not lose any funding as a result of the current tertiary-education-funding reviews. The assurance follows indications from the Minister that announcements will be made soon that will involve shifting funding from low-priority and low-quality courses to areas of high priority and excellence.

Trevor Mallard was also responding to a statement from National Party Education spokesperson, Bill English, who said that polytechnics would be hit hard by the Minister's move to renege on a three-year deal to "wind down" from the controversial courses. "Mr Mallard's actions are totally unfair to polytechs that did not exploit the community education loopholes," he said.

A number of 5.1 community education courses gained notoriety last year, among them Christchurch Polytechnic's Cool-IT programme,

and those described by Mr English as "phantom computer" and sing-along radio courses.

Trevor Mallard said that the current reviews of tertiary education expenditure are designed to ensure that funding is reinvested in, and shifts to, areas of demonstrated quality. "This is about ensuring taxpayers get value for money, but it is not to save the Government money as the savings will be reinvested in tertiary education," he said. "It is ironic that Bill English spent most of last year criticising community education funding, labelling it as a "scandalous waste of taxpayer funds". Now he wants to keep it. So what does National stand for?"

WORK TO START ON BUILDING EXPERTISE IN THE USE OF THE ADVANCED NETWORK

The Ministry of Research Science and Technology (MoRST) has contracted the Next Generation Internet Society New Zealand (NGI-NZ) to help ensure New Zealand researchers will be well-informed and ready to use the Advanced Network high-speed, broadband network when becomes operational towards the end of this year.

The Advanced Network initiative, which is being led by the MoRST, will connect researchers and educationalists around New Zealand as well as internationally, allowing them to share their computing facilities and access high performance computers and instruments. They will also be able to share and get access to complex information faster and more economically.

The Chief Executive of the Ministry of Research, Science and Technology, Dr Helen Anderson says the Advanced Network will be a new tool for the research and education communities in this country. "By allowing the speedy transfer of huge amounts of information, the Advanced Network will open new doors to the New Zealand research community, especially for collaborative work with their colleagues in New Zealand and internationally."

"But we want to be sure that our research and educational institutions and individual researchers are ready to make the best use of the potential of the network. This agreement with the NGI-NZ is a key one in a series of steps encouraging the use of the Advanced Network in that it will ensure that we have prepared our researchers to use it to its full potential when it becomes available," Dr Anderson says.

Under the agreement, NGI-NZ will coordinate a range of support activities targeting prospective users and members of the Advanced Network, including seminars with overseas experts in advanced networking applications, assistance for technical research visits overseas, and technical workshops.

The Chair of NGI-NZ, Neil James says the joint programme with central government is an important first step to build expertise in the Advanced Network.

"We are pleased to be involved in this initiative to ensure the research, science and education community have the resources they need in place to make the best use of the opportunities that the Advanced Network will provide.

Over forty countries already have one or more advanced networks and the New Zealand network will allow researchers here to link in to those systems.

NEW APPOINTMENTS TO MARSDEN FUND COUNCIL

Four new members have been appointed to the Marsden Fund Council – the body that advises on, and makes decisions about, how the Government's investment in cutting-edge science under the Marsden Fund should be used.

The new members of the Council are: Professor Christine Winterbourn of the Christchurch School of Medicine and Health Sciences; Dr Lydia Wevers, Director of the Stout Research Institute in Wellington; Dr Richard Blaikie, deputy director of the MacDiarmid Institute for Advanced Materials and Nanotechnology and an Associate Professor at the University of Canterbury; and, Dr Rupert Sutherland, a geoscientist at the Institute of Geological and Nuclear Sciences (GNS).

To carry out its role, the Council needs members from a range of research, science and technology disciplines and the new members bring to it expertise in the fields of biomedical sciences, humanities, physical sciences and engineering, and earth sciences and astronomy.

A new Chair has also been appointed to the Fund Council to replace Dr Diana Hill, who has completed two terms with the Council and is standing down. The position will now be held by Dr Garth Carnaby – a specialist in wool textiles and Deputy-Chair of the Council.

The Marsden Fund is one of 11 funds through which the Government funds research, science and technology, known as Vote RS&T. It was set up to support excellence in research and to broaden and deepen the research skill base in New Zealand. It funds cutting-edge science that contributes to the global advancement of knowledge. It is administered by the Royal Society of New Zealand.

Brief profiles of the new members and the Chair

Dr Christine Winterbourn

Dr Christine Winterbourn has a BSc and MSc with first class honours in chemistry from The University of Aucklandand a PhD in Biochemistry from Massey University. She currently holds a personal chair as professorial research fellow at the Pathology Department of the Christchurch School of Medicine. She is also a Fellow of the Royal Society of New Zealand. Dr Winterbourn's field of research is the study of the chemistry and biochemistry of free radical reactions and the affect these have on the body's physiological and pathological processes.

Dr Lydia Wevers

Dr Lydia Wevers' background is in the humanities. She has an MA with first class honours from Victoria

University, a Master of Philosophy in English from St Anne's College, Oxford and a PhD in English from Victoria. She is currently Director of Victoria University's Stout Research Centre, which specialises in the study of New Zealand history, society and culture. Dr Wevers has published widely on New Zealand writing and culture.

Dr Richard Blaikie

Dr Blaikie holds a BSc with first class honours in physics from the University of Otago and a PhD in physics from the University of Cambridge in the UK. He is currently Associate Professor at the Department of Electrical and Computer Engineering at the University of Canterbury. He is also the deputy director of the MacDiarmid Institute for Advanced Materials and Nanotechnology. He is working on nanotechnology applications involving the use of optics and electron beam lithography.

Dr Rupert Sutherland

Dr Rupert Sutherland gained a BA with first class honours in the natural sciences at Cambridge University in the UK in 1989 and a PhD from the University of Otago in 1995. He is currently a principal scientist at the Institute of Geological and Nuclear Sciences (GNS) in Lower Hutt. His particular areas of study include plate tectonics in the South Pacific, the geological and tectonic history of New Zealand, New Zealand hydrocarbon geology and marine geology.

Dr Garth Carnaby

Dr Garth Carnaby has a BSc with first class honours in textile technology, a PhD from Leeds University in the UK and a DSc from the University of New South Wales. He also has an honorary DSc from De Monfort University in the English city of Leicester – the centre of the British knitting industry – and is a Fellow of the Royal Society of New Zealand. Dr Carnaby worked for a number of years as a researcher in the New Zealand wool industry and applications from his work include re-designed tufting needles to reduce breakage in carpet making and new uses for coarse wools in luxury textiles. More recently he moved into management and between 1992 and 2004 was chief executive of the Wool Research Organisation of New Zealand, now known as Canesis.

SUCCESS THREE-FOLD FOR VICTORIA RESEARCHERS

Three talented young Victoria University researchers, working in different disciplines, have won prizes at the 2005 MacDiarmid Young Scientists of the Year Awards, held in Auckland on Wednesday 22 June.

Kirsten Keown, a PhD student in the Clinical Psychology Programme, has won the People & Society category for her research into the assessment and treatment of child molesters.

Phil James has won the Agriculture, Forestry & Fishing category for his PhD research that could transform kina fishing into a valuable export industry.

Eusebio Scornavacca has been named runner-up in the ICT & Creative category for research into using mobile phones to promote interactive learning in the classroom. Eusebio, who is originally from Brazil, is completing a PhD while also lecturing in Electronic Commerce at Victoria's School of Information Management.

Vice-Chancellor, Professor Pat Walsh, congratulated the three students on their success.

"The MacDiarmid Awards are extremely competitive so the result is a tribute to the skill and tremendous hard work of these three researchers, who are investigating three very different subject areas. I know they will act as role models and encourage our students to continue in their research careers.

"These awards confirm and reinforce Victoria's commitment to pursuing excellence in research and also recognise the quality of our academics who are supervising and teaching. The release of the first Performance-Based Research Fund results, in 2004, confirmed Victoria's status as one of New Zealand's top three research-led universities and that a high proportion of our staff are internationally distinguished."

The Awards, organised by the Foundation for Research, Science & Technology, are named after Victoria University Alumnus and Nobel Prize winner scientist Professor Alan MacDiarmid. They are designed to celebrate publicly the achievements of New Zealand's future leaders in science. Kirsten and Phil each received a cash prize of $2,000, while Eusebio was awarded $1000.

NZIC CHEMICAL EDUCATION TRUST

2005 DISTRIBUTION

Applications are invited from secondary school chemistry teachers (senior chemistry teachers via Head of Science) for grants from the Trust to promote the teaching of chemistry in their school. Grants of about $400 are envisaged but greater or lesser amounts may be applied for.

Applications should be received no later than 1 September 2005 and addressed to:

Dr. P. T. Holland

NZIC Chemical Education Trust

Cawthron Institute, Private Bag 2, Nelson

Analysts Three*

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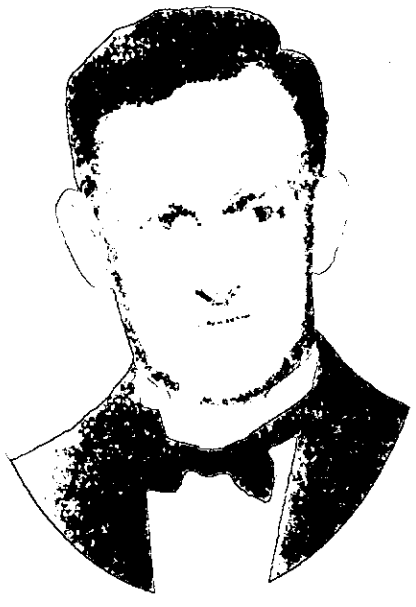
*This is the second and final part covering the life and times of Les Ruddle, Roy Gardner, and Gilbert Lawrence; for Part 1 see: *Chemistry in New Zealand*, **2004**, 68(3), 22-30.

Roy Gardner
FRIC, FNZIC 1898–1967

Roy Gardner (RG) was born in Masterton (his father Alfred H. was a printer) and grew up there qualifying as a Pharmaceutical Chemist apprenticed to Mr H. T. Wood. He then spent a few years in that occupation[1] and during the great flu pandemic immediately following WWI he was working in a prominent pharmacy in central Auckland where his life long friend Reg Combes was an apprentice. The then proprietor, overcome by events (or panic) more or less abandoned his responsibilities and Roy stepped in and took charge during what was a very demanding time. There were shortages of needed pharmaceuticals and Roy improvised with manufacturing arrangements not usual in a pharmacy.

He gained a BSc at Auckland (1921) and an MSc in Chemistry followed in 1922 at Otago University (OU) from work on the essential oils of manuka (*Leptospermum scoparium*), a topic of his own choosing supervised by Prof. J.H.K. Inglis. Further independent studies followed while he was a teacher at King Edward Technical College (Dunedin) between 1922 and 1933 (including a full-time year as a John Edmond Research Fellow at OU; 1928) on the essential oils of New Zealand plants. This had none of the selective separation and sensitive structure elucidation techniques of today. I recall him mentioning that they were expected to do their own combustion analyses for elemental composition (C, H) of purified substances using a large furnace and several grams of sample - the OU microanalytical facility (the only such laboratory in New Zealand) was not established until 1937. Then everything was macro, or at best semimicro in scale, and generally involved non specific chemical methods requiring considerable ingenuity of the analyst. The work was hard-going and progress was slow. Large samples of plants were needed for separation procedures, crude in contrast to modern methods.

For this work and his publications Roy was awarded a DSc (1930) by Otago.[2] During this period he was Head of Science at King Edward Technical College and had studied in 1927 for the FRIC (Sect. E, Foods & Drugs) by examination.[3] He served on the Board of Governors of King Edward Technical College and, when his children were at secondary school, he shared homework hours with them studying Chemical Engineering for M.I.Chem.Eng. by correspondence. He was a foundation member of the NZIC (Associate 1931, Fellow 1935), Otago Branch Chairman (1949-1950), 6th President (1940-1941), and accorded the Institute's highest award - Honorary Fellowship in 1963. He served on the NZIC Council and Membership Committee for several years. He was also President of the Otago Branch of the RSNZ (1942-1943) and President of the Pharmaceutical Sciences section of ANZAAS in 1935.



Above: Dr Roy Gardner, ANZAAS photo ca. 1935.

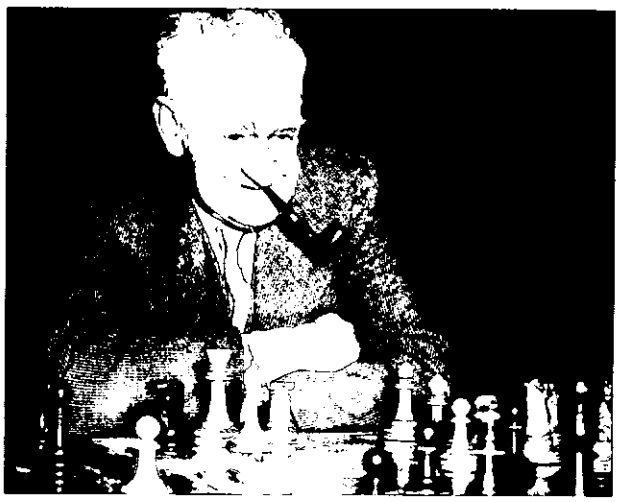
For many years Roy Gardner was an examiner for the New Zealand Pharmaceutical Society and advised on many matters especially of an educational and scientific nature, as is recorded in their minutes (1930-1945). In 1936 he acted as an expert advisor for the Society in its successful opposition of attempts by *Boots the Chemists* to establish a chain of pharmacies here as in Great Britain.[4] Roy provided the most comprehensive feasibility study ever written for New Zealand on the pharmaceutical industry. It was included[5] in the 1936 parliamentary report on Boots's attempt to establish pharmacies in New Zealand at about the same time that Social Security (with its free doctors and medicines) was introduced.

Above: Arriving for the *Boots* hearing.

In 1933 he gave up the security of his pension-provided senior teaching position of 10 years to establish a private consultancy laboratory (despite the severe economic recession) at 41 Dowling Street, Dunedin. This became known as *Dr. Gardner and Partners Ltd.*, listing his occupation as *Consulting Industrial Chemist.* When this became known, Prof. Inglis (OU Chemistry) called him to his office to remind him of his responsibilities as a family man, especially in the middle of a major economic recession. However, Roy subsequently commented to the author that he had had a fall back position in the form of an abundance of part time teaching (particularly evening) at the King Edward Technical College; he was a very versatile teacher. Furthermore, H.W. Lawrence & Son (The Laboratory, Johnsonville, Wellington) generously referred all inquiries from Otago and Southland to him. This gesture led to a very friendly relationship between Roy and Gilbert Lawrence (the son) which he often mentioned.

When the author joined the staff of OU in 1964 for the newly created BPharm course Roy was a part-time senior lecturer in Pharmaceutical Chemistry (1962-64) and the OU representative for the Central Institute of Technology (CIT) Council. He was familiar with what actually happened in 1963 when the staff refused to set the examinations.[6] He also worked several half-days each week in the pharmaceuticals analytical quality control laboratory of the Kempthorne Prosser & Co., *New Zealand Drug Company Ltd.* (in Stafford Street), as they were short staffed at the time [the company was a supply composite of Surgical and Dental goods, Sulfuric Acid manufacturing plants, and (especially) Fertilizer Works in addition to the Pharmaceuticals Factory]. Roy also gave an annual lecture series on applied chemistry at OU, based on his experience as a public analyst and consultant. These lectures were mainly on water quality and its evaluation, both chemical and microbiological,[7] with the author privileged to attend after his arrival. By then he was a fairly recent widower, living alone in a flat in Queen Street, City Rise. This provided a good opportunity for the author to have him home for a meal most weeks. At that time Roy had commenced playing bowls, was teaching himself German (I think) with the aid of audiotapes, and was President of the NZ Chess Association. His sense of humour was never far away. He recalled a Central Otago trip when on obtaining petrol for his car, the attendant surprisingly advised him of the amount and then verbatim *within the accepted limits of error Dr. Gardner;* he was a former pupil of King Edward Technical College!

Roy took part in the early discussions that led to university training for pharmacists. From our discussions, it was clear that he would have been interested in a career in teaching in pharmacy had a suitable top position arisen within New Zealand, even at the expense of leaving his Dowling Street practice.[8] One cannot but wonder how much better things might have been had he been the Principal of the College of Pharmacy in Wellington, following Mr Pryor's retirement (ca. 1943). He was the obvious choice after so many years as an examiner for the Pharmaceutical Society's final examinations and I know he would have accepted the role had it been offered.



