

Section 1

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President's Report

It was a pleasure to welcome the University of Otago (New Zealand) as a member of AINSE this year. The President and Scientific Secretary visited Dunedin in March 2006, presenting aspects of the AINSE process to academics from various departments as well as giving a lecture in the Department of Chemistry. The preparatory work of Professor Hans Coster and the Scientific Secretary in establishing New Zealand connections during 2004-5 is a pleasure to acknowledge here and we hope that others from New Zealand will join AINSE in due course.

The year also began with the opening (by the Science Minister Dr Brendan Nelson) of the STAR accelerator facility. This is greatly enhancing AINSE's activities in the archaeology, and environmental sciences providing, for example, reliable dating and quick service. New services to analysis in materials science are also in place. The cooperation of the ANSTO's Institute of Environmental Research is warmly acknowledged in this project, as is the support of all the universities who contributed to the major Australian Research Council RIEF Grant proposal, which bought the accelerator. AINSE will continue to leverage funds for new facilities at ANSTO for the benefit of nuclear science and technology in Australia. In 2005 negotiations were begun for the gift of the accelerator to ANSTO. This process is well underway and we expect resolution by July 2006.

In 2005, also, proposals for access to ANSTO facilities through the AINSE Specialist Committees were very strong. A web-based "single-portal" system for proposal submission and review came into action for the first time. I congratulate the AINSE staff on the achievement of this. The words "single-portal" mean that all proposals for the use of HIFAR whether from AINSE members, ANSTO or post-graduate scholars, all came under the review of the Materials –Structures and Dynamics Specialist Committee. Committees continue to function very well and the systematic rotation of membership introduced last year has shown its advantages. A good sign for the future has been the great interest in self-nomination for AINSE Specialist Committee membership by distinguished scientists after a call for this by the Executive in 2005. We expect the flow of talent onto the committees and their strength in evaluation of proposals to continue. AINSE's strategic plan demands quality outcomes through rigorous peer review and contestability.

In December 2004 the initial round of bench marking of the quality of AINSE scientific performance was reported to the Council. The first sectors of the AINSE program tested were the Structures and Dynamics Specialist Committee's activities. Inputs, outputs and outcomes (in terms of citations and leverage of external funding) were all part of the performance criteria. A very good outcome showing the strength of AINSE sponsored work against ANSTO's internal program put both operations into a very good light. The second sector of AINSE's work, environment, geoscience and archaeology has been under review by a similar process in 2005 led by Professor Allan Chivas, from the University of Wollongong, and Dr Ann Henderson-Sellers of ANSTO's Institute of Environmental Research. Ann has gone to a senior position in Geneva with the World Climate Research Programme and we wish her well.

In 2005 it was decided that proposals for access to neutron scattering facilities at the OPAL reactor would come in through a "single-portal" review system proposed by the Bragg Institute. This will start up when the new reactor is in operation and the Review Committee will have two AINSE-nominated members. The AINSE Structures and Dynamics Specialist Committee will continue to exist and will have a special remit of advising the Council in



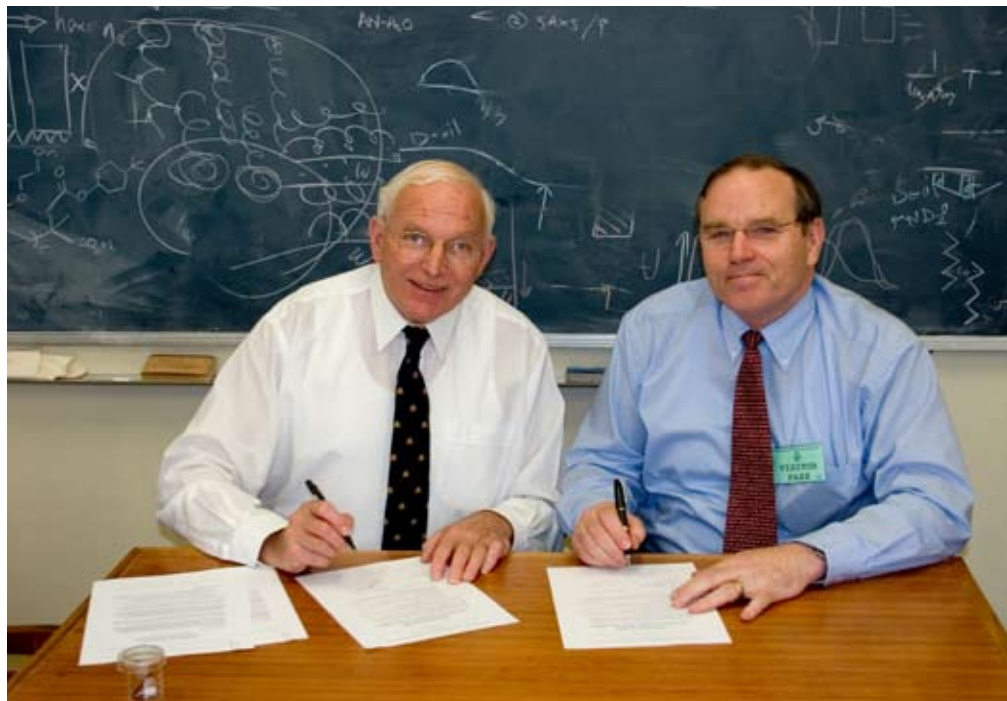
this area as well as the promotion of further outreach processes to ensure the long-term success of the OPAL reactor for science and technology in the universities.

Associated with this outreach, the AINSE Council decided in December 2005 to launch a new AINSE Research Fellowship Scheme. This scheme is aimed at attracting young "high fliers" into university systems to form excellent groups capable of doing new science in the area of neutron scattering - in the first instance. Funds will be provided as a result of the changing norms for funding at major research facilities recommended by the National Collaborative Research Infrastructure Scheme (NCRIS) report of 2005. AINSE made two different submissions to the NCRIS process review. The Research Fellowships are funded up to the top of the Level B (university scale) and with generous allowances for setting up, travel, conference attendance and experimental work at the OPAL reactor. All AINSE university members have been invited to participate and possible extensions for this scheme through financial "buy-in" by universities can be negotiated. The "tenure track" aspect of the scheme is important - aiming to have the universities collaborating on the appointments from the outset.

AINSE has continued to support major conferences and exhibitions in nuclear science. The International Conference on Neutron Scattering (ICNS) in December 2005, strongly backed by AINSE, was a success with 737 registered delegates from 38 countries and over 600 poster presentations. The collaboration between AINSE, ANBUG and ANSTO produced the excellent result and I thank all concerned for their contribution. The conference proved to be a model for continuing AINSE involvement.

A key development of the year was the signing of the new Memorandum of Understanding between AINSE and ANSTO by the President of AINSE and the Chief Executive of ANSTO (Dr Ian Smith) on the 21st December 2005. This memorandum covers the period 2006-2011 and embodies the close collaborative relationship between AINSE and ANSTO. This collaboration is now approaching 50 years in duration. In that connection, the AINSE Council has commissioned a history of AINSE to be produced in 2008 marking the 50th anniversary of AINSE operations. The track record already apparent in distinguished appointments in Australia and overseas is very strong and it is hoped that the history will feature this.

