NZIC Chemistry IN NEW ZEALAND

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Front cover: Representation of the Australian Synchrotron. See article by Haverkamp, p.12. Image prepared by Matt Walters, School of Biological Sciences, University of Canterbury.

Comment from the President

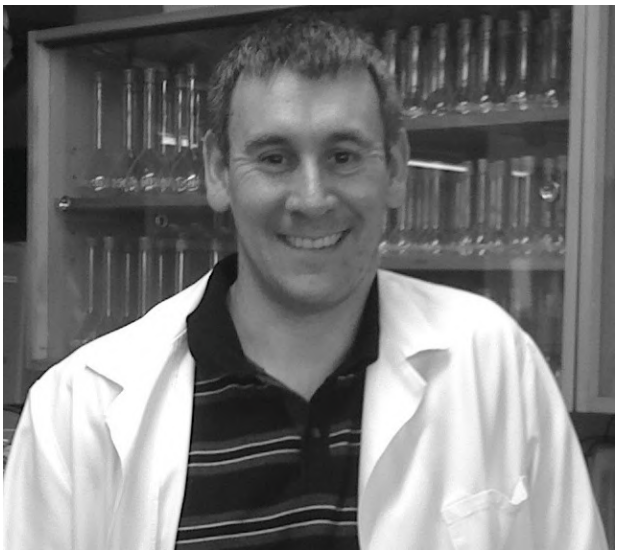
Welcome to the first issue of *Chemistry in New Zealand* for 2013, a year I hope you will find both professionally and personally fulfilling. I am looking forward to seeing many of you at the biennial NZIC conference, hosted by our Wellington branch. I am also looking forward to meeting with you when I visit the branches for the Presidential address. This year I will be breaking with convention and visiting all of the branches in the first half of the year, as I would like to take the opportunity to listen to your suggestions and ideas on what you think our organisation is doing well and what we could be doing better.

I'd like to thank Julian Eaton-Rye for his very able leadership in 2012. In 2013, there are a number of issues I would like us to focus on, including two raised by Julian in his Presidential address – being more active in the public (and political) arena, and increasing our membership. As New Zealand's professional chemistry organisation I believe we have a responsibility to engage with the public both through public lectures, and by contributing to science-related policy documents. We have some wonderful science communicators in our midst and they must be encouraged and supported to share their knowledge and enthusiasm for chemistry with the public. In a society that is increasingly science and technology based, the more chemistry we can explain to the public, the better.

I would also like to see greater and more co-ordinated support by our organisation for those teaching chemistry in secondary schools. Most branches are already engaged with schools through activities such as chemistry quizzes, while nationally we have the Denis Hogan Chemical Education Award which often is awarded to a secondary school teacher. We also have some brilliant chemistry outreach programmes coming out of various tertiary institutions which should be celebrated more widely. Finally, with the introduction of new NCEA achievement standards such as "AS91388 - Demonstrate understanding of spectroscopic data in chemistry" there will be new opportunities to work with schools to promote chemistry, both as a fascinating subject and as a career option. The chemistry students of today are the NZIC members of tomorrow.

I'd also encourage branch members to nominate colleagues for NZIC and other awards to celebrate the stellar chemistry work being done around New Zealand. My congratulations to 2012 winners of the NZIC prizes: Associate Professor Richard D. Tilley of Victoria University (Maurice Wilkins Centre prize for chemical science), Professor Brian Robinson and Dr Stephen C. Moratti, University of Otago (Industrial and Applied Chemistry prize) and Rudi Jansen, Middleton Grange School (ABA Books Denis Hogan Chemical Education award). 2013 will also see the award of the biennial Easterfield medal, so please make sure you nominate eligible colleagues for these awards.

Finally, I would strongly encourage all of you to become more involved in your branch events and to get to know your branch committees. Share your ideas with them so they can be passed on to Council. It is only by active participation in the NZIC that you will get the most out of being a member, and that the NZIC will grow in relevance and membership.



Dr Michael Edmonds
NZIC President

Biographical note:

Michael Edmonds is a senior lecturer and programme manager in the Department of Applied Sciences and Allied Health at Christchurch Polytechnic Institute of Technology (CPIT). He completed his undergraduate and postgraduate degrees at Massey University. His PhD, completed in 1995, involved the development of a novel method for the synthesis of the E-ring of the antibiotic salinomycin and was carried out under the supervision of Dr Margaret Brimble. After a short, but extremely educational, eight months as a secondary teacher in 1995, he moved to his first postdoctoral fellowship position with Professor Ari Koskinen at the University of Oulu, Finland, working on the design and synthesis of prolyl 4-hydroxylase inhibitors. This was followed by a FoRST postdoctoral fellowship with Associate Professor Andrew Abell at the University of Canterbury (UC) working on the design and synthesis of novel HIV protease inhibitors. In 1999, Michael won the first FiRST award, a science poster communication award presented by the Foundation of Research, Science and Technology.

In 2000, Michael moved to CPIT as a lecturer in biological and analytical chemistry, and continued research with Associate Professor Abell, producing novel monofluorinated organic compounds until 2009, and publishing several journal articles and book chapters. In 2009, Michael was appointed programme manager for the School of Applied Sciences and Allied Health. He continues with some teaching in analytical courses in the Bachelor of Applied Science at CPIT, supervises student research projects, and has begun writing a series of articles on the history of chemistry. Michael is an avid science communicator and writes the *Molecular Matters* blog at *sciblogs.co.nz*, a collaboration involving around thirty scientists from around New Zealand. He also delivers public presentations on chemistry and science in general. In 2012, Michael underwent media training with the SAVVY programme developed by the Science Media Centre and Dr Mark Quigley of UC. As well as being a member of the New Zealand Institute of Chemistry, he is also a member of the Royal Society of New Zealand, the Science Communicators Association of New Zealand and the Canterbury Science Teachers' Association.

New Zealand Institute of Chemistry

supporting chemical sciences

January News

BRANCH NEWS

CANTERBURY

The Branch is pleased to announce that Dr *Jan* ***Wikaira*** has been elected a Fellow of the NZIC.

Professor *Justin* ***Gooding***, Director of the Australian Centre for Nanomedicine, based in the School of Chemistry University at The University of New South Wales, Sydney, gave a presentation on 17 September entitled *Nanotechnology and Biosensors: From detecting small molecules and drugs to the monitoring of the activity of whole cells*. Prof Gooding's work primarily involves the surface modification of nanoparticles and nanoporous photonic crystals for applications in sensing and cell biology. In his presentation to the Canterbury Branch he showed how self-assembling mono-layers that modify surfaces and carbon nanotubes and nanoparticles can be used in the construction of biosensors to detect enzymes, DNA, peptides and other chemicals in biological fluids without sample preparation. The presentation included a demonstration of his blood glucose monitor for diabetics that consists of a small attachment that is inserted into an iPhone. The iPhone then interprets the results from the biosensor which can then be stored or forwarded to a physician.

The annual Trivia and Truffles Quiz Night was held on 16 October in a packed staff club. The administration of the quiz improves every year in its efficiency. Thanks to Dr *Michael* ***Edmonds*** who shouldered most of the burden of formulating the questions and acted as "Ring Master" at the quiz. This year also saw a number of students appearing in super hero fancy dress! First place in the quiz went to 'Zincing Caps On' (Nathaniel Gumby, James Shields, Reilly Poff), Second place went to 'LDA Basically Amazing' (Andrew Brown, Stewart Alexander, Shimon Endo, Matthew Spence) and in third place were 'Sugar Daddies' (Jan Wikaira, David Anderson, Matt Polson)

Associate Professor *Julian* ***Eaton-Rye***, Department of Biochemistry at The University of Otago and NZIC President gave a presentation on 7 November entitled *Photosynthesis: How plants power the planet*. The presentation covered the chemical and biographical history of photosynthesis on earth, from photosynthetic bacteria metabolizing hydrogen sulfide through to organisms that could use photosynthesis to cleave water. This produces oxygen as waste (the general formula for this process being:

$CO_2 + H_2A \rightarrow (CH_2O) + H_2O + 2A$

where H_2A can be H_2S or H_2O) changing the atmosphere in the process. The historical details of how the chemistry of photosynthesis was elucidated spanned centuries and involved characters and incidents that were both incendiary and tragic: from Jan Baptista van Helmont's experiments to determine where plants get their mass to Jan Ingenhouze's discovery – building on the work of Joseph Priestly – that light was required for photosynthesis, and Cornelius van Niel's elucidation of the general photosynthetic formula above. The biographical details added spice to the chemistry and made for an informative and enjoyable presentation.

CPIT

CPIT's Year 10 chemistry competition was held on 21 November. The competition involved 19 teams from 12 schools carrying out several practical laboratory techniques, including measuring the ice point of a thermometer and identifying four white crystalline solids, as well as completing a knowledge quiz. The chemistry competition ran smoothly, as usual, thanks to the organisation of Dr *David* ***Hawke*** and chemistry technician *Elena* ***Streltsova***. The results were: 1st: Anna, Grace, Maddie (Christchurch Girls' High School): 87.5%; 2nd equal: Sam, Emily, Harry (St Andrew's College) and Clara, Akane, Nicholas (Riccarton High School), both on 87%; 4th: Benjamin, Michael, Anthony (Christ's College): 81.5%; 5th: Joshua, Eywin, Luke (Christ's College): 81%

The same competition was run in Timaru on 19 November and included five teams from four schools. The results were: 1st: Timaru Girls' High School, 84.5%; 2nd: Mountain View High School, 81%; 3rd: Mountain View High School, 78.5%.

The Canterbury Heads of Science day for science teachers was also held at CPIT on 21 November with around 70 teachers attending various talks and workshops. A workshop run by Dr Michael Edmonds (CPIT) and *David* ***Paterson*** (Cashmere High School) discussed practical activities which are being developed between the two institutions to assist with student learning in the new AS91388 NCEA Achievement Standard "Demonstrate an understanding of spectroscopic data in chemistry". This workshop was well received. The day was sponsored by the Canterbury Science Teachers' Association and CPIT.

University of Canterbury

Sandra ***Atkinson*** (Masters Research Group) has been shortlisted for the final of the Royal Society of Chemistry/Chemistry World International Science Communication Competition. This competition is open to undergraduate and postgraduate students and early researchers (within 10 years of graduation) anywhere in the world (http://my.rsc.org/chemcareers/cwcompetition/registration), and involves either writing an 800 word piece or creating a five minute multimedia presentation on a topic related to chemical science. Sandra's written entry, entitled *Solvent use (and abuse): The impact of solvents on the future of chemistry*, was one of the 20 short-listed entries.

Vlad ***Golovko*** has secured funding from the Ministry of Science and Innovation as part of the grant application by a team of scientists led by Dr *John* ***Kennedy*** from GNS. Their "Smart Ideas" project, focused on development of infra-red reflecting coatings, was allocated $900,000 over two years.

On 26 September, a meeting of tertiary and secondary science educators was held at the Dovedale campus of the University of Canterbury to discuss ways to improve the interface between the teaching of science in secondary and tertiary institutions. Attendees included teachers from secondary schools around Christchurch and academics from the three main tertiary institutions in the region, including chemists Associate Professor *Richard* ***Hartshorn*** (University of Canterbury), Dr *Carol* ***Smith*** (Lincoln University) and Dr Michael Edmonds (CPIT). A wide range of topics was discussed, including the lack of understanding amongst students of the wide variety of science careers available to them, the value of contextualised teaching, and how students find assessments at tertiary level very different from those at secondary level. The meeting was deemed to be very productive by all attendees and will likely become (at least) an annual event.

MANAWATU

The Manawatu Science and Technology Fair was held in August. NZIC Education Trust Prizes for the best exhibit relating to chemical principles were awarded to Ronan Carroll of Palmerston North Normal Intermediate School and Vidya Vijayakumar of Taihape Area School.

Manawatu Branch Treasurer David Shillington awarding NZIC Education Trust Prizes to Ronan Carroll (left) and Vidya Kijayakumar (right).

A tour of New Zealand Pharmaceuticals in September was organised by *Ghislaine* ***Cousins***. In addition to touring the site, visitors were told of the history of the company and their products.

Also in September, this year's RSC Australasian Lecturer Justin Gooding, from the School of Chemistry and Australian Centre for NanoMedicine, the University of New South Wales, gave a talk on *Nanotechnology and Biosensors*, focussing on the detection of small molecules and drugs, and on monitoring the activity of whole cells.

In November, *Julian* ***Eaton-Rye*** visited Palmerston North and gave an insightful talk at Te Manawa on the chemistry involved in the process of photosynthesis as part of his presidential tour.

The Manawatu Branch held its Annual General Meeting in November, and has a wide range of activities planned for the year ahead. These include a student event, the regional and national High School Chemistry Quiz, and a Technicians of Manawatu evening.

Landcare Research

Benny ***Theng*** has recently returned from China where he spent three months as a visiting scientist/professor at the Institute of Geochemistry, Chinese Academy of Sciences in Guiyang at the invitation of Professor Lee Xinqing**,** who had a sabbatical year at Landcare Research, Palmerston North in 2008. Over seven consecutive weeks, Benny gave a short course on the clay-polymer interaction, based on his book *Formation and Properties of Clay-Polymer Complexes.* During his stay in China, Benny and his wife (Judy) also had the chance to visit the far north-west province of Xinjiang where Prof. Lee is trialling the use of biochar to improve crop production in salt-affected soils under irrigation. On a separate occasion, Prof. Lee and family took Benny and Judy to see the breathtakingly beautiful karst landscape around Guilin.

New Zealand Pharmaceuticals

In 2010, NZP made a decision to implement a formal framework around its environmental management systems, opting for ISO14001. A consultant was engaged to assist with the initial system mapping and core requirements, and over the past 18 months, NZP developed the initial system to one that works for the company, and culminated in a successful ISO14001 certification audit. This capped off a great year where NZP also reached one million hours without a loss of time injury.

There have also been some changes in the R&D Department at NZP. Dr *Ghislaine* ***Cousins*** has moved from R&D to Production, where she has taken on a new role as the Production Manager of the Specialty Products Facility. In order to foster closer ties between the two NZP sites in Palmerston North and Reading (England), it has also been announced that Dr Sally Whiting and Dr Jim Boydell will be seconded from Reading to Palmerston North for three years beginning in January 2013. Both Sally and Jim received their PhDs from Southampton University in England. Jim was first to join Dextra, in July 2006, followed by Sally, who has been with the company since April 2008.

Massey University, Institute of Fundamental Sciences

Congratulations to *Tracey* ***McLean*** who has successfully defended her PhD thesis on the synthesis and spectroscopy of dipyrrin complexes and will graduate in May. Tracey was supervised by *Shane* ***Telfer*** and *Mark* ***Waterland***. *Islah* ***Islahudin*** has recently submitted his PhD thesis. Islah was supervised by *Jeff* ***Tallon*** of Industrial Research Limited, and Shane Telfer and Mark Waterland. Congratulations also to *Haidee* ***Dykstra***, *Heather* ***Jameson*** and *David* ***Nixon***,

who have recently completed their Honours degrees. Heather is commencing her studies towards a PhD this month.

The following students are currently undertaking summer research projects: *Josh* ***Blazek*** and *Arielle* ***Hiscox*** with Shane Telfer; *Jessie* ***Owen*** with *Bill* ***Williams***; *Damian* ***Jones*** with Mark Waterland; and *Nick* ***Francis*** with *Geoff* ***Jameson***. The 300-level NZIC prizes for 2012 will be awarded to *Jessie* ***Owen*** and *Josh* ***Blazek***.

In September *David* ***Harding*** gave an inaugural professorial lecture on *Drug Design and Delivery: Pure or Applied Research?*. In his lecture, he looked into the differences between pure and applied research, and whether they could truly be defined in many cases.

Congratulations to Mark Waterland who has been promoted to Associate Professor. In addition to this, Mark has also been made a Fellow of the NZIC.

On 1 January 2013 the Institutes of Molecular Biosciences and Fundamental Sciences at Massey University in Palmerston North were merged. The new Institute retains the Institute of Fundamental Sciences banner, and comprises 55 academic staff, 35 general staff, 20 postdoctoral fellows and approximately 110 PhD students. The Institute teaches nine majors: biochemistry, chemistry, genetics, mathematics, microbiology, nanoscience, physics, plant biology and statistics. Prof *Simon* ***Hall*** is the Acting Head of Institute. Prof *Peter* ***Derrick*** commenced a new position in January across chemistry, physics and biology at the University of Auckland, and will establish mass spectrometry facilities there.

Recent talks at Massey University have included *Ajay* ***Pannu*** (Massey University), who spoke of the work he completed whilst undertaking his PhD and prior to joining *Paul* ***Plieger's*** group at Massey; *Mark* ***Turnbull*** (Clark University), who presented his research on structural correlations in low-dimensional Cu(II)-based molecular magnetic materials; Professor *Byeang Hyean* ***Kim*** (Pohang University of Science and Technology), who presented his research on the design and construction of fluorescent nucleic acid systems; and Professor *Siva* ***Umapathy*** (Indian Institute of Science), who talked about some of the varying applications of laser spectroscopy from physics to biology and medicine.

Ross ***Davidson*** has taken up a postdoctoral fellowship at the University of Durham with Professor Paul Low. The project he is working on is expected to provide important molecular information concerning quantum interference effects in molecular frameworks and will interface closely with a range of national and international partners to exploit these systems in single molecule electronics platforms. Since finishing his PhD (with supervisors *Andrew* ***Brodie***, *Eric* ***Ainscough*** and Mark Waterland**)**, Ross has been busy taking Earth Science papers and writing up work from his thesis.

Mark Waterland being awarded his NZIC fellowship certificate by Manawatu Branch Chair Gareth Rowlands.

Massey University, PGP Group

Paul ***Plieger*** and *Gareth* ***Rowlands*** are sharing a summer student (*Amy* ***Toms***) funded through MURF to explore the design and synthesis of new nano-magnets. Paul was awarded $930k (Marsden Fund) over the next three years to develop chelating agents for beryllium in collaboration with Prof. Penny Brothers (University of Auckland) and Prof. *Bill* ***Henderson*** (University of Waikato). *Mezdi* ***Jazi*** has commenced his PhD in the area of sensitive sensors for anion detection. *Nirosha* ***De Silva*** has successfully completed her first year PhD confirmation oral, and is making excellent progress in her search for new nano-magnets. *David* ***Nixon*** has completed the requirements for his BSc(Hons) degree and is searching out PhD opportunities. *Nick* ***Bent*** (MSc) continues to make steady progress on his nano-capsule project.