Above: President of NZ Chess Association (1964).

I always felt that Roy Gardner's standing had a significant part in persuading Prof. F.G. Soper (Professor of Chemistry then Vice-Chancellor OU; 1946-47 NZIC President) to approve the establishment of pharmacy degrees. The graduates were targeted to fill specialised areas such as industrial quality control for pharmaceutical and closely related industries, senior hospital and health department positions, and to become future pharmacy educators. The 4-year (B.Pharm.) degree included four second year advanced units (Chemistry, Biochemistry, Physiology, Microbiology) already taught for the BSc degree, followed by Pharmaceutical Chemistry, Microbiology, and Pharmaceutics I at year-3, and Pharmaceutical Analysis, Pharmaceutics II and Pharmacology at year-4. About ten graduates a year was thought to be a suitable outcome. The decision to proceed was not without controversy.

Within the University the serious financial constraints were responsible particularly as the course started with two staff and only one student! Externally, the Department of Education, driven by Dr. C. E. Beeby, was promoting the 2-year Dip. Pharm. course at the newly founded CIT, a somewhat elite feature compared with the earlier vocational technical training.

The University of New Zealand had reviewed future training needs for pharmacy[9] and with advice, though controversial, from Sir Harry Jephcott (chemist, pharmacist and barrister-at-law; Managing Director, Glaxo Laboratories Ltd., England, and Chairman of the University of London School of Pharmacy Council) the Senate asserted the principle that two kinds of pharmacy training be adopted. OU was proposed for the university course since most of the ancillary subjects were taught for the then only Medical School. It was reputed that Dr. Beeby (or his staff) thought the university Course unlikely to proceed because of the small numbers (6-8) of graduates needed annually for New Zealand. Little interest was shown by the OU Science Faculty and pharmacy went to the Medical Faculty, then independently funded and not a part of the UGC. The Dean (Sir Edward Sayers) solicited the interest of Assoc. Prof. F.N. Fastier, (HoD. Pharmacology - the most closely related subject in the Medical School) who agreed to take it on until more permanent arrangements could be made. Pharmacology was renamed as the Department of Pharmacology & Pharmacy and continued until 1971 when Pharmacy was transferred to Science as an independent Department akin to most other countries at the time. An annual intake of up to 20 students was set early on (anything less might have raised doubts within the University), but it wasn't until 1970 that it approached this level.

At OU in 1964, Roy wished he had been 10 years younger, as being Head of the Pharmacy School would have suited him fine and he would have been very good I'm sure. On a visit, CIT pharmacy students asked him if they could do postgraduate research at Otago should they be allowed to transfer to the degree course at OU. Roy expected this to be possible by the time they were ready to enter and, in 1963, some CIT students did transfer to the second year undergraduate course. By 1966 they were seeking postgraduate entry but a lack of resources at that stage limited entry to all postgraduates until 1968 after the UGC made a large grant for instrumentation.

Several chemists employed by OU had worked in Roy's laboratory in their earlier careers. All spoke of his important contributions and reflected that it was a pity he had not been better rewarded financially especially as there was a widely held view in scientific circles, that he had no counterpart in the South Island. Relative to other chemists, and in work areas requiring far less qualified people, he seemed to have been rewarded less. Financially he would have been profoundly better off had he owned a Pharmacy but, with his talents and active mind, this would have been a mundane waist devoid of the challenges he embraced. He would also have found the daily repetition intolerable. I think Roy may have reflected on finances, as many do, as he became older when practicalities take over from idealism, but he never complained. The outlay for the laboratory premises over the years was sufficiently large to be remarked upon to close colleagues when the lease was surrendered.

The Dowling Street laboratory at No. 41 was approached from the building entrance by stairs with lead covered steps; I had the feeling it was like going to Sherlock Holmes's rooms. There were five distinct areas, *i)* the office with an oak roll-top desk and large glass fronted bookcase with four sliding glass panels, and below them four smaller sliding wooden panels with storage shelves behind. There was a table with typewriter and other office equipment for a part-time lady secretary, *ii)* another similarly sized room next to the office with a microscope, Plate camera, and other microscopy accessories on a bench. On another bench there were water baths and some more specialized apparatus including a tintometer; this was the closest to what might be described as an instrument room with a refractometer and polarimeter stored in their boxes under benches. There were cupboards fronted with doors around the walls that contained clean ready-to-use glassware. Both these rooms overlooked Dowling Street but the main laboratory *iii)* was off these rooms, extending to the back of the building, and it had benches around the walls and a large table in the middle of the room. Most of the day-to-day work was done in this area; a recently acquired Mettler balance was in a very small room off one corner. A much used, electrically heated, water-jacketed oven was also there and was the only oven I recall seeing in use. This contrasts with work practices in LWR's (Les W Ruddle) lab where I never saw ovens in use, although they must have been required at times. Water baths were in common use in both their labs (LWR and RG) and charring of samples, always a risk with electric ovens or direct flame heat sources, was not possible with water shielded heating equipment. Off the main lab was *iv)* a large walk in safe with storage shelves for chemicals all around. Also off the main laboratory was *v)* a small narrow room at the rear that seemed to hang on the outside of the building, its original function possibly that of a washroom. It was very airy and was used for Kjeldahl digestions and similar operations; the Kipps apparatus (H_2S generator) was also in this room. The labelling of chemical containers was done in a small section of the lab by using neat Indian ink printing and finished with varnish or wax. Staff were always advised at the outset how to handle containers to avoid contamination and to preserve the labels – a habit retained from pharmacy training. Thus, except for the Mettler balance, the facilities were generally of the same era as Les Ruddle's. However, at his retirement dinner, Roy said that a factor in closing the lab was an impending need for investment, *e.g.* in a UV/visible spectrophotometer (then an expensive item), with more new work coming from Southland than industrially declining Dunedin.

Upon entry to the laboratory to hand in samples there was an insistence of recording *client name and address*, with other details, at the counter. Roy was rather emphatic over this as it appears that in an early oversight staff were unable to send out the account for work done *and the client was never seen again*! In contrast, Jim Dunckley recalls that samples arrived periodically on the doorstep in a 2.5 L

Winchester container with an attached envelope containing a £10 note. Roy dealt with this and the analysis himself, but nothing appeared in records *Inward or Outward*, about which he was otherwise so particular, and these became known as *unmentionables*. It is thought that these were for alcohol content determination from the infamous Hokonui clandestine whisky producers *hidden in the mists of Southland*. The fee was more than generous and the sample size *multiply* rewarding!

Microbiological work, including the preparation of media, plates and tubes/slopes, *etc.*, and their sterilisation, was also carried out in the laboratory. Among the equipment for this work were two professionally built incubator cabinets (22 °C and 37 °C) that had an inner glass door to allow observation without exposing the contents when the outer door was opened. They may have come from an earlier era because on top of each was a carbon filament light bulb that provided a weak glow during operation. I had heard of such filaments from the very early days of lighting and suspected they were rather fragile. However, they had survived intact (presumably over a long period) as I cannot imagine where a replacement in kind would come from even then. There was also a pressure vessel (similar to a pressure-cooker) for sterilisation above 100 °C. Roy seemed quite proud that he had taught himself the techniques of microbiology and told the professionals at Otago University so.

Roy was surprised when, on the death of Mr W. B. Seymour[10] (Manager of the Kempthorne Prosser, NZ Drug Company Ltd., Dunedin Factory), he found himself as a beneficiary in the form of a refractometer and polarimeter. There may have been other items also as books with the name W.B. Seymour survived (*e.g.* T.E. Wallis, *Analytical Microscopy*) and subsequently passed to the author together with a significant part of Roy's library including: W. Crookes, *Select Methods of Chemical Analysis (chiefly Inorganic)*, Longman, Green & Co, London, 1871; E.J. Parry, *Food and Drugs, Vol. 1 (The Analysis of Food and Drugs, Chemical and Microscopical)*, Scott & Greenwood & Son, London, 1911. Volume 1 endured as a well worn and well respected work evident in every private analysts laboratory visited by the author in New Zealand and overseas, even in the 1960s and 1970s. This copy and its companion from LWR's library (*Vol. 2: The Sale of Food and Drugs Acts, 1879 – 1907)* sit together to this day. All of these heirlooms survive in the possession of the author.

It needs to be realized that most of the books referred to here and in the earlier articles[11] stood as authoritative sources of information for several decades simply because there was no rapid change in techniques in those times. Moreover, up until then the British Pharmacopoeia was a much consulted reference with a philosophy of sound but simple analytical methods that could be performed by a pharmacist even in a remote location (in days of Empire). By the 1970s, with rapid instrumental advances, this was no longer feasible and was abandoned when superior procedures were available.[12] Additionally, the proliferation of authorship has minimised the use of single authoritative sources.

Roy also received *The Analyst* and held back issues to Vol. 1 (1876) purchasing them when they were reprinted and made available to Members of the Society for Analytical Chemistry at substantially discounted rates.[13] I am not sure what prompted him to outlay on these except perhaps his strong interest in analytical chemistry. He made the collection over to the library at OU when he closed the laboratory.

The reference literature in Roy's laboratory included a typed record of most of the commonly performed analyses as an *In-house Manual*. It included relevant tables taken from Journals for ready reference, *e.g.* Lane & Eynon's Method for sugar determinations[14] - *an almost full-titre bolas of sample solution being added to boiling Fehlings reagent before quickly completing the titration with methylene blue internal indicator* - was empirical; tables were needed and a burette with a well off-set delivery outlet prevented steam condensation obscuring the scale.

While a wide range of work was involved in his analytical practice one unique area that Roy brought to the B.Pharm. analysis course was microscopy. He had a very good *SERVICE* Microscope (W. Watson & Sons Ltd, London; No. 63265) with many accessories that included a home built Plate Camera attachment. Also there was a large, hinge-lidded wooden box that contained round wide-mouthed bottles holding reference samples. These included powdered vegetable drugs, *e.g.* opium, digitalis leaf, nux vomica seed, cascara bark, ipecac root, *etc.* and fibres, *e.g.* silk, wool, rayon, hemp, nylon, several synthetic plastics, *etc.* Additionally, there was an open wooden box containing light filters, ready to use stains (Sudan Red), solvents (Cuoxam) and reagents (chloral hydrate, Cedar Wood Oil "Polak's", Lycopodium Powder, Canada balsam, *etc.* There was also a small 9.5 cm diameter rotating round brass table with microscope slide clips, used for the preparation of slides with sealed cover slips. It is likely he was introduced to this for his FRIC, but over the years an expertise had been acquired that I doubt anyone else in New Zealand would have had. The microscope featured a mechanical stage (with micrometer scales graduated in Cartesian X and Y directions), a substage condenser with iris diaphragm and filter holder, a substage illumination

Above: Plate Camera (r. rear), Reference Samples (l. rear), Cover-slip Table (mid right), Stage Micrometer (black) & Eyepiece graticule (both foreground).

attachment (Condenser Vertical ILLUMINATOR No. 684, W. Watson & Sons Ltd., London,), three objectives (including oil immersion), and a selection of eye pieces. Although the available accessories were complete as expected for a specialist professional user, there was no Camera Lucida[15] but the Plate camera likely gave photomicrographs considered adequate. However, additional facilities for particle size measurement caught my interest. A two-scale ruled microscope slide (Watson, Stage Micrometer) with 10 divisions separated at 0.1 mm and then 10 divisions of 0.01 mm was available. When viewed with the eye piece micrometer (a disc with a ruled graticule inserted into the eye piece) the graticule could be calibrated and used to determine sample particle sizes under standardised conditions. In similar vein, the mechanical stage could be used for larger distances but with reduced accuracy. In short, Roy was very well set up to get the best from his microscope in a way uncommon in a chemical laboratory.[16]

From time to time forensic work arose as had with LWR[11] and I gained the impression that all analysts regarded it as challenging and testing. Often, it was work that did not stop with the initial inquiry. With suspected poisoning, Roy would inform the police if there was any disturbing aspect to the inquiry as non-disclosure could place him in an illegal situation and this needed to be made known at the outset. Similarly, Gilbert Lawrence told me of a Wellington case where a wife attempted poisoning her husband's porridge (I think). The police were informed, secretly observed the additions, seized the sample, and had the Government Analyst corroborate Gilbert's conclusion; all appeared as expert witnesses in the ensuing trial. The poison was either arsenic or thallium and present in a commercially available rodenticide. The poisonings of animals were sometimes investigated, but only where the value compared with the cost of the analysis (which could be substantial). Refrigerated storage facilities for the preservation of biological and postmortem samples were not readily evident in most laboratories I was familiar with in these early years. Alcohol preservation was most likely used and, in any case, is needed in a preliminary step of the Stas-Otto procedure in toxicology.

Appearance as an expert witness was a familiar role for Roy, especially for the Parliamentary Inquiry into *Boots entry to New Zealand*.[4] He mentioned other occasions where court evidence was involved and the importance of adherence to methods and apparatus laid down in official procedures (BP or Foods & Drugs Act, *etc.*) and he cited instances where improvisation had been ruled out. Roy must have been very good in this role as his manner and authoritative incisive-response would have been convincing. Moreover, for choice of words and anticipation he would have had few equals; he knew quite a number of the leading figures in the legal fraternity throughout New Zealand.

I recall Roy being involved over a horse which, inadvertently or otherwise, had been fed cocoa shells, a by-product from Cadburys chocolate production. The husks were commonly sold to smother weeds in gardens akin to bark use today but they contain theobromine; as far as I can recall the horse owner was given the benefit of the doubt. There was also a Dunedin case where a positive alkaloid test from a horse sample turned out to be due to hordenine {[(*p*-hydroxyphenyl)ethyl]dimethylamine} from barley consumption which was ruled accidental.

Much of the regular work was on a contract basis for, *e.g.* Speights Breweries, The Malt Company, Fertiliser Works, *etc.* Periodically, well established companies with their own laboratories would have independent checks performed, or seek advice on problems too time consuming for their own staff. One-off tasks came from the public or other bodies needing answers that the analyst could provide. Unlike Les Ruddle who was employed as a Director in charge of manufacturing by H.F. Stevens Ltd. with regular 8 am to 5 pm hours, Roy Gardner's livelihood depended entirely on his consulting and analytical work (and the occasional lecture, *etc.*) and this involved him in the laboratory at all hours. He had no counterpart elsewhere in the South Island.

With his chemical engineering qualification, Roy became an enthusiast for industrial chemistry innovation particularly from the shortages that arose especially during WWII. British Chemicals Ltd. was a local venture in which Roy had a financial interest and it provided goods such as plastic combs, hair clips, pharmaceutical toiletries, and other products not readily available at the time. These were manufactured at a factory in Filluel Street (almost in the centre of Dunedin) until it was destroyed by fire. One must wonder if the plastic reference samples with the microscope came from there. He was also involved in a potato starch production project and a sample, in a 500 g wide-mouth reagent bottle, labelled *Potato Starch, Cornwar, Canterbury, 1940* survives today. He spoke of the war years projects as having lacked financial support from Government with what money that had been available being *too little and too late* for survival.

A retirement dinner for Roy was organised by Dr. F.N. Fastier, with speakers from OU (Prof. Soper), Otago Branch NZIC (Dr. J.C. Dacre), local pharmacy interests (Mr. W.P.C. Clifford) and a financial presentation (£15-15-0)[17] was made. On arrival in Auckland Roy used the gift for a combination filing cabinet and bookshelves that he made up himself starting from a metal frame welded by his son. He posted me a photograph of the splendidly finished article to show at the next NZIC meeting and to others who had been at the dinner.

On retirement, the contents of Roy's laboratory went to some of the companies he had done work for so that they could continue on their own account, and to the Chemistry and Pharmacology/Pharmacy Departments at OU. His assistant (Bruce Johnston) transferred to Pharmacy with half his salary paid by the University and half from a Malt Company contract transferred from Roy's lab as they depended on someone to do their analyses. There was a marked willingness to take over the lab contents and make the disposal easier for Roy, in appreciation of his long service in the region. Hugh Parton popularly set the tone for this and others were happy to do the same. Although there were various discussions about the provision of

analytical services in the South Island (and possible university contributions) nothing formal came out of this. Arthur Campbell, the author and others at OU, and Alan Metcalf at UC helped out where possible but it was not until the 1980s before independent analytical service laboratories were set up by Dr. Warren G. Bryson in Dunedin and Mooyman & Hornby Laboratories in Christchurch. By that time Nelson's Cawthron Institute was also contracting private analytical work.