Professor John W White
President of AINSE
3rd April 2006



Professor John White and Dr Ian Smith signing the AINSE/ANSTO Memorandum of Understanding to govern relations between the two organisations for the next 5 years

Scientific Secretary's Report

During 2005 under the leadership of our current President, Professor John White, AINSE has continued to move the organisation forward. Our second benchmarking document, which focussed on accelerator science and dating, is well underway and now we will progressively move to benchmarking other areas of activity.

The AINSE Council meeting in December was a great success, thanks to University of Queensland's Councillor, Dr Paul Meredith.

The extension of membership to New Zealand Universities has continued with GNS Science becoming a full member, along with The University of Canterbury. In addition Otago University became a financial member in December for 2006. I welcome these new members and look forward to further discussions with several other New Zealand universities in the coming year.

AINSE's conference activities saw us underwriting our second major international Conference, the International Conference on Neutron Scattering. This conference made a modest profit for the organisation and contributed to the conference revenue, see figure 1. The NTA conference, rebadged this year as Nuclear and Complementary Techniques of Analysis Conference, included a significant number of papers based on synchrotron measurements. It was held off shore for the first time ever – in Wellington New Zealand and I am grateful to the team at GNS Science who provided valuable assistance in organising this meeting. The introduction of the International Travel Scholarship which is designed to assist students and post doctoral fellows to present their work at international meetings, has continued to grow with nine scholarships being awarded throughout the year, more details can be seen on pages 18-19.

In August the immediate Past President Professor Hans Coster and I attended the trans Tasman meeting Australia-New Zealand Bilateral Science & Technology Meeting on Tuesday 23 August and contributed to discussion on cooperative arrangements across the Tasman.

For the first time in my period as Scientific Secretary this year we recorded three Patent applications in the Publications section.

The Plasma Group has been working on increasing awareness in the newest and largest plasma fusion experiment, ITER. They have been lobbying for Australian involvement in this important international collaboration. DEST support has been secured for a workshop for this purpose and it will be attended by academics, potential industry partners and senior ITER representatives. This workshop will be conducted during 2006.

Council and Committees

On AINSE Council the following changes occurred during 2005:

Monash University's Dr Trevor Hicks was replaced by Professor Rob Norris;

University of Technology Sydney's Professor Evan Leitch was replaced by Professor Greg Skillbeck;

Victoria University's Professor Albert McGill was replaced by Professor Michelle Towstoles;

The University of New South Wales' Professor Hans Coster was replaced by Professor Bob Burford;

Flinders University's Professor Peter Teubner, was replaced by Dr Michael Brunger;



Queensland University of Technology's Professor Riaz Akber was replaced by A/Professor Ray Frost;

The University of Southern Queensland's Professor Malcolm McKay was replaced by Professor Graham Baker.

ANSTO's Professor Ann Henderson-Sellers had accepted a position of Director of the World Climate Research Programme in Geneva. She will be missed and AINSE wishes her all the best in this challenging new role. Also Dr Henk Heijnis as moved on to the Sydney Water Catchment Authority. Henk has been one of the most dedicated supervisors of students at ANSTO and contributed in many other ways including the Winter School program and the Quaternary Science Workshops.

AINSE is grateful for the dedication and generosity of all those who contributed to the various committees and Council. Without their input the organisation would not be able to move forward with such surety.

The commitment to refresh membership of the specialist committees has resulted in at least one change on each of these committees, see page 6 of Section 2 of this report for more information.

Finances

In 2005, income of \$3,015,662 was made up of \$2,366,993 from membership fees, \$391,250 from external grants, \$169,843 from interest, \$75,474 from conference income and \$9,971 from other sources. Membership subscriptions are reviewed annually to determine AINSE support for each university. On average, for the period 2000 to 2005 inclusive, universities received research and training benefits amounting to 3.24 times their subscriptions, which represents a small increase on the average reported last year, 3.13.

AINSE's operating expenses in 2005 were \$2,877,428, leaving a surplus for the year of \$138,234, see figure 2. The majority of AINSE funds are used to facilitate travel and access to Lucas Heights for university researchers and their research students and while the initial budget for 2005 Awards was \$1.6 million uptake was \$1,464,493.

The Financial Statements for the calendar year 2005 are in section 2 of this report starting on page 8 were prepared by ANSTO Finance and audited by Mr Phillip Escott of Escott Aston and Co.

Awards and postgraduate research awards

A total of 189 Awards were made in 2005 and another 34 were carried over from previous years. Figure 3 shows the distribution of AINSE Awards by specialist area. Research highlights in each of the specialist areas are given below on pages 6 to 15. Progress reports for each of the projects can be found on our home page. Of the 189 Awards 155, or 80% were conducted in collaboration with ANSTO. First time award holders in 2005 represented 27 per cent of the cohort, this ratio has been stable in the past few years. I attribute this continuing high influx, in part, to the diligence of our Councillors and to my university visit program; in 2005 I spoke with researchers and students at 19 member campuses. My thanks go to the Councillors without whom these visits would be much more difficult to organise and not nearly as effective.

In 2005, 11 of the 60 AINSE Postgraduate Research Award holders received an award for the first time. During the year five PhD theses were received and two candidates withdrew. The AINSE postgraduate research award holders accessed the facilities for a total of 1866 days. In addition, another 91 students gained access to the facilities via awards held by their supervisors for a total of 668 days.

This year we record 216 papers published in refereed journals, and 16 books or chapters of books; 172 conference presentations and 155 theses not previously reported including 36 dated 2005. Details of publications can be found in section 2 of this report.

Acknowledgements

I thank the ANSTO CEO, Dr Ian Smith who has provided constructive advice throughout the year and supported AINSE in many ways. I also extend my thanks to all those from the universities and ANSTO, there are far too many to name individually, for their help and advice throughout the year.

In the AINSE Secretariat Ben Thompson, Rhiannon Still, Nerissa Phillips and Sandy O'Connor have continued to work to maintain the long standing reputation of a friendly, responsive and cooperative secretariat.

Finally, a special thanks to Peter Thompson at Apt Ventures Pty Ltd who has provided invaluable assistance with the compilation of this report.

Dennis Mather
Scientific Secretary

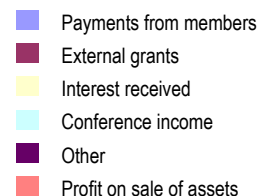
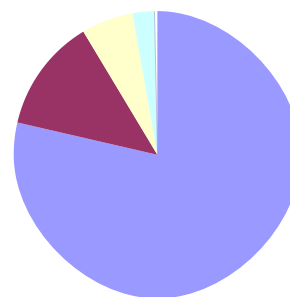


Figure 1 Operating Revenue

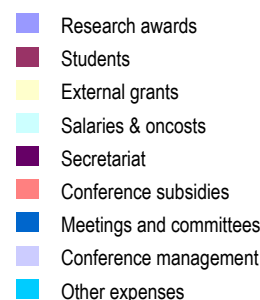
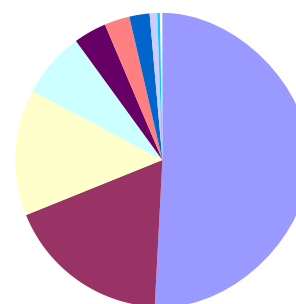