OTAGO

The Branch held its annual dinner in late October at the Technique restaurant of the Otago Polytechnic. Predinner speaker, Jules Kieser from the Faculty of Dentistry, University of Otago, spoke on *Gunshot analyses, lessons from the David Bain case*. The Branch Annual General Meeting was held in November following a seminar on photosynthesis by Otago-based NZIC President, *Julian* ***Eaton-Rye***.

University of Otago, Department of Chemistry

The polymer and supramolecular group (led by *Steve* ***Moratti*** and *Lyall* ***Hanton***) was very pleased when Steve and *Brian* ***Robinson*** were jointly awarded the NZIC Prize for Industrial and Applied Chemistry – a real comment on the whole group's hard work and dedication. *Dan* ***Hutchinson*** successfully defended his PhD thesis on polymer gel actuators, having just arrived back from giving a poster at the International Conference on Coordination Chemistry (ICCC) in Valencia. *Smita* ***Ghosh*** gave a talk at the ACS meeting (Phil-

adelphia). *Jaydee* ***Cabral*** was an invited lecturer and session chair at the IUPAC 8th International Conference on Novel Materials and Synthesis (NMS-VIII) & 22nd International Symposium on Fine Chemistry and Functional Polymers (FCFP-XXII) in Xi'An, China. A recent boost was the awarding of a large NHMRC grant in Australia, in collaboration with P. J. Wormald from Adelaide, for work to extend the group's medical gels for use in abdominal surgery.

Anton ***Wiebe***, a masters student from Mainz University, is currently a visiting researcher among Brookers Bunch, and is working closely with PhD students *Reece* ***Miller*** and *Sebastien* ***Dhers***. Brookers Bunch Honours students *Ross* ***Hogue*** and *Michael* ***Bennington*** completed excellent research projects and are now taking a well earned rest after completing their final honours exams. *Scott* ***Cameron*** successfully defended his PhD thesis in his recent oral exam; he is now a postdoctoral fellow in the Carbohydrate Research Group at IRL in Lower Hutt. PhD students *Rajni* ***Wilson*** and Sebastien Dhers, along with postdocs *Humphrey* ***Feltham*** and *Raf* ***Kulmaczewski***, as well as *Sally* ***Brooker*** (on a short sabbatical), participated in the ICCC in Valencia in September. Sebastien and Humphrey then visited Rodolphe Clérac and Corine Mathionère in Bordeaux for a fortnight to learn more about collecting and interpreting magnetic data, whilst Raf and Sally headed to Dublin to work with Martin Albrecht. Sebastien, Humphrey and Sally reunited in Orlando, Florida, for the ICMM conference before returning to Dunedin – via a department seminar visit at UC Berkeley for Sally. In other news, Sally has recently been invited to join the Editorial Boards of two top journals: *Inorganic Chemistry* and *Coordination Chemistry Reviews*.

Raphael ***Horvath*** of the Gordon group defended his PhD successfully in October and graduates next year. His thesis entitled *A photophysical investigation of d^6 metal polypyridyl complexes* was placed on the Division of Science Exceptional PhD Theses list. Raph is currently a postodoctoral fellow with Mike George and Martyn Poliakoff in Nottingham. *Geoffrey* ***Smith*** completed his MSc in Raman spectroscopy of dairy products, with credit; Geoff graduates in December. *Mike* ***Fraser*** (postdoc) and *Chris* ***Larsen*** (PhD student), both working with *Keith* ***Gordon*** and *Nigel* ***Lucas***, attended the Gordon conference on Donor-Acceptor Materials in August, where they presented posters and then went on to the ICCC in Valencia in September. Mike gave a talk on *Electronic properties of Re(I) complexes with sulfur-containing polypyridyl ligands*, and Chris presented a poster on *Low band-gap Re(I) dipyridophenazines with appended electron-donating groups*.

A group of spectroscopists attended the 23rd International Conference on Raman Spectroscopy (ICORS) in Bangalore, India. This conference had quite an Otago connection, as the chair of the meeting was Siva Umapathy who obtained his PhD from Otago in 1987 under the guidance of *Jim* ***McQuillan***. At this conference Keith Gordon spoke on using Raman/resonance Raman spectroscopy with computational chemistry to understand the properties of new materials. *Sara* ***Fraser*** (PhD student) spoke on classification techniques for determination of counterfeit Cialis by Raman spectroscopy. *Holly* ***van der Salm*** (PhD student) gave a poster on spectroscopic studies of Re(I) complexes of substituted dipyridophenazines, and *Stasi* ***Elliott*** (PhD student) gave a poster on a systematic spectroscopic and computational study of rhenium(I) complexes of bidentate pyridyl-1,2,3-triazole ligands. In addition, *Mark* ***Waterland*** (Massey; PhD in the Gordon group, 1998) gave a talk on mapping the excited-states of dipyrrins, and *Clare* ***Strachan*** (PhD in the Gordon group, 2005) spoke on insights into pharmaceutical dosage form structure and drug release using CARS microscopy.

Keith Gordon attended "Spec 2012-Shedding New Light on Disease" in Chiang Mai in November, where he spoke on Raman spectroscopy as a method of determining gallstone composition and relating spectral features to patient profiles. The talk was based on work done by Sara Fraser in collaboration with medical staff from Auckland and Dunedin.

Chris Larsen and Holly van der Salm presented a poster at the MacDiarmid PhD and Postdoc Symposium in Christchurch (November), *Modelling future materials*, for which the target audience was high school outreach.

PhD student *Dagmara* ***Jaskolska*** was welcomed to *Carla* ***Meledandri***'s group in early October. Dagmara received her BSc and MSc in Chemistry from the University of Wrocław, Poland, and spent time in Spain as an Erasmus student during her MSc studies.

Guy ***Jameson*** was recently awarded a travel grant from the 2012 International Mobility Fund administered by the Royal Society of New Zealand on behalf of the Ministry of Business, Innovation and Employment to promote international connections within the New Zealand research system.

Photo of most of the New Zealanders at ICORS – from left to right: Sara Fraser, Mark Waterland, Keith Gordon, Clare Strachan, Stasi Elliott and Holly van der Salm.

The grants are to initiate research with collaborators in the United States, and Guy will be collaborating with David Goldberg at John Hopkins University.

Nigel ***Perry*** and *John* ***van Klink*** of the Plant Extract Research Unit, along with biologist Arjan Scheepens from Plant & Food Research, Mt Albert, were successful with a funding application to the new "Smart Ideas" initiative run by the Ministry of Business, Innovation and Employment. Their research will help to develop NZ's unique natural mānuka resource by using foliage extracts with relaxant action to produce new evidence-based functional foods. John has also been awarded an Erasmus Mundus scholarship by the European Advanced Spectroscopy in Chemistry group. He visited Helsinki to look at techniques for studying biosynthesis of flavonoids, and visited Bergen for applications of NMR to anthocyanins.

A one-day symposium on *The role of the ocean in a changing climate* was held at the Hutton Theatre, Otago Museum. The day included general talks from the co-directors of the Centre for Chemical and Physical Oceanography (*Keith* ***Hunter***, *Rob* ***Murdoch***), presentations showcasing the research of members and collaborators of the Centre, and the presentation of the University of Otago Research Group Award 2012 to the Centre by DVC, Richard Blaikie.

University of Otago, Department of Biochemistry

An NZIC travel grant supported PhD student Jared Fudge to attend the ComBio 2012 conference held in Adelaide in September 2012. He reported that "particularly interesting chemistry-themed plant talks included metabolic engineering of crop plants to produce Omega-3 long chain polyunsaturated fatty acids using enzymes from microalgae, with a view to increasing dosage whilst simultaneously reducing fishing pressure". Jared was awarded the Best Student Poster award from New Zealand Society of Plant Biologists (NZSPB) for his poster entitled *How do odd SOCs regulate flowering time in* Medicago truncatula*?*

ChemQuest first place winners from St Pauls Collegiate – from left to right: Paul Newton-Jackson, Hannah Clare and Mark Davis with Martin Brock from Hill Laboratories.

University of Otago, School of Pharmacy

PhD student *Madlen* ***Hubert*** reported to the Branch on her experiences at the 8th World Meeting on Pharmaceutics, Biopharmaceutics and Pharmaceutical Technology (PBP) in Istanbul, Turkey earlier in the year. Madlen received travel support from the Branch, allowing her to present a poster *Physicochemical and biological characterization of PIM mimetics, novel immune modulating agents*. She described the conference as "a good chance to present my work and obtain valuable feedback from members of the various fields represented".

WAIKATO

University of Waikato

In the annual ChemQuest competition, held recently by the Department of Chemistry, St Paul's Collegiate School in Hamilton snatched back their title. Since 1997, St Paul's Collegiate has won the competition eight times, but never more than twice in a row. Almost 200 students from the greater Waikato region and Bay of Plenty participated. As usual, this was a fun-filled evening for students studying NCEA level 2 Chemistry.

Prizes were awarded as follows: 1st place: St Paul's Collegiate: (Paul Newton-Jackson, Hannah Clare, Mark Davis); 2nd place: Hamilton Boys' High School: (James Peacock, Caleb Sampson, Samuel McCabe); 3rd place: Te Awamutu College: (Aggie Melville, Regan McCorquindale, Sarah Murphy); 4th place: Tauranga Boys' College; 5th place: Hillcrest High School. The quiz was generously sponsored by James & Wells Intellectual Property and Hill Laboratories, as well as the Faculty of Science and Engineering, University of Waikato. Question master was *Bill* ***Henderson*** with *Brian* ***Nicholson*** the chief judge, ably assisted by numerous other staff and students from the Department.

The Chemistry Department has welcomed a new academic staff member, Adam Hartland. Adam is an environmental analytical chemist and a graduate of the University of Birmingham. Prior to arriving at Waikato, Adam was a Postdoctoral Research Fellow at the University of New South Wales. His current research concerns the chemical evolution of ground waters on a range of temporal and spatial scales. He is also developing collaborations in diverse disciplines, including transport of engineered nanoparticles in low-permeability media, the application of fluorescence lifetime imaging to the distribution and composition of organic molecules in rocks, groundwater fauna as recorders of geochemical and hydrological processes using ion microprobe analyses, and trace elements in stalagmites as recorders of anthropogenic surface disturbances.

Megan ***Grainger*** has been awarded a Claude McCarthy Fellowship to finish her PhD studies. Megan's research examines the factors that af-

fect the chemical conversion that occurs in mānuka honey resulting in the 'unique mānuka factor' (UMF). She is working to produce a model that will predict the ideal conversion environment. The Claude McCarthyFellowship allows Megan spend two months at the University of Montana to work with Professor Emeritus Richard Field, a physical chemist who specialises in nonlinear dynamics.

Professor Justin Gooding (the 2012 RSC lecturer) from the School of Chemistry at UNSW gave an excellent talk on biosensors recently. Part of his talk was to demonstrate the workings of a blood glucose sensor which could be attached to an Apple iPhone for read-out of results – which fascinated the audience. Another excellent talk, the President's address by current NZIC President Associate Professor *Julian* ***Eaton-Rye***, focussed entirely on the scientific and social history behind the development of the current scientific knowledge on photosynthesis. This was much appreciated by an audience comprised of both chemists and biologists.

Retirement of Associate Professor Alan Langdon

Alan ***Langdon*** retired from the Chemistry Department at the end of August after more than forty years of service. He arrived in 1971 as one of the original staff of the School of Science as it was then called and proceeded to establish a strong and broad research reputation. Alan's interests were in physical, technological and environmental chemistry fields, but spanned both chemistry and engineering, as did his teaching. Amongst his many other roles, Alan was heavily involved in the inception of the Faculty's distinctive BSc(Tech) and MSc(Tech) degrees and in the establishment of a Centre for Technology. He served for many years as a committee member of the Waikato NZIC branch committee.

Recently, Alan became a "poster boy", appearing on billboards, the backs of buses and in print media such as *The Listener*, with his postdoctoral student *Hilary* ***Nath***. Together, they developed a "low-tech" electrochemical water filter which is a cheap and efficient method to disinfect drinking water with low levels of chlorine and can also be used to treat contaminated bore water.

Alan Langdon contemplating his new life as a digger driver!

At his retirement function, Alan was presented with a hard hat, fluorescent vest, toy digger and lollipop stop sign, as a response to his earlier quip that when he retires he is going to buy a digger and build a wetland on his Tuhikaramea property (which does get quite wet in winter). The lollipop sign had the +/- sign on it, alluding to Alan's career long attempt to get students to appreciate the importance of errors and the opportunities sometimes suggested by outliers.

Also at the event, engineering colleague Brian Gabbitas recited the following ode that he had composed for the occasion.

Ode to Alan

Alan's been here a long time
He has experience galore
And Alan has the answer
'Cos he's seen it all before

At the Centre of Technology he had the Midas touch
Then it changed to a department when the EFTS increased so much
And now it's engineering with BSc's and new BE's
Back then 'twas all so simple and life was such a breeze!

But now we have the admin. chores that give us lots to do
Like ASP and PGS and PBRF too
How do we do our research, there seems so little time to spare
With funding applications that drive us to despair

But, Alan's been here a long time
He has experience galore
And Alan has the answer
'Cos he's seen it all before

We wish Alan well in his retirement and the best of luck with his "wetland."

WELLINGTON

Dr *Ian* ***Brown*** of IRL was nominated by the Wellington Branch and elected to the position of 2nd Vice-President of NZIC, from the start of 2013.

The Branch congratulates Dr *Richard* ***Furneaux***, Director of the IRL Carbohydrate Group, who has been awarded the RSNZ Thompson Medal for his outstanding and inspirational leadership of carbohydrate chemistry research and its commercial application to biotechnology in New Zealand. Also, Prof *Shaun* ***Hendy***, from IRL and Victoria University, received the 2012 Callaghan Medal from RSNZ for his outstanding work in raising public awareness of science and its role in increasing economic prosperity. Shaun is a leading physicist yet a member of NZIC, with an ability to communicate scientific ideas through his column *A Measure of Science* on Sciblogs, and regular broadcasts on *RadioNZ Nights*. He stepped down from his role as Deputy Director of the MacDiarmid Institute on 1 January.

Former Wellington member *Jack (J.H.)* ***Futter***, known to many of NZIC's older members, died on 10 September. Also that month, Dr. Martyn Coles, appointed A/Prof at Victoria in 2011, provided the Branch with a synopsis of the chemical world that he finds fascinating. It was presented under the title: *Rocks, dots and crystals: Having fun with fluorescence*. Martyn has been a collector of crystals for many years and he gave an illuminating discourse on naturally occurring minerals that display fluorescence either inherently or through occluded impurities. His presentation was elegantly illustrated with examples from his own collection. He joined Victoria from a lecturing position at the University of Sussex.

The next meeting was held on 21 November, coinciding with the AGM that saw Dr *Peter* ***Hodder*** relinquish the Chairmanship after a remarkably successful four years in the job. The new Chairperson is Dr *Joanne* ***Harvey***, a member of the Branch Committee for several years; Dr *Nicola* ***Gaston*** has taken on the secretary role while Dr ***Suzanne Boniface*** has retained the position of Treasurer for another year. The AGM concluded with the presentation of the NZIC Fellowship to organic chemist, Dr *Bradley* ***Williams*** (who spent a sabbatical in SCPS, and is now an organic group leader at IRL), and the 2012 Maurice Wilkins Centre prize for excellence in chemical research to Dr *Richard* ***Tilley***. Congratulations to them both.

Following the AGM, Prof *Graham* ***Le Gros*** (Director, Malaghan Institute of Medical Research) gave his lecture *The good, the bad and the ugly of parasite infection and the associated immune response* to a good-sized audience. He told us about the Institute's work to establish protective immunity to helminth nematodes through vaccination. This is currently a major global health objective not least because of human hookworm. He estimated that up to one billion people world-wide are infected, posing significant economic and health issues on the poorest countries. Surprisingly, the immune cytokine cell (substances secreted by specific cells of the immune system that carry signals locally between cells) responses and vaccination strategies that could be used to provide immunity against such infections remain largely undefined. The use of green fluorescent protein/interleukin-4 (IL-4), reporter mice, cytokine gene-deficient mice and truncated infection studies with *N. brasilienisis* and *H. polygyrus* are now being used to identify the role different tissues, immune cells and molecules play in mediating immunity to invading helminth parasites. The role of IL-4 producing CD4 T cell and basophil recirculation and memory cell development was discussed with respect to helminth infection-induced immunity and suppression of chronic inflammatory diseases.

Environmental Science & Research Ltd.

In September *Josh* ***Potaka*** and *Nardia* ***Foote*** joined the Toxicology Analysis Team at ESR as technicians. Nardia, with an MSc in Forensic Science from Auckland University, has several years' experience working in a laboratory, including involvement with QA documentation. Josh recently graduated from Victoria University with a BSc in Biotechnology.

Dr *Keith* ***Bedford*** (General Manager, Forensics), Dr *Helen* ***Poulsen*** (Forensic Toxicologist) and *Jessica* ***Baker*** (Senior Technician) attended the Australian and New Zealand Forensic Science Society's 21st International Symposium (ANZFSS 2012) in Hobart in September. Jessica presented a well-received poster at the conference entitled *Drug use by hospitalised drivers in New Zealand*. Helen and Keith attended a post-conference workshop hosted by the Forensic and Clinical Toxicology Association, where they gave a joint presentation *Designer Drug Prevalence and Trends in New Zealand*. Helen also represented New Zealand in a full-day meeting of the Toxicology Special Advisory Group (SAG), a group made up of representatives from each Australian state and NZ forensic departments. Keith also attended the SAG meeting as the NZ representative of forensic laboratory managers.

ESR held its annual Forensic Client Function last October. It provides an opportunity for ESRs clients and stakeholders to come together to attend a diverse range of seminars presented by ESR Forensic staff during the day and then meet less formally in the evening. The 100 attendees

Incoming Wellington Branch chairperson, Dr Joanne Harvey, presenting the Maurice Wilkins Prize to Dr Richard Tilley and (right) the Fellowship certificate to Dr. Bradley Williams.

received the presentations well: highlights included talks by Forensic Service Centre Scientist *Dave* ***Neale*** and Forensic Toxicologist Dr Helen Poulsen. Dave spoke about ESR's 3D imaging capabilities in crime scene investigation, while Helen described *How to poison your husband in a way ESR cannot detect*, which proved to be especially popular.