One final act in closing the laboratory was to recover precious silver, and to a lesser extent gold, from accumulated residues. Roy did this himself. The silver recovery was from about 30 years accumulation and the metal residue was melted into an ingot that was sold to a jeweller for several hundred pounds (£) - a windfall that even surprised Roy. The furnace only just lasted (probably with a bit of help from Roy) for this final task. In addition, residues from opium assays had yielded some 20 g of pure morphine over the years and this came to the Pharmacy School with other chemicals from the Dowling Street lab.

At the final stage of Roy's time in Dunedin before departing to live with his family in Auckland he came to morning tea in the OU Chemistry Department. In a good humoured way he was asked: *Would you miss having a lab to work in, to do a titration,* etc., *when the mood took you*? He jokingly responded that he might, *as it was good to be able to do a Reichart Miesel value when the urge called!*

After moving to Auckland he assisted in construction work on three flats erected on the property adjoining that of his son (Donald) mentioning laying 500 concrete blocks *with my own fair hands* and enjoying it. He intended to marry a longstanding friend of the family and live in one of the flats. Additionally, he was to become the part-time librarian for the Fertilizer Manufacturers Research Association and editor of the *NZ Pharmacy Journal*. Regrettably none of these came to fruition with his unexpected sudden death on 8 April, 1967.

In writing this account I am left wondering why more wasn't done in 1964 to archive examples of work accomplished, lab records, *etc.*, when the lab was being closed. Roy was rather private about the closure and disposal, preferring to do that by himself. However, when he did leave Dunedin his historical records, including those from his pharmacy connections, were donated to the author and they remain in file boxes to this day. Although the author corresponded with Roy after he left, the close contact was for 1964 only.

The chemistry part of Roy's career has been fairly well documented elsewhere and it has been the almost forgotten pharmacy side that has been given emphasis here. His major publications and publications about him in the *Journal of the New Zealand Institute of Chemistry* are collected in Appendix I.

Gilbert Alexander Lawrence

OBE, FRIC, FNZIC 1893–1972

Above: Gilbert A Lawrence.

Englishman Henry William Lawrence (1865-1942) had a contract with the Rothamsted Agricultural Research Station (Harpenden, England) to provide nitrogen content estimations for agricultural products by the then relatively new Kjeldahl Method. This occupied mornings only and he canvassed for more general work for a full day in his private analytical practice laboratory. He had been employed on the staff at Rothamsted for10 years, and for eight years earlier by Dr. Voelcker Sr. in the Royal Agricultural Society laboratory.[18] Thus he was an experienced analyst before emigrating to New Zealand in 1901 and it was the Rothamsted association that had led him to naming his son Gilbert in commemoration of its famous Director, Sir Joseph H. (Henry) Gilbert (1817-1901).

H.W. Lawrence was very well placed to meet the needs of New Zealand primary agricultural exporters who had to provide their overseas customers with quality assurance specifications (tallow, fertilizers, *etc.*) as a condition of purchase. However, initially he worked for the Department of Agriculture and also lectured to farmers on the importance of fertilizers. And *Dr. Gilruth and H.W. Lawrence carried out some of the earliest experimental work in this country on (animal feeding) stock foods and also tackled the question of producing starter cultures for use in the dairy industry and established a system of supplying standard starters to dairy factories.*[19] He then founded the private consultancy and analytical practice in Johnsonville in 1907 or 1908.

On arrival in New Zealand Gilbert was 8 years old. He was occupied as a motor mechanic at the outbreak of WWI, but enlisted on August 9, 1914 and served as a soldier, initially in Samoa and then at Gallipoli where he was wounded and evacuated to England. He and LWR[11] would have been in close proximity in Gallipoli but I don't think they knew each other at that time. On returning to New Zealand Gilbert was employed by the Health Department before joining his father's practice. During this time he took university studies for a BSc even though he never attended secondary school, entering under the open-entry provision from age 21. As a student at Victoria College he would walk the 8 to 9 miles home.

Gilbert Lawrence was the first person in New Zealand to take the examinations for Fellowship of the Royal Institute of Chemistry in 1927 and was a foundation member of the NZIC, having contributed to the earlier organization and formation of the Wellington Branch; he was elected FNZIC in 1935 and Hon. FNZIC in 1963. He was the 5th NZIC President (1938-1939), succeeded by Roy Gardner in 1940. It is notable that Gilbert and Roy were the first Presidents from outside the university sector (the first four Presidents,

W.P. Evans, T. H. Easterfield, H.G. Denham, and F.P. Worley held chairs in the New Zealand Provincial Colleges) and says much for the eminence and the high esteem in which Consultants and Private Analysts were held.[20] Gilbert was also a President of the New Zealand Section of the RIC.

Not only did Gilbert have a very distinguished career as a chemist, consultant, and analyst, with a 1964 OBE awarded for Scientific And Community Services (Refrigeration),[21,22] but also he played a leading role in community affairs being a JP. Like his father, Gilbert, was involved in many civic minded community activities including local bodies. Both were enthusiasts for emerging transportation developments, the father beginning with a Penny-Farthing bicycle that he rode from London to Glasgow more than once, then motor cycles and motor cars followed; both were early members of the Automobile Association. Gilbert was an advocate for routing of the railway line north through Johnsonville.[20]

The original laboratory became known as *H.W. Lawrence & Son, The Laboratory, Johnsonville, Wellington,* after Gilbert joined and each cited their occupation as *Analytical and Consulting Chemist*. Freezing works and other primary agricultural industry exporters had found a need for quality control to meet specifications and sought the means for doing this. Obviously a central authoritative *Consultancy* with talented staff, and qualifications accepted by overseas clients, had advantage over anyone trying to set up their own independent arrangements. Thus founding demand came from the exports of meat, fertilizer, dairy products and the like, and early work included demands for assaying gold and other mineral prospecting samples. The latter continued into the post WWII years when a search was made for uranium minerals in New Zealand.

Above: 3 Hardy St., East Block (ca. 1921).

Above: West Block (1930s) and adjoining link-block (Offices, Library, Instrument Rooms).

Initially the laboratory operated from space at the home in Johnsonville and then from a dedicated laboratory building, erected in 1920 or 1921 as the *NZ Freezing Works Laboratory* on adjoining land. Although the original home still stands on a north side section next door, the laboratory (with additions over the years) is on fenced-off land and located by itself at 3 Hardy Street in Johnsonville. The original East block is recognizable by its distinctive roof vents from the earlier era. The West block is an independent building erected in the late 1930s on sloping land that allowed basement storage to be included for chemicals etc.[23] More recently the two gabled-roof buildings have been linked by a flat roof construction with wide corridor and adjoining offices and special rooms. The supporting library was housed in the corridor area. Before gas became available in Johnsonville, the laboratory generated its own supply from naphtha using a commercial process. Thomas Borthwick Ltd. is mentioned as perhaps the first client (and a very important one) for whom tallow and fertilizer analyses were conducted.

Microbiological work was obviously an important skill in the laboratory for examination of water, beverages, dairy products and food quality. Early on, important work was done on yeasts and the supply of selected strains to the food and beverages industries. Initially, this work was performed in the West block laboratory and is thought an important motivation in its erection. Microbiological work is still conducted at 3 Hardy Street, but under the new consultancy (see below).

As an aftermath of the 1931 Napier earthquake, much work was undertaken on construction materials, especially concrete and mortar. The silica content of a large number of samples was determined to compare collapsed buildings with those that survived. The analyses required special attention to detail as silica is soluble in dilute acid as long as it is not warmed. Gilbert referred to this work on construction materials in his article concerning the NZ Standards Institution and the desirability for having guidelines and/or specifications for articles of commerce (see citation 6, Appendix II). The 33 years since this was written has not seen the need for such safeguards disappear - *New Zealand Leaky-Buildings Syndrome!* Moreover, during the 1960s the State Advances Corporation (the government mortgage finance provider for younger New Zealand first home owners) provided much work on the content of preservatives (boron and arsenic particularly) used in the treatment of wood for residential house construction. The Johnsonville laboratory did most of these analyses as others declined. A band saw, a mill, and an electric furnace were needed for sample preparation. As an aside, it is interesting to note that the ever talented C. (Ces) W.G. Mason (1905-1977)[11] went on to *pioneer preservative impregnation of timber* for commercial use in New Zealand, and he is perhaps best remembered for the importance of his contribution in this role.[24]

Sometimes it was necessary to prepare reagents unavailable commercially or difficult to acquire. Two such examples were silver diethyldithiocarbamate (a reagent for the colorimetric determination of arsenic), and sodium starch glycollate (in place of starch in iodimetry) the purification of which involved water washing by tedious dialysis over extended periods. Platinum equipment was commonly used in analysis[11] and was undoubtedly used in the Johnsonville laboratory. However, zirconium crucibles became preferred to platinum for molten sodium peroxide fusions because they are more stable to the harsh conditions and avoid contamination of the analysis by the metal. Iron or nickel crucibles used for more routine alkali fusions were also attacked causing some contamination.

Consultations from the insurance industry to identify the cause of damage to goods and property involved evidential analytical *detective work*. Damage could come from water (condensation, rain or sea), corrosion (atmospheric or electrolysis etc), spray and dust (particulate, paint, *etc.*), packaging, and other inadvertent events. The analyses required a circumspect approach often with need for the insurance company to provide an irrefutable history for the damaged goods that all parties accepted (see citation 5, Appendix II). However it was the analysis of stock feed that created much work with samples arriving daily from the Christchurch Company, D. H. Brown, until taken over by Northern Roller Co. (Auckland) who then set up their own laboratory. Such ebb and flow in work was an inevitable feature of client success and growth, to the point of setting up their own analytical facilities.

Forensic work was always a feature of the consultancy but trends changed over the years with the old favourite of arsenic poisoning becoming less popular (easy detection upon exhumation) to use of vegetable poisons (alkaloids, *etc.*) that are less durable and were more difficult to detect. Hence it was not surprising that Racing Conference work came to the laboratory for the monitoring of substances likely to affect performance and outcomes in horse racing. This was on an *as required basis* in 1952 but on a *regular contract* from 1954. New facilities to handle the steady volume of samples were needed together with an ability to deal with new substances and situations as there was no lack of contrivance in the sport; rapid screening methods and multiple confirmation tests were essential. For this work Gilbert used photomicrographs of crystalline derivatives of illicit doping substances in presenting evidential confirmation for court proceedings. Some samples were shown to be abnormal without formal identification, *e.g.* level too low, but they would be noted and a more-frequent-than-random testing would follow; the offender was usually caught! As things developed, the stringent accreditation of personnel became mandatory and required a significant period of work experience under an authorized person before examination for which the correct identification of some 5 or 6 substances was essential. A failure to meet the exacting demands required re-examination after a further period of training with outright rejection after three fails. Moreover, Court work was almost inevitable and required a senior person to accompany the newly accredited staff member until familiarity in the expert witness role had been attained. Considerable adjustment had to be made from the periodic, and mainly one-off forensic tasks previously undertaken in the laboratory.

The Johnsonville Laboratory maintained links with analytical laboratories in Australia and the UK. In the UK this was mainly with Daniel C. Griffith & Co. Ltd., International Commodity Samplers & Analytical Chemists (Cargo & Goods Examiners), Witham, Essex. This is not surprising as even in the author's recent experience, overseas consultants are pleased to know of the existence of suitably qualified people for local advice, and holding recognizable qualifications and memberships still has its place.

Only a selection of the work performed by the consultancy has been mentioned. However, it will be realized that because of its early establishment, central location, very well qualified and talented staff, and its excellent reputation, this lab had the most comprehensive work range and was certainly the busiest of the laboratories described in this series of articles. Only in Auckland could one find a comparable comprehensive analytical service, namely that of Dr. T.J. (Jim) Sprott that was established in the 1940s. I have noted how well Roy Gardner and Gilbert Lawrence got on together and obviously enjoyed each other's company. Jack Futter mentioned that the *Private Analysts* generally got on well together often sharing work and facilities especially where the best and most suitable equipment needed was only available in one location; Lawrence's sent work to Sprott along these lines. However, there had been an earlier period where relations between the government laboratories and Lawrence's were less than good. This seemed to arise from a contract for forensic work awarded to the Johnsonville lab that the other lab missed out on but the differences slowly faded and all worked well together.

That Lawrence's laboratory record keeping was thorough comes from a story Gilbert related. Fellmongers were concerned about the future availability of sodium sulfide (used for de-hairing pelts) at the outbreak of WWII. As it happened the same question had arisen for this with WWI. A large scale user wrote reminding them of this earlier report on the possibility of Na_2S production in New Zealand. Old records, somewhat yellow with 25 years storage, were retrieved and were found to refer to experiments for sodium sulfide production from caustic soda and sulfur and gave other substitutes which would act as depilatories! Several other similar WWI emergency contingencies re-emerged with WWII.

Following Gilbert's retirement in 1963, the name was changed to include *Chemical Service Laboratories Limited* and the consultancy continued only briefly with L.F. Addis-Smith[25] as Managing Director due to his early and unexpected sudden death. Thereafter John Futter and Edgar Cone (co-workers from Gilbert's time) formed a partnership and continued until retirement approached when Geoff Beresford and Murray Friar (from the BP laboratory in Petone) and Norman Holden purchased the business. After some 6-7 years SGS approached the partners and acquired this and most other private labs in

New Zealand in 1990, including medical facilities. However, they were unable to retain the Racing Conference work, which went to ESR (Auckland) by then canvassing for external work, with Geoff Beresford accompanying it. The SGS takeover, with ongoing plans for the Wellington region, was short lived and the partnership dissolved. With closure of the laboratories threatening, Elizabeth Badart (who had remained in employment there from the earlier era) offered to continue with routine work under the title *Laboratory Support Services* for which there has been a continuing demand. Microbiological testing was taken on by the (separate) consultancy, *Microbiology Consultancy & Testing Services Ltd.* who successfully survives to the present day and can still be found in the laboratory premises at 3 Hardy St, Johnsonville.[26] My first visit was in the late 1960s and by then there was a significant presence of modern instrumentation but all of the classical analytical facilities described above were available in a readily usable layout as might be expected for such a busy laboratory.

In reviewing *25 years of the Chemist and Industry* in 1955,[27] Andrews and Brooker cite H.W. Lawrence & Son as *the oldest consultancy of those still functioning, with a well merited reputation for the service it has given and continues to give industry, now under the direction of Gilbert A. Lawrence.* In his GAL obituary Ces Mason[21] describes H.W. Lawrence and Son, Johnsonville as the first industrial consulting and advisory service in chemistry set up in New Zealand. More comprehensive coverage of the historical endeavours of New Zealand chemists can be found in *Chemistry in a Young Country.*[19]

Gilbert's co-workers remember him with admiration as a hard-working and very able chemist adept at constructing his own apparatus. The author was introduced to him by Roy Gardner at the 1965 Dunedin Conference. He was a tall, handsome, genial man who one enjoyed conversing with. By then Gilbert had retired and Roy was revisiting from Auckland.

Gilbert wrote several interesting and informative articles with a rather wide-ranging historical and philosophical vein in them. The citations appear in Appendix II. The paper on *Chemistry in New Zealand Industry* refers specifically to the keeping of records. This has already been mentioned in some detail earlier.[11]

Acknowledgements

Facilities for production of the manuscripts were generously made available by the Chemistry Department, University of Canterbury. Alistair Duff photographed exhibits and provided the illustrations needed for publication, Nathan Alexander assisted with computer filing, and my ever willing colleagues in Rm. 858 helped with computer-usage very often. Grateful acknowledgement is made to the New Zealand Defence Force Archives for accurate information (LWR & GAL). Prof. Arthur D. Campbell of Dunedin retrieved information on Roy Gardner, and Jim Dunckley (Palmerston) provided some recollections. Jack Futter and Elizabeth Badart provided details of the Gilbert Lawrence laboratory. Denis Hogan suggested that I write *Analysts Three*, read the manuscript and was instrumental in gaining NZIC publication of the series. To all I express my gratitude.