Figure 2 Operating Expenses

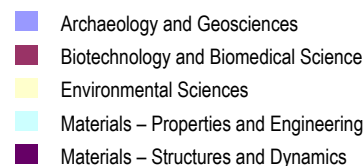
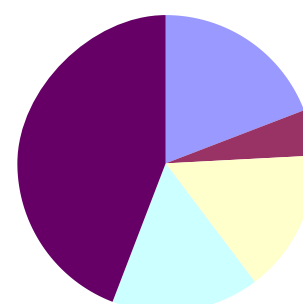


Figure 3 Awards Expenditure by Specialist Area

Research Highlights

Archaeology and Geosciences

Carbon-14 dating of neolithic migration

In 2003-2004, archaeological research in the Batanes Islands (northern Philippines) established that a Neolithic population from Taiwan arrived at least 3000 years ago. The relevant site, called Sunget, on Batan Island, was dated by conventional carbon-14 dating of charcoal and marine shell, and by Accelerator Mass Spectrometry (AMS) carbon-14 dating of burnt food residues inside pottery. Because of suspicions about the validity of the Sunget dates from food residue scraped from inside pottery vessels, Professor Peter Bellwood of the Australian National University and Dr Geraldine Jacobsen at ANSTO sought to compare results using different materials from two other Philippine archaeological sites newly discovered in 2004: Torongan Cave and Anaro, both on Itbayat Island, Batanes.

The food residue and marine shell dates from Torongan Cave conform well to depth-age expectations, and do not indicate excessive error for the food residue samples caused by reservoir effects. These results tighten the dating profile for the initial migrations of Neolithic Austronesian-speaking peoples from Taiwan into the Philippines and Indonesia to around 4000 years ago. These migrations continued eventually to populate the whole Pacific region, including Polynesia and New Zealand.

These migrations were followed, after 3500 years ago, by the development of a trading and manufacturing network utilising Taiwan jade that involved Taiwan, the Philippines, East Malaysia and southern Vietnam. The Anaro food residue date fits well within a carbon-14 sequence associated with the continuous import of jade from Taiwan to Itbayat between 3000 and 1300 years ago. A new date was also established from the Sunget site, taken from an external resin coating on pottery, with the intention of comparing the result with the two previously obtained food residue dates from Sunget of around 3000 years ago. In this case, it is clear that the ancient potters were using fossil resin rather than tapping a fresh resin source.

The archaeological results conform well with the view that Austronesian migrations commenced from Taiwan about 4000 years ago and then proceeded to the Batanes Islands and Luzon. The available data on comparative carbon-14 results on different materials do not indicate any marked deviation between food residue and marine shell dates.



Excavations in Torongan Cave, Itbayat Island, northern Philippines.

Humans, climate change and Kangaroo Island

Environmental changes that have occurred in the catchment of the Murray-Darling Basin, especially since deglaciation, began and during the Holocene Epoch (the last 12,000 years), are being studied by Professor Patrick De Deckker and Dr Franz Gingele of the Australian National University (ANU), and Drs Eva Calvo and Carles Pelejero of the ANU and the Institut de Ciències del Mar (Barcelona, Spain).

Samples of planktic foraminifers (microscopic calcareous organisms that live near the surface of the oceans) have been extracted from a deep-sea core offshore Kangaroo Island and dated using ANSTO's Atomic Mass Spectrometry facilities.

Results have yielded a good chronology for climate changes spanning the last 13,000 years in the Murray Darling Basin. One important finding is that the last 5,000 years saw a progressive increase in aridity in eastern Australia and this is backed up by records from two lakes in south-east Australia. Other, preliminary results indicate that the increase in aridity coincides with a progressive sea-surface temperature drop over the last few thousands of years. It is anticipated that the results on sea-surface temperature changes recorded off Kangaroo Island will indicate the time frame for oceanic temperature changes off South Australia generally.

Gaining a thorough understanding of environmental changes over a long period should give us some perspectives on the degree to which these changes are influenced by human activity. And being able to observe the historical patterns may allow us to be better at anticipating future environmental challenges.

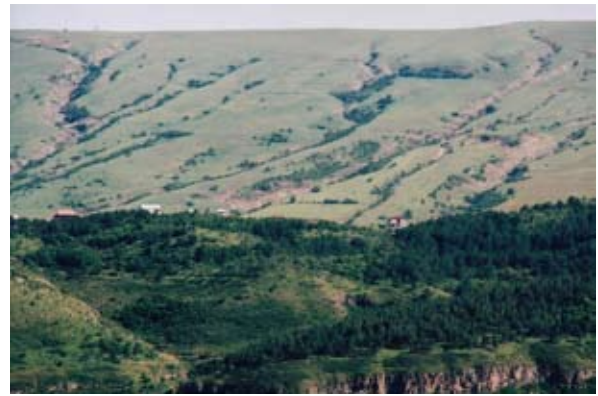
It is important that we gain a better understanding of patterns of climate change in the Australian region. This work on a deep-sea cores provides a strong link between changes that occurred not only at sea but also in the entire Murray-Darling Basin.

Prehistoric climate and agriculture in western Asia

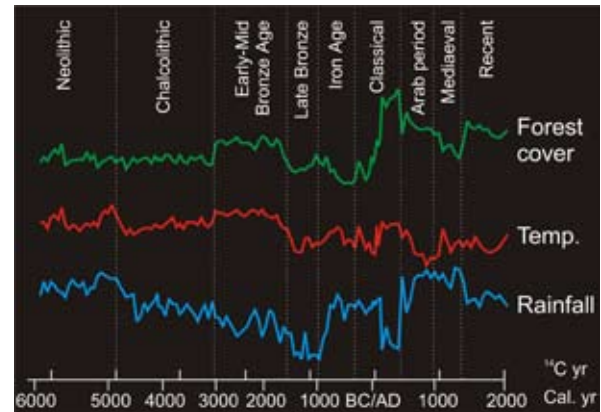
Western Asia is regarded by many as the birthplace for many agricultural plants and grain agriculture. To the north of Turkey and Iran, the Caucasus region is the home of the grape vine, many cereals and various fruit trees. Agriculture emerged in the Caucasus at an early date, but we know relatively little about prehistoric environmental conditions and their impact on culture and economy.

AINSE Postgraduate Research Award scholar, Simon Connor, has been investigating the problem of prehistoric environments of the Caucasus with the support of Dr Eliso Kvavadze of the Georgian Palaeobiology Institute and Dr Ian Thomas and Associate Professor Tony Sagona from the University of Melbourne. Analysis of pollen in AMS radiocarbon-dated sediment cores from eight sites shows that environmental conditions at the time of early agriculture were very favourable to cereal crops. As climates changed, people changed their economic strategies to exploit the new conditions, or used fire to manipulate the landscape to suit their needs. The present-day landscapes of the Caucasus have been shaped by a long history of human impact.

The relationship between temperature, rainfall and forest cover shown in the graph opposite is an indication that people's settlement choices through prehistory in the semi-arid parts of the Caucasus were governed, to an extent, by climate. During warmer periods highland environments were settled, while in cooler periods the highlands were abandoned for the lowlands. During drier periods, grazing became the predominant agricultural activity, while in wetter spells cereal cultivation expanded. So, even though humans were able to manipulate the vegetation cover to their advantage, they had to react to climatic changes with flexibility.