Victoria University – School of Chemical and Physical Sciences

Prof *John* ***Spencer*** has stepped down as Head of the School of Chemical & Physical Science after eight years in the job. His term saw some difficult times from which he led the enterprise to become the thriving and vibrant institution that it now is. There was a celebration of his tenure at which time physicist, Prof Uli Zuelicke, took over the reins: Thank you John.

Dr *Nicola* ***Gaston***, the School's new senior lecturer in physical chemistry, began her duties at the beginning of October, and Dr *Rob* ***Keyzers*** gained promotion to senior lecturer at about the same time. Dr *Natalie* ***Plank***, the wife of chemist *Justin* ***Hodgkiss***, has been appointed to a Physics lectureship. Richard Tilley's PhD student *Wai Ruu* ***Siah*** has successfully completed her PhD studies, as have *Anna* ***Win*** and *Ashna* ***Khan*** of the Timmer-Stocker group.

Twenty-four high school teachers from as far away as Kerikeri and the Waikato came to Victoria on 6-7 September to attend a two-day workshop on organic spectroscopy. A new NCEA year-13 standard covering the use of IR, ^{13}C NMR spectroscopy and mass spectrometry as tools for the identification of organic molecules is now being implemented and, given that many high school teachers graduated quite some years ago, their background in these techniques was limited. The workshop provided participants with the opportunity to familiarize themselves on the interpretation of spectroscopic data, and have some hands-on use of the instruments. The workshop, organised by *Suzanne* ***Boniface***, was taught by *Peter* ***Northcote*** and *Rob* ***Keyzers*** with able assistance from *Jonathan* ***Singh***, *Brad* ***Anderson*** and *Kathryn* ***Allan***. It was well-received, with many of the participants stating that attendance at our workshop should be mandatory for anyone who will teach this standard in the future.

Greg ***Haslett*****,** a former MSc student in the Timmer-Stocker group and now half-way through his PhD at Cambridge, visited Victoria in mid-September to renew acquaintances and tell us about his current *Studies Towards the Total Synthesis of Madeirolide A*, a novel marine macrolide isolated from from the marine sponge *Leiodermatium* sp., which was collected off the coast of Porto Santo, Madeira, Portugal, by a group from Florida Atlantic University.

Prof *J. Justin* ***Gooding*** (School of Chemistry, University of New South Wales) gave his RSC-RACI-NZIC lecture entitled *Biosensors: Some of the challenges to making useful devices and some solutions* to the Branch and School on 18 September. He outlined some of the generic solutions to the important challenges, such as making devices dip and read, how to design a selective interface for sensing, how to limit non-specific adsorption of proteins to surfaces, how to detect low concentration of analyte in a reasonable time, and strategies for *in vivo* monitoring.

Fishing for chloride in salty waters using photoactive foldamers was the title of A/Prof *Amar* ***H. Flood***'s (Indiana University, USA) lecture to the MacDiarmid Institute in early October. A NZ PhD graduate and former postdoctoral of Fraser Stoddart, Amar's independent studies have evolved macrocycles and foldamers that address the removal of chloride from aqueous solution. As an abundant anion, chloride plays critical roles in human biology and chemical processes, so that mastering ways to manipulate its availability across many environments has far-reaching consequences. The Flood group focuses supramolecular chemistry to this by using triazole-based receptors that are easy to make and modify. A new class of light-active foldamers has been created that catch and release chloride, and thereby regulate its concentration. Extracting highly-hydrated chloride ions from aqueous solutions by employing the principles present in proteins like chloride channels (ClC), they have, for the first time with synthetic receptors, shown that the hydrophobic effect can be used to extract hydrophilic guests equally as well as hydrophobic ones.

It was something of a coincidence that A/Prof *Sara* ***Skrabalak***, also from Indiana University, gave her seminar *Seeding a new kind of garden: new synthetic strategies to architecturally-controlled bimetallic nanostructures* the following day (5 October). She told how, by coupling co-reduction techniques with a seed-mediated method, her group has shown that nucleation can be separated from the growth of bimetallic nanocrystals. This has enabled the synthesis of dendritic, symmetrically-branched, concave, and shape-controlled alloyed nanocrystals. Sara visited Richard Tilley's group for a two-week period under the ACS 'Global Research Experiences, Exchanges and Training Program' (GREET) that had her PhD student *Nancy* ***Ortiz*** working in the Tilley group for eight months, the first to come to NZ in this 2011-initiated venture.

Equally important was the announcement that Richard Tilley has received funding of $1,000,000 over 2 years for his "Smart Ideas" project *Magnetic nanoparticles for biological applications*. Magnetic nanoparticles of iron with dimensions of less than 100 nm have great potential in biological applications to replace weakly magnetic iron oxide or rust particles that are currently used. A team from Victoria and Auckland Universities, The Malaghan Institute for Cancer Research and Wellington Hospital are to develop and commercialise such nanoparticles for general bio-applications as a quick-to-market product and also as theranostic agents. The latter are set to revolutionize cancer treatment because they can be used for diagnostic imaging whilst at the same time providing therapy and curing the cancer (theranostic = therapeutics + diagnosis).

Prof *Kate* ***McGrath*** and *Natasha* ***Evans*** were named as the leading innovators in the Grow Wellington Innovations for Health Challenge for their work on developing new materials that have the potential to be used as hard tissue implants. The sum of

Sara Skrabalak and Nancy Ortiz (of the GREET program) with Richard Tilley.

$50,000 was awarded to support the research.

Prof Sir *Richard* ***Friend*** (Cavendish Laboratory, Cambridge) visited the School on 17 October, the day after his Wellington public lecture as the capital's involvement with the RSNZ's 2012 Distinguished Speaker. He gave a lecture entitled *Charges and excitons in organic semiconductor LEDs and solar cells*, in which he described excitons in molecular semiconductors and their low dielectric screening and their subsequent impact in LED and solar cell usages. He went on to describe current designs for organic photovoltaic diodes and his group's involvement in developing an optical 'pump-push' technique in which an IR push pulse can separate charge-transfer excitons previously generated in the above band gap pump pulse.

Prof *Duncan W.* ***Bruce*** (University of York, Heslington, UK) visited the School for three days in late October to renew contacts and extend his research collaborations. In a seminar entitled *Liquid crystals shining bright*, he described not simply archetypal materials for flat panel displays, but their behaviour that offers much potential for self-organisation. The ultra-strong polymers Kevlar® and spider silk owe their strength to fabrication from the liquid crystal phase, while many of the lipids that constitute cell membranes are liquid crystalline in nature. He described the work of his group that has led to liquid-crystalline ppy complexes of Pt^{II} and Ir^{III} with the objective of combining enhanced emission efficiency with other advantages of liquid-crystalline fabrication. The chance discovery of mild oxidative routes to Pt^{III} which gave metal-metal-bonded dimeric complexes with bridging carboxylate ligands, directly analogous to the dinuclear Pd^{III} complexes prepared by Powers and Ritter, was discussed. Prof *S.* ***Umapathy*** (Chemistry-Indian Institute of Science, Bangalore, India) visited in early December giving a lecture entitled: *Laser spectroscopic applications from physics to biology and medicine.* He described how lasers have become an essential light source in spectroscopic applications owing to their inherent coherence and intensity. These properties enable both time (fs) and spacial (nm) resolutions required to study materials at the nanoscopic to microscopic level, and also their dynamics on the femtosecond to seconds time scale.

The Victoria December graduation ceremonies conferred PhD degrees on: *Giancarlo* ***Barassi*** (Johnston), *Jacqui* ***Barber*** and *Jonathan* ***Singh*** (Northcote), *Ashna* ***Khan*** and *Anna* ***Win*** (Stocker/Timmer), *Alec* ***La Grow*** and *Wai Ruu* ***Siah*** (Tilley); and MSc degrees on: *Peter* ***Clark***, *William* ***Greenbank***, *David* ***Koedyk***, *Bryan* ***O'Leary***, *Peter* ***Moore***, *Eldon* ***Tate*** and *Helen* ***Woolner***.

Presentation of the Grow Wellington Innovations for Health Challenge Award to Kate McGrath and Natasha Evans (right) by Grow Wellington's CEO, Gerard Quinn (left) and General Manager – Science and Technology, Adrian Gregory.

Article

The Australian Synchrotron – A powerful tool for chemical research available to New Zealand scientists

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Introduction

The Australian Synchrotron began operation in 2007 and provides outstanding opportunities for chemical researchers in New Zealand. There are ten beamlines that provide techniques to suit many different types of research, including several of interest to chemists and chemical engineers. Easy access to this synchrotron facility gives New Zealand science a boost and enables the use of some of the latest and best methods that exist. This article gives a snapshot of some of the techniques available, illustrating them with examples from recent work.

The synchrotron should perhaps be better thought of as the Australasian Synchrotron, since a portion of the funding for construction of the initial suite of beamlines and for operation comes from New Zealand. The initial funding was from the state government of Victoria, and there were contributions from many of the major Australian universities, the Australian Nuclear Science and Technology Organisation (ANSTO), CSIRO and the Government of the Commonwealth of Australia. New Zealand also contributed: the New Zealand Government matched the funding provided by the major New Zealand universities and some of the Crown Research Institutes. Altogether New Zealand contributed A$5 million to the construction cost of A$221 million, with an additional contribution of A$5 million to operational costs.

The ownership of the Australian Synchrotron is vested in a company in which the contributors to the facility hold shares, a convenient way to define ownership. The contributors from New Zealand hold shares in the company through the vehicle of the New Zealand Synchrotron Group Ltd (NZSG). In October 2012, the management of the Australian Synchrotron passed to Synchrotron Light Source Australia, a wholly-owned subsidiary of ANSTO.

Gaining scientific access to the synchrotron is rather simple and those who are allocated time through the competitive application process not only get to use a beamline, but currently, their airfares to Melbourne are paid and there is free accommodation on-site for up to three experimenters. Three times a year there is a call for proposals when applicants submit an outline of the science they would like to do, with details of the experiment(s). Each beamline has a designated panel of experts that assesses the proposals, assisted by anonymous reviewers, so that the available beamtime is allocated to the best proposals. The use of the Australian Synchrotron by New Zealand-based researchers has grown steadily (Fig. 1). This has been assisted by 'foundation investor' time, which is a fixed allocation of time to each of the organisational groups that funded the construction of the synchrotron. This beamtime does not undergo the usual merit assessment and has enabled new and inexperienced users to obtain easy access to the synchrotron.

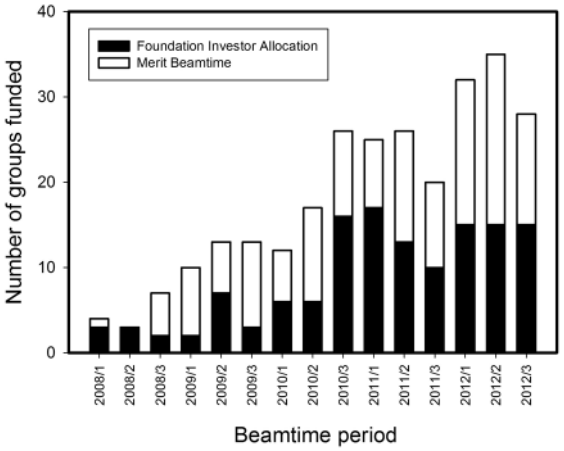

Fig. 1. New Zealand-based user access to the Australian Synchrotron.

Experiments at the synchrotron are supported by a team of beamline scientists for each beamline. The beamline scientists provide expert help for all experiments, and should always be consulted by users prior to submitting a proposal. These scientists not only keep the beamlines running in optimal condition, but they are constantly improving, adding to and developing the beamlines. My experience of the beamline scientists has been excellent – nowhere have I met such a helpful, dedicated and knowledgeable group of scientists who want to ensure that my experiments work. Although the physical equipment is state-of-the-art and of very high quality, the beamline scientists are the key to the success of this large science facility. The culture is very much one of "can-do" and "we will make it easy for you", and it extends to other support staff at the Australian Synchrotron, many of whom were scientists before they stepped into administrative or support roles and who, therefore, have an understanding of the users.

There are ten beamlines. Four are based on diffraction – Powder Diffraction (PD), Small and Wide Angle X-ray Scattering (SAXS/WAXS), Molecular Crystallography (two beamlines MX1 and MX2); three are based primarily on spectroscopy – X-ray Absorption (XAS), Far Infrared and High Resolution Infrared (FIR/HRIR), Soft X-rays (SXR); and three are primarily imaging techniques or spectroscopy based imaging – Imaging and Medical (IM), Infrared Microspectroscopy (IRM), X-ray Fluorescence Microscopy (XFM). The beamlines most heavily used by New Zealand-based researchers are MX (75 groups in 2011-2012), followed by SAXS (32), with moderate use also of SXR (15), XAS (14), PD (14) and IRM (12). Less

use has been made of XFM (5) and FIR/HRIR (3). Examples from two spectroscopy and two diffraction beamlines are given in the discussion that follows.

X-ray Absorption Spectroscopy Beamline – XANES and EXAFS

The X-ray Absorption Spectroscopy (XAS) beamline was apparently the first to record data from a sample at the Australian Synchrotron. There was already an established base of knowledgeable users in XAS as a result of the Australian National Beamline Facility being established at the Photon Factory in Japan in 1992. That facility now consists of a dedicated XAS beamline that is equipped and staffed by Australians; it will close in 2013.

There are two techniques that have been usually used on this beam line – X-ray Absorption Near Edge Spectroscopy (XANES) and Extended X-ray Absorption Spectroscopy (EXAFS). The first of these gives chemical information (especially oxidation state) and, in simple terms, is often used for a "fingerprint" identification of chemical environments. The second technique gives structural or crystallographic information and is, therefore, a cousin to the diffraction methods, although it is element-specific and does not necessarily require long range crystal order.

The basis of XAS is a scan of the X-ray energy across an absorption edge for the element of interest and measuring either the absorption of the X-rays by the sample or the fluorescence from the sample. The technique is, therefore, specific to the element for which the edge has been chosen and is applicable to a wide range of elements. It is difficult to create a sufficiently intense, tuneable X-ray source for a small-scale laboratory instrument so XAS is mostly performed at synchrotron facilities, although laboratory based instruments are available.[1]

An example where XANES has been useful is in the study of metal nanoparticle formation in plants. Trace metal concentrations in plants have long been used in geoprospecting[2] and it has long been known that some plants can hyperaccumulate metals,[3] even to the extent that concentrating precious metals has been proposed as a method for phytomining.[4] More recently the prospect of using plants to produce metal nanoparticles for applications such as catalysts has been proposed.

The accumulation of various precious metals in plants, both land plants and microalgae has been studied. While transmission electron microscopy combined with energy dispersive spectroscopy can identify that the precious metal elements are present as small particles in the plants (Fig. 2),[5] XANES is able to determine the chemical state of the elements present.[6-7] For example, gold in the metallic state can be distinguished from various gold salts (Fig. 3). Combined with a similar study of the deposition of various other precious and semi-precious metals, this has also enabled the redox environment and capacity of plants to be inferred.[7]

EXAFS, which involves a transformation of the absorption spectra, recorded to well past the absorption edge energy, provides a distribution of distances from the element

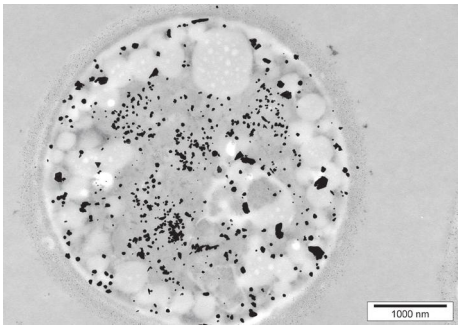

Fig. 2. Transmission electron micrograph of an unstained section of the microalga *Chlorella vulgaris* containing Au nanoparticles (dark spots).

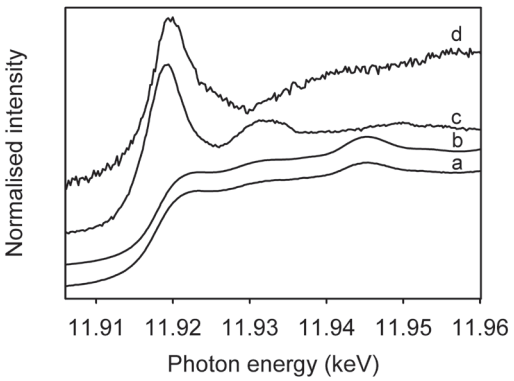

Fig. 3. XANES spectra of a) Au foil. b) *Chlorella vulgaris* containing Au nanoparticles. c) $HAuCl_4$. d) $Au(OH)_3$. Reproduced from reference 6.

of measurement to its nearest neighbours. For example, in the mixed oxide of iridium and ruthenium,[8] which is a very good electrocatalyst for oxygen evolution, it is possible to determine the spacing of the atoms around each atom of the element of the chosen absorption edge. An example for Ru is shown in Fig. 4.

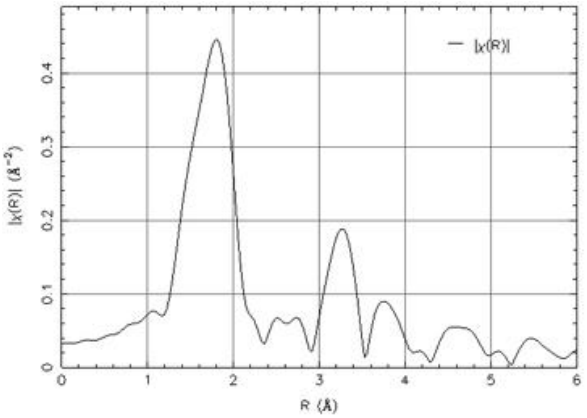

Fig. 4. Radial distribution function obtained from EXAFS of Ru in $(Ir_{0.75}Ru_{0.25})O_2$ (Samples produced by Owe and Sunde as in reference 8). Data processed using ATHENA (reference 19).