Appendix I

The important publications of Roy Gardner are:
1. *The Basis Of Prosperity In New Zealand*, Gardner, R., Coulls Somerville Wilkie Ltd., Dunedin, 1939.
2. *Industrial Development of New Zealand*, Gardner, R., Progressive Publishing Society, Wellington, 1941.
3. *Analysis of Malt Extract by Selective Fermentation*, Gardner, R., *The Analyst*, **1939**, *64*, 103-108.
4. *Foodstuff Colours and their Identification*, Gardner, R., *J. NZIC.*, **1938**, *3*(3), 82-89.
5. *Essential Oils of Metrosideros*, Gardner, R., *J. Soc. Chem. Ind.*, **1931**, *50*, 141-144T.
6. *Essential Oil of Manuka* (Leptospermum scoparium), Gardner, R., *J. Soc. Chem. Ind.*, **1925**, *44*, 528-530T.
7. *Essential Oil of Manuka* (Leptospermum scoparium), Gardner, R., *J. Soc. Chem. Ind.*, **1924**, *43*, 34-35T.
8. *Notes on the Chemistry of the New Zealand Flora*, Gardner, R., *NZ J. Sci. Tech.*, **1923**, *6*, 147-151.
9. *Further Notes on the Chemistry of the New Zealand Flora*, Gardner, R., *NZ. J. Sci. Tech.*, **1924**, *7*, 220-221.
10. *The Relative Positions in Materia Medica of Inorganic, Synthetic Organic and Natural Organic Substances*, Gardner, R., Presidential Address, Section O - Pharmaceutical Sciences, ANZAAS Report, Vol. XXII, Melbourne 1935, 389-399.
11. *Chemistry in the Brewing Industry*, Gardner, R., *Chemistry in the Development of New Zealand Industry*, NZ Section, Institute of Chemistry of Great Britain and Ireland, and NZIC, December 1941, 59-61.

Most of the references to Roy Gardner in *Journal of the New Zealand Institute of Chemistry (J. NZIC)* are 1940-1945 when space was at a premium. They are brief but do include his term as the 6th NZIC President (1940-1941). The following are noted:
1. A Message From The President, *J. NZIC.*, **1940**, *4*(1), 2-3.
2. Presidential Address, *J. NZIC.*, **1940**, *1*(1), 5-9.
3. Presidential Address, Savoy Restaurant, NZIC Dunedin Conference, January 1941, *J. NZIC*, **1941**, *1*(1), 6-12; a special discussion: *Chemists and the War Effort* with audience participation and chaired by Roy Gardner followed: *Ibid.*, **1941**, *5*(1), 12-13.
4. A Message From The Retiring President, *J. NZIC.*, **1941**, *5*(4), 4.
5. A Lecture on Use and Manufacture of Plastics, *e.g.* from casein, in NZ, *J. NZIC.*, **1945**, *9*(1) 19-20.
6. Hon. FNZIC Biographical details, *Chem. in NZ.*, **1964**, *28*(1), 24-25.
7. Obituary: Roy Gardner (1898-1967) by Parton, H.N., *Chem. in NZ.*, **1967**, *31*(3), 62.

Appendix II

Important publications of Gilbert Lawrence are:
1. *The Frozen Meat Industry*, *J. NZIC.*, **1936**, *1*, 45-48.
2. *Chemistry and Civilization*, *J .NZIC.*, **1937**, *2*, 44-53.
3. NZIC Presidential Address, *The Chemist and the Community*, *J. NZIC*, **1938**, *3*(1), 22-31.
4. *Chemistry in New Zealand Industry*, *J. NZIC.*, **1941**,

5(4), 2-3.
5. *The Chemist and Insurance, J. NZIC.*, **1968,** *32*(1), 5-9.
6. *Forty Years in Standards, J. NZIC.*, **1972,** *36*(3), 86-87.

References and Notes

1. *The President, J. NZIC.*, **1940**, *4*(2) 2.
2. Gardner, R., *The New Zealand Species of Metrosideroa, and their Essential Oils* (University of Otago, 1929), Union List of Theses of the Universities of NZ, Suppl. 1955-1962 (Theses 1910-1954; Additions and corrections), p.58.
3. FRIC (Fellow of the Royal Institute of Chemistry) was originally Fellow of the Institute of Chemistry (FIC) and is now FRSC (Fellow of the Royal Society of Chemistry).
4. Parliamentary Industries and Commerce Committee, Report of Proceedings of Inquiry into the Petitions of: The Pharmaceutical Society of NZ; Boots Pure Drug Co. Ltd.; the Wholesale Druggists Association of New Zealand; the Dunedin Retail Chemists 'Assistants' Industrial Union of Workers, 1936.
5. A major part of Boots claim for establishing pharmacies in New Zealand was the benefit that would arise from manufacturing skills they would bring here. At that time (1936) the vast majority of pharmaceuticals in use in New Zealand were manufactured locally, *e.g.* by KP, HFS, *etc.* The compromise reached was that Boots could establish a limited number of pharmacies in New Zealand and the few products whose preparation needed a specialized level of skill were imported, *e.g.* thyroid preparations, insulin, *etc.*, The technical manufacturing claims made by Boots in 1936 appear to be a contrivance that Roy comprehensively unmasked; *Boots* have all but disappeared now from New Zealand.
6. The author [then Manager, Urgent Pharmacy (ChCh) Ltd.] was persuaded to act as final year examiner following three visits to Christchurch by Pharmacy Council President Frederick Castle. It was the only occasion where all examining and marking was carried out by one person.
7. An Otago Branch lecture *Water Analysis*, cited in some detail reveals much experience and judgement in the subject; see: *J. NZIC*, **1941**, *5*(3), 14-15.
8. He was the obvious choice for Head of the School of Pharmacy following the 1943 take over of the private coaching school of Mr. Sydney H. Pryor (when his health began to fail) by the Pharmaceutical Society. Mr. Pryor had been persuaded to move his Auckland Correspondence College to the Pharmacy Board Building on Cambridge Terrace in Wellington, and *to prepare all students who came to him for the pharmacy examinations* (see Combes, R., *Pharmacy in New Zealand, Pharmaceutical Society of NZ, Ray Richards, Auckland, 1981).* Upon Mr. Pryor's retirement, there were no competing circumstances for Roy - a new Head had to be found. However, Roy was not approached and a person with an MPS was appointed; he was dismissed for unbecoming conduct within a short time. The subsequent Head of the Pharmacy College (1945) was the successful Mr. S. E. (Syd) Wright MSc, MPS, ARAIC, ANZIC, an Australian who later became Foundation Professor of Pharmacy at Sydney University.
9. Parton, H., *The University of New Zealand,* Auckland University Press/Oxford University Press, 1979, 138-139.
10. William Benjamin Seymour is cited as an early NZIC Otago Branch Chairman, see: *J. NZIC.*, **1955**, *19*(Nov - Silver Jubilee Issue), 71-72.
11. Pt. I: McKeown, R.H., *Chem. in NZ.*, **2004**, *68*(3), 22-30; McKeown, R.H., *Chem. in NZ.*, **2004**, *68*(4), 6-11.
12. The author learnt first hand from Dr. C.A. (Johnny) Johnston (Secretary & Scientific Director, British Pharmacopoeia (BP) Commission) and Dr. D.C. Garratt (Chairman, BP Commission) of the philosophy that allowed relaxation of this provision for *our man in Dar-es-Salaam.* Both were eminent analysts in charge of large laboratories prior to their statutory appointments and their texts were used as references in the advanced courses at OU.
13. The early history of the Society and the publication of *The Analyst* may be found in *The Practising Chemists - A History of the Society for Analytical Chemistry (1874-1974),* Chirnside, R.C. and Hamence, J.H., Society for Analytical Chemistry, London, 1974; no explanation to account for the reprinting is evident.
14. Lane, J.H. and Eynon, L.J. *J. Soc. Chem. Ind.*, **1923**, *42*, 32-37T and 463-467T.
15. Camera Lucida reproductions were regarded as superior to photomicrography in some regards by pharmacognosists.
16. After some years Roy's microscopy collection became scattered throughout the buildings of the Department, *e.g.* the eye pieces and objectives were housed separately from the microscope. With University approval the author took charge of the independently valued collection maintaining it for Departmental use; it remains in the private collection of the author.
17. This would then have amounted to a week's salary for a well paid person; see: *J. NZIC.*, **1965,** *29*(1), 26.
18. Obituary: Henry William Lawrence (1865-1942), Anon., *J. NZIC.*, **1942,** *6*(3), 1-2.
19. *Chemistry in a Young Country* (Williams, P.P., Ed), NZIC, 1981.
20. Hughson, W.G, *J. NZIC.*, **1955,** *19*(Nov, Silver Jubilee Issue), 2-12.
21. Obituary: Gilbert Alexander Lawrence (1893-1972), Mason, C.W.G., *Chem. in NZ.*, **1972**, *36*(3), 88–89.
22. Hon. FNZIC Biographical details, *J. NZIC.*, **1964**, *28*(1), 27-28.
23. The building was leased to the National Dairy Association from the late 1930s to the 1940s for the manufacture of silver nitrate.
24. Obituary: C.W.G. Mason (1905-1977), Shorland, F.B., *Chem. in NZ.*, **1978,** *42*(1), 18-20.
25.Obituary: Laurence F. Addis-Smith, anon., *J. NZIC.*, **1966,** *30*(1), 40.
26.A regrettable outcome of the changes at 3 Hardy Street has been the loss of the substantial library.
27.Andrews, J.C. and Brooker, S.G., *J. NZIC.*, **1955**, *19* (Nov - Silver Jubilee Issue), 27-38.

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NEWS

The 2004 *Nufarm Prize for Industrial and Applied Chemistry* **was presented to** *Drs. Richard Furneaux* **and** *Gary Evans* **of Industrial Research Limited by the President at the Wellington meeting in May. Furthermore, the President has accepted an invitation to attend the 13th General Assembly of the Federation of Asian Chemical Societies and the 11th Asian Chemical Congress in Seoul (23-26 August).**

Tenders for the NZIC Professional Secretariat have been assessed and a contract awarded to ***Richard Rendle*** of Christchurch. Richard is the current Hon. General Secretary and not the first to hold this position and run the Secretariat. We look forward to a long and productive time working with him. The move of the Secretariat from Auckland to Christchurch has necessitated obtaining a new NZIC postal address as per:
NZIC, P O Box 39112, Harewood, Christchurch.

The contract for Managing Editor of *Chemistry in New Zealand* has been awarded to Rebecca Hurrell and Fiona Summerfield of Christchurch. They will take responsibility for production with effect from the September 2005 issue.

BRANCH NEWS

AUCKLAND

Branch Chairperson **Brent Copp** received his BSc (Hons) and PhD degrees from the University of Canterbury, where he studied the isolation, structure elucidation, and structure-activity relationships of biologically active marine natural products under the guidance of Profs. Blunt and Munro. He undertook postdoctoral research with Jon Clardy at Cornell and Chris Ireland at Utah followed by a year in industry as a isolation chemist with Xenova Plc. He then returned to New Zealand to a lectureship at The University of Auckland, where he is currently a Senior Lecturer. His research interests include the discovery of antitumour, antituberculosis, and anti-inflammatory agents and the application of small molecules to study complex biological processes in chemical ecology and chemical genomics.

Above: Brent Copp.

Prof. Harry Allcock (Penn State) addressed the Branch in March on *The Commercialisation of Long-Range Research - or How to Handle the Tug of War Between Science and Commerce* imparting his first-hand experience of commercialisation of research findings, particularly in relation to his pioneering studies of polyphosphazene polymers. Involved in research for more than 40 years, he has been used as a prototype for model commercial ventures by the US government and was able to cast a critical eye over the reasons and motives of the various parties involved in long range research commercialisation.

Long range research is the first of three critical steps leading to the successful commercialization of an original idea or finding; the second is the identification of users and demonstration of utility. The last step is optimisation and manufacturing scale-up. Until 1990, US universities were content to do long range research, publish results, and allow industry to pick up the ideas and develop them. However, in the 1990s a number of factors led to universities becoming involved in the complete commercialisation process. These included the trend in industry to replace managers with engineering and chemistry backgrounds with ones with business and finance expertise, an overall reduction in research and development staff, and the passing of laws which allow universities to own patents.

The example of discovery and development of the silicone industry in the 1940s was used as one of the most successful examples of the old approach - annual global production of silicones is now 2 million tonnes worth $US8–10 billion. Prof. Allcock also illustrated failings in the old process, talking of his experience of application of his own research findings of the PN-F and PN-A polyphosphazene polymer family in the 1970-80s. These polymers were heat resistant and water repelling, and were taken up for military applications – until the end of the Cold War when government funding stopped and the major manufacturer would not license the patents.

Prof. Alcocck's involvements in the new process where the university has complete control of the commercialisation process and develops start-up companies were also discussed. Penn State has had mixed success in this regard with one of the earlier start-up companies going through three CEOs in two years - valuable lessons were learnt and are currently being applied including:
1. Choice of a CEO with administration experience in a similar industry.
2. Keep to the original plan (until it has been shown to be non-viable).

3. Have a small academic organisational panel (they lose interest when the company starts to function!).
4. Long term funding ($US4-20 million) is required - usually only available from private industry.
5. Keep the Company small with intellectual property rather than material production its chief concern.

Prof. Alcock advised that at Penn State University patent license fees were distributed 40% to the inventors and 20% to the University itself (half of which goes to the Chemistry Department).

The University of Auckland

The building housing the Chemistry Department has finally been fully refurbished, with the move back to the fourth floor. We now occupy floors 4-7, with a few specialist labs on level 8; Electrical & Computer Engineering has moved into two of the floors beneath us. The laboratory space is excellent, with many fume hoods in the synthetic areas and with student areas outside the laboratories. However, we have already grown sufficiently in numbers that we are straining at the seams - especially as the first cohort of students reach year four of BSc(Hons.) Med. Chem.

Our congratulations go to **Laurie Melton** who has accepted a Chair in Food Chemistry and **Dr. Peter Swedlund** who was awarded the LH Briggs Prize for the best PhD thesis at Graduation Breakfast.

The Department has had a number of short term overseas visitors lately. These have included **Prof. Ekke Hahn** (design and synthesis of new ligand systems, including those based on *N*-heterocyclic carbenes - Münster, Germany), **Prof. Peter Gill** (computational quantum chemistry - RSC, ANU), **Prof. Rainer Beckert** (cycloamidines - Jena, Germany), **Prof. Peter Tasker** (high added-value coordination chemistry by ligand design – Edinburgh) and **Prof. Zelimir Gabelica** (mesoporous Cu and (Cu-Zn) aluminate catalysts - Alsace, France). **Dr. Jagjit Khurma** is spending four months in the Department on sabbatical leave from USP (Fiji) collaborating with Allan Easteal on a biopolymer-focused project.

CANTERBURY

The Branch was saddened to hear of the death on 14 April 2005 of **Jack Austin** a well respected former lecturer at UC; an obituary will appear in the next issue.

Branch Events

March saw the **NZIC Annual Student BBQ**, an evening talk from **Prof. Peter Tasker**, and a special **NZIC Easter Seminar** that combined morning tea with Physics, **Professor Harry Allcock's** RSC talk, and a final farewell to **Jack Fergusson** who, having retired from the Department over a decade ago, has relinquished his role as coordinator and lecturer of the Department's summer preparation course. Our April meeting welcomed **Vickie McKee**, (Loughborough, UK) back to the Department and in May we hosted the NZIC President **Graham Bowmaker.**

Chemistry Department University of Canterbury

Newly enrolled 400-level students include **Jackson (Lin) Sun** (PGDipSc) (China) and **André Pinkert** (Germany) and with **John Blunt** and **Murray Munro, Till Cremer** (Germany) with **Owen Curnow, Boris Berseneff** (France) - a visiting student working with **Alison Downard** and **Keith Baronian** (CPIT) for four months. **Kelly Flood** and **Mutita Klanchantra** have enrolled for MSc degrees while new PhD students **Ron James** is with **Leon Phillips, Seth Jones** with **Andrew Abell** and **Jim Coxon, Sam Edwards** with **Murray McEwan** and **Colin Freeman,** and **Hayden Peacock** is with **Andrew Abell.**

Prof. Richard Keene (James Cook, Townsville) a regular visitor to Canterbury with a strong collaboration with **Peter Steel** has been appointed as Adjunct Professor. **Drs. Steven McNabb** and **Matt Polson** have joined **Andrew Abell** and **Peter Steel**, respectively, as postdoctoral fellows. **Anna McConnell** won the Sir George Grey Scholarship (best 300-level student in Science) and a UC Alumni Association Scholarship; **Victoria Peddie** has been awarded a UC Senior Scholarship.