Cultural landscape around Tbilisi, the capital of Georgia



Timeline of changing landscapes and climates from a site near Tbilisi reconstructed from pollen data and AMS dates

Gelam of Mua

In a legendary tale from Torres Strait, Gelam is an ancestral hero whose homeland is along the northeastern coastline of the island of Mua in the central-western Straits.

Over the past five years the local Mualgal Native Title group and Dr Bruno David of Monash University have worked with a multidisciplinary team of university-based scientists to research the cultural and natural history of Gelam's homeland. Research has been prompted by the great importance of this area to the indigenous people of Mua and by its being endangered by rising sea levels. Atomic Mass Spectrometry radiocarbon dating at ANSTO has been central to these investigations.

Bulbul from Gerain ridgetop

According to legend, Gelam lived amidst the dune-fields of Bulbul, and hunted and cooked Torres Strait pigeons on the nearby ridge-top at Gerain.

Geomorphological investigations by Meredith Orr from Monash University indicate that the Bulbul beach ridges date to the last 3000 years, but burning activity evidencing the presence of people at Bulbul dates exclusively to the last 900 years. Therefore, if Gelam was an historical figure, he most likely lived at Bulbul sometime during the last 900 years, the period of anthropogenic burning in this area. Along the Gerain hilltop nearby, hunting camps date only to the last 290 years, although it is not yet known whether or not the Gelam story is restricted to that time partly because only some parts of the ridge-top are yet to be surveyed.

These results have revealed detailed archaeological and geomorphological sequences for this part of Torres Strait. They have also identified that the Gelam oral tradition is likely to be less than 900 years old. The major implication is that the Gelam story was not introduced by colonising Melanesian seafarers to the Strait around 3500-2500 years ago, but rather dates to a more recent period of Mua's cultural history.

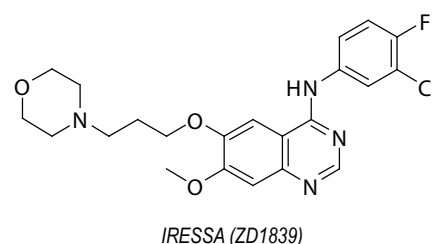


Research Highlights

Biomedical Science and Biotechnology

Research collaborations between ANSTO and several universities have been significantly refined during the last few years with a clear focus on applications of radiopharmaceutical science in imaging cancer and neurodegenerative disorders. Several highlights of this research have resulted from collaborations between ANSTO and the Universities of Sydney and Wollongong.

The focal point of research in 2005-2006 has been in the area of radiopharmaceutical development. In particular development of novel ligands suitable for radiolabelling with Single Photon Emission Computer Tomography (SPECT) and Positron Emission Tomography (PET) isotopes for imaging the above diseases.



Computational modelling of the growth factor receptors

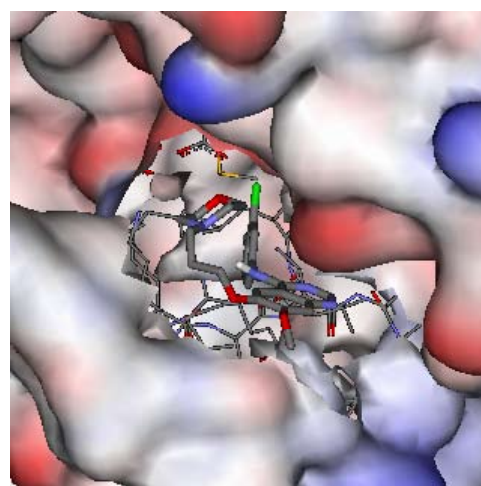
The transmembrane proteins—the epidermal growth factor (EGF) and the vascular endothelial growth factors (VEGF) together with their intracellular receptor tyrosine kinase (RTK) domain—are important mediators in the signalling processes that regulate cell division, growth and differentiation. The over expression of growth factor receptors has been implicated in human cancers. Recent antitumour development has therefore been directed toward the components of this receptor signalling system. Furthermore the relatively high levels of growth factor expression in tumours suggests that radiolabelled tracers can be developed for use in imaging cancers in nuclear medicine.

Associate Professor Paul Keller and his team at the University of Wollongong have been collaborating with Dr Andrew Katsifis at ANSTO in a project to design and synthesise novel new small molecule inhibitors of receptor tyrosine-kinases, incorporating a variety of radiohalogens that may be used to image and study tumour growth and proliferation with both PET and SPECT.

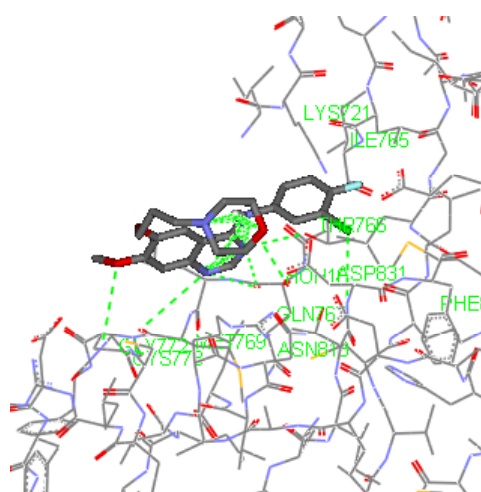
The processes of increasing the number of EGF/VEGF receptors (up-regulation) in cancer cells are well established targets for cancer treatment. This is also supported by the presence of a number of drugs that inhibit EGF/VEGF receptors such as IRESSA (ZD1839). These inhibitors also show great potential for being developed as radiopharmaceuticals for cancer diagnosis and therapy.

Molecular modelling studies on the crystal structure of these receptors has been undertaken to investigate how the drugs bind (for example, IRESSA in the EGF receptor binding pocket). The docking of these inhibitors is being used to gain more insight into what structural features are most beneficial for binding. This information could lead to the development of new inhibitors and radiopharmaceuticals with higher affinity and specificity for the EGF/VEGF receptors.

A clear understanding of the ligand–protein interactions is not only assisting in the development of novel analogues, but is also assisting in the design and development of radiopharmaceutical analogues by optimising where the incorporation of the radio halogens iodine and fluorine should occur.