Soft X-ray Beamline – XPS and NEXAFS

The Soft X-ray (SXR) beamline operates in the energy range 100 – 2500 eV. At this energy X-rays are strongly absorbed by air and, therefore, the path of the X-rays, from the source to detector, including the sample environment, needs to be in a vacuum. The two techniques that use this beamline are X-ray Photoelectron Spectroscopy (XPS) and Near Edge X-ray Absorption Fine Structure (NEXAFS).

For the technique of XPS, a fixed-energy X-ray source is incident on a sample and the energy spectrum of the excited electrons ejected from the sample (photoelectrons) is recorded. The soft X-rays penetrate only a short distance into the sample and the electrons ejected can escape only from even closer to the surface, making this a surface-sensitive technique. Each element present in the sample emits electrons with a series of energies characteristic of that element. It is possible to obtain quantitative measurements (within a few percentage points) of the elemental composition of a surface. The precise energy of peaks in the photoelectron spectrum depends on the chemical environment of the element, so that the position of these peaks may shift for different chemical states. The shift in energy can sometimes be quite substantial (several eV). It is therefore possible to get some information about the chemical states on the surface. It is also possible to quantify the proportion of each chemical state for a particular element, by deconvoluting a complex peak (sometimes the peaks are quite separate) and measuring the areas under the peaks. Good books about XPS include one by Briggs and Grant.[9]

One of several advantages of synchrotron-based XPS is that it is not constrained by a single X-ray energy – normally the case for a laboratory-based instrument (typically with an Al or Mg anode as an X-ray source). One reason this is an advantage is that the depth of analysis depends on the energy of the photoelectrons: higher energy electrons exit from a greater average depth. The kinetic energy of the photoelectrons (E_K) depends on the binding energy of the electron with the atom (E_B), and the X-ray energy incident on the atom ($h\nu$) in this way: $E_K = h\nu - E_B - \varphi$, where φ is the surface work function. Therefore, by choosing the appropriate X-ray energy, it is possible to dictate the photoelectron energy and thus the analysis depth (for a particular photoelectron peak).

This ability to choose the analysis depth is particularly pertinent to the study of nanoparticles. Nanoparticles are of interest in many fields and one fairly recent development is the production of core-shell nanoparticles, in which a thin layer of one substance coats a core of a different material. These find application, for example, in catalysis and photonics. Synchrotron-based XPS can be used to measure the elemental composition and chemical state at various depths in these nanoparticles by varying the X-ray energy (and therefore the photoelectron energy and escape depth). In contrast to this 'energy resolved' method available only at synchrotron sources, the two alternative methods of XPS-based depth profiling that are used on flat surfaces, viz., angle-resolved depth profiles and ion sputtering to etch the surface between analyses, that are the only ones available in the home laboratory, are not much use on nanoparticles.

A specific example of the use of Synchrotron-based XPS on core-shell nanoparticles has been the analysis of a core-shell electrocatalyst designed for oxygen evolution.[10] The core is antimony-doped tin oxide (ATO; the antimony doping gives the tin oxide ionic and electrical conductivity), and the shell consists of an active catalytic material containing a mixture of IrO_2 and RuO_2, created to achieve the superior catalytic activity of RuO_2 while retaining the superior stability of IrO_2.[11] By selecting X-ray (photoelectron) energies of 100 eV, 350 eV, and 1400 eV, it was possible to analyse for elemental and chemical composition at the approximate depths of 0.5, 1 and 2 nm. The example shown (Fig. 5) demonstrates the difference in the chemical state of Ir at different depths (for a range of samples that had undergone different heat treatments).[10]

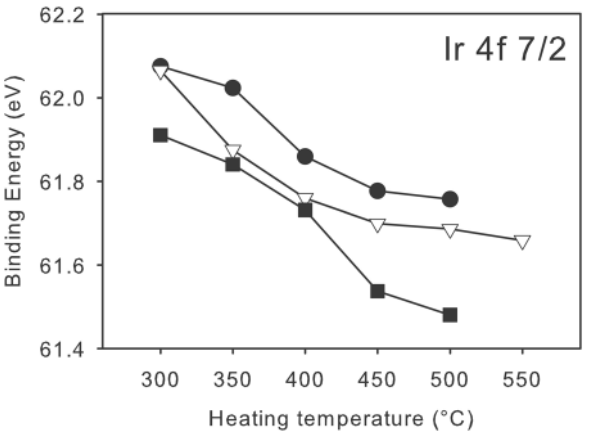

Fig. 5. Electron binding energies for Ir 4f7/2 on core-shell particles at different analysis depths. Circles 100 eV photoelectron energy; triangles 350 eV photoelectron energy; squares 1400 eV photoelectron energy. Adapted from reference 10.

NEXAFS is another technique available on the Soft X-ray beamline. Despite the similarity of the acronym, it is not EXAFS; rather it is more akin to XANES (an easy way to remember this is that NEXAFS could be the abbreviation for "Not EXAFS").[12] NEXAFS is used for analysing light elements on surfaces (light elements have strong absorption edges in the soft X-ray region). NEXAFS is most often applied to carbon, and the resulting spectra depend on both composition and orientation. NEXAFS[13] (and XPS)[14] have been used to study the formation of fluorocarbon films on graphite anodes that can develop during the aluminium smelting process. Both techniques were able to identify a partially fluorinated carbon film forming on the surface under very high overpotential conditions. NEXAFS has an advantage over XPS in that the spectrum produced is very orientation dependent if the sample's surface structure is anisotropic and is, therefore, able to give some structural as well as chemical information. For example, the orientation of graphite on the surface of the carbon anodes used in the aluminium electrode study was readily apparent.[13]

Powder Diffraction Beamline

In X-ray powder diffraction (PD), a powdered crystalline or partially crystalline material is irradiated with a monochromatic X-ray beam and the diffraction pattern recorded, i.e., the angles and intensities of the diffracted X-rays are recorded. The basic technique dates back to Debye and Scherrer from about 1916 and builds on the work of the Australian physicist Bragg from 1912. The technique can provide very precise information about the structure of crystalline materials – the positions of atoms in a unit cell, the distortions present in the structure and the crystallite size.[15]

The PD beamline at the Australian Synchrotron has many advantages over typical laboratory-based systems. The key advantages arise from the very high X-ray flux possible; very high resolution (owing to very precise measurement of the diffraction angle, itself a result of a monochromatic, highly collimated beam); the ability to choose the X-ray energy (to balance absorption effects and resolution requirements); rapid data collection owing to the type of detector employed; and the ability to use high-energy X-rays and therefore high q for experiments involving total scattering analysis. The wavevector, q, depends on X-ray wavelength, λ, and scattering angle, θ, by the relationship $q = 4\pi \sin\theta/\lambda$.

Because of the high resolution possible, small changes in crystal structures can be accurately measured, and the good signal-to-noise ratio enables a small amount of a particular component in a mixture to be detected. The detector that allows rapid collection of high-resolution diffraction patterns simultaneously records the diffraction intensity over an angle of 80º to an intrinsic resolution of 0.0004°. To measure a larger angular range, the detector needs to be moved once. This means that it is possible to measure metastable systems or fairly rapidly changing processes during, for example, heating or chemical reactions. A diamond anvil cell is also available and enables studies of pressure effects on crystal structure.

An example where these features have been exploited was in a study of a series of mixtures of IrO_2 and RuO_2. The electrochemical behaviour of the materials had been characterised and related to the structure. PD revealed that they consisted of single-phase materials except for one mixture, which had a small portion of a second component[8] (Fig. 6). It was also possible to accurately determine the shift in the lattice parameters with the change in composition (Fig. 7), showing that as Ru is added the unit cell contracts in the c-axis.

The ability to use high-energy X-rays at high flux enables analysis of the pair distribution function (PDF) of a total scattering spectrum. PDF is a powerful technique for nanostructured materials that lack a high level of crystallinity.[16,17] The data processing involves a Fourier transform of the scattered X-ray intensity with wave vector. It produces a pair distribution, which is a probability distribution of the distances between pairs of atoms in the material (Fig. 8). The PDF of a structure can also be calculated *a priori* so that experimental data can be compared with a structural model or the model fitted to the data (Fig. 8).

In order to get a good PDF, it is necessary to measure the scattered intensity to a high level of q, i.e., high angle and short wavelength and to get good counting statistics, including at high q. Synchrotron radiation is ideal for this. Typically, a home laboratory source will use Cu Kα radiation, which has a wavelength of 1.54 Å (although Ag or Mo sources that produce shorter wavelengths are available). However, on the PD beamline at the Australian Synchrotron, X-rays at high intensity of 21 keV (0.59 Å) can be obtained. This energy is sufficient to obtain data suitable for PDF analysis. PDF measures pairwise distribution, average atom to atom lengths, rather than distances determined from average lattice positions (which is the case in conventional X-ray PD). For some structures, these are not the same. A more detailed description, with some interesting examples, is in the book by Egami and Billinge.[17]

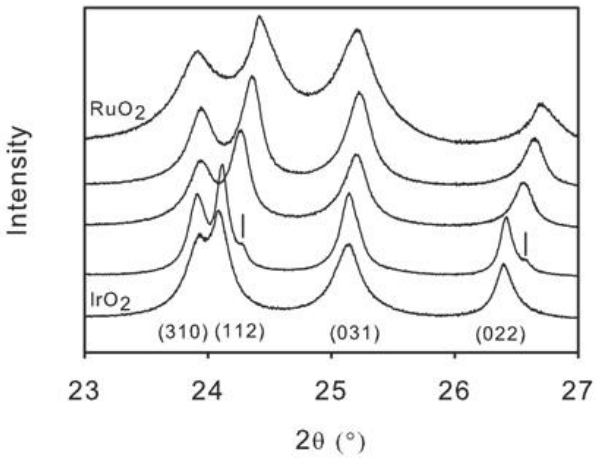

Fig. 6. A portion of the X-ray diffraction patterns for $Ir_{1-x}Ru_xO_2$ heated to 600 ºC ($x < 1$) and RuO_2 heated to 500 ºC for (offset patterns, bottom to top) x = 0, 0.25, 0.5, 0.75 and 1. Vertical bars indicate shoulders on pattern for $Ir_{0.75}Ru_{0.25}O_2$. Miller indices indicated below peaks. Reproduced from reference 8.

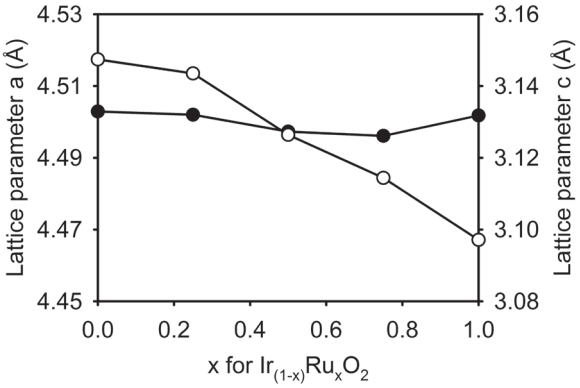

Fig. 7. Lattice parameters a (•) and c (◦) obtained by Rietveld refinement of powder diffraction data for compositions in the range $Ir_{1-x}Ru_xO_2$. Adapted from reference 8.

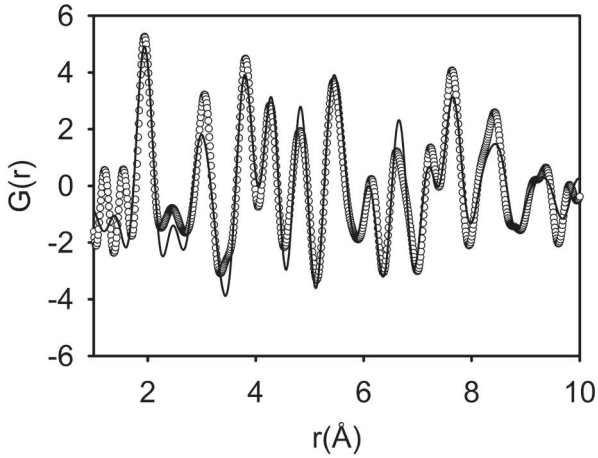

Fig. 8. PDF of nanocrystalline anatse TiO_2. Circles are the PDF calculated from data; The solid line is calculated PDF from an adjusted model of anatase. Data processed using PDFGetX2 (see reference 20), modelling performed using PDFGui (see reference 21).

Small Angle X-ray Scattering Beamline

Small Angle X-ray Scattering (SAXS) is another scattering technique but one that measures very small scattering angles. It is, therefore, suitable for very different samples compared to those appropriate for the PD beamline. Scattering at small angles provides information about larger structural features than does the PD beamline. It is commonly applied to solid polymer materials (both biopolymers – such as proteins – and engineering polymers) and to nanoparticles and polymers in suspension.

The SAXS/WAXS beamline at the Australian Synchrotron has a very good Pilatus detector that captures a full 2D scattering pattern. For studies of aqueous suspensions, the pattern obtained is likely to be the same at all azimuthal angles, so that the 2D capability of the detector is not fully used. Instead, the scattering pattern is normally converted to a single *I* versus *q* plot as the first step in the data processing. However, for solid materials, the anisotropic nature of the material can be fully analysed, possibly yielding quite complex scattering patterns.

For samples suspended in liquids, typically one might be interested in the shape or conformation of a macromolecule in this environment, and SAXS can provide this information. The technique can be complementary to analysis on the MX beamline, which is typically used for determining the full structure of a macromolecule that has been successfully crystallised. It is also possible to obtain shape and size distribution information from SAXS for nanoparticles in suspension.

SAXS is a technique that is available in home laboratory instruments; however, SAXS at the Australian Synchrotron has several advantages. The combination of the high X-ray flux and very sensitive detector enables very rapid acquisition of full spectra (of the order of a second) so that it is possible to monitor reactions that take place over a few minutes or hours. Also, the X-ray beam can be focussed to a minute spot on the sample, typically 250 x 80 μm, enabling mapping of the structure of an inhomogeneous material (as are many natural materials).

For solid samples, it is possible to apply stress to the sample while it is being exposed to SAXS and observe the material's structural behaviour while under stress. We have built a device for stretching leather and biological tissues on the SAXS beamline while recording scattering patterns and used the results to improve our understanding of the average structure, the variation of structure though the tissue and the deformation behaviour under stress. Although so far only a portion of the information contained within the diffraction patterns has been used, this technique has been very revealing of structure-function relationships. More specifically, the relationship between ovine and bovine leathers and strength has been found to be due in large part to the orientation of the collagen fibrils.[18] The orientation can be easily seen in the diffraction patterns (Fig. 9) and can be quantified as an orientation index. The *d*-spacing of collagen can be used as an internal strain gauge in collagen materials to help to understand how the forces are transmitted and accommodated within a material as it is strained. For example, when leather is being stretched, often the fibres first rearrange to become more aligned and then the individual fibrils begin to stretch as seen by the increase in the *d*-spacing (Fig. 10).

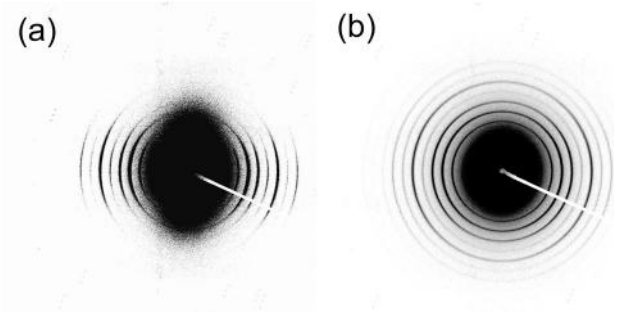

Fig. 9. SAXS scattering pattern of; a) leather with aligned collagen fibrils, b) leather with a more isotropic arrangement of collagen fibrils. The rings are due to the collagen d-banding (the rings are different reflection orders of the same structures). The distance from the centre (equatorial angle) is due to d-spacing, the variation around the rings (azimuthal angle) is due to the alignment of the fibrils.

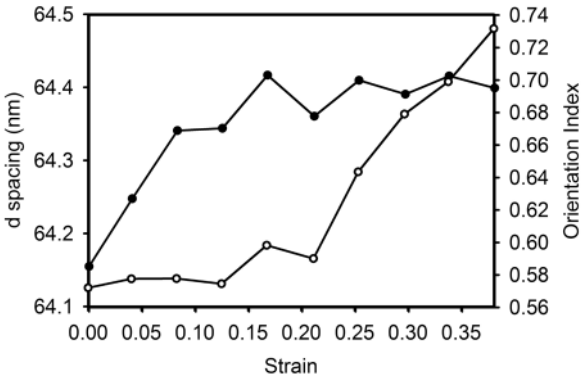

Fig. 10. Stretching of ovine leather d-spacing and orientation measured edge-on versus strain: (○) d-spacing and (●) orientation index. Reproduced from *J. Agric. Food Chem.* (2012) **60**, 1201−1208 ©American Chemical Society.

Concluding remarks

The Australian Synchrotron is a state-of-the-art, world class facility right on our doorstep. Access is generously facilitated by the NZSG and supported by expert and helpful beamline staff. Just four of the beamlines, and only some aspects of the techniques available, have been outlined briefly here, but the hope is that this article has conveyed some of the powerful capability of the Australian Synchrotron for chemical research and will stimulate further enquiry and interest.

Acknowledgements

Much of the work described in here was performed at the Australian Synchrotron – on one of four beamlines: the SAXS, PD, XAS and SXR. Dr Don Smith of the NZSG provided the AS usage data. Katie Sizeland, from Massey University, assisted with figure preparation and provided useful advice. Prof Jim Metson, from the University of Auckland, gave helpful advice on the content.[22] Sue Hallas of Nelson edited the manuscript.

References

1. Bunker, G. *Introduction to XAFS: A Practical Guide to X-ray Absorption Fine Structure Spectroscopy*; Cambridge University Press,

2010.