Profs. John Brown (Physical and Theoretical Chemistry, Oxford) and **Peter Tasker** (Edinburgh) have spent 2-2½ months with us as **Erskine Fellows** and **Hartmut Spiering** has completed his visit. Sabbatical visitors now include **Prof. Richard Gammon** (Chemistry and Oceanography - Washington at Seattle), and **David Charutz**, and **Bob Pipal.**

MANAWATU

Student participation at the Manawatu Branch reached an all time high when **David Shillington** and **David Harding** organised a trip to Mangatainoka's Tui brewery. The brewing process was discussed and demonstrated starting from mashing, to hops boiling, to fermentation, and to aging. The lifecycle was completed with a tour of the bottling plant and a sample (or two) of the finished product.

Massey University

Giovanna Lucia Moretto graduated PhD early in May. Her thesis assessed the utility of ion beam analysis for the evaluation of conducting polymer materials and involved a marriage of two disparate areas developed by NZ Nobel Prize winners Lord Rutherford and Alan MacDiarmid.

Dr. Fiona Cochrane and **Leonardo Negron** have recently joined **Emily Parker**'s group. The former from postdoctoral study at Washington State (USA) to help with protein generation and purification with experience of investigating two gene families involved in the phenylpropanoid pathway of plants. Born in Puerto Rico and raised in the USA, Leonardo has a pharmacy and medicinal chemistry background from St John's University, New York, and extensive pharmaceutical company experience. He will investigate synthesis of inhibitors of 3-dehydroquinate synthase, the second enzymic step of the shikimate pathway during PhD studies. **Hemi Cumming** and **Jeff Yeoman** round up the new members of the Parker group starting MSc projects later this year.

Dr. Geoff Waterhouse (PhD Auckland – **Prof. Graham Bowmaker**) has transferred his NZST Postdoctoral Fellowship to work with **Mark Waterland** at Massey University on the self-assembly of photonic crystals and is dividing his time between Palmerston North and Auckland (with **Jim Metson**). **Trevor Kitson** and **Paul Buckley** were awarded the 2004 IFS teaching awards and **Kee Teo** gained the Massey Award for Excellence in teaching first year students. **Al Nielson** has been elected as a FRSC for research effort directed at understanding olefins polymerisation by early transition metal compounds for the rational synthesis of polymers.

Prof. Harry Allcock (Penn State), the world's leading authority on the design, synthesis, and properties of phosphazene polymers that contain inorganic elements, and the development of uses for these materials, visited Massey in March. He spend time with **Eric Ainscough, Andrew Brodie**, postdoctoral **Carl Otter**, and PhD student **Steve Kirk** discussing their collaborative Marsden-funded research programme on polyphosphazenes. He gave a seminar, *Inorganic-Organic Synthesis as a Vehicle to Models, Macromolecules and Materials* and spoke to the Branch on *The Commercialization of Academic Research: Five Examples and Several Lessons* (see above). This well attended meeting took the form of a BBQ at the Fonterra Research Centre to which students were also invited.

Above: Prof. Harry Allcock (left) at the BBQ.

The 5th Annual Chemistry Research Symposium was held in late February to provide an opportunity for postgraduates and postdoctorals to summarise their work research and outline future plans. Opening remarks were from **Trevor Kitson** on the central role of electrons in chemistry and he challenged presenters to mention *electron* at least once in their talks; most did so! The presentations were of a high standard and all were congratulated for their ability to convey the essence of their work succinctly within the 15 minute limit (with help from the vigilant Mr. Blinky).

John Ayers was presented with the RSNZ Thomson Medal at a recent meeting of its Manawatu Branch. The Medal was awarded in recognition of an outstanding contribution to the application of science and technology - in particular of ion exchange resins for use in the dairy industry.

Above: Presentation of the RSNZ Thomson Medal to John Ayers by Andrew Brodie, RSNZ Councillor.

New Zealand Pharmaceuticals

NZP has won a technology makeover comprising $350,000-worth of hardware, software and consulting services from Microsoft and HP. It will assist the innovative business to enhance knowledge management and communications as part of a strategic business plan that includes product diversification and operational expansion. Managing Director, **Richard Garland**, says the technology makeover is a timely boost for the business: *We are at a stage where careful, strategic investment in technology and process is needed if we're to maintain our global competitiveness, while at the same time realising our aggressive plans to grow the company. The makeover allows for work with some of the best people in the business to integrate a technology solution that is 100% aligned to business outcomes, as opposed to technology that's bolted on*, says Dr. Garland.

Andrew Lewis has joined NZP as its General Manager. He has broad experience in the manufacturing industry and has been employed to strengthen the management team with responsibility for coordinating the day to day general management of the company. Andy holds a BSc in Technology Management and an MBA.

Dr. Ghislaine Cousins recently joined the Product Development team to specialise in preparing new carbohydrates for commercial development. Her projects are partly funded by the FRST Technology for Business Growth. Ghislaine completed her PhD on the use of chiro-inositols in asymmetric synthesis at Victoria University of Wellington and returned from postdoctoral work on glycopeptide synthesis in Mainz (Germany – **Prof. Kunz**). Additionally, a new R&D contract has been let with **Assoc. Prof. David Harding** encompassing enzyme catalysed synthesis of specialty carbohydrates.

The Board was pleased to learn of **Dr. Selwyn Yorke's** Fellowship of NZIC for his work in promoting Chemistry in biotechnology and industry.

OTAGO

NZIC President, **Prof. Graham Bowmaker**, visited Dunedin in May and gave his Presidential address *Shedding*

Light on Molecular Structure: Applications of Spectroscopy in Structural and Materials Chemistry as well as discussing NZIC.

University of Otago

Recent visitors include **Prof. Lawrence Parkhurst** (Nebraska-Lincoln) who has spent several months in the Biochemistry Department and gave a seminar on Förster Resonance Energy Transfer in the study of ligand binding and conformational changes associated with protein-DNA interactions. **Dr. Michael Murphy** who heads a research group studying mitochondrial dysfunction at the MRC-Dunn Human Nutrition Unit in Cambridge UK (and Hon. Fellow in both Chemistry and Biochemistry visited **Prof. Rob Smith** to discuss their joint project in this area as the exciting work selectively blocks oxidative damage thereby providing a new approach to treating a range of pathologies whose origin is in mitochondrial damage. The interface between Chemistry and Biochemistry will be receiving an additional boost this year with the appointment of **Dr. Kurt Krause** to the second Chair in Biochemistry. He received MA and PhD degrees in chemistry from Harvard University and an MD from the Baylor College of Medicine and is a crystallographer with a special interest in structure-aided drug design and structure-function relationships in proteins in general. On the structural side of things NZIC student representative **Peter Mace** has won the inaugural Elman Poole Travelling Fellowship for 2nd and 3rd year PhD students. This allowed him to embark on a 3-month trip to the Brookhaven synchrotron facility on Long Island, NY and study proteins implicated in sheep fertility in Helsinki and York, all part of a project jointly funded by Ovita. On the biomedical side **Drs. Liz Ledgerwood**, **Fabienne Lecomte** and **Mike Hubbard** received an HRC 3-year project grant to study the function of Erp29, a protein-folding assistant up-regulated in cancer; **Prof. Warren Tate** and colleagues **Drs. Liz Poole**, **Chris Brown** and **Russell Poulter** have secured a 3-year HRC project grant to study post-transcriptional processes as Drug targets for HIV and Hepatitis B and C viruses. In addition **Drs. Ian Morison** and **Liz Ledgerwood** also received a one-year Strategic Development Grant in the recent HRC funding round. The identification of a specific mutation impairing the supply of calcium to light-sensing cells in a North Island family suffering from a history of visual and intellectual disorders has produced an important paper in the *Proceedings of the National Academy of Sciences (USA)* for **Dr. Marion Maw** and her team in Biochemistry. In the plant realm **Dr. Julian Eaton-Rye** has received the 2005 New Zealand Society of Plant Physiologist's *Outstanding Physiologist Award* for research on photosystem II, the water-splitting complex of photosynthesis. Photosynthesis was also the topic of a recent Biochemistry seminar given by **Dr. Robert Strzepek**, a FRST-funded postdoctoral working with **Dr. Philip Boyd** and **Prof. Keith Hunter** in Chemistry. He discussed part of his PhD work (UBC) on the role of iron uptake and photosystem stoichiometry in diatoms in the Southern Ocean.

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WAIKATO

It is with sadness that the Branch notes the death of Norman Clare, a Past-President, Editor, and stalwart of the NZIC in a Waikato rest home recently; an obituary will appear in the next issue.

Waikato University

Bill Henderson has been awarded a personal Chair in Chemistry for his outstanding contribution to chemistry since joining Waikato in 1992. He has a variety of research interests, with much of his recent work centred on the use of electrospray mass spectrometry as an analytical tool, and as a technique to underpin synthetic inorganic chemistry. He has recently confirmed his international reputation with the publication of a monograph *Mass Spectrometry of Inorganic and Organometallic Compounds* co-authored with Waikato PhD graduate **Scott McIndoe**. Bill has also made many contributions - his *magic shows*, his teaching, and his administrative skills.

We recently farewelled **Ralph Thomson** (SRO in charge of NMR facilities) after 24 years with Chemistry. Two new PhD students have commenced research, **Stephen Gardyne** with **Lyndsay Main** and **Brian Nicholson** working on the use of manganese compounds in organic synthesis, and **Dougal Laird** with **Michael Mucalo** working on novel uses for bovine bone in bio-medical implants.

The Vice-Chancellor, **Roy Crawford** officially opened the Department's new mass spectrometry suite recently. This suite houses the Finnigan LCQ LCMS, the Platform II electrospray mass spectrometer, and the Bruker MALDI-TOF, as well as the new Bruker MicroTOF.

Prizes recently awarded for outstanding 2004 undergraduate performance were the Orica-Chemnet Prize (1st year) to **Ben Deadman** and **Matthew Whyte**, the Waikato Branch NZIC sponsored JE Allan Prize (2nd year) to **Paul Lu**, and the Dow Agrosciences Prize (3rd year) to **Jolene Brown**.

MSc graduate **Rachel Bennett** visited and gave a departmental seminar entitled *The Application of Isotope Mass Spectrometry to Forensic Science*. This fascinating talk covered Rachel's visits to labs in the UK and US where this powerful this technique is being developed. Rachel has recently left ESR for a new career in technical sales. **Jacinta Dalgety** returned to New Zealand following two years as a quantitative education researcher for London Metropolitan University. She holds a Ministry of Education post in the Demographics and Statistical Analysis Unit. Jacinta who completed her PhD in chemical education research with **Richard K. Coll**, has particular interest in the impact of policy at governmental and organizational level on science education in school and university classrooms, and currently seeks to provide statistical evidence to aid rational debate in emotive educational issues (NCEA and scholarships).

NIWA

Michael Ellwood (Hamilton) and **Michelle Kelly** (Auckland) are using the germanium signature of deep sponges to reconstruct changes in deep-ocean nutrient concentrations in collaboration with **Profs. Maher** (Canberra) and **De Deckker** (ANU). Results suggest that a major redistribution of silicon and germanium occurred in the waters east of New Zealand during the last ice age with glacial intermediate waters at mid-latitudes enriched in silicon. Such a finding strengthens the hypothesis for the *silicic acid leakage* from the Southern Ocean to low latitudes, which suggests a switch from silicon to nitrate depletion in the glacial Southern Ocean. This would allow silicon to *leak out* to low latitudes to be subsequently consumed by diatoms. This hypothesis is among the leaders that explain lower atmospheric CO_2 concentrations during glacial times.

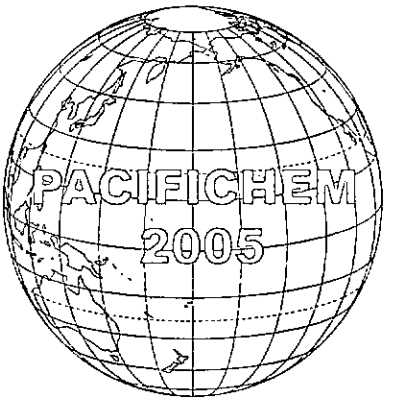
WELLINGTON

March saw **Prof. Alcock** continuing his tour through New Zealand with the lecture as in Auckland (see above). The April meeting of the Branch attracted a large audience thanks to the speaker, **Dr. Sarah Russell**, and the current popularity of TV shows like CSI and New Detectives that have made forensic science and chemistry more fashionable. Forensic toxicology (or the analysis of biological samples for the presence of drugs and poisons) has had a resurgence of interest because of this and new techniques have made it less likely the presence of a drug or poison will escape detection. This talk provided an overview of the field, how chemistry is applied in the field, and the presentation of a typical case. May saw the Presidential Branch visit and excellent lecture (as described for Otago) by **Prof. Graham Bowmaker**, who provided a survey of the interaction of electromagnetic radiation (radio, microwave, infrared, visible light, etc.) and the powerful spectroscopic methods that ensue for the determination of molecular structure. As noted above the 2004 ***NuPharm Prize*** was presented to **Drs. Richard Furneaux** and **Gary Evans** IRL and Richard also received his ***Fellowship*** certificate.

Victoria University

The potential anticancer agent, *peloruside*, discovered by **Drs. Peter Northcote** and (his former student) **Lyndon West** in a marine sponge living in Pelorous Sound is to be developed in association with University of Texas Southwestern Medical Center and Dallas-based Reata Pharmaceuticals. The development of peloruside has been patented in the US by Victoria Link Ltd.

Dr. Ken MacKenzie attended the Spring meeting of the American Ceramic Society presenting an invited paper in the geopolymer symposium and then, in June, an International Geopolymer meeting in Paris presenting collaborative work between VUW, IRL and the German Aerospace Centre (DLR). Two PhD students from Chiang Mai University, Thailand, currently are working with him on the development of new functional electronic materials, and another will be joining the group later in the year.



15-20 December 2005

Update

Registration & Accommodation opens on the Web on 18 July 2005:

www.pacifichem.org

The abstract submission process for Pacifichem 2005 closed after receiving some 11,500 entries to the Technical Areas of the Congress [see *Chem. In NZ.*, **2004**, *68*(4), 32] as well as general papers. Pacifichem 2005 promises to be the biggest and best yet!

The Organising Committee met in early June to complete the daunting task of scheduling the 225 symposia, spread through the 658 half-day sessions, and include the general papers. Important now is the fact that all those who have submitted an abstract for presentation or who simply plan on attending the Congress register and make their accommodation arrangements. ***This can only be done electronically and the web site (see above) opens to these on July 18.*** Flights to and from Honolulu in December are limited and intending delegates are strongly encouraged to make their airline reservations now if this has not been done.

Registration Fees

Member of Sponsor Society	US$455
Non-Member	US$560
Student	US$130
Accompanying Persons	US$55

Member fees are available to members of the six co-sponsoring Societies [ACS, CSC, CSJ, KCS, RACI, and NZIC] and the ten Official Participating Organizations.
** Student registration fees are available to full time students enrolled in an undergraduate or postgraduate degree; they are ***not*** available to postdoctorals.

Hotel Accommodation

Pacifichem Housing will open on the Pacifichem web site on July 18, 2005. A selection of discounted hotel accommodations in Waikiki beach has been arranged for participants. Prices for hotel sleeping rooms range from $US109-$255

Should anyone require assistance please do not hesitate to contact the NZIC Pacifichem representative:
Prof. Brian Halton (Phone: 04-463-5954 (direct)
Email: brian.halton@vuw.ac.nz).

Patent Proze

By John Landells and Helen Palmer

Merck v Integra – A Safe Harbour From Infringement In The US

In a previous Patent Proze, we looked at the law relating to research tool patents, in particular the US case of *Integra v Merck* (see *Chem. In NZ.*, **2004**, *68*(1), 13). The battle between Merck and Integra has been running since 1996, when Integra filed a patent infringement suit against Merck, the Scripps Institute and a researcher at Scripps. The dispute has since reached the US Supreme Court, which issued its decision on 13 June 2005 (*Merck KGaA v Integra Life Sciences I, Ltd, et al.*).