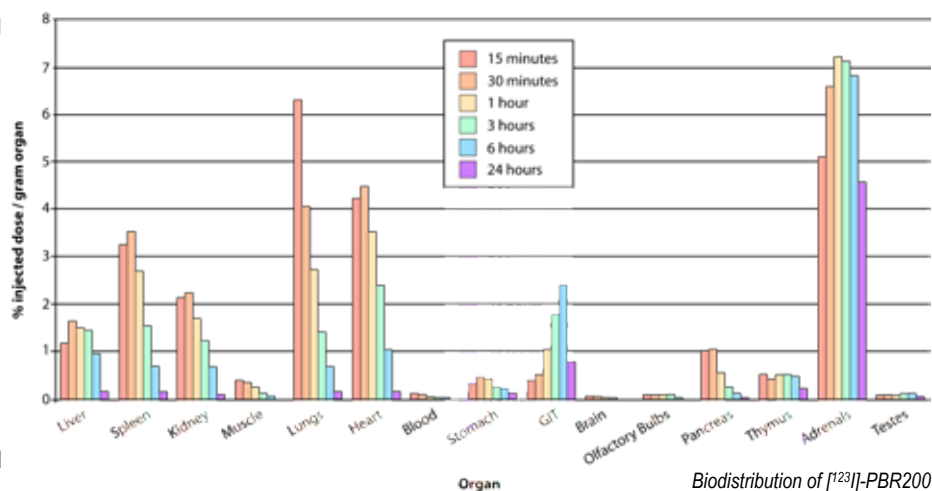
IRESSA in EGF receptor binding pocket
Docked structure shown in cavity of the binding pocket



IRESSA in EGF receptor binding pocket
Docked structure showing binding interactions with amino acid residues of the binding pocket

Novel ligands for imaging the peripheral benzodiazepine receptor

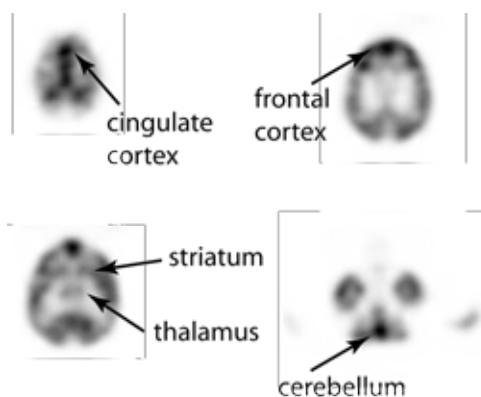
Research by Dr Andrew Katsifis at ANSTO and by Associate Professor Paul Keller and AINSE postgraduate scholar Taryn Homes from the University of Wollongong has led to the development of a series of halogenated N,N-dialkyl-2-phenylindol-3-ylglyoxylamides with high affinity binding for the peripheral benzodiazepine type receptors implicated in neurodegenerative disease and cancer. This receptor is found in a higher density in cancers of the ovary, liver, colon, melanoma, breast, and also in neurodegenerative diseases such as Multiple Sclerosis and Alzheimer's disease. The synthesis of compounds which bind to this receptor have potential to be used for studying these diseases, and also for potential diagnoses.



The most potent of these ligands synthesised during the last 12 months was radiolabelled with the short lived SPECT radioisotope iodine-123 and evaluated in rodents. The radiolabelled compound, named $[^{123}\text{I}]\text{-PBR200}$, was prepared in high yield then injected into normal Sprague-Dawley rats to determine its biodistribution.

The biodistribution data suggests that the compound has properties suitable for further development as a potential imaging agent for neurodegenerative disorders. Taryn Homes will continue optimising this ligand as well as evaluating it in a number of animal models of disease.

So far many compounds have been synthesised which have been shown to bind specifically to the receptor, and one has been radiolabelled with the radioisotope iodine-123. This radiolabelled compound shows promising results in preliminary animal studies, and it is planned that this compound will be tested in animals in tumours.

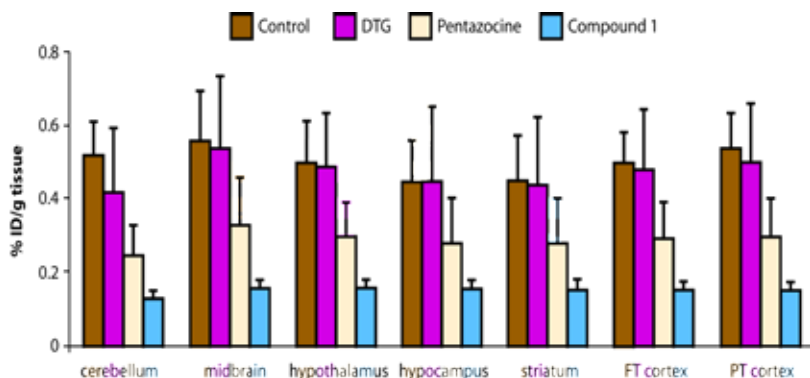


The uptake, as indicated by the dark regions, of the carbon-11 derivatised sigma radioligand in the brain of a healthy male baboon using a Siemens PET/CT scanner after 1 hr post injection.

Synthesis and *in vivo* evaluation of sigma receptor radioligands

A collaborative project involving Dr Michael Kassiou from Sydney University and Dr Andrew Katsifis at ANSTO has been investigating the imaging potential of sigma specific radioligands in neurodegenerative disease and cancer. Although sigma receptors are known to be involved in several central nervous system disorders, their mechanisms have not been fully understood.

The research has identified lead compounds based on arylalkyl 4-benzyl piperazines which were subsequently modified for radiolabelling with the radioisotope iodine-123 and carbon-11 for SPECT and PET imaging respectively. The resultant iodine-123 and carbon-11 labelled radiopharmaceuticals were evaluated *in vitro* and *in vivo* in both rodents and non-human primates. It was found that both the iodinated and the methyl ether (carbon) analogues showed high sigma-1 inhibition. SPECT studies of the iodine-123 radioligand



in rats were performed at ANSTO while PET studies of the carbon-11 radioligand in primates were carried out at Sydney University. These studies provided information that showed that both these sigma selective compounds have good uptake in brain regions containing sigma receptors.

In summary, the research has produced compounds that demonstrate specific sigma receptor binding *in vitro* and *in vivo* and should serve as templates for the development of other selective sigma-1 receptor radioligands for imaging neurodegeneration and cancer using SPECT and PET.

The uptake of iodine-123 radiolabelled sigma-1 ligand in rat brain (brown) with competition studies with known sigma ligands (purple, yellow) and non-radiolabelled analogue (blue) indicating that the uptake in the brain was specific.

Research Highlights

Environmental Science

Smoky season in Launceston

The city of Launceston, Tasmania, experiences significant air pollution during winter months and it has been thought that residential wood combustion is the main source of particulate matter with a diameter less than 10 microns (PM10).

As well as being a technique for dating historical artefacts, carbon-14 analysis applied to air particulates provides direct quantification of fossil carbon sources compared to modern ones (i.e. biomass), thereby distinguishing between pollution originating from fossil fuel exhaust and that from woodsmoke. Wood, like all living things, has a constant amount of carbon-14 in it. Since carbon-14 has a half-life of 5730 years, none remains in fossil fuels which are millions of years old. Thus measuring the amount of carbon-14 in the air pollution particles can reveal the relative contributions of woodsmoke (modern) and fossil fuels.

Dr Timothy Jordan and Dr Andrew Seen of the University of Tasmania, Dr John Gras from CSIRO Marine and Atmospheric Research and Dr Geraldine Jacobsen from ANSTO used the ANTARES particle accelerator for carbon-14 analyses of PM10 sampled in Launceston. These revealed that modern carbon sources contribute 97-99% of the total organic carbon mass of wintertime ambient PM10 particles, supporting the conclusion that woodsmoke is the main contributor to Launceston air pollution. Fossil carbon sources were found to contribute a relatively constant, and small, concentration characteristic of transport-related emissions in a relatively small city like Launceston.