2. Brooks, R. R. *Journal of Geochemical Exploration* **1982**, *17*, 109-122.
3. Brooks, R. R.; Reeves, R. D.; Morrison, R. S.; Malaisse, F. *Bulletin De La Societe Royale De Botanique De Belgique* **1980**, *113*, 166-172.
4. Anderson, C.; Moreno, F.; Meech, J. *Miner. Eng.* **2005**, *18*, 385-392.
5. Haverkamp, R. G.; Marshall, A. T.; Van Agterveld, D. **2007**, *9*, 697-700.
6. Luangpipat, T.; Beattie, I. R.; Chisti, Y.; Haverkamp, R. G. *Journal of Nanoparticle Research* **2011**, *13*, 6439-6445; Beattie, I. R.; Haverkamp, R. G. *Metallomics* **2010**.
7. Haverkamp, R. G.; Marshall, A. T. *J. Nanopart. Res.* **2009**, *11*, 1453-1463.
8. Owe, L. E.; Tsypkin, M.; Wallwork, K. S.; Haverkamp, R. G.; Sunde, S. *Electrochimica Acta* **2012**, *70*, 158-164.
9. Briggs, D.; Grant, J. T. *Surface Analysis by Auger and X-Ray Photoelectron Spectroscopy*; IM Publications, 2003.
10. Haverkamp, R. G.; Marshall, A. T.; Cowie, B. C. C. *Surface and Interface Analysis* **2011**, *43*, 847-855.
11. Marshall, A. T.; Haverkamp, R. G. *Electrochim. Acta* **2010**, *55*, 1978-1984.
12. Stöhr, J. *NEXAFS Spectroscopy*; Springer-Verlag: Berlin, 1992.
13. Haverkamp, R. G. *To be published*.
14. Haverkamp, R. G. *Journal of Materials Science* **2012**, *47*, 1262-1267.
15. Pecharsky, V.; Zavalij, P. *Fundamentals of Powder Diffraction and Structural Characterization of Materials*, 2nd ed.; Springer, 2008.
16. Haverkamp, R. G.; Wallwork, K. S. *J. Synchrotron Radiation* **2009**, *16*, 849-856.
17. Egami, T.; Billinge, S. J. L. *Underneath the Bragg Peaks: Structural Analysis of Complex Materials*; Permagon: Oxford, 2003.
18. Basil-Jones, M. M.; Edmonds, R. L.; Allsop, T. F.; Cooper, S. M.; Holmes, G.; Norris, G. E.; Cookson, D. J.; Kirby, N.; Haverkamp, R. G. *J. Agric. Food Chem.* **2010**, *58*, 5286-5291; Basil-Jones, M. M.; Edmonds, R. L.; Cooper, S. M.; Haverkamp, R. G. *J. Agric. Food Chem.* **2011**, *59*, 9972-9979; Basil-Jones, M. M.; Edmonds, R. L.; Norris, G. E.; Haverkamp, R. G. *J. Agric. Food Chem.* **2012**, *60*, 1201-1208.
19. Ravel, B.; Newville, M. *J. Synchrotron Rad.* **2005**, *12*, 537-541.
20. Qui, W.; Thompson, J. W.; Billinge, S. J. L. *J. Appl. Crystallog.* **2004**, *37*, 678.
21. Farrow, C. L.; Juhas, P.; Liu, J. W.; Bryndin, D.; Bozin, E. S.; Bloch, J.; Proffen, T.; Billinge, S. L. J. *J. Physics: Condensed Matter* **2007**, *19*, 335219.
22. Metson, J. B. *Chemistry in NZ.* **2005**, *69*, 2-9.

Conferences

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Article

The application of N-acetylmannosamine to the mammalian cell culture production of recombinant human glycoproteins

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Keywords: sialylation, glycoproteins.

This mini-review covers recent developments in the understanding, role and value of N-acetylmannosamine (ManNAc) as a compound that can improve sialylation during the production of recombinant human glycoproteins.

Introduction

Sialic acid (N-acetylneuraminic acid, NeuAc, Neu5Ac) is an essential terminal sugar on the glycan moieties of many functional and structural human glycoproteins. A key intermediate in the biochemical process to form sialic acid is the monosaccharide, ManNAc, which is formed by the bifunctional enzyme UDP- N-acetylglucosamine / N-acetylmannosamine epimerase kinase (GNE). ManNAc is an intermediate in the formation of the final product of the GNE enzymatic transformation, ManNAc-6-phosphate, which is subsequently condensed with pyruvate to form the 9-phosphate of sialic acid. At this point the sialic acid is either modified to form other sialic acids or is activated in the cell nucleus to form the nucleotide CMP-sialic acid prior to bonding to galactose (the intermediate terminal sugar of the glycan in glycoprotein formation, by means of a sialyl transferase,[1] Fig. 1). This is normally the last step in the biosynthesis of a wide range of glycoproteins which are found in all human tissues.

The functional quality of the GNE enzyme is now recognised as one of the defining features in the efficient production of glycoprotein therapeutic drugs.[2] Incomplete sialylation can lead to poor therapeutic efficacy and short half-lives along with the possible formation of antibodies;[3] hence, there has been considerable research in recent years to optimise the sialylation process.

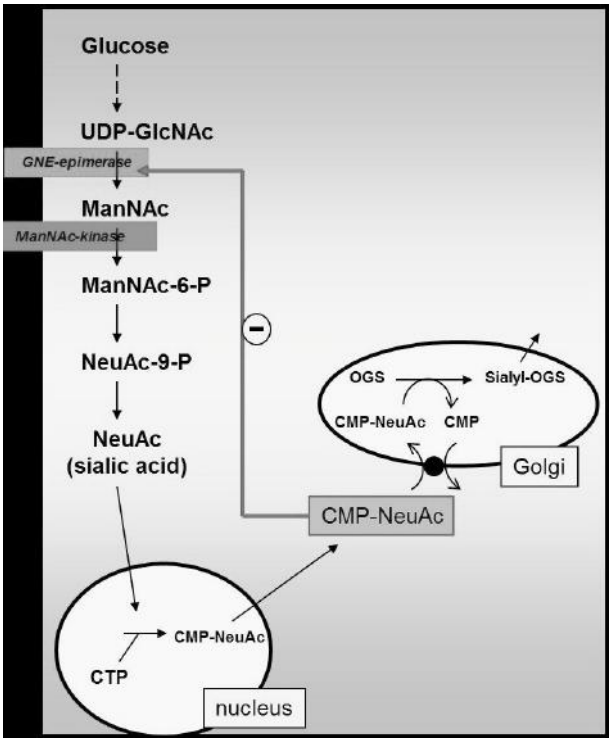

Fig. 1. Sialic acid biosynthesis and conjugation

The failure of the GNE enzyme is also the cause of "Hereditary Inclusion Body Myopathy" (HIBM), also known as "GNE Myopathy", which is a rare genetic disorder with no available therapy.[4] Disease symptoms emerge in adulthood and slowly lead to progressive muscle weakness. There is evidence that HIBM is caused by hyposialylated muscle proteins. There is also evidence that the malfunction of other sialylation-pathway enzymes could contribute to several glomerular kidney diseases[5] owing to the lack of the sialic acid terminal sugar on several kidney glycoproteins.

Recombinant proteins as therapeutic drugs

Recombinant human glycoproteins are finding increasing applications in therapy and the trend is likely to escalate as new discoveries are harnessed through cell culture technologies. Furthermore, therapeutic applications are evolving for diseases in which there has never been a prior form of therapy. Consequently, there is a great deal of interest in developing new products for the healthcare sector. The compound annual growth rate of these recombinant human glycoproteins is 16%; double the average growth rate of the pharmaceutical sector.[6]

There is normally some level of sialylation of specific glycans within a glycoprotein, but with the observation that incomplete sialylation leads to reduced biological activity and/or increased immunogenicity, it becomes relevant to assess the cell-lines and culture media to improve performance and yield, and reduce manufacturing costs. ManNAc is a potential non-nutrient culture medium ingredient that can increase sialylation to therapeutically effective levels that is receiving attention. This report assesses the benefits of using ManNAc in Chinese Hamster Ovary (or CHO cells, the mammalian "work-horse" cell type for the production of therapeutic recombinant human glycoproteins) cultures to produce sialylated glycoproteins.

Issues around ManNAc and glycoprotein sialylation

The benefits of using ManNAc as an ingredient in a model CHO cell line to produce recombinant human interferon-γ was investigated in some detail.[2] ManNAc was chosen over sialic acid as the preferred additive to the culture medium because it is a specific precursor for intracellular synthesis of sialic acid and it has greater cell membrane

permeability than sialic acid itself and CMP-sialic acid, at physiological pH. The authors (Gu and Wang[2]) were able to measure a nearly 30-fold increase in intracellular concentration of CMP-sialic acid upon ManNAc feeding, and increased incorporation of the precursor into the sialylated product. While sialylation was significant, it was always incomplete on the pre-sialylated biantennary glycan structures at specific asparagine glycosylation sites. The incomplete sialylation might have been because a sialidase removed the sialic acid once formed on the glycan, or perhaps there was limited access of the CMP-sialic acid to the Golgi apparatus[7] in the cell nucleus, or perhaps there was limited steric accessibility for the sialylation to occur. The authors concluded that more dramatic sialylation could occur for proteins with low sialylation profiles and more easily accessible sialylation sites.

Another group published their work soon after the Gu and Wang paper[2] and noted that while the CMP-sialic acid pool increased, they did not identify increased sialylation of the human tissue inhibitor of metalloproteinase (TIMP-1) glycoprotein either in CHO cells or in the murine myeloma NS0 cell lines.[6] It was suggested that there could be three basic variables that could affect sialylation: (i) availability of sialyltransferases; (ii) abundance of competing acceptor sites; (iii) availability of nucleotide-sugar substrate in the Golgi. These three issues continue to be the key problems today.

A significant secondary outcome from the addition of ManNAc was the increase in the ratio of NeuAc versus N-glycolylneuraminic acid (NeuGc) moieties on the therapeutic protein product. The increase in the proportion of NeuAc over NeuGc helps to "humanise" the glycoprotein because NeuGc is not produced in the human body.[8]

Research on the benefits of adding ManNAc to various glycoprotein production systems continues. It is clear that the structural heterogeneity of glycans is sensitive to fed batch (initial single large dose) to interval feeding (periodic smaller doses through the production), culture type and environment, nutrient balance, waste accumulation, oxygen levels, pH and temperature. Therefore, process control is critical to improving the production of the glycoproteins.

Erythropoietin (EPO) is a heavily sialylated glycoprotein hormone, and recombinant human EPO is used therapeutically to enhance the production of red blood cells. There are up to 14 sialic acids per EPO molecule with 4 sialic acid molecules on each tetra-antennary *N*-glycan and 2 sialic acid molecules on the *O*-glycans. By use of a novel CHO-EPO cell line, it was demonstrated[9] that the addition of ManNAc increased the sialylation of the EPO, although a genetic modification of the GNE enzyme was claimed as best of all. However, genetic modification of cell lines is a competitive R&D area and a commercially very sensitive and secretive operation, and scaling up to commercial production introduces technical and regulatory complications. ManNAc supplementation is likely to enhance a range of culture types without breach of specific patents, and furthermore, supplementation does not affect the regulatory environment because it is not changing the way the cell synthesises the glycoprotein. This is particularly important when a company files an Investigational New Drug (IND) application with the FDA in the USA. INDs need to be accepted by the FDA prior to any organisation starting any first in human, or clinical, trials in the USA.

Baker[10] noted the availability of CMP-sialic acid could be limited in the Golgi. However, she also demonstrated that the addition of ManNAc beneficially increased the ratio of NeuAc versus NeuGc in the glycan structure.

Bork[9] reported that ManNAc "could influence" cell proliferation and differentiation, which are indicative signs of toxicity. Bork's concern was proved not to be a problem in mammals themselves because high dose cell culture and oral toxicity studies in two animal species have been undertaken and there was no observable toxicity.[11] Whether this is important in cell cultures is a moot point.

Bork also suggested that ManNAc was too expensive for commercial applications, so NZP undertook calculations to assess the cost of its cell culture grade ManNAc[12] versus the value of the glycoprotein in question. ManNAc becomes a minimal cost at just a few dollars per gram compared to some therapeutic glycoproteins valued at up to US$1000 per gram. The issue raised by Bork becomes inconsequential and ManNAc addition to the culture medium is rightfully the first-choice approach to increase intracellular sialic acid concentrations in a large-scale production process.[1]

In another review,[13] published concurrently with the review by Bork,[9] it was noted that in all technologies to produce therapeutic glycoproteins – be they by CHO, NS0, HEK, BHK or PERC.6 cell lines – there are issues with expressing the complete human glycoprotein with constraints in glycosylation. There was also an emphasis on glycoform profiling because of the growing issues surrounding the NeuGc glycan variant.

In a study on the impact of feeding nucleoside sugar precursors to CHO cells,[14] it was demonstrated that ManNAc plus cytidine increased the CMP-sialic acid pool in line with published results from Gu and Wang,[2] but it did not lead to a synergistic increase in the glycoprotein sialylation. Along with the range of results found in this study, it provided further evidence that mechanisms exist in the Golgi that inhibit glycoprotein sialylation.

In order to overcome the problems associated with effecting utilisation of raised levels of the CMP-sialic acid for enhanced glycoprotein sialylation, there have been attempts to insert improved transporters and sialyltransferases in the CHO cell.[15] At the same time the investigators improved the function of the GNE enzyme, although this seems a little pointless considering ManNAc feeding has already been proven to increase the CMP-sialic acid pool. The authors argue that ManNAc is too expensive, but it is now recognised that the current cost of the chemical at scale is insignificant compared to the value of the glycoprotein and so this argument can be dismissed.

In the most recent relevant publication,[16] a "high throughput method" for the quantification of sialylation on gly-

coproteins was developed and the authors' assessment confirmed earlier observations that there are different mechanisms operated by different mammalian cells to produce glycoproteins. This is unsurprising and within their own work they detected significant interclonal variability in the sialylation of the interferon-γ glycoprotein model. A key result of this thesis once again demonstrated that the addition of ManNAc at concentrations as low as 2mM (plus a specific metal ion cofactor) enhances the sialylation and production of interferon-γ. It will be interesting to note the breadth of the relevance of the metal ion co-factor in future work.

Conclusion

The addition of ManNAc to the culture medium can make a special and essential contribution to maximising the sialylation of certain therapeutic glycoproteins. Some mammalian cell cultures are more efficient with the sialylation mechanism than other types of mammalian cell lines, although there are many factors that can influence the sialylation yield. It is likely that the best utility of ManNAc will be in the production of proteins that do not have sterically hindered sites that prevent the sialyltransferase from operating efficiently in the final step of the glycosylation process. The addition of ManNAc to the medium might also gain extra value where the NeuGc content in a glycoprotein should be minimised. Increased sialylation reduces the risk of immunogenicity and extends the half-life of therapeutic glycoproteins.

Owing to the recent availability of ManNAc in large volumes at modest cost, it has become an essential culture medium ingredient for research with the possibility that it could provide an important function in large scale recombinant human therapeutic glycoprotein production.

Acknowledgement

Comments from Dr Barry Old (NZP) and Dr Richard Furneaux (IRL) are gratefully acknowledged.

References:

1. Bork, K.; Horstkorte, R.; Weidermann, W. *J. Pharm. Sci*. **2009**, *98*(10), 3499.
2. Gu, X.; Wang, D.I.C. *Biotech and Bioeng*. **1998**, *58*(6), 642.
3. Weiss, P.; Ashwell, G. *Prog. Clin. Biol. Res*. **1989**, *300*, 169.
4. Huizing, M.; Krasnewich, D.M. *Biochim. Biophys. Acta*. **2009**, *1972*(9), 881.
5. Galeano, B.; Klootwijk, R.; Manoli, I.; Sun, M.; Ciccone, C.; Darvish, D.; Starost, M.F.; Zerfas, P.M.; Hoffmann, V.J.; Hoogstraten-Miller, S.; Krasnewich, D.M.; Gahl, W.A.; Huizing, M. *J. Clin. Invest.* **2007**,*117*(6), 1585.
6. Werner, R.G.; Kopp, K.; Schlueter, M. *Acta Paediatrica*. **2007**, *96*(s455), 17.
7. The Golgi apparatus, also known as the Golgi complex or Golgi body, is an organelle found in most eukaryotic cells.
8. Varki, N.M.; Varki, A. *Lab. Invest*. **2007**, *87*(Sept), 851
9. Bork, K.; Reutter, W.; Weidemanna, W.; Horstkorte, R. *FEBS Lett*. **2007**, *581*(22), 4195.
10. Baker, K.N.; Rendall, M.H.; Hills, A.E.; Hoare, M.; Freedman, R.B.; James, D.C. *Biotech. Bioeng.* **2001**, *73*(3), 188.
11. Shen, J.; NCATS, TRND.; private communication.
12. www.nzp.co.nz/index.php/products/microbiological-media-and-fermentation-ingredients/n-acetyl-d-mannosamine-mannac.html.
13. Hossler, P.; Khattak, S.F.; Zheng, J.L. *Glycobiol*. **2009**, *19*(9), 936
14. Wong, N.S.C.; Wati, L.; Nissom, P.M.; Feng, H.T.; Lee, M.M.; Yap, M.G.S. *Biotech. Bioeng*. **2010**, *107*(2), 321
15. Son, Y.D.; Jeong, Y.T.; Park, S.Y.; Kim, J.H. *Glycobiol*. **2011**, *21*(8), 1019.
16. Markley, L.R.A.; Wang D.I.C. *DSpace@MIT*. **2011**, http://dspace.mit.edu/handle/1721.1/65762.

Grants and awards

Bayer Primary School Science Fund

The Bayer Primary School Science Fund is sponsored by Bayer and administered by the Royal Society of New Zealand. This fund is to give primary schools the opportunity to apply for funding required to teach and enhance both environmental science and 'nature of science' activities. A primary school can request a maximum sum of up to $2,000 to help fund activities.

Details of application forms are on the website.