Integra owns five patents relating to particular peptides. Merck funded research at Scripps which involved using the peptides as "positive controls". The efficacy of certain mimetic compounds, which were designed to work in the same way as the peptides, was measured against these positive controls.

The question at issue was whether the use of Integra's patented peptides to develop new drugs was exempt from liability for infringement under Section 271(e)(1) of the US Patent Act. This section provides that it is not "an act of infringement to...use...or import into the United States a patented invention...solely for uses reasonably related to the development and submission of information under a Federal law which regulates the...use...of drugs". The "submission of information" includes the submissions that need to be made to the FDA for an Investigational New Drug Application (IND) or a New Drug Application (NDA).

The Federal Court had previously held that Merck's and Scripps' use of the peptides was an infringement, because it was only "general" research to identify potential compounds of interest, and therefore did not fall within the exemption allowed for by Section 271(e)(1).

However, the Supreme Court has overturned the judgment of the Federal Court. In a unanimous decision, the Supreme Court has interpreted Section 271(e)(1) broadly, holding that "the use of patented compounds in preclinical studies is protected under Section 271(e)(1) as long as there is a reasonable basis for believing that the experiments will produce the types of information that are relevant to an IND or NDA".

The Court accepted that there are some limits on Section 271(e)(1). "Basic scientific research on a particular compound, performed without the intent to develop a particular drug" may not fall within the bounds of the Section.

The Supreme Court's decision leaves some questions unanswered. For example, what really is meant by "a reasonable basis for believing" that your experiments may produce results that could be used in a submission to the FDA? And what of so-called "research tool" patents? The Court explicitly declined to give an opinion about whether Section 271(e)(1) "exempts from infringement the use of research tools in the development of information for the regulatory process". However, it is possible that the *Merck* case could be cited by litigants endeavouring to persuade future Courts grappling with this issue that the use of patented research tools would fall within the Section 271(e)(1) exemption.

Rather than settling the law in this area, it appears that the Supreme Court has opened something of a can of worms. Uncertainty still remains, both for patentees and for those wishing to take advantage of the "safe harbour" that Section 271(e)(1) provides.

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

Patent Proze
Baldwins
P O Box 852, Wellington
Email: email@baldwins.com

John Landells

Helen Palmer and John Landells of Baldwins specialise in chemistry and biotechnology patents. Helen joined Baldwins in 2000. She is a registered patent attorney and has a PhD in chemistry from The University of Auckland. John joined Baldwins in 2003. He has a PhD in chemistry from the University of Otago and an LLB.

Helen Palmer

Obituary
Ian McDonald

Ian Robert Clark McDonald OBE, MSc, FNZIC, MRIC, born in Wellington on August 14, 1925, died in Wellington on February 20, 2005. He was a Scientist, Science Manager, and Dominion Analyst.

Ian Mac, as he was known by his many colleagues, joined the Dominion Laboratory of the DSIR as a cadet in 1946 after a brief time in the RNZAF. As was common in those days, he studied part-time for his degrees at Victoria College specializing in natural products organic chemistry. With the *Dominion Laboratory* (Wellington) (later Chemistry Division) then located in an old brick building in Sydney Street West, he would have had plenty of exercise in those years walking up the steep Bolton Street to University! After graduation he took two years leave for additional experience in England at the Forest Products Laboratory at Princes Risborough.

In the Dominion Laboratory he began a Wood Chemistry Section that examined the extractives of native timbers, *e.g.* Kauri gum and manool from pink pine (*Halocarpis biformis*), and collaborated with the fledgling NZ Pulp and Paper Industry that was harvesting *Radiata* and other *Pinus* species, demonstrating the potential of by-products. As an example, Mac showed that turpentine from *Radiata* pine was particularly valuable through its high content of β–pinene. But it was just not organic chemistry research. Locally-sourced filler clays used in paper manufacture had proved to be highly abrasive to paper cutting knives and his team sorted out the necessary processing to get the clay accepted. He did extensive work on rot-proofing textiles and when NZ Railways had a problem with rotting tarpaulins Mac produced new orange plastic-coated ones that were a common sight for many years on freight wagons.

In the 1950s and 60s organic chemistry changed rapidly and Mac was prominent in introducing the new techniques of instrumental analysis, such as UV/visible, IR, and NMR equipment. The installation of the New Zealand's first instrument at DSIR (Gracefield) saw rapid progress in determining chemical structures and Mac used it to solve the structure of, *e.g.* the plant hormone zeatin. His efficiency in management led to wider responsibility for project and client work and in 1971 he was appointed *Dominion Analyst*. The position dated back to 1865 with the establishment of the *Colonial Laboratory* and the *Colonial Analyst*; the *Dominion* name came in 1907). The position had statutory responsibility for a range of analyses and investigations for Government that included food, water, and pharmaceuticals quality for the Health Dept. under the Food and Drugs Act. The Dominion Analyst was also responsible for the analysis of illicit drugs and forensic and toxicology samples for Police and Customs. Branch Government Analyst Laboratories were established in Dunedin, Christchurch and Auckland. When prosecutions undertaken by the Police and regulatory agencies were successful it was often because their cases were supported by DSIR critical and impartial analyses. Mac rigorously maintained the quality of the DSIR analytical services, which were rarely questioned in Court. Cases sometimes did not come to Court often because DSIR did not support Police suspicions.

Methods were continuously updated. Thus, when samples from alcohol and drugs in driving cases became numerous more rapid analyses were needed. Mac managed the development and use of automated blood alcohol analysis and also the development of fast, reliable methods of breath analysis. These tasks required a high degree of organisation as well as skills in chemistry, electronics, mechanics, and quality assurance.

With his talents for science administration and leadership he was appointed the Director of Chemistry Division in 1979 (~250 staff). Three years later he was convinced somewhat reluctantly to move to DSIR Head Office as a Chief Director where he had responsibility for about 850 staff in eight Divisions specialising in chemistry, physics, mathematics, engineering, nuclear sciences, and social sciences (most of this work transferred in 1992 to form the basis of what is now Industrial Research Ltd. and the Institute of Environmental Science and Research.

He was a popular manager, always ready to give his time and be a mentor to promising young staff, many of whom now hold senior positions in today's science organisations. He was never happier than smoking or chewing his pipe and having a long debate on matters of mutual interest. Over a 40-year period a wide range of New Zealand scientists enjoyed the privilege of working with him and fondly remember his quirky sense of humour. Many will recall having to revise some pet theory after receiving a memo, typically written in green ink, with some kindly but pertinent criticisms.

For services to science, and particularly for his work as Dominion Analyst, he was awarded the OBE upon retirement in 1985. Over the next 20 years he and wife Pamela travelled frequently and widely in UK, Europe, and the USA, as well as enjoying life in their beloved Paekakariki, his home of 40 years. He was a leader in many community activities, had a long a deep association with Freemasonry and was Past Master of the Tawera-o-Kapiti Lodge; he was also a devoted member of St Peter's Church. For many years he was a volunteer Fire Brigade member and a member of the Kapiti College Board of Governors. He was a hands-on organiser in building the local Scout den. Both at work and in the community, those who knew him recognised Mac's genial warmth and kindness. He is survived by his wife Pamela, son Duncan, and daughters Deborah, Fiona and Sarah.

Gordon Leary, Jim Ellis

Plant Metabolomics: New Challenges For Chemists

Daryl D. Rowan,[1] *Martin B. Hunt,*[1] *Janine M. Cooney,*[1] *Albert Koulman,*[2] *Susanne Rasmussen,*[2] *and Geoffrey A. Lane*[2]

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Metabolomics – analytical chemistry in the genomics world

The genomics revolution in biology has been made possible by major advances in analytical technologies for polynucleotides. However, until recently genomics had little impact on the practice of analytical chemistry. With the full DNA sequences (genomes) of multiple organisms completed, scientific attention has shifted to identifying the functions of the many genes identified and to developing an integrated molecular understanding of the functioning of living organisms. Gene function is apparent in the flux of metabolites within a living organism: the *metabolome*.[1]Understanding this metabolome is the goal of metabolomics and the challenge functional genomics presents to analytical chemists. Metabolomics aims to *provide a comprehensive profile of* ***all*** *the metabolites present in a biological sample*[2]... and the ... *measurement of the complete metabolic response of an organism to an environmental stimulus or genetic modification*[3] It brings with it the system-wide perspective of genomics, viewing the metabolic state of an organism as a whole, to provide a rational basis for manipulating metabolism (metabolic engineering) and for a more complete understanding of living systems.

Metabolomics places new demands on analytical chemists. Rather than the highly sensitive and selective trace analysis that has been the focus of analytical chemistry, the analyst is now called upon to measure all the metabolites in a biological sample, very rapidly, and very cheaply. Current analytical technologies include using fingerprinting techniques to screen and classify large numbers of samples, targeted analysis of particular metabolites, metabolic profiling of primary and secondary metabolites, and metabolite flux analysis to understand movement through biochemical networks.[4] Sophisticated analytical instruments including high field NMR and tandem (GC, LC, FT)-MS techniques are needed to handle the large numbers of analytes and samples measured in metabolomics experiments. Even with the best current analytical technologies, comprehensive metabolomic analysis remains an elusive goal rather than a reality.

Challenges of plant metabolomics

For New Zealand, understanding and improving the performance of commercially important plants is crucial to remaining an internationally competitive economy. HortResearch and AgResearch collaboration aims to develop plant metabolomics to provide new tools and approaches for plant improvement. Plant metabolomics is, in essence, phytochemical analysis on a whole-genome scale[5] and, for the analytical and phytochemist, it provides an opportunity to participate in modern genomic and biological research. Challenges arise from both the multidisciplinary nature of the research and the enormous chemical diversity of plant metabolites. In parallel with micro-array measurements of gene expression, metabolomics is being applied increasingly to analyze gene function and the effects of interactions of genes and environment on plant performance, *e.g.* in cold acclimation in the model plant *Arabidopsis thaliana*, grown in the New Zealand Controlled Environment Laboratory (Palmerston North).[6,7] Metabolomic techniques enable phytochemists to rapidly search for new chemicals in mutant screening programs, plant breeding lines and transgenic plants, and the efficient engineering of plants to produce useful chemicals. For example, the metabolic engineering of Arabidopsis to accumulate 4% dry weight of the cyanogenic glycoside dhurrin with *marginal inadvertent effects*... has recently been reported.[8]

The enormous diversity of phytochemicals, both in terms of their structures, chemical properties, and the range of concentrations at which they occur in nature, places huge technical demands on any comprehensive and unbiased analytical technique. Some 100,000 phytochemicals are known[9] (fortunately not all from the same sample), ranging in physical properties from gases (ethene) to amorphous polymers (lignin). The development of analytical methods to measure hundreds of different metabolites at a time with optimization and automation is enormously challenging.[10,11]

Progress in analytical methodology

Progress in metabolomics depends on the power of the analytical methodologies available but as yet no single analytical technique can give a complete profile of the plant metabolome. It appears that a combination of broad-spectrum profiling methods to analyze major components, and of targeted methods to analyze key metabolites occurring in very low concentrations, *e.g.* hormones, will continue to be required. Nevertheless, the coupling of partial and selected views of the *metabolome* with the measurement of changes in gene expression

(transcriptomics) is already yielding a deeper understanding of biological processes.

Gas Chromatography-Mass Spectrometry Methods

GC-MS analysis easily provides useful profiles of plant primary metabolites and remains the primary technique of plant metabolomics, generally by analyzing the derived trimethylsilyl ethers.[12] Time of flight (TOF) mass spectrometers have been widely adopted since accurate mass measurement allows for compound identification, better library matching, and resolution of overlapping chromatographic peaks. The usefulness of GC-MS is increased by the free availability of specialised retention MS libraries of both known and unknown metabolites, *e.g.* see: <http://csbdb.mpimp-golm.mpg.de/csbdb/dbma/msri.html>.

Liquid Chromatography-Mass Spectrometry Methods

HPLC and LC-MS are widely used and usually targeted[13] for a specific class of compounds, *e.g.* phenylpropanoids. The limitations of LC-MS include the effects of ionisation suppression and the limited opportunities for library searching. These are being tackled through the use of stable isotopes[4] and the use of tandem MS/MS for component fingerprinting and identification (see below).

Arabidopsis *metabolomics*

Research has been undertaken using LCQ LC-MS/MS (Ruakura) and high resolution GCT TOF GC-MS (PN) instruments for a metabolomics investigation of plants of *Arabidopsis thaliana*, that over express the regulatory gene, *pap1* (Production of Anthocyanin Pigment 1) in the Palmerston North Controlled Environment Laboratory.[14] Over expression of *pap1* results in increased biosynthesis of red anthocyanin pigments throughout the plant giving red/purple leaves and pink roots and flowers from an obvious phenotype. Harvested leaves of *pap1* and control plants were extracted, derivatized, and analyzed for primary metabolites by GC-MS (Fig. 1) and for phenolics and anthocyanin pigments by HPLC (Fig. 2). HPLC analysis showed a 45-fold increase in total anthocyanins with significant change in the composition of the anthocyanin pigments (Table 1) and of some (but not all) of the other phenolic constituents. Identification of the anthocyanins by LC-MS/MS showed increased proportions of peaks M and N (Fig. 2) suggesting that the biosynthetic system was running at near capacity. GC-MS analysis of 50+ primary metabolites (including amino acids, organic acids, sugars, and intermediates in the biosynthesis of aromatic amino acids) showed no significant changes in the pool sizes of these compounds thus demonstrating an impressively selective regulation of metabolism. This contrasts with the results from RNA expression studies that showed significant changes in gene expression for multiple types of genes (data not shown).

Infusion Electrospray Injection-Mass Spectrometry

The red colouration of *pap1 Arabidopsis* is exceptional and high throughput analytical methods are normally required to identify the metabolic mutants. One approach is to omit the time-consuming chromatographic separation of individual compounds and to collect only MS data. Multivariate data analysis can then be used to classify samples, *e.g.* as mutant or wild-type, based on their mass spectral *fingerprints*.[15] This infusion ESI-MS approach trades short analysis times and high sensitivity against the inability to distinguish compounds of identical mass. With the very high mass resolution of Fourier Transform MS, molecular formulae can be determined and several thousand sample components identified, *e.g.* see: <http://www.phenomenome.com/cap_discovery.htm>. The University of Auckland has such an instrument.

We have adopted a different strategy, namely that of operating at nominal unit mass resolution but with MS-MS technology to establish ESI-MS^n metabolic fingerprinting. A recently acquired linear ion-trap LC-MS^n instrument provides full scan MS^1 mass spectra (useful for the classification of samples) together with mass spectral fragmentation data on all the major MS^1 ions in each sample. The fragmentation data consists of a series of spectra resulting from consecutive fragmentation reactions of each major ion (200+) in the full mass fingerprint. This high level of information gives the opportunity to determine directly the identity of components at a chemical class level or better.

The endophytic fungi of grasses are a major research focus at Grasslands. Wild-type strains of the fungus *Neotyphodium lolii*, commonly found in New Zealand

Table 1. Total concentration (mean ± SD) and mean % relative composition of different anthocyanins in control and transgenic plants of *Arabidopsis thaliana*.