Launceston on a smoky day



Launceston on a clear day

Intense forest fires a recent development

Understanding the relationships between soil, vegetation, climate and fire is vital to the management of forest systems. To this end PhD student Alex McLeod and Professor Peter Kershaw from Monash University have investigated tall open eucalypt forest and their supporting soils in the Central Highlands of Victoria.

Pieces of charcoal, almost all derived from Eucalyptus, were obtained from a range of soil depths in profiles covering different slopes and aspects within the transition area (ecotone) between temperate rainforest and tall open forest. Atomic Mass Spectrometry (AMS) radiocarbon dating indicates that forest fires were concentrated within three relatively discrete time intervals: predominantly more than 45,000 years ago, between 13,000 and 11,000 years ago, and within the last 2500 years. It is thought that the lack of charcoal between about 45,000 and 13,000 years ago is due to a sparse tree coverage during low rainfall and temperatures of the last glacial period. The gap between about 11,000 and 2,500 years ago is thought to be the result of low fire frequency under relatively wet and stable climatic conditions, and possibly a more extensive rainforest cover. The present fire regime of occasional intense fires appears to have been in operation for only the last 2,500 years. The mix of charcoal ages in the soil profiles suggests also a relatively recent onset of soil instability.

These soil-vegetation-climate-fire relationships provide a firmer basis for understanding the tall open forest system and potentially can be applied to rational future fire management.



Nature of tall open forest in the study area dominated by eucalypts that regenerated after the 1939 fires above a tree fern understory)

Ancient amino acids give new understanding on estuary evolution

Amino acids combine to form structural proteins in the shells of invertebrate organisms. After their death, the protein within the shell begins to degrade. Because some of the chemical changes are time dependent they can be used in dating fossils. Aminostratigraphy, in conjunction with thermoluminescence dating, radiocarbon ages, lead-210 profiles, and litho- and biostratigraphic analysis, allowed the detailed assessment of the geomorphological evolution of wave-dominated barrier estuaries that formed in incised valleys on the southeast coast of Australia.

Recently graduated AINSE Postgraduate Scholar Dr Craig Sloss, along with Professor Colin Murray-Wallace and Associate Professor Brian Jones of the University of Wollongong and Dr Henk Heijnis of ANSTO, using lead-210 and acid racemisation techniques, found that the estuaries investigated have an evolutionary pathway that is different to previous models of barrier estuary evolution, placing a greater emphasis on the influence of the antecedent Late Pleistocene landsurface. They have also shown that Holocene transgressive sands are more extensive than previously anticipated and form a basal, near basin-wide, shell-rich deposit that extends almost up to present sea-level. This contrasts with established models for barrier estuary evolution on the southeast coast of Australia where Holocene postglacial marine transgression sandsheets were restricted to the mouths of incised valleys and back-barrier central basin muds lie directly over the antecedent Pleistocene landsurface.

This research has highlighted the potential of the aspartic acid racemisation reaction observed in fossil molluscs as an important supplement for dating Holocene marginal marine deposits, particularly where the application of more established dating techniques is limited. For example, aspartic acid racemisation has the potential to date material younger than 500 years where obtaining accurate carbon-14 ages is problematic. This research has also provided chronologies on relatively recent sedimentary successions allowing the quantification of sedimentation rates, and assists in assessing the impact of human activities on sedimentation within estuarine environments.



Estuaries studied on the southern coast of New South Wales

At the beginning of 2006 Dr Sloss commenced as a lecturer in Physical Geography at Massey University.

The secret life of sweetlips

In an attempt to unravel the (secret) life history of large reef fish such as the sweetlip and red emperor, ANSTO recently worked with one of the country's leading marine biologists— Associate Professor Graham Pegg of the Central Queensland University, with the assistance of Dr Kathryn Prince and Robert Russell at ANSTO—in an initial assessment of the secondary ion mass spectrometry (SIMS) facility.

SIMS is an ultra-high vacuum surface instrument capable of detecting elements ranging from hydrogen to uranium in quantities of parts per million to parts per billion. The SIMS technique allows analysis of the chemical make-up of thin sections of fish ear bones – otoliths – which are like the 'black box recorder' of the life history of the fish. Because the otolith is formed at fertilisation and grows by daily increments, there are usually clear annual growth increments evident. As an ion beam strikes the surface of the otolith it causes ions, atoms and molecules to be sputtered from the surface.

Continuous detection of the sputtered material during the SIMS analysis enables scientists to create a depth profile of the surface of the otolith, essentially allowing them to 'see' the layers of the otolith.

As the otoliths grow they incorporate trace elements from the surrounding environment into their skeletal structure. Professor Pegg hopes SIMS can further his work on studying the migration behaviour of reef fish larvae, juveniles and adult fish.

"This work may help determine if the new reef zoning plans for the Great Barrier Reef will work in the long term," he said.



Research Highlights

Materials – Properties and Engineering

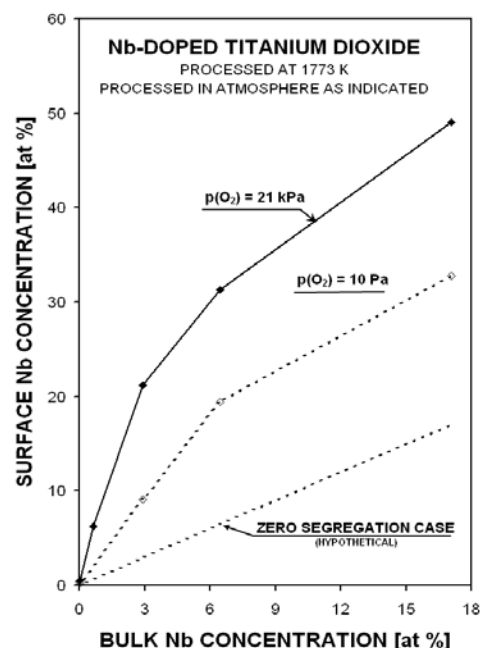
Surface segregation of niobium in niobium-doped titanium oxide

Niobium-doped titanium oxide finds uses in gas sensors: for example, for measuring oxygen levels, humidity, carbon monoxide or carbon dioxide levels. Under illumination, it can remove bacteria and other contaminants from polluted water streams. Similarly, it can be used for removing airborne pollutants.

In solids like niobium-doped titanium oxide, which are mixture of two or more components, the surface concentration of niobium changes when the material is exposed to high temperatures. This is an example of a phenomenon called segregation. As a consequence, the surface properties of a material differ vastly from those of the bulk. In the case of metal oxides, segregation is expected to be influenced by the activity of oxygen in the reaction chamber during processing. Awareness is growing that functional properties of solids are strongly influenced, or even determined, by segregation.

A project by AINSE Postgraduate Scholar Leigh Sheppard and Professor Janusz Notwotny of the University of NSW, and Dr Kathryn Prince and Dr Lou Vance at ANSTO, studied segregation of niobium in niobium-doped titanium dioxide at elevated temperatures with controlled oxygen pressure. Using Secondary Ion Mass Spectrometry (SIMS), niobium segregation was observed to enrich the surface of niobium-doped titanium dioxide by up to 50 fold over the nominal doping level. Such a high surface concentration strongly indicates that the surface properties are entirely different from the bulk phase. The extent of segregation was observed to depend strongly on the oxygen pressure.