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See: www.royalsociety.org.nz/programmes/funds/bayer-primary-school-science-fund/

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Closing date for preliminary proposals: Wednesday 27th February 2013

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The 2012 Nobel Prize in Chemistry

Brian Halton

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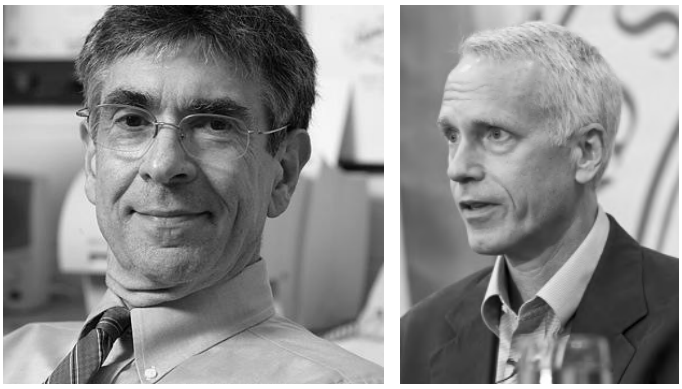
(e-mail: *brian.halton@vuw.ac.nz*)

The Royal Swedish Academy of Sciences awarded the 2012 Nobel Prize in Chemistry to ***Robert J. Lefkowitz*** of the Howard Hughes Medical Institute and Duke University Medical Centre, and ***Brian K. Kobilka*** of Stanford University School of Medicine, USA, for studies of G-protein–coupled receptors.



Left: Robert J. Lefkowitz (courtesy of Quivetta Lennon, Duke University, NC); right: Brian K. Kobilka (from Linda A. Cicero/ Stanford News Service)

Each of the billions of cells in the body has tiny receptors that enable it to sense its environment, so it can adapt to new situations. This year's recipients gained the award for ground-breaking discoveries that reveal the inner workings of the *G-protein–coupled receptors* (GPCRs). These receptors form a remarkable modular system that allows the transmission of a wide variety of signals over the cell membrane, between cells and over long distances in the body. Today, we understand the molecular mechanism of how these receptors work in intricate detail, in large part because of the studies by Kobilka and Lefkowitz. Scientists knew that hormones such as adrenalin had powerful effects in increasing blood pressure and making the heart beat faster. They suspected that cell surfaces contained some kind of recipient for hormones, but what these receptors actually consisted of, and how they worked, remained obscure for most of the 20th century.

In 1968, Lefkowitz began to use the radioactivity of ^{125}I to trace cellular receptors by attaching the radioactive iodine isotope to various hormones. This unveiled several receptors, among them a receptor for adrenalin, β-adrenergic receptor. His team extracted the receptor from the cell wall and gained an initial understanding of how it works. However, in the 1980s, Brian Kobilka, a newly recruited postdoctoral fellow accepted the challenge to attempt to isolate the gene that codes for the β-adrenergic receptor from the human genome and was, ultimately, successful. When the researchers analysed the gene, they discovered that the receptor was similar to one in the eye that captures light and then realised that there is a whole family of receptors that look alike and function in a similar manner. Today this family is referred to as G-protein–coupled receptors. About a thousand genes code for such receptors, for light, flavour, odour, adrenalin, histamine, dopamine and serotonin, etc., and about 50% of all medications achieve their effect through G-protein–coupled receptors.

The studies by Lefkowitz and Kobilka have proved crucial to understanding how G-protein–coupled receptors function.

Introduction

As human beings we have sensors in our eyes, nose and mouth for light, odours and flavours. Within our body, cells have similar sensors for hormones and signalling substances, such as adrenalin, serotonin, histamine and dopamine. Cells repeatedly use the same basic mechanism for reading their environment through G-protein–coupled receptors, but their nature and mode of action only recently have been determined. We all know how the body reacts to a frightening situation – senses are heightened, e.g., heart rate increases and we are on guard!

In a human being, tens of thousands of billions of cells interact, most of them with distinct roles. Some store fat; others register visual impressions, produce hormones or build up muscle tissue. In order to function, it is vital that our cells work in unison, sense their environment and know what is going on around them. For this, they need sensors. Every human cell is surrounded by a plasma

membrane, a phospholipid bilayer. The membrane makes it possible for the cell to maintain a specific mix of biochemically active species, while preventing unwanted entry of other substances from the outside environment. For proper function, the biochemical machinery inside the cell needs to be able to receive instructions from the outside. Robert J. Lefkowitz and his former postdoctoral student Brian K. Kobilka were awarded the 2012 Nobel Prize in Chemistry for having mapped how the family of G-protein–coupled receptors (GPCRs) work. This family includes the receptors for adrenalin, dopamine, serotonin, light, flavour and odour. In fact, most physiological processes depend on GPCRs and about one half of all medications act through these receptors, among them β-blockers, antihistamines and various kinds of psychiatric medications. Changes in hormone levels on the outside of the cell elicit adaptive changes in enzyme activity on the inside. Odour molecules affect cells in the olfactory epithelium and substances in food influence chemical activities in taste bud cells, which in turn induce electrical signals that transfer information to the brain. Indeed, human cells are constantly communicating with each other and the surrounding environment, which requires a molecular framework and a mechanism for transmission of information across the plasma membrane. Additionally, in the body, signal transmission may take place over long distances. To be able to respond promptly, the brain needs rapid information from our senses, for vision, smell, taste and hearing. Again, this requires a molecular mechanism for transmission of information over the plasma membrane.

The receptor – an elusive enigma

At the end of the 19th century scientists began to experiment with the effects that adrenalin has on the body. They discovered that it makes the heart rate and blood pressure increase and that it also relaxes the pupils. They suspected that adrenalin worked via nerves in the body, and so they paralyzed the nervous system of laboratory animals only to find that the effects of adrenalin were still manifest. They concluded that cells must have some kind of receptor that enables them to sense chemical substances in their environment, e.g., hormones, poisons, and drugs. However, for decades, all attempts to find these receptors failed. Scientists wanted to understand the size, shape and nature of the receptors, and how they conveyed signals to the cell. They knew that adrenalin was administered to the outside of the cell, and that it led to changes in its metabolism that they could measure inside the cell. Each cell has a wall, a membrane of fat molecules that separates it from its environment. Thus, the essential questions are: "How did the signal get through the wall?" and "How could the inside of the cell know what was happening on the outside?" The receptors remained unidentified for decades even though drugs were developed that specifically have their effect through recognition by one of these receptors. In the 1940s, the noted American pharmacologist Raymond Ahlquist examined the response of different organs to various adrenalin-like substances. His work led him to conclude that there were two different types of receptors for adrenalin: the α-receptor that primarily makes smooth muscle cells in blood vessels contract, and the β–receptor that primarily stimulates the heart. It was shortly after this discovery that the first β–blockers were developed. Now β–blockers are among the most frequently used heart medicines. Undoubtedly, such drugs produced effects in the cells, but how they did so remained a mystery. We now know why the receptors were so difficult to find: they are relatively few in number and are mostly encapsulated within the wall of the cell. After some twenty years Ahlquist began to feel lost in his theory about the two distinct receptors, writing at about the end of the 1960s, "To me they are an abstract concept conceived to explain observed responses of tissues produced by chemicals of various structures." At about that time, Robert Lefkowitz, started the studies that have stamped his mark on the history of these receptors.

Luring receptors out of their hiding places

Lefkowitz was a high-achieving young student with his mind set on becoming a cardiologist. However, he graduated at the height of the Vietnam War and was required to do his military service. For him this was prescribed in the US Public Health Service laboratory at the National Institutes of Health in Bethesda, Maryland. There, he was presented with the challenge of finding the receptors! Lefkowitz's supervisor suggested attaching ^{125}I to a hormone so that as the hormone binds to the surface of a cell, the radioactivity would make it possible to track the receptor. However, it was essential also to confirm that the coupling of the hormone to the cell took place on the outside of the cell and that it was this that triggered a process already known to take place in the interior of the cell. Were Lefkowitz to succeed, there could be no doubt that he had, in fact, discovered a biologically functioning receptor. He began by working with adrenocorticotropic hormone (also known as corticotropin or corticoliberin) that stimulates the production and release of corticosteroids in the adrenal gland. However, there was no real success until the second year of study when, in 1970, he published two articles, one in *Proceedings of the National Academy of Sciences,*[1] the other in *Science*,[2] outlining the discovery of an active receptor. This achievement led him into full-time research and, subsequently, he was recruited to Duke University in North Carolina. In new laboratories, Lefkowitz formed his own research team and, while he was never to become a cardiologist, he worked on heart disease and began to focus on receptors for adrenalin and noradrenalin, the so-called adrenergic receptors or adrenoceptors. Using radioactively tagged substances, including β-blockers, his research group examined how these receptors work and eventually, and with great skill, they managed to extract a series of them from biological tissue. Meanwhile, knowledge about what happens inside cells grew, and researchers found that what they call G-proteins were activated by a signal from the receptor. The G-protein, in turn, triggered a chain of reactions that alter the metabolism of the cell. Thus, by the early 1980s, scientists were beginning to understand the process by which signals are transmitted from the outside of the cell to its inside.

The gene – a key to new insights

In the 1980s, Lefkowitz decided that his research group should try to find the gene that codes for the β-receptor.

This decision was crucial to the award of the Nobel Prize. The gene contains the code that is read by the cell when it joins amino acids together to create a protein, such as a receptor. If the research group could isolate the gene and read the blueprint for the β-receptor, insight as to how the receptor works would be gained. At about that time, Lefkowitz hired a young doctor, Brian Kobilka, whose fascination with adrenergic receptors was born of experience in hospital intensive care where a dose of adrenalin could make the difference between life and death. The hormone opens up a swollen respiratory system and speeds up the heart rate. Kobilka wanted to study the power of this drug in its smallest molecular detail, and he approached Lefkowitz and his team of researchers and joined them.

During the 1980s, trying to find a particular gene in the body's genome was akin to finding a needle in a haystack and so this technically very challenging project was slow to advance. However, Kobilka had an ingenious idea that made it possible to isolate the gene and then, with great anticipation, the researchers began to analyze its code. This revealed that the receptor consisted of seven long and fatty (hydrophobic) spiral strings of amino acids – so-called helices. This told them that the receptor probably winds its way back and forth through the cell wall seven times. It had the same number of strings and same spiral shape as previously found for rhodopsin, the light receptor in the retina of the eye. This led them to ask whether these two receptors were related, even though they had completely different functions. Robert Lefkowitz later described this as "a real eureka moment". He knew that both adrenergic receptors and rhodopsin interact with G-proteins on the inside of the cell. He also knew of about thirty other receptors that work via G-proteins. The conclusion was, then, that there had to be a complete family of receptors that look alike and function in the same manner. Since this ground-breaking discovery, the puzzle has been assembled piece-by-piece, and now detailed knowledge about GPCRs – how they work and how they are regulated at the molecular level – is known. Lefkowitz and Kobilka have been at the forefront of this entire scientific journey, and in 2011, Kobilka and his team of researchers reported a finding that crowned the work.

Imaging adrenalin effects – a crystal structure

After having isolated the gene, Brian Kobilka moved to the School of Medicine at Stanford University in 1989. There he set out to obtain an image of the receptor, something regarded by most scientists as unattainable. For Kobilka, this programme took many years, as imaging a protein involves many complex steps. Eventually, he and his group were able to obtain a suitable crystal for X-ray analysis. What needs to be noted here is that the bulk of protein crystal structures have been gained from water-soluble entities whose solubility facilitates crystallization. Far fewer researchers have managed to obtain the structure of a protein located in the fatty membrane of the cell. GPCRs are by nature very mobile (they transmit signals by moving), but inside a crystal they have to remain almost completely stationary. Getting one of them to crystallize was, therefore, a major challenge that took Kobilka over two decades to solve, finally being achieved in 2011.[3] They obtained an image of the receptor at the precise moment that it transfers the signal from the hormone on the outside of the cell to the G-protein on the inside of the cell. The image, published in *Nature*,[3] shows new details about GPCRs, including what the activated receptor looks like when it opens up a void where the G-protein likes to bind. Such knowledge surely will be useful in the future development of new pharmaceuticals.

Life needs flexibility

The mapping of the human genome has revealed close to a thousand genes that code for GPCRs. About half of those receptors receive odours and are part of the olfactory system. A third of them are receptors for hormones and signalling substances, such as dopamine, serotonin, prostaglandin, glucagon and histamine. Some receptors capture the light that hits the eye, while others are located on the tongue and give us our sense of taste. Over one hundred receptors still present challenges as their purposes have yet to be established. Besides discovering many variations in the receptors, researchers, with Lefkowitz and Kobilka in the lead, have found that receptors are multifunctional, because a single receptor can recognize several different hormones on the outside of the cell. Moreover, on the inside, they not only interact with G-proteins, but also with proteins called arrestins, a small family of proteins important for regulating signal transduction. The realization that these receptors are not always coupled to G-proteins has seen them increasingly referred to as seven-transmembrane receptors (7TM), after the seven spiral-shaped strings that wind their way through the cell wall. The receptors' number and flexibility enable the fine-tuned regulation of cells that life requires.

References

1. Lefkowitz, R.J.; Roth, J.; Pricer, W.; Pastan. I. ACTH Receptors in the Adrenal: Specific Binding of ACTH-^{125}I and Its Relation to Adenyl Cyclase. *Proc Nat. Acad. Sci*. **1970**, *65*, 745-752.

2. Lefkowitz, R.J.; Roth, J.; Pastan. I. Radioreceptor Assay of Adrenocorticotropic Hormone: New Approach to Assay of Polypeptide Hormones in Plasma. *Science***, 1970**, *170*, 633-635.

3. Chung, K.; Rasmussen, S.G.; Liu, T.; Li, S.; DeVree, B.T.; Chae, P.S.; Calinski. D.; Kobilka, B.K.; Woods, V.L. Jr.; Sunahara, R.K. Conformational changes in the G protein Gs induced by the β2 adrenergic receptor. *Nature* **2011**, *477*, 611–615.

Additional information is available from: *www.nobelprize.org*

Feature

Some Unremembered Chemists

A series of articles that explores the lives and work of selected chemists who have made a significant contribution to the advancement of the discipline, the profession and well-being of mankind, yet who are little remembered.

John Mercer FRS, FCS, MPhS

Part I. The formative years

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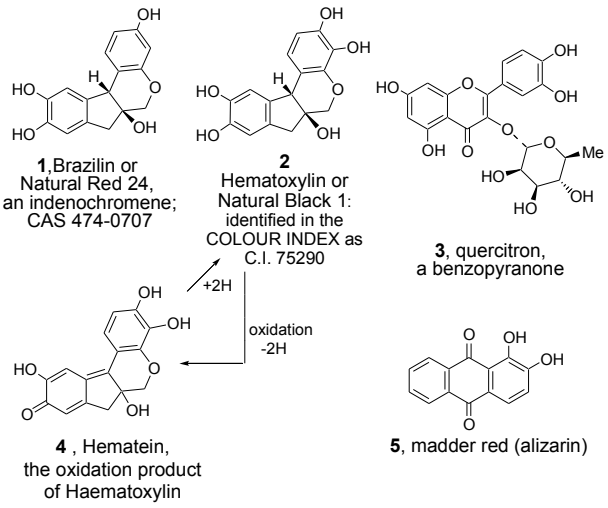
John Mercer (*http://commons.wikimedia.org/wiki/File:John_Mercer_(Chemist).jpeg*)

John Mercer was born on 21 February 1791 in the town of Great Harwood in Lancashire, England, the second son of a Lancashire cotton spinner.[1] At the time of his birth his father ran a cottage industry spinning mill by the side of Dean Brook, the stream that feeds the Clayton-le-Moors and Great Harwood reservoir. The advent of machinery and the formation of large cotton mills led his father to alter tack and he leased '*The Stoops Farm*' to the east of the small township off the road to Whalley. In 1799, there was a major crop failure in the district and the virulent epidemic that followed that claimed many lives, including that of John's father; he died on 7 August, 1802 when John was eleven years old. By then John was in his second year of work as a bobbin winder, subsequently to become a hand weaver. The family was very poor. John's mother, Betty, remarried in 1806, and he became half-brother to William, who was born that year. John lived with various relatives over the years. However, when John was 10 years old Mr Blenkinsop, a neighbour and pattern designer at the nearby Oakenshaw Print–Works in Clayton-le-Moors (where cotton calico[2] cloth was dyed) started to teach John to read and write and introduced him to long division in mathematics before he moved away.[3,4] John continued his education himself and gained a reputation as 'adept at figures';[3] he also became a self-taught musician and played several instruments and formed a choir and a band.[3] Later, John Lightfoot, who was the Excise surveyor at the same calico dye works (each square yard of printed calico was levied with threepence excise duty) and known to visit Harwood frequently, befriended John and taught him higher mathematics, teaching him with his own sons who were calico dyers at the works.[4,5] Mercer was a keen learner and soon became even more recognized for his aptitude with figures and the skill he had from his self-taught music. The wars of the era required John to join the militia, something that he found uncongenial as he was inept and too clumsy. He was put in the "awkward squad" that led to his nickname of *Awkward John*; subsequently, he was transferred to the band and music.[3]

On one occasion, when visiting his mother he saw his half-brother, William, seated on her knee and wearing an orange dress. That single vision changed his life forever as he decided that he should become a dyer. As quoted in the book by his nephew Edward Parnell,[3,4] John Mercer was "all on fire to learn dyeing", but he had had no instruction in the subject, no books, nor the means to obtain them. However, he found that the dyers of the area bought their supplies from a druggist in Blackburn, a larger town some eight kilometres away. He went there and asked for dyestuffs, but had no idea what it was he needed.

The druggist gave him the names of the common materials then in use: peach wood (*Caesalpinia echinata*) from a tropical tree with a prickly trunk and Brazil wood (another form of *Caesalpinia echinata*, which is a dense, orange-red heartwood that takes a high shine and is the premier wood used for making bows for stringed instruments), which yield the red pigment Brazilin known as Natural Red 24 (**1**); alum [potassium alum, the potassium double sulfate of aluminium often designated, $KAl(SO_4)_2\ 12(H_2O)$ but correctly $Al_2(SO_4)_3.K_2SO_4.24H_2O$], which when added to water clumps the negatively charged colloidal particles together into flocs; copperas [iron(II) sulfate, $FeSO_4\ 7H_2O$], which dissolves in water to give the the blue-green $[Fe(H_2O)_6]^{2+}$) complex; logwood (*Haematoxylum campechianum*) from which hematoxylin or Natural Black 1 (**2**) is extracted, and the oxidation product of which is hematein (**4**); and quercitron, the yellow natural dye (**3**) obtained from the bark of the Eastern Black Oak (*Quercus velutina*), a forest tree indigenous to North America.[6]

Mercer checked his money and found that he could afford to pay threepence for each dyestuff. He purchased the materials available. He was very fortunate in being allowed a suitable place to begin his experiments where he had the necessary equipment for his trials, which were carried out



Scheme 1

as rule-of-thumb experiments. Thus, it was by close observation and the maintenance of accurate records that he acquired considerable knowledge of the properties of the dyestuffs and the way in which to provide the colours used in dyeing then in vogue. Some mineral dyes such as Prussian blue, manganese bronze, chrome yellow, antimony orange, and iron buff pigments were fixed to cotton with the use of egg albumen or blood, but wheat gluten or milk lactarine (casein) were also used. Heat and acid were also needed to make them colourfast. Brazilin had been used since at least the Middle Ages to dye fabric, and in the formulation of inks as well. The specific color produced depends on the manner of preparation: in an acidic solution it is yellow, but in an alkaline preparation it is red. In contrast, alum was added to the water so that the negatively charged colloidal particles clump together into flocs.