Sample	Total anthocyanins (mg/g DM)	Mean % relative composition of major anthocyanins by peak			
		D	J	M	N
Columbia wildtype control	0.4 ± 0.1	31	100	10	14
Empty vector control	0.3 ± 0.0	25	100	11	
Pap1 Arabidopsis (seed line 1)	15.5 ± 1.1	28	100	131	48
Pap1 Arabidopsis (seed line 3)	11.8 ± 1.5	25	100	135	46

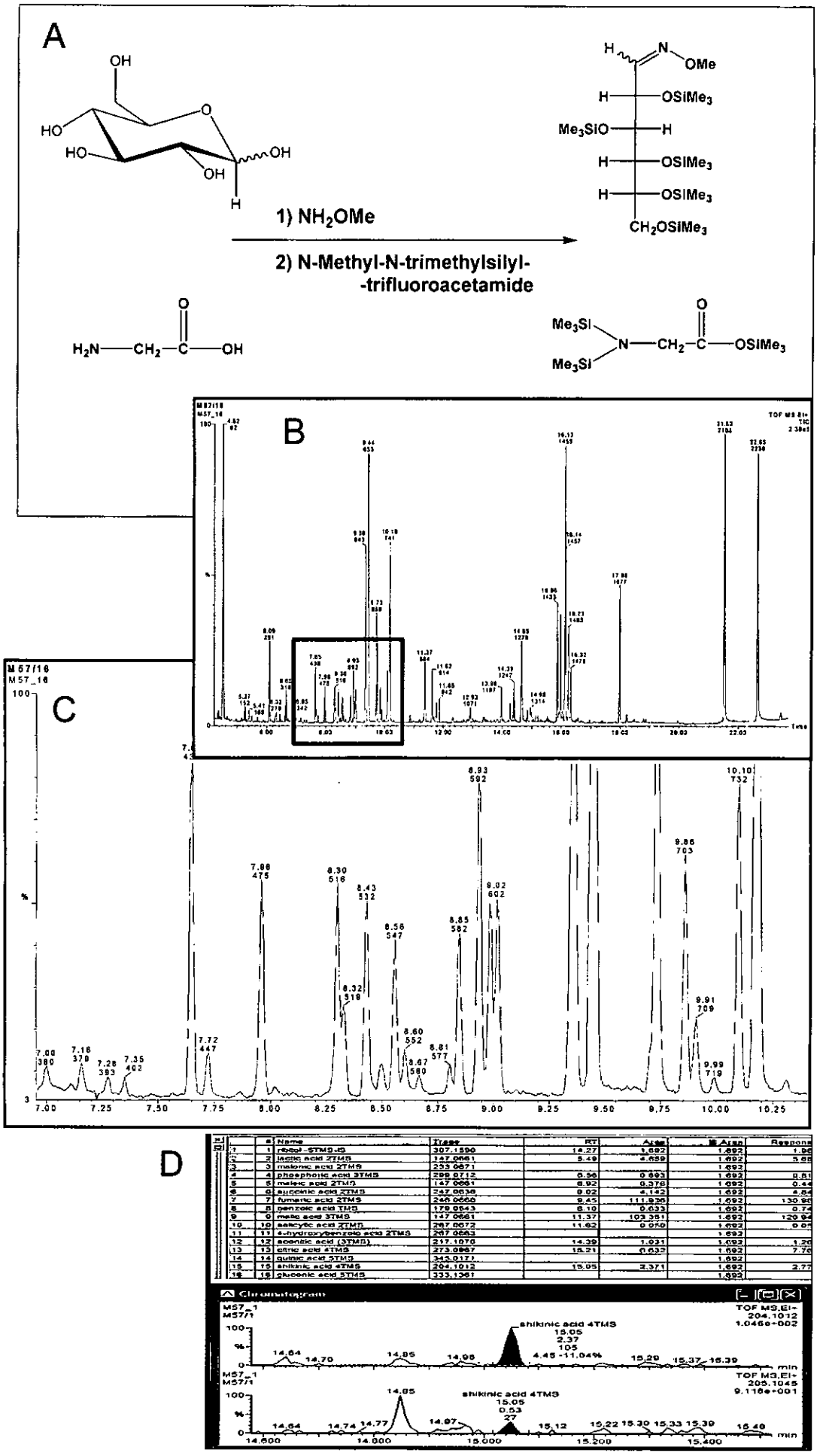
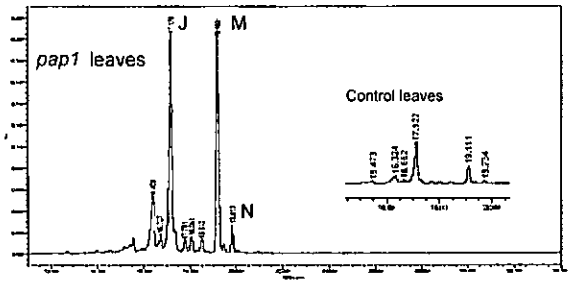
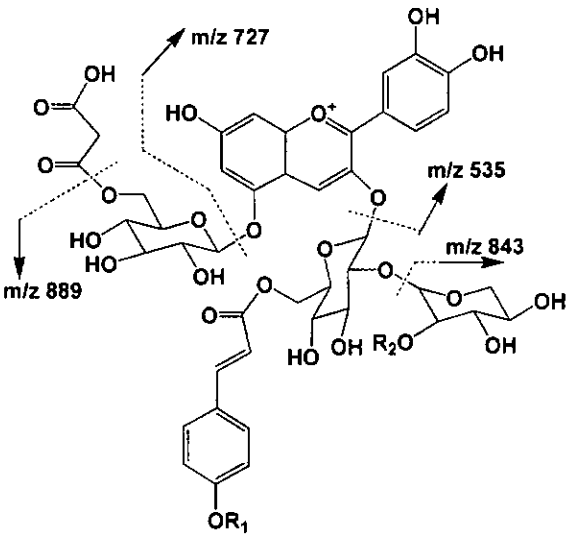


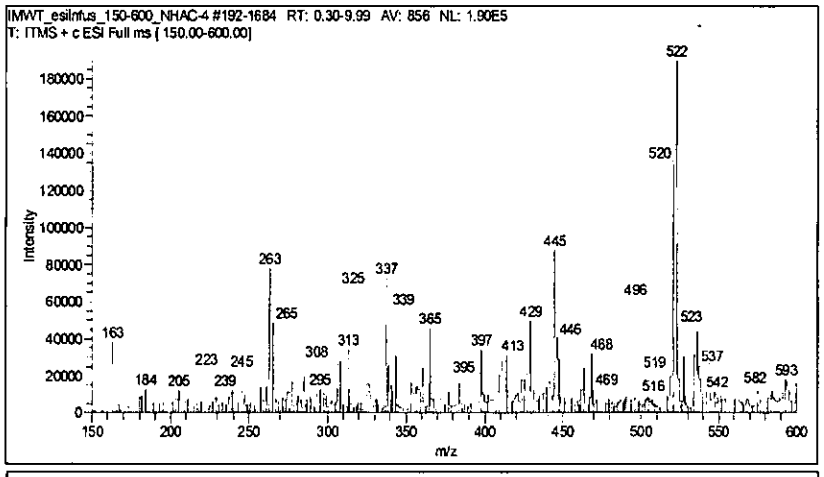
Fig. 1. GC-MS analysis of silylated extracts from leaves of *Arabidopsis thaliana*: derivatisation (A), partial GC-MS (B) and expansion (C), and analysis report using selected mass spectral ions for quantitation (D) for export to external database.





M (M^+ 975) $R_1 = R_2 = H$
N $R_1 = H$, R_2 = sinapoyl ester
J R_1 = β-D-glucopyranosyl, R_2 = sinapoyl ester

Fig. 2. C-18 reverse phase HPLC profile at 530 nm of anthocyanins in leaves of control and *pap1 Arabidopsis thaliana* with structures of selected anthocyanins identified by LC-MS/MS.



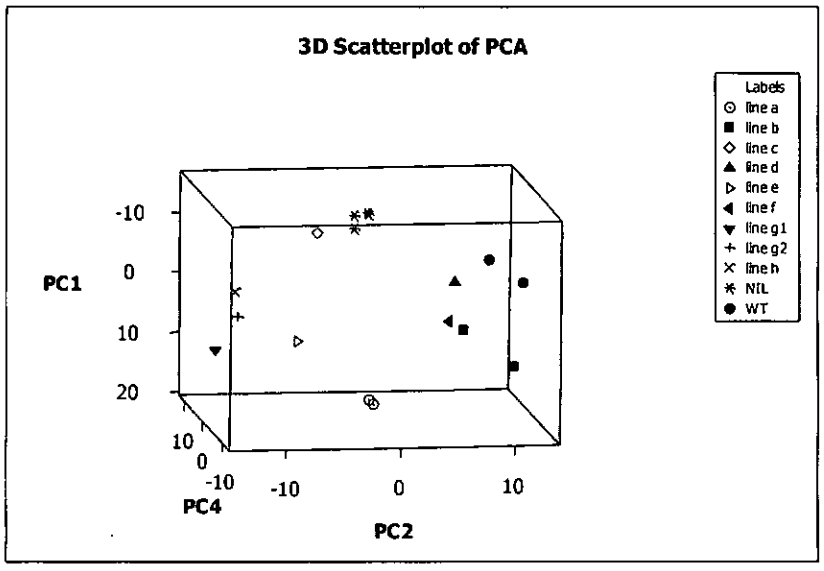


Fig. 3. Typical MS^1 ion profile of infused seed extract and (lower) projection of a Principle Components Analysis of the profiles for a set of seed extracts showing PC1, PC2 and PC4; NIL, uninfected seed; WT, seed with common *N. lolii* strain, lines a – h, seeds with different selected fungal strains.

perennial ryegrass, produce the neurotoxin lolitrem B, thought to be the causative agent of ryegrass staggers, together with the toxic ergot alkaloid ergovaline, and the insect feeding deterrent peramine. Endophyte strains that produce the insect feeding deterrent but not the toxic factors have been selected and released commercially. There is ongoing interest in discovering additional strains with useful properties, and the MS fingerprinting technique has been applied to provide an overview of the metabolic variation between strains. A set of seed samples was screened by direct infusion of an isopropanol extract into the mass spectrometer and ions in the range *m/z* 150 – 600 and their fragments collected. The resulting MS^1 ion profiles were combined and analyzed by principle component analysis (Fig. 3). This showed that uninfected (NIL) and infected seed with the common wild type (WT) endophyte and with different selected strains, could be differentiated by their ion profiles. Investigation of the fragmentation patterns of key ions is on-going and indicates the presence of several new compounds in addition to the known endophyte alkaloids.

Conclusion

Plant metabolomics, both internationally and in New Zealand, is very much a *work in progress* with exciting challenges in analytical and plant chemistry. We hope this article awakens the enthusiasm of chemists to this opportunity for conducting some interesting chemistry.

Acknowledgements

Ours thanks go to Paul Austin and Cara Norling for growing the plants, Andrew Allan for transgenic *Arabidopsis*, Dwayne Jensen for LC-MS, and Brian Tapper for seed samples with selected strains of fungal endophytes.

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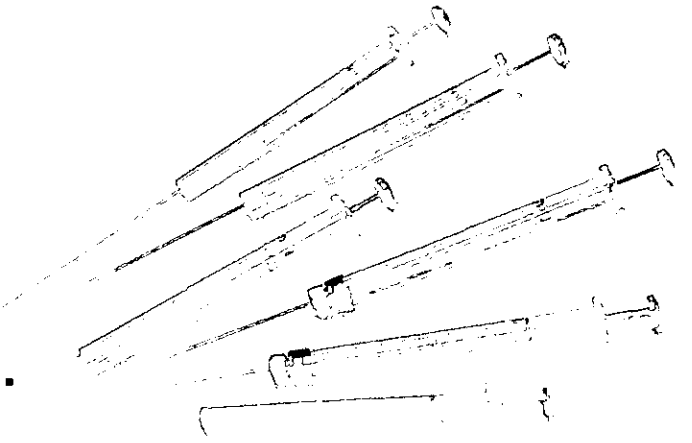

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Raman Spectroscopy – From Single Molecules to Single Cells

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Since its discovery over 75 years ago, the Raman Effect has grown from a technique practised only by experts with dedicated, high-resolution spectrometers and expensive sources to one applicable to nearly all areas of physical and biological science. A brief introduction to the Raman Effect, its differences and similarities to other spectroscopic techniques, and the various enhancement mechanisms that have contributed to its successful application across such a broad range of disciplines is provided. The article then traces this remarkable development by surveying of some of the more common techniques in use today, describing some of the current instrumentation and outlining some of the strengths and pitfalls of Raman spectroscopy. Finally applications of Raman spectroscopy ranging from single-molecule spectroscopy to biological imaging are surveyed.

The Raman Effect

Following the x-ray scattering experiments of Compton, and a theoretical paper in 1923 by the Russian theorist, Smekal,[1] C. V. Raman examined the light-scattering properties of a number of pure liquids.[2] The large majority of the scattered light was observed at the same frequency as the incident light (Rayleigh scattering) but a very small portion was at shifted frequencies as predicted; this inelastically scattered light became known as Raman scattering. Raman's observation was remarkable given that his light source was nothing more than the bright Calcutta sun. In modern terms we think of Raman scattering using energy level diagrams of Fig. 1 where $|\, i \,\rangle$ and $|\, f \,\rangle$ are initial and final vibrational states and $|\, e \,\rangle$ is an electronically excited state of the molecule. Stokes scattering occurs when the scattered photon has a smaller frequency (longer wavelength) than the incident photon and Anti-Stokes scattering occurs when the scattered photon has a greater frequency (shorter wavelength). Typically the frequency of the scattered light is given in terms of the Raman Shift, which is the difference in frequency between the incident and scattered light. Because $|\, i \,\rangle$ and $|\, f \,\rangle$ are vibrational states the Raman shifts correspond to the vibrational frequencies of the molecule. In this way Raman spectroscopy complements infrared (IR) spectroscopy. The dashed line is a so-called *virtual state* that arises from the description of the scattering state using 2nd order perturbation theory in the full quantum mechanical treatment of Raman scattering.[3]

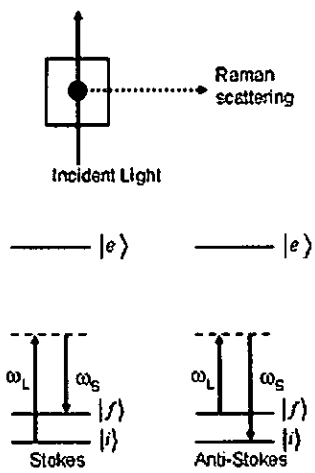

Fig. 1. The Raman Effect: A schematic experimental arrangement (upper) and energy levels in the Stokes and Anti-Stokes processes (lower).

In *ordinary* Raman scattering the energy of the incident photon is much less than the lowest electronic transition of the molecule, *e.g.* 514 nm photons impinging on cyclohexane. Under these conditions Raman scattering is extremely weak, its magnitude typically given in terms of the Raman scattering cross-section (σ_R). For neat liquids, *e.g.* cyclohexane, the Raman cross-sections are on the order of 10^{-30} cm^2 (10^{-14} Å^2) for visible excitation, which compare with cross-sections for linear absorption on the order of 1 Å^2 for a strongly allowed electronic transition (ε_{max} 50,000 L mol^{-1} cm^{-1}).

Raman Spectroscopy

Like many spectroscopic techniques, the popularity of *Raman* with chemists has been influenced by instrumentation and light source developments. At the time of Raman's discovery infrared spectroscopy was difficult, requiring exotic cell materials with restrictions to the mid-infrared range. By contrast, the new Raman technique required readily available light sources (mercury arc lamps), easily constructed spectrographs and, perhaps most importantly, sample cells that could be constructed from glass. Moreover, Raman's technique used a single spectrograph and detector (photographic plates) to cover the entire frequency range - what we now call the terahertz region to the near infrared. Whereas 30 years later, IR spectroscopy had advanced with commercial instruments available, Raman techniques had remained stagnant. The first revolution in Raman spectroscopy occurred with the advent of the laser (late 1950s to early 1960s) as these provided incredibly intense, highly directional monochromatic radiation – the perfect source for Raman spectroscopy; photomultipliers that allowed the direct recording of Raman spectra were available. However, lasers required expertise beyond the interests and capabilities of most synthetic chemists and the capital costs

were prohibitive for many users. Thus, in the mid-1970s IR spectroscopy remained the technique of choice. The last 20 years has seen a number of *enabling technologies*, and with the discovery of dramatic enhancements in the magnitude of the Raman Effect, the scope and applicability of Raman spectroscopy has expanded dramatically; some of these are listed in Table I.

The Charge-Coupled Device (CCD) detector (a by-product of military research with subsequent commercial development for imaging systems) is commonly found in digital cameras and camcorders and is a 2-dimensional array of light-sensitive pixels typically with thousands of pixels in each dimension. The essential difference between a CCD detector used for spectroscopy and one used for video-imaging is that imaging CCDs have a high data capture rate (and spectroscopic CCDs have an extraordinarily low thermal noise). From a spectroscopic point of view each column of pixels acts as an independent exit slit and detector that allows the CCD simultaneous detection of over 1000 pixel columns. This eliminates the need to tediously scan the dispersed light passing the exit slit of the spectrometer, reducing acquisition times from tens of minutes to seconds. Holographic diffraction gratings have allowed the physical size of Raman spectrometers to shrink due to their very high groove densities. As a result, spectrographs with equivalent dispersion have halved in size from focal lengths of 1 m to 0.5 m and below.