This research is a step towards the ability to use of segregation as a tool for engineering ceramic materials with desired surface and bulk properties so that they can perform optimally in service.



The effect of oxygen pressure, $p(O_2)$ on the surface niobium concentration for different bulk niobium concentrations

Surface chemistry of DNA recognition interfaces

The Human Genome Project has led to the identification of genes and DNA mutations that are implicated in genetic disorders. Diagnosis of such disorders depends upon detection of specific sequences of DNA, and devices capable of doing this will soon be in high demand. In order to develop efficient DNA recognition interfaces for inclusion in such devices, a good understanding of how DNA interacts with a surface is necessary.

Dr Justin Gooding and AINSE Postgraduate Scholar Ms Freya Meams from the University of NSW and Dr Ken Short from ANSTO employed atomic force microscopy of DNA-modified gold substrates in order to study the behaviour of end-immobilised DNA. The images obtained showed that single-stranded DNA is flexible enough to lie over the substrate, while double-stranded DNA is more rigid and stands up off the substrate. Such differences between the interactions of the two forms of DNA with the substrate were found to be significant enough to be exploited for detection of specific DNA sequences.



A schematic diagram for the proposed behaviour of DNA end-immobilised on gold for the single-stranded (a) and hybridised (b) DNA-modified substrates

New stresses in power plants

Components used in power generation plants are subjected to mechanical stresses and thermal cycling during operation. Many power plants have been designed to operate at a steady base load during service. In order to maintain today's increasing energy demand, plant cycling occurs. This involves operation at higher or lower load to meet energy demands at a particular time. The expansion and contraction of components such as steam pipes during cycling introduces stresses and strains to the components and this may cause a reduction in mechanical properties or, in the worst case, a failure. The influence of these changing conditions on the fatigue behaviour of, and the consequent damage to, the components requires continual assessment.

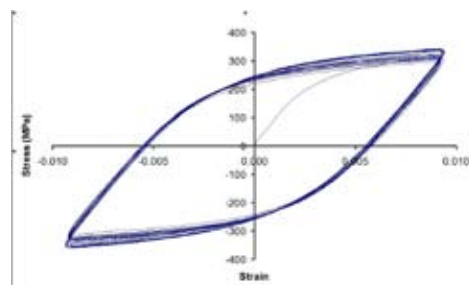
AINSE Postgraduate Scholar Mark Callaghan and Dr Wing Yeung of the University of Technology, Sydney, are collaborating with Dr Mikl Law, Dr Philip Bendeich and Mr Sam Humphries at ANSTO to develop a high temperature, low cycle fatigue test system. A novel non-contact capacitance extensometry technique was incorporated in the measurement and control of strain in specimens during testing. This technique differs from conventional extensometry which has disadvantages such as a lack of rigidity, the build up of stress concentration and contact effects, all of which lead to premature failure of the specimen and therefore inaccuracies in results. As well as standard-size specimens, miniature specimens were designed for testing because they present advantages such as the in-service removal of specimens from components using minimum material volume, thus reducing component structural integrity effects.

The extensometry technique was validated by determining strain calibration curves, and the results were verified through finite element analysis simulations. Full-scale testing on virgin chromium-molybdenum standard fatigue specimens allowed a strain-life curve to be constructed to characterise the fatigue life. The results show consistency and confirm the capabilities of the test system.

At present, the miniature fatigue testing method is being developed in order to compare the results with the standard specimen. The experimental plan for miniature testing includes testing virgin material, followed by actual service-aged plant material (100,000-200,000 hours of service life), with scope for welded material. The benefits of this research include increased ease and accuracy of high temperature fatigue testing through the technique developed, where in-service materials can be taken from components, without contributing to a reduction in component life.



Mechanical testing specimens in descending order: Standard fatigue specimen; miniature fatigue specimen; Young's modulus impulse excitation specimen and miniature creep specimen.



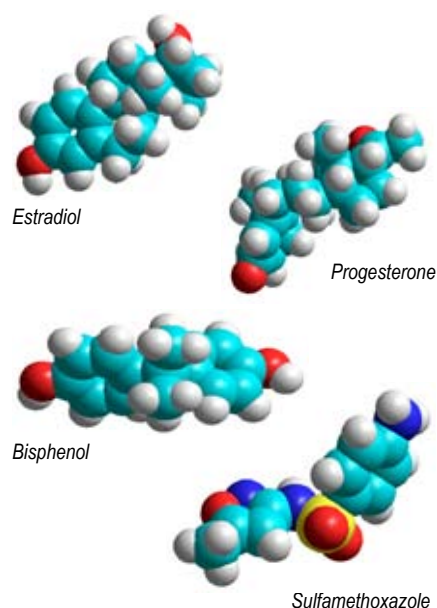
The hysteresis loop for 2.25Cr-1Mo alloy steel, fatigue tested in air at 540°C, at 1 Hz 1.0% and strain amplitude.

Cleaning up wastewater

Trace contaminants such as steroid hormones, hormone mimicking compounds, and pharmaceuticals in secondary treated wastewater effluents and in freshwater bodies are a serious and ongoing concern because of potential adverse impacts on the health of humans and wildlife. Effective removal of such contaminants is essential not only to protect the environment but also to secure our valuable water resources. Given the apparent difficulty in effectively removing trace contaminants from wastewaters by conventional means, scope exists for the use of membranes—particularly nanofiltration (NF) and reverse osmosis (RO) membranes—in improving their removal.

The removal of these trace contaminants by NF/RO membranes was examined by a research team consisting of Dr Andrea Schäfer and recently graduated AINSE postgraduate scholar Dr Long Nghiem at the University of Wollongong, with Dr Karin Soldenhoff and Dr Mihail Ionescu at ANSTO. The use of radiolabelled compounds allow the team to measure the concentrations of contaminants, in the range of a few nanograms per litre or lower. Rutherford backscattering spectroscopy was also used to characterise the membranes.

Several important findings emerged. The retention of neutral trace organics by a tight NF or RO membrane is dominated by the size of the contaminant molecules. In the case of a loose NF membrane both electrostatic repulsion and size govern the retention of negatively charged trace organics. Depending on the contaminants present, in this latter case, retention may be a function of pH, with much greater retention observed for negatively charged organics. For uncharged organic species, properties such as hydrophobicity and polarity can influence the separation process. These findings have a strong potential to improve the quality of recycled waste water.



Research Highlights

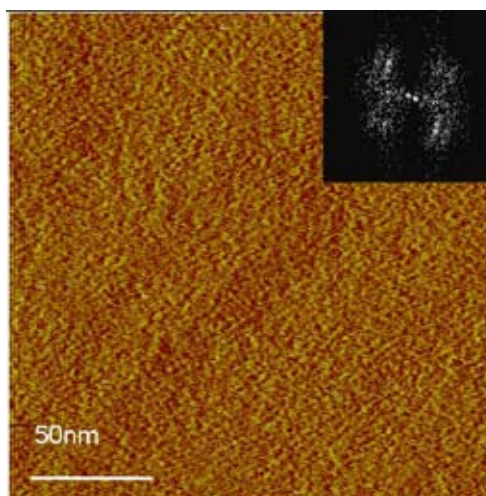
Materials – Structures and Dynamics

Nano-patterned surfactant films

Surfactants are known to spontaneously self-assemble both in solution and at a solid surface. Globular, cylindrical and bilayer films that are typically only 2-5 nm thick are known to form on a surface. These self-assembled surfactant films are used in a variety of applications from mineral flotation and corrosion inhibition to nano-templating.

Dr Annabelle Blom and Professor Greg Warr at the University of Sydney have found a novel mesh structure which forms when they mixed two surfactants with different preferred curvatures in varying ratios. The structure has been imaged using atomic force microscopy. By mixing two surfactants with different preferred curvatures and varying their proportions, the morphology of the film could be altered and the complete range of structures observed.

Working with Dr Andrew Nelson at ANSTO, the reflectivity from four different contrasts were measured using the angular dispersive X172 neutron reflectometer. From this work, the exact proportion of the two surfactants within the film was determined revealing the surface enrichment in one surfactant which was present in trace amounts in solution.



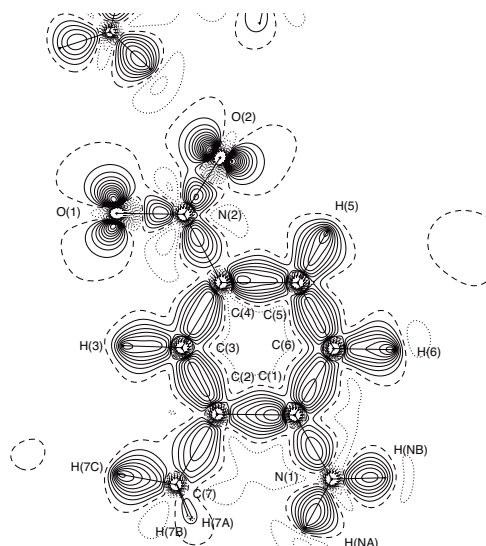
200 nm atomic force microscope image of a self-assembled mesh structure on quartz

Detecting hydrogen atoms through the blur

The electron distribution of molecules in crystals can be obtained from the analysis of accurate x-ray diffraction data, providing a powerful tool for determining various electronic properties of molecules. This information has wide ranging applications, such as assisting the design of pharmaceuticals and elucidation of their mode of action.

The diffraction experiment can be likened to long exposure photographs, where moving objects appear blurred. Because the exposure times are many hours and atoms vibrate billions of times per second, results will be a mixture of the distribution of electrons, and 'blurring' due to the motion of the atoms. Accurate representations of the electron distribution requires separation of the two effects—a straightforward process for most atoms except hydrogen, which is abundant in organic compounds but hard to detect using x-rays. Neutron diffraction is sensitive to the position and motion of hydrogen, and can complement the x-ray diffraction data, but it is impractical to measure neutron diffraction data for every crystal of interest. For these, the motion of the hydrogen must be approximated.

AINSE Postgraduate Scholar Andrew Whitten and Professor Mark Spackman from the University of Western Australia, with Dr Wim Klooster and Dr Ross Piltz from ANSTO, aim to approximate hydrogen atom motion using theoretical techniques, and to validate the results using neutron diffraction data collected at ANSTO. If successful, it may (where neutron diffraction data is lacking) be adopted by others to increase the accuracy of charge density studies, which in turn will help make conclusions drawn from these studies much more meaningful.



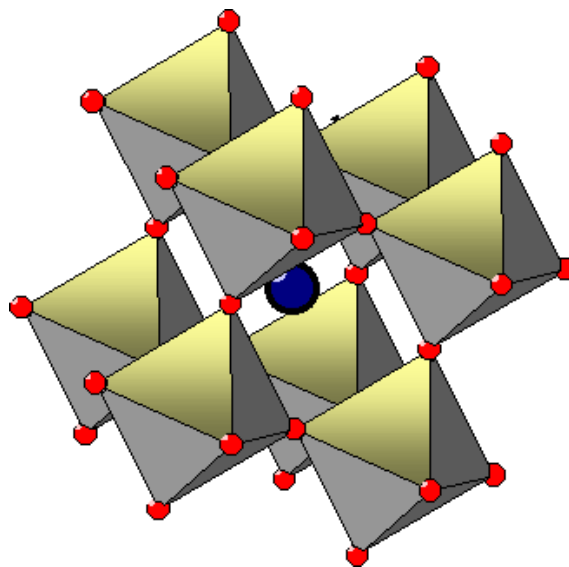
The image depicts a molecule of 2-methyl-4-nitroaniline, highlighting electron density concentration (solid contours) and depletion (dotted contours)

Investigating the structures of photocatalytic perovskite materials

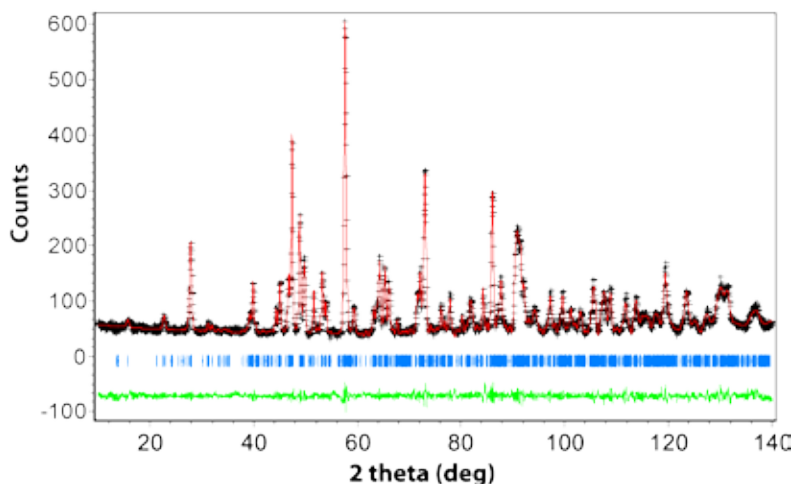
Members of the extensive family of perovskite-related materials often have interesting and technologically important physical properties, with many members being ferromagnetic materials, fast oxide conductors and superconductors. For example, the cobalt niobate triple perovskites (with general formula $A_3\text{CoNb}_2\text{O}_9$ where A = barium, strontium or calcium) have been found to have excellent microwave-range dielectric properties, which make them promising candidates as resonators for mobile phone-based communication. They have also been shown to act as visible light-driven photocatalysts, capable of catalytically producing hydrogen and oxygen from pure water—a technology that, if harnessed, could have important implications for the future of hydrogen fuel generation.

Professor Ray Withers, Valeska Ting, Dr Yun Liu and Dr Lasse Norén from the Australian National University have been investigating the structures of these materials using the High Resolution Powder Diffractometer (HRPD) at ANSTO. Neutrons are comparatively more sensitive to the positions of light atoms (such as oxygen) in materials containing heavy metal atoms. Therefore, neutron powder diffraction was considered the best technique with which to detect subtle changes in the structures of these oxygen-containing perovskite ceramics.

This work is aimed at better understanding the structural characteristics of these materials and how changes in structure may affect their physical properties. If a link can be found between the crystal chemical structures of such photocatalytic materials and their performance as catalysts, such research may be helpful in the efficient design and engineering of new photocatalyst materials having increased catalytic efficiency.



The basic perovskite structure