By the age of 16 years Mercer was a hand-loom weaver and, following his experiments with the Blackburn dyes, he vowed to become a dyer and in this he was successful. He formed a business with a partner using the remnants from the Great Harwood loom weavers and gained success to the extent that his experiments with dyestuffs attracted the attention of the Fort brothers, the owners of the Oakenshaw Print Works. In September 1809, when he was 18 years of age, he was offered an apprenticeship in the colour-shop at the works.[3,4] However, the old foreman there felt threatened by John and offed him no useful information, giving him instead duties more becoming an unskilled labourer;[3] the foremen of colour-shops tended to keep their dyer's art a secret and their mixes empirical.

By 1810, Napoleon's decrees on trade (1793-1810) had reached the point where all printed calico and other British manufactured goods arriving in France were burnt and no more were permitted to be imported. The impact of this at the Oakenshaw site was so severe that the owners offered for surrender their apprentice indentures to those who chose to leave. So it was that after ten months of apprenticeship John Mercer accepted the offer and returned to the hand loom.

At about this time John gained lodging with the Wolstenholme family and stayed with them for some time. In 1813 he converted to "the truth of Christian religion", and had resumed work as a dyer as well as weaving and again he was successful. However, it was not until 1814 that he was able to gain more chemical knowledge. By then he had become engaged to Mary Wolstenholme, some six years his senior, and described as "a very superior woman".[3] A licence to marry could not be obtained in Great Harwood but required attendance at the office in Blackburn and, whilst there, John visited a second-hand bookstall on the market where, it appears, he devoted more attention to securing *The Chemical Pocket Book* or *Memoranda Chemica: arranged in a Compendium of Chemistry* (James Parkinson, 3rd edn., 1803) than to gaining the marriage licence. This was not his first chemistry book as John Lightfoot had presented him[3] with a copy of the 1787 *The Table of New Nomenclature* proposed by De Morveau, Lavoisier, Bertholet, and De Fourcroy. However, on its own the *Table* was of little help. The Parkinson book, however, opened up a new world, especially when coupled with the *Table*. From his earliest experiments, John adopted the view that that is was only through a thorough knowledge of the properties of the dyeing materials and their behaviour under a variety of conditions that the operation of the dyer could be performed intelligently. The books convinced him that all this knowledge depended upon chemical science and that it was on chemistry that the extension of his art rested.

John Mercer married Mary Wolstenholme on 17 April, 1814 and their first child, Mary Mercer, was born on 27 November that year, but survived a mere 17 days. It was not until 1817 that his second child, Mary Clayton Mercer, was born; she was the first of a further five children (three girls and two boys), none of whom married. John continued in his chemical quest and his first major discovery came in 1817. It related to the orange coloured clothes that he had seen his step-brother wearing.

Given the short account of 'the sulphide of antimony' in the chemical pocket book, Mercer performed a series of experiments and then tested his resultant formulations on calicos available. The results gave rise to his "antimony range" of dyed calico. He found that the alkaline sulfantimonates (salts of the hypothetical sulfantimonic acid, H_3SbS_4) provided an excellent medium to give a bright orange colour on calico – he fixed antimony sulfide (Sb_2S) to produce orange calico prints, something that had previously been unattainable. At that time, orange colours were provided from mixes of quercitron yellow (**3**, Scheme 1) and madder red (**5**), but Mercer's antimony orange more appropriately supplied the need. Moreover, it was capable of combination and interspersion to give a good variety of styles unlike the madder-quercitron combination.

Mr Lightfoot advised John to make his discovery known and available to Hargreaves, Dugdale and Co., the proprietors of the Broad Oak works in Accrington, which he did. On his way to Accrington to provide the necessary instruction to Mr Hargreaves' dyers he happened to meet Mr. John Fort, his former employer at the Oakenshaw works. Fort had heard of the Mercer "antimony orange range" and took the opportunity to offer him the job of experimental chemist at his works at an initial salary of 30s ($NZ3) per week,[3] something that Mr Hargreaves had omitted to do. This led to Mercer being re-employed by the Fort brothers,

by then 1818, when formally he became a chemist in the colour shop. His successes were such that he was offered and accepted a partnership in the company in 1825, and he remained associated with the firm until its dissolution in 1848, at which time he elected to retire, by then a rich and famous man.

.... to be continued.

References and Notes

1. Lancashire Lantern: *Lancashire Pioneers*: www.lancashirepioneers.com (accessed Dec 2012).
2. Calico is a plain-woven textile made from unbleached, and often not fully processed, cotton.
3. *The Life and Labours of John Mercer, F.R.S*, E.A. Parnell, London: Longmans Green, 1886, xiv, pp.342.
4. The Palissy of Calico-Printing, a review of Parnell's book by T.E. Thorpe, *Nature*, **1866**, *35*, 145-14.
5. *The Oxford Dictionary of National Biography: John Mercer*; see: www.oxforddnb.com/view/article/18573?docPos=3 (accessed Dec 2012).
6. Lancashire Lantern: *Lancashire Pioneers*: www.lancashirepioneers.com (accessed Dec 2012).

Letter to the Editor

A response to the "top ten" chemistry challenges

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In the October issue of *Chemistry in New Zealand*, we saw a list of the top ten of Chemistry's Greatest Challenges, followed by "If you have the answers, publish first in *CiNZ*". First is not possible, but I have answers to two.

First, homochirality

Work backwards! The first to reproduce prevails through Darwinian evolution, as anything that cannot is eaten/degraded. Reproduction requires the template. The first template is the RNA duplex, which forms in part because the duplex is observed to be at a lower energy than the individual strands. A duplex requires regular pitch and uniform "twist". That is only achieved by a uniformly chiral ribose. This can be achieved once a nucleic acid strand can fold, because one of the catalytic effects is to hydrolyse nucleic acid strands, and those most easily accessed are those not involved in a duplex. Thus, at one stage, inside a vesicle, a nucleic acid strand (not homochiral) could fold well enough to catalyse the hydrolysis. Now further condensation will lead to the duplex, by removing errors and keeping that suitable for the duplex.

The real question is, "Why RNA?" Some other sugars give stronger duplexes and are more easily formed than ribose, at least through the Butlerov mechanism. (In my opinion, there has to be some other way to get to ribose.) The reason lies in how phosphate esters form in dilute cool aqueous solution. It cannot be through enzymes, because the probability of such an entity forming by chance is extraordinarily low (given the amino acids have to be properly sequenced and there are 39 of them to choose from). My answer is through the decay of an excited state leading to excited vibrational energy. The bases absorb the light, and it has been demonstrated that you can make ATP this way. The vibrational energy has to be focused, and I argue this is only possible through furanoses (pyranoses are too rigid); hence, the choice of ribose as the only sugar with reasonable levels of furanose in aqueous solution. Polymers form because, owing to osmotic potential, the energy of polymers per mer is lower inside vesicles or micelles. No other nucleic acids can possibly form in dilute aqueous solution, including that based on ribopyranose, which again is actually at a lower energy than that of ribofuranose.

By this mechanism, it could be D or L, and which is chosen is by chance. Incidentally, if true, there can be no under-ice life on Europa: there is no material to make vesicles, there is no photochemistry under the ice, and it is most unlikely that there is the necessary absorbing agent. Another reason is that the mechanism of formation of Jovian satellites that I proposed eliminates the absence of significant levels of nitrogen; this is actually confirmed by limited observations.[1]

Second, an improved theory of chemical bonding

I have an alternative interpretation of quantum mechanics, based on the premise that there is a wave, and that the wave is the reason there is particle diffraction. The next premise is that to influence the particle during diffraction, the phase velocity of the wave must equal the particle velocity, which fixes the energy of the wave with respect to that of the particle. As an aside, this fully explains the otherwise inexplicable results of the two-slit experiment, and the "which way" experiments. To observe the particle, you have to interact with it, and any interaction will change the momentum/energy, which resets the wave, hence diffraction history is lost. That condition means that the energy of the bond is simply a problem in standing wave physics, which is basically back to Pythagoras' theorem. The hydrogen molecule is the simplest molecule (actually simpler than the hydrogen molecule ion). The second premise – which is a premise for all quantum mechanics – is that action is quantised and a stationary state is only possible when this occurs. The third premise is that waves follow standard wave relationships, including being factorisable.

The wavelength of the electron is two Bohr orbits, i.e., $4\pi a$, where a is the Bohr radius. (There are no nodal surfaces, and a wave must have a crest and a trough, therefore a period has two cycles, which, as an aside, is why there is a surfeit of half quantum numbers.) The Exclusion Principle arises because, in general, we have a crest *or* a trough, but electrons can pair if and only if we have a crest *and* a trough. The action in the region must remain constant, and although the frequency doubles in the zone, electrons emerging can go in either direction. Accordingly, the periodic time to a given atom is constant (otherwise the wave would not be single-valued and there would be

self-interference). At constant periodic time and constant action, mL^2 is constant; double the mass means L^2 halves, hence the covalent radius is $a/\sqrt{2}$. For hydrogen, this is predicted, counting *only* electric field relationships, as 37.4 pm; observed, it is 37.1 pm. Not exact, but I have left out some minor variables. The frequency in the bond zone doubles; therefore, since the energy of the wave is proportional to the energy of the particle (in one variant, equal to) the additional energy in the bond zone is 1/3 the Rydberg energy of the hydrogen atom, or 437.4 kJ mol^{-1} (observed, 436 kJ mol^{-1}). The principles apply to the covalent bond in general, except that all other atoms have an additional complication, as they require the orbitals outlined in my 1987 article[2] with an understanding of what changes with electron pairing. The Woodward Hoffmann rules also follow from the requirement that a two-electron stationary wave must have a crest and a trough, except the signs are wrong in the average text book; plus must overlap with minus as the signs indicate the phase of the wave.

The above is obviously a very brief summary; more details on each can be found in my e-books (Amazon) *Elements of Theory.*[1,3] You may not believe the above, which is good, because that would entice you to try and falsify it. I am reasonably convinced it is correct.

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References

1. Miller, I.J. *Elements of Theory. Book 2, Planetary Formation and Biogenesis*. Amazon, 2012.
2. Miller, I.J. *Aust. J. Phys.* **1987**, *40*, 329-346.
3. Miller I.J. *Elements of Theory. Book 1. Aristotelian Methodology in the Physical Sciences*. Amazon, 2011.

Accelerating examination of your patent application

Tim Stirrup and Katherine Hebditch

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Owing to backlogs at the patent office of some countries there can be a wait of up to six years to examine a patent application. This delay can have serious ramifications for commercialisation and may mean that by the time the patent has granted, the technology being protected is yesterday's news. We examine the ways in which you can jump the examination queue and get that patent granted pronto.

After filing a patent application at a national patent office, the application is generally examined to assess whether it meets a number of patentability criteria. The main criteria are novelty (the invention has not been published or used before) and inventive step (the invention is not obvious). The time taken from filing a patent application at a national patent office to having the patent granted is called the patent pendency.

The patent pendency varies from country to country from about one month (for a "convention" application in New Zealand) to about six years (for a national phase application in Brazil). The average pendency for the major patent jurisdictions, i.e., US, Europe, Japan, Australia is about three years. By requesting accelerated examination this pendency can be reduced to about six months.

Why accelerate examination?

A patent applicant will generally be keen to commercialise their invention. Without an indication of patentability, there is uncertainty about what technology the patent will cover (if any). After examination in even one jurisdiction, patent filing strategy and financial strategy can be formulated with more certainty and the likelihood of success in other jurisdictions is more predictable.

As long as the examination finds the invention to be patentable, earlier examination also potentially leads to earlier grant of a patent. This can have knock-on advantages as follows:

- It provides the ability to license/sell/enforce the patent,
- There may be increased investor confidence in granted patent compared to applications,
- Release of investor finance may be dependent on patent(s) being granted,
- Patent assets may be used to increase company value or as leverage during business transactions.

Why not to accelerate examination?

Until a patent is granted, there is uncertainty about the final monopoly the government may grant. This uncertainty can discourage competitors, which may be beneficial to a growing business, especially if the protection you actually expect to be granted is fairly narrow. Other reasons to delay examination include where the applicant may need more time to develop the invention, or may wish to align the patent claims with the actual product to be sold.

Also, there is the cost issue. Some countries levy a fee for accelerating examination and all costs associated with examination, grant and renewal (official fees and attorney fees) are brought forward which may be undesirable. This is especially true for start-up companies in the early stages of commercialisation where funds are tight.

How to accelerate examination

There are four main routes to obtain accelerated examination in most countries:

1. Request accelerated examination at the national patent office.

2. *Green* technology request for expedited examination.
3. Patent Prosecution Highway (PPH).
4. PCT Patent Prosecution Highway (PCT-PPH).

The method that you choose will depend on your patent protection strategy, the nature of the invention and the place where the application has been filed.

1. Request to Patent Office

This method has the advantage that it does not rely on the application having been previously examined at another patent office (which methods 3 and 4 do). However, restrictions on eligibility for accelerated examination are present in many countries. For example, the United States Patent and Trademark Office (USPTO) normally requires the applicant to carry out and provide details of a pre-examination search and analyses the patentability of each patent claim. There are also limits on the number of patent claims that can be included. These requirements can be costly and may unnecessarily narrow the scope of protection afforded by the patent. In late 2011, the USPTO brought in a separate *Prioritized Examination* option which is considerably less cumbersome than the standard accelerated examination procedure. However, this Prioritized Examination procedure costs US$4800 to pursue, which is a major drawback for some applicants.

The patent offices of Australia, Europe and Canada are much more relaxed and will allow requests for accelerated examination without any difficulty. Unusually, the Intellectual Property Office of New Zealand (IPONZ) will only allow accelerated examination to occur if there are "good and substantial reasons", such as suspected infringement. This is a fairly high bar to set but is perhaps justified by the generally efficient examination process of IPONZ as a whole.

2. Green *technology request for accelerated examination*

Several national patent offices offer accelerated examination if the invention is a *green* technology. Australia, Canada, the UK, China, Japan, South Korea and Brazil have green technology accelerated examination programmes with varying requirements.

This option is obviously limited by the technology of the invention. There is no firm agreement between the patent offices as to what exactly constitutes *green.* The Canadian IP Office considers that the patent application must *relate to technology the commercialization of which would help to resolve or mitigate environmental impacts or conserve the natural environment and resources.* The UK IP Office simply requests a statement on why the application is *environmentally friendly* while the JPO goes to the other extreme of requiring that the invention *has an energy-saving effect and contributes to CO_2 reduction*. While some technologies, e.g., a novel wind turbine, would clearly be eligible, for border-line *green* technology, e.g., a new, lighter polymer material that, if used in cars, would increase fuel efficiency eligibility should be assessed on a country-by-country basis.

3. Patent prosecution highway (PPH)

The PPH is a series of bi-lateral agreements between national patent offices to rely on the previous examination search of an overseas office. The aim of the PPH agreements is to reduce office workload by not replicating the examination efforts of other patent offices with a high quality standard. The ultimate goal is to decrease pendency of patent applications.

Generally, if a patent claim has been accepted by one of the selected patent offices, let's call it Office A, a PPH request can be made to a second patent office (Office B). Office B will then allow the application to jump the examination queue and will rely on Office A's patentability search and examination when conducting their own examination.

The patent claims submitted to Office B must correspond with claims allowed by Office A to be eligible for accelerated examination. Often, documentary evidence showing that Office A has accepted the claims will also be required.

Examination will still be conducted by Office B and issues may be raised on the basis of local law or different interpretation of prior art documents. Therefore the PPH process isn't a sure-fire way to get your patent accepted in another country, but it does reduce the time taken to examine it.

Countries that have at least one PPH agreement with another country include Australia, Austria, Denmark, Europe, Singapore, Finland, Russia, Hungary, Spain, Mexico, Portugal, Sweden, Israel, Nordic Patent Institute, Taiwan, Norway, China, Iceland, Philippines, Japan, the United States, the UK, Canada and Germany. The PPH cannot be used between all of these countries in all circumstances and new agreements are being formed all the time between existing and new countries.

The PPH programme has been a great step forward in international patent office co-operation; it has the potential to significantly reduce waiting times and ease the time (and expense) of obtaining granted patents. The programme is especially useful for applicants with a relatively broad market who wish to obtain protection in a number of countries.

4. Patent Co-operation Treaty Patent Prosecution Highway (PCT-PPH)

A patent applicant is normally provided with 12 months in which to file overseas applications after the filing of their initial application. Filing a PCT application (before 12 months is up) provides a further 18 months to decide on which countries to make further applications (referred to as *national phase* applications).

As part of the PCT application process an international search is carried out by an International Searching Authority (ISA). In reality, the ISA is a national patent office with high quality standards and a good breadth and depth of examiner expertise in different areas of technology. The PCT application does not confer any patent rights (i.e., it is not a granted patent) but it does provide a

means to delay the decision of which countries to file in (the national phase applications). The international search provides an indication of whether a patent will be granted once it is filed in each separate country. Even though an international search has been carried out, most countries in which a national phase application is filed will carry out their own search and examination to decide whether to grant a patent in that country.

The PCT-PPH is a series of agreements between ISAs and national offices whereby the national offices accelerate national phase examination and make use of the patentability search of the ISA. To be eligible to accelerate your national phase application using the PCT-PPH, at least one claim must be deemed novel, inventive and industrially applicable by the examiner of the ISA.

IP Australia (the Australian patent office) is often the preferred ISA for New Zealand PCT applicants owing to the efficient and thorough examination they carry out and the lower fees than some other ISAs. However, IP Australia only has a PCT-PPH agreement with the USPTO. This means there is no option to accelerate your national phase application in a country other than the US using the PCT-PPH. A way around this obstacle is to request that the ISA is the USPTO.

Again, the national patent office accelerating the application will not automatically accept the opinion of the ISA, although a favourable opinion can never hurt.

A word on IP strategy for NZ-based applicants

If you know that you would like to accelerate examination of your patent application, consider filing your first (priority) application in the US; this opens up far more possibilities for using the PPH. Also, when filing a PCT application, consider using the USPTO as the ISA. This opens up opportunities to accelerate examination in far more countries than if IP Australia is used.

Finally, let your patent attorney know as early as possible that you wish to accelerate examination. This will enable them to tailor the filing strategy to suit your needs.

If you have any queries regarding intellectual property related matters (including patents, trademarks, copyright or licensing), please contact:

tim.stirrup@baldwins.com and/or *katherine.hebditch@baldwins.com* Patent Proze, Baldwins Intellectual Property, PO Box 5999, Wellesley Street, Auckland

Katherine Hebditch and Tim Stirrup of Baldwins Intellectual Property in Auckland specialise in chemistry and biotechnology patents. Katherine obtained her PhD in organic chemistry from the University of Manchester in the UK in 2004. She is currently working towards registration as a patent attorney. Tim obtained his PhD in molecular biology from the University of Southampton in the UK in 2007. He is also working towards registration as a patent attorney.

Dates of Note

Felix Hoffmann, the German chemist who discovered aspirin while working for Bayer & Co. was born on 21 Jan, 1868. The experimental aircraft *Voyager* completed the first non-stop, around the world flight without refuelling on 23 Jan, 25 years ago. ***Charles Glen King***, the American biochemist who discovered vitamin C, died 25 years ago on 24 Jan. On that same day in 1868, ***John Davy***, the English chemist, first prepared, named and characterised phosgene and, in 1848, ***Horace Wells***, the American dentist, pioneered the use of surgical anaesthesia. That day (24 Jan) also marks the 65th anniversary of IBM dedicating its *Selective Sequence Electronic Calculator* (SSEC); it handled both data and instructions using electronic circuits made with 13,500 vacuum tubes and 21,000 relays, and occupied three sides of a 9 m x 18 m room. ***Victor Moritz Goldschmidt***, the Swiss-Norwegian geochemist, mineralogist and petrologist who established a theoretical background for geochemistry, was born on 27 Jan, in 1888 – 125 years ago, the day that the National Geographic Society was formed in the US. Crystallographer Dame ***Kathleen Lonsdale*** was born on 28 Jan, 1903. On 29 Jan in 1978, Sweden became the first nation to curb aerosol sprays to halt the destruction of the ozone layer. ***Orville Wright***, the American inventor and aviator, died 65 years ago on 30 Jan. ***Theodore William Richards***, the American analytical chemist who was awarded the 1914 Nobel Prize for Chemistry in recognition of his accurate determinations of atomic weights, was born on 31 Jan, 1868 and died on 2 Apr, 1928.

Sir ***George Gabriel Stokes***, the British physicist known for his spectroscopy work, died on 1 Feb, 1903. The first sale of anti-knock gasoline containing tetraethyl lead was on 2 Feb, 1923. February 7 marks the fifth anniversary of the death of ***Alan MacDiarmid***, and the 75th anniversary of the death of ***Harvey S. Firestone***, the American industrialist who developed straight-side pneumatic tyres used on the Model T Fords. It is also the day in 1953 that ***Wilder Dwight Bancroft*** died. He was the American physical chemist who introduced a number of thermodynamic

and colloidal concepts into American physicochemistry. His favourite demonstration proved something whichever way it went: a solution of iodine in water is shaken with charcoal, filtered and tested with starch paste. If the colourless solution does not turn the starch blue, the experiment shows how completely charcoal extracts iodine from aqueous solution. If the starch turns blue, the experiment shows that the solution, though apparently colourless, still contains iodine which can be detected by means of a sensitive starch test. February 7 also marks the day 150 years ago that ***John Newland*** announced his Law of Octaves in which he organised the known elements in order by atomic weight. This was based on his noticing that after each interval of eight elements, similar physical and chemical properties reappeared. The article *On relations among the Equivalents* (*Chem News*, **1863**, *7*, 70-2) was ridiculed by The Chemical Society to the extent that little significance was then attached to atomic weights. However, he was recognized, belatedly, in 1887 by the Royal Society with the award of the Davy Medal – but only after Mendeleev had more successfully introduced his table.

Victor Mordechai Goldschmidt, the German mineralogist who made important studies of crystallography – publishing the *Index der Kristallformen* in three volumes (1886-91), was born on 10 Feb, 1853. ***Frederick Cossom (Fred) Hollows***, the NZ-born Australian physician and a leader in the campaign to combat eye diseases (especially trachoma), died 20 years ago on 10 Feb, as did ***Wilhelm Röntgen*** in 1923. ***Robert W. Holley***, the US biochemist who shared the 1968 Nobel Prize in Physiology or Medicine (with Nirenberg and Khorana) for work that helped to decipher the genetic code chemically, died on 11 Feb, 20 years ago. ***Anders Gustav Ekeberg***, the Swedish chemist who discovered the element tantalum in 1802, died 100 years ago on 11 Feb. ***Julius Arthur Nieuwland***, the Belgian-born American organic chemist who studied reactions of acetylene and invented neoprene, was ordained as a priest before earning his PhD (1904) and was born on 14 Feb, 1878. ***Gottlieb Sigismund Kirchhof***, the German-Russian chemist who applied the first controlled catalytic reaction to produce glucose, developed a method for refining vegetable oil, and experimented with brewing and fermentation, died on 14 Feb, 1833. ***Friedrich Konrad Beilstein***, the Russian chemist who compiled the *Handbuch der Organischen Chemie*, was born on 17 Feb, 1838. On 18 Feb, 100 years ago, English chemist ***Frederick Soddy*** introduced the term *isotope* to science; he received the 1921 Nobel Prize for Chemistry for investigating radioactive substances.

February 22 marks 185 years since German biochemist ***Friedrich Wöhler*** informed Jakob Berzelius that he had synthesized urea, the first synthesis of an 'organic' from inorganic precursors, while 23 Feb marks 120 years since ***Rudolf Diesel*** received a German patent for his diesel engine. DuPont began commercial production of nylon toothbrush bristles on 28 Feb, 75 years ago. ***Giulio Natta***, the Italian chemist who contributed to the development of high polymers, was born on 26 Feb, 1903, the day in 1878 that the French scientist ***Emile Littré*** choose the word *microbe* (rather than *microbial*) for certain microorganisms, even though it was coined from two Greek words that together would mean short-lived rather than small life. ***David Keilin***, the Russian-British biochemist who discovered cytochromes as enzymes critical to the cells' use of oxygen, died on 27 Feb, 50 years ago. February 28 marks 60 years since ***James Watson*** who, from early on what was a Saturday, spent his time at the Cavendish Laboratory in Cambridge, shuffling cardboard cutout models of the molecules of the DNA bases: adenine (A), guanine (G), cytosine (C) and thymine(T). After a while he discovered their complementary pairing. Together with Francis Crick he submitted their first article on the structure of DNA to *Nature* on 6 Mar, 1953. He was born on 6 Apr, 1928. On 29 Feb, 1908, Dutch scientist ***Heike Kamerlingh Onnes*** told an academy meeting that the previous day he had produced solid helium.

Arthur Kornberg, the US biochemist who shared the 1959 Nobel Prize for Physiology or Medicine (with Ochoa) for the discovery of the mechanisms in the biological synthesis of DNA and isolated the first DNA polymerising enzyme, was born on 3 Mar, 1918. ***Albert Bruce Sabin***, the Polish-American physician and microbiologist best known for developing the first oral polio vaccine in 1955, died on 3 Mar, 20 years ago. On that day in 1863 the National Academy of Sciences was chartered with President Abraham Lincoln approving the Act of Congress which established it. On 6 Mar, 1913, ***Niels Bohr*** mailed his first paper describing his new ideas on atomic structure to his mentor, Ernest Rutherford; it was the first of three historic papers on the subject. On 7 Mar 130 years ago ***Johann Kjeldahl*** reported to the Chemical Society of Copenhagen his procedure, still used in the present time (the Kjeldahl method), to enable the laboratory determination of the nitrogen content in organic compounds. ***Walter Kohn***, the Austrian-American physicist who shared the 1998 Nobel Prize in Chemistry (with Pople) for his work on the development of the density-functional theory, was born on 9 Mar, 1923. On the same day in 1893, ***James Dewar*** advised a meeting of the Royal Society that he had succeeded in freezing air into a clear, transparent solid; he died on 27 Mar, 1923.

One year ago on 10 Mar ***Frank Sherwood Rowland*** died. He was the Armenian chemist who shared the 1995 Nobel Prize for Chemistry with Molina and Crutzen for research on the depletion of the Earth's ozone layer. ***Johann Rudolf Glauber***, of salt fame and regarded by many as the German father of chemistry, died the same day, but in 1668. ***Henri-Étienne Sainte-Claire Deville*** was the French geologist and chemist who invented the first industrial process for producing aluminium; he was born on 11 Mar, 1818. ***Walter Norman Haworth***, of projection formulae fame, was born on Mar 12, 1883. ***Vladimir Ivanovich Vernadsky***, the Russian geochemist and mineralogist who was a founder of the sciences of geochemistry and biogeochemistry, was born on 12 Mar, 150 years ago, while Sir ***William Perkin***,of aniline purple fame, was born on the same day 175 years ago (1838). ***Joseph Priestly***, the English chemist who discovered oxygen, was born on 13 Mar, 1733. Sir ***Derek H.R. Barton***, the joint recipient of the 1969 Nobel Prize for Chemistry (with Hassel)

for research that helped establish conformational analysis, died on 16 Mar, fifteen years ago. ***Mario Molina***, the Mexican-American chemist who shared the 1995 Nobel Prize for Chemistry (with Crutzen and Rowland) for research on the ozone layer, has his 70th birthday on 19 Mar. Sir ***Walter Norman Haworth***, the English chemist who shared the 1937 Nobel Prize for Chemistry (with Karrer) for work determining the chemical structures of various carbohydrates and the synthesis of vitamin C, was born on 19 Mar, 1883.

Pierre-Joseph Pelletier, the French chemist known for his work on vegetable bases and the resulting contributions of alkaloids in medicine, was born on 22 Mar, 225 years ago. ***Adolf Friedrich Johann Butenandt***, the German biochemist and co-winner (with Ruzicka) of the 1939 Nobel Prize for Chemistry for pioneering work on sex hormones (primarily the isolation of estrone) was born on 23 Mar, 1903. March 25, 1843 saw the Thames Tunnel – the world's first tunnel under a navigable river – opened for pedestrians between Rotherhithe and Wapping. ***James B. Conant***, the chemist President of Harvard University and 1951 University of NZ honorary DSc, was born on 26 Mar, 120 years ago. ***Elija McCoy*** (the real McCoy) was born on 27 Mar, 1843; he held many patents for the automatic lubrication of machinery. March 27 was the day in 1933 that polyethylene was discovered by ***Reginald Gibson*** and ***Eric William Fawcett***. ***Auguste Bravais***, the French physicist and mineralogist, best remembered for his work on the theory of crystals, with Bravais lattices named after him, died 150 years ago on 30 Mar. ***Richard Pearce*** reputedly flew his powered heavier-than-air machine, some nine months before the Wright brothers on 31 Mar, 1903.

April 2, 1938, saw Du Pont researcher ***Roy J. Plunkett*** and his technician ***Jack Rebok*** accidentally discover polytetrafluoroethylene (PTFE; Teflon). ***Martin Julian Buerger***, the American crystallographer who devised or improved many of the standard methods, techniques, and instruments of modern crystal-structure analysis, was born on 8 Apr, 1903. On the same day in 1818 ***August Wilhelm von Hofmann***, the noted German heterocyclic chemist, was born. ***Paul-Louis-Toussaint Héroult***, the French metallurgist and chemist who invented the electric-arc furnace, was born on 10 Apr, 150 years ago. On that same date in 2003, the retirement of all *Concorde* supersonic jets was announced simultaneously by British Airways and Air France.

On 12 Apr, 1888 (125 years ago), a French newspaper mistakenly published an obituary for Albert Nobel, inventor of dynamite, calling him "a merchant of death." The mistake was that it was Albert's brother, Ludwig, who had died (aged 56, because of heart trouble). However, shocked by the newspaper's report, Albert began to seek a change in public opinion, which led to his decision to establish the Nobel Prizes. Insulin became generally available for use by diabetics on 15 Apr, 1923. ***Ernest Solvay***, the Belgian industrialist who invented the commercially viable ammonia-soda process – the Solvay Process – for producing sodium carbonate, was born on 16 Apr in 1838, 175 years ago. ***Rosalind Franklin***, the English X-ray crystallographer who contributed to the discovery of the molecular structure of DNA, died 65 years ago on 16 Apr, the day in 1943 that the hallucinogenic effect of LSD, was first observed. ***Justus von Liebig*** died on 18 Apr, 1873. It is also the 175th anniversary of the birth of French chemist ***Paul-Émile Lecoq de Boisbaudran***. Although relatively unknown, he developed and improved the spectroscopic methods developed by Kirchhoff. In 1859, he set out to scan minerals for unknown spectral lines and later discovered the elements gallium (1875), samarium (1880), and dysprosium (1886). He ranks with Bunsen, Kirchoff and Crookes as one of the founders of the science of spectroscopy.

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Science in the News

2013 Science Investment Round

The Ministry of Business, Innovation and Employment (MBIE) organised a roadshow and visited a number of research institutions in December last year to highlight their 2013 Science investment round.

It plans to run investment processes for the following areas with the maximum amount of funding per annum as follows:

Biological Industries	$38.4 million
High-Value Manufacturing and Services	$7.8 million
Energy and Minerals	$2.3 million
Health and Society	$2.3 million
Environment	$2.2 million

Applicants will be asked to provide a brief outline of their research proposal, which needs to be submitted by 8 February 2013.

For Biological Industries Research Fund applications the MBIE Portal closes 3 April 2013.

For all other research fund applications the MBIE Portal closes 4 April 2013.

See: *http://www.msi.govt.nz/get-funded/research-organisations/2013-science-investment-round/*

Science in the News continued...

The Prime Minister's Science Teacher prize 2012

Peter Stewart, Head of Chemistry at Papatoetoe High School was the recipient of the 2012 Prime Minister's Science Teacher prize. This award is given in recognition of an outstanding teacher of science and translates as a $150,000 prize with the recipient receiving $50,000 and the recipient's school receiving $100,000.

Mr Stewart has succeeded in increasing high school student's interest in studying chemistry at his South Auckland school. Student chemistry numbers at level two have increased by 44% and are up by 100% at level three. Students studying chemistry are students in other subjects and this is resulting in an increase in the number of students gaining chemistry scholarships.

He prepares chemistry workbooks and summaries for his students, video tutorials along with resource notes, homework papers and quizzes, and he participates in seminars and open days to promote science to primary and intermediate schools.

Mr Stewart was the subject of a Campbell Live programme on television on 29 November 2012 where he explained how he encouraged student enthusiasm in chemistry through experiments which involved making solar balloons, water rockets, vortex cannons and parachute landing systems. His students were all enthusiastic about the subject he taught and were keen to continue studying chemistry as they really enjoyed his lessons.

Mr Stewart states: "I enjoy thinking of ways to make science relevant, telling them stories, doing the unexpected and creating a sense of wonder. If they're excited, curious and engaged in science, they are open to learning.

"The highlight is the success of students. It is such a pivotal time, going through high school and making decisions that set their lives for many years to come. If you get them to see they can achieve, it helps them succeed.

"I'm competitive, I'm project driven, I'm always wanting to do better and I want to find how I can get 100 percent pass rates for students because I want them to see succeed."

Marsden fund awards 2012

The Marsden Fund supports research excellence in science, technology, engineering and maths, social sciences and the humanities. A total of 1113 preliminary proposals were submitted to the Marsden Fund 2012 and of these 229 were called to submit full proposals. From these 86 proposals were allocated $54.6 million, which represented a success rate of 7.7%. More than one-third of these awards were Marsden Fast-Starts, designed to support outstanding researchers early in their careers (between zero and seven years after their PhD). These data are published on the Marsden website at *http://marsden.rsnz.org/*.

The Marsden Fund Council chairperson Professor Juliet Gerrard stated:

"The Marsden Fund supports the very best investigators to do world-class basic research. Marsden lets our brightest investigators work on their best ideas, without worrying about short-term priorities. Many of these ideas are high risk, but potentially very high gain. In the long term, we expect some of these projects to make a big difference to New Zealand, in terms of economic growth, social issues, and a wider understanding of who we are as New Zealanders.

"It is widely accepted worldwide that the most important breakthroughs are made when the best researchers are funded to work on their most exciting ideas. This is what makes the Marsden Fund so vital for the long term success of New Zealand and makes Marsden researchers such an inspiring community.

"The huge enthusiasm of New Zealand researchers to engage in basic research means the Fund is always oversubscribed and it is a great pity that we are not able to fund more of these obviously worthy proposals, which have been ranked by international referees as the very best in their fields. However, it is great to be able to fund such a wide variety of projects from across the country and the academic spectrum and know that they are all of exceptionally high quality. New Zealand produces researchers that are of the very highest calibre and their Marsden-funded research is highly respected internationally."

Chemistry awards included:

Dr Joseph Lane, The University of Waikato: 'Photodissociation of nitrous oxide in the atmosphere'

Dr Paul Plieger, Massey University: 'The good without the bad: selective chelators for beryllium'

New Zealand Science students selected for Realise the Dream

The National School Science and Technology Awards 2012

Realise the Dream, sponsored by Genesis Energy is a competition aimed at secondary school students in Years 9 – 13 who enter after being nominated by their teacher. Each student must produce a piece of outstanding scientific work in the form of a science project, an electronics software project or a technology project. Nominations are forwarded to The Royal Society and a Realise the Dream judging panel meets to select the finalists.

Students who are successful at this selection panel meeting are then eligible to be selected for a number of awards.

These include the following:

Genesis Energy Supreme Award: a monetary award and all expenses paid trip to attend the European Union