A *notch* filter is a narrow-band line filter that rejects the relatively intense Rayleigh (elastic) scattering, a bane of Raman spectroscopy. The performance of a modern notch filter is impressive. They have optical densities of 8 and greater (OD 1 roughly equates to a Beer-Lambert absorbance of 1) over a frequency range of a few hundred reciprocal centimetres, and transmittances close to 100% outside of this region. The use of notch filters has allowed Raman spectroscopists to use a single spectrograph in place of double and triple units with an even more dramatic reduction in the physical size (and increase in throughput) of the instrument. In combination with *plug'n'play* solid-state diode lasers these advances have shrunk the size of Raman spectrometers to the extent that hand-held versions are now commercially available.

Table 1. New apparatus and techniques in Raman spectroscopy.

New Apparatus or Technique	Advantage
CCD Detector	Multi-channel detection, low noise, robust
Holographic Diffraction Gratings	High groove densities, high dispersion power
Narrow-band filters	Excellent Rayleigh and stray light rejection
Solid–state diode lasers	Cheap, compact, easy-to-use light sources
Fourier Transform techniques	Allows NIR excitation and detection (for fluorescent and/or biological samples
SERS and resonant enhancements	Increases magnitude of Raman effect

Raman spectroscopists have followed in the footsteps of their IR colleagues by utilizing interferometers and Fast Fourier Transform (FFT) techniques in addition to dispersive spectrometers. Typical FT-Raman instruments use near-IR excitation (>1000 nm) along with single-element near-IR detection. Near-IR excitation virtually eliminates interference from fluorescence (the other bane of Raman) and thus FT-Raman techniques are particularly useful for biological materials and pharmacology.[4,5]

Combining these advances with the natural advantages of Raman spectroscopy, *i.e.* use of simple cell materials and visible radiation, accounts for the surge in the interest of Raman spectroscopy. However, none of these advances changes the fundamental paucity of the Raman Effect. Fortunately, under certain conditions, the *ordinary* Raman Effect can be enhanced many orders of magnitude and for these reasons it is becoming more widespread. Two principle mechanisms account for amplifying the Raman Effect – *resonance* and *surface*-enhanced effects.

Enhancing the Raman Effect

The Resonance Raman Effect

When the incident photon frequency (Fig. 1) is experimentally tuned to approach the electronic transition of the molecule (easier said than done!) a very interesting and useful change occurs in the magnitudes of the Raman cross-sections as shown by examining the denominator in a simplified expression for σ_R:

$$\sigma_R \propto \left| \sum_n \frac{\langle f|\mu|n\rangle\langle n|\mu|i\rangle}{i(\omega_L - \omega_{ni}) - \Gamma} \right|^2$$

In this expression $|n\rangle$ are vibronic states of the electronic excited state depicted in Fig. 1 and $\langle f|\mu|n\rangle$ and $\langle n|\mu|i\rangle$ are the transition dipole moments for $|n\rangle \rightarrow |f\rangle$ and $|i\rangle \rightarrow |n\rangle$ respectively, *i.e.* μ_{fn} and μ_{ni}. As the frequency of the incoming light w_L approaches the frequency of the transition between $|i\rangle$ and $|n\rangle$, ω_{ni}, the denominator becomes very small (but is prevented from becoming zero by the phenomenological damping term, Γ) and the Raman cross-section increases in magnitude. This equates to a resonance condition between the transition dipole moment matrix element, μ_{ni}, and the radiation field. Raman scattering under these conditions is known as *resonance Raman scattering*. Whereas typical Raman cross-sections under non-resonant conditions are 10^{-14} Å^2 (*vide infra*), typical resonant Raman cross-sections are 10^{-10} Å^2. The keen-eyed reader will have noticed that the electronic transition dipole moment appears quadratically in the expression for σ_R, thus the

magnitude of the resonant enhancement is strongly dependent on the allowedness of the resonant electronic transition.

The resonance Raman Effect has been employed very successfully in the spectroscopy of biological systems. In haemoglobin, the iron porphyrin exhibits very intense electronic transitions and therefore shows strong resonance enhancement. Haemoglobin possesses an enormous number of Raman active vibrational modes, however the resonance enhancement of the *spatially localized* porphyrin electronic transition amplifies the porphyrin vibrational modes to the extent that the surrounding protein modes are below the noise level. Thus resonance Raman spectroscopy can selectively probe the vibrational modes of the porphyrin, *e.g.* the mode of oxygen or carbon monoxide binding.[6] The recent availability of excitation sources in the UV range (via frequency doubling the output of intense visible lasers) has led to the development of techniques for probing the localized electronic transition of aromatic amino acid residues (trytophan). This has allowed the dynamics of protein chains to be followed *in vivo*.[7] Those familiar with IR spectroscopy may wonder about interference from water vibrational modes - Raman spectroscopy has the natural advantage to biological systems of the small Raman cross-section of water.

The Surface-Enhanced Raman Effect

Recent physical and analytical chemistry literature has a large of number of papers devoted to surface-enhanced Raman spectroscopy. The original paper on the surface-enhanced Raman Effect was published in 1974 by McQuillan *et al*,[8] who were developing spectroscopic probes of reactions at electrode surfaces. The binding of pyridine onto Ag, an ideal electrode material, was being investigated. In what turned out to be a key approach they used freshly reduced Ag electrodes that exhibited a very rough, nanostructured morphology. Although they were examining just a monolayer of adsorbed pyridine, they observed truly remarkable signal intensities; later work by Moskovits[9] revealed the role of silver surface plasmons (collective electronic oscillations). Changes in polarizability are the primary mechanism for Raman activity and the Ag surface-plasmons, in resonance with the incident radiation field, generate large changes in the molecular polarizability that lead to greatly enhanced Raman scattering. The plasmon enhancement effect increases as the surface curvature increases, hence the large effect for nanocrystalline and colloidal metal surfaces.

The interest in the surface-enhanced Raman Effect increased dramatically following reports by Nie[10] of blinking in surface-enhanced Raman scattering experiments – originally thought to be due to single-molecule SERS (an analogous effect had been previously observed in single-molecule fluorescence experiments) but later thought to be due to diffusion of dye-labelled Ag colloids in and out of the scattering volume. The surface-enhanced Raman Effect has attracted the interests of analytical chemists because of its remarkable sensitivity and information content[11] (Note: a Raman spectrum offers a fingerprint spectrum in the same manner as an IR spectrum). In combination with microfluidics and optical fibre collection optics SERS enhancement has provided sensitivities that are orders of magnitude greater than existing fluorescence methods.[12] Typically the SERS effect is generated using Ag or Au colloids as these substrates spatially confine the SERS effect to the dimensions of the colloid. As such, the SERS effect has attracted a lot of attention in monitoring biological processes.[13]

Temporal and Spatial Resolution with Raman Spectroscopy

Temporal Resolution

Development of pulsed laser technology has seen the advent of a number of so-called pump-probe techniques that can follow electronic and vibrational excited-state dynamics. Vibrational analogues of multidimensional NMR techniques have been developed that follow the coherent evolution of vibrational superpositions and allow the separation of inhomogeneous and homogeneous contributions to vibrational line-shapes. For isolated molecules in solution or the gas phase the inhomogeneous contribution is relatively small, but for complex systems such as glasses, polymers and proteins the inhomogeneous broadening can be substantial. Whereas in NMR spectroscopy a single RF pulse is required to prepare spin populations and coherences, Raman spectroscopy needs a pair of pulses to prepare the corresponding vibrational states (Fig.2). In 2-D NMR spectroscopy a signal is collected along two time axes and then Fourier Transformed to the frequency domain to give the familiar 2-D NMR spectrum. In much the same way that a 2-D NMR spectrum maps out couplings between nuclear spins, a 2-D Raman spectrum maps out the couplings between vibrational modes.[14] 2-D Raman was experimentally demonstrated recently by Fleming and co-workers.[15,16] Because pairs of pulses are required to prepare and modulate Raman coherences, a 2--D Raman experiment requires 5 optical fields to be synchronized both spatially and temporally. Given that typical Raman inverse linewidths are on the order of a few picoseconds, and time delays between pulses are just a few tens of femtoseconds (10 fs = 3 mm) observing a 2D Raman signal is a most impressive experimental feat. The energy level diagram is shown in Fig. 2. The Raman scattering tensor (the experimental observable) are shown in Fig. 3. A Fourier Transform of Fig. 3 would produce a 2-D spectrum that displays off-diagaonal couplings, exactly analogous to the NMR case. The change in sign of the tensor element evident in the insets of Fig. 3 is related to the detailed rotational and translational dynamics of the liquid.

Spatial Resolution

The advantage of using visible (as opposed to IR) radiation in Raman spectroscopy is perhaps most obvious in the field of microscopy and imaging. Because Raman of this, existing microscope technology, *e.g.* confocal fluorescence microscopy, can be adapted easily to Raman spectroscopy. Thus, with the excellent spectral resolution provided by the appearance of vibrational modes in a Raman spectrum, the spatial resolution (l/2 is the theoretical Abbe diffraction-limited spot size) of visible light can also be utilized. This

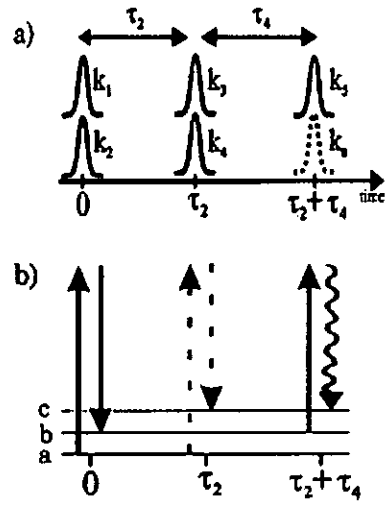

Fig. 2. Pulses and energy levels in a 5th order 2-D Raman experiment. The first pulse pair at t = 0 prepares a coherence between $|a\rangle$ and $|b\rangle$, the second pulse pair at $t = t_2$ prepares a coherence between $|a\rangle$ and $|c\rangle$, and the fifth pulse, at $t = t_2 + t_4$ stimulates the Raman scattered photon (wavy line) in a transition from $|b\rangle$ and $|c\rangle$ (Reprinted with permission from David A. Blank, *J. Chem. Phys.*, **2000**, *113*, 771. Copyright 2000, American Institute of Physics).

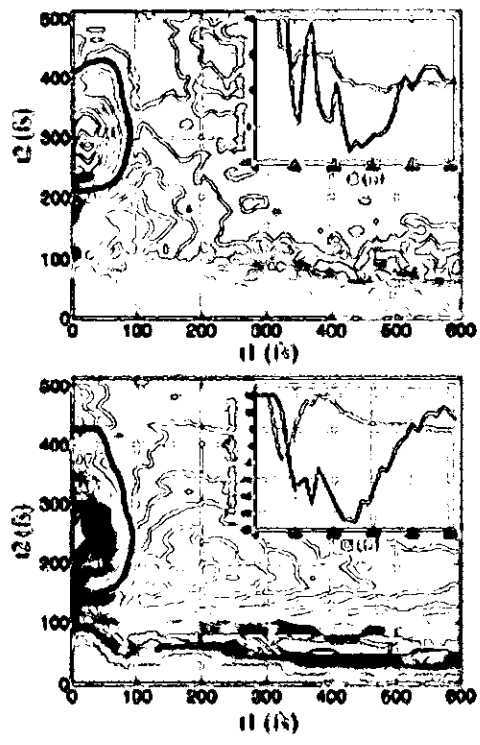

Fig. 3. Tensor elements of the 5th-order Raman signal from CS_2 (a) The R_{zzzzmm} element. Inset shows slices along $t_1 = 0$ fs (solid) and $t_1 = 100$ fs (dashed), (b) the R_{zzmmzz} element. Inset shows slices at same times as (a). Solid line indicates a nodal plane. The subscripts indicate the polarizations of the incident and scattered radiation, m indicates the magic angle, 54.7° (Reprinted with permission from Ref. 16. Copyright 2002 by the American Physical Society).

has led to the development of Raman medical imaging.[17] The Raman spectrum of a typical tissue sample has clear bands characteristic of different tissue types, *e.g.* amide stretches in protein, CH_2=CH_2 stretches for adipose tissue, or phosphate modes for bone tissue. By setting the spectrometer to a fixed position, *e.g.* phosphate mode at 960 cm^{-1}, a map of the phosphate content of a bone tissue specimen can be obtained. Raman *dyes* may also be used.

In imaging applications the use of an array detector such as a CCD is essential. Two types of images may be obtained. When both dimensions of the CCD are used to record the position of the scattering volume, a *global* image is produced, but when one dimension is used to display spectral information a line-scan image is obtained. Clinical applications are possible when the spatial and spectral capabilities of Raman microscopy are combined with a hand-held Raman unit.

Summary

Raman spectroscopy offers a unique combination of spectral, spatial and temporal resolution using UV/visible and near-IR excitation. Recent advances in new methods such as SERS and Raman microscopy have seen Raman spectroscopy move from a technique practised by experts with specialized and expensive equipment to a technique with applications from ultrafast spectroscopy to biomedical diagnostics and imaging. Continuing advances will see Raman spectroscopy move from the laboratory and into commercial applications.

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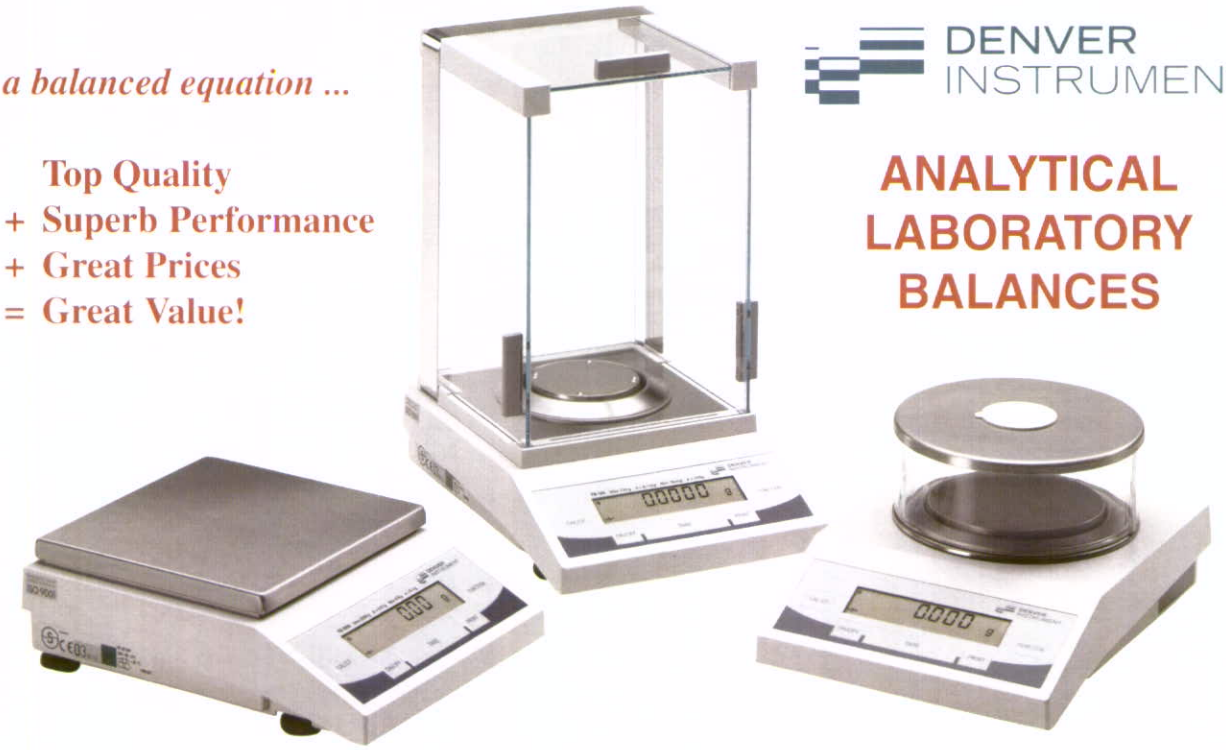

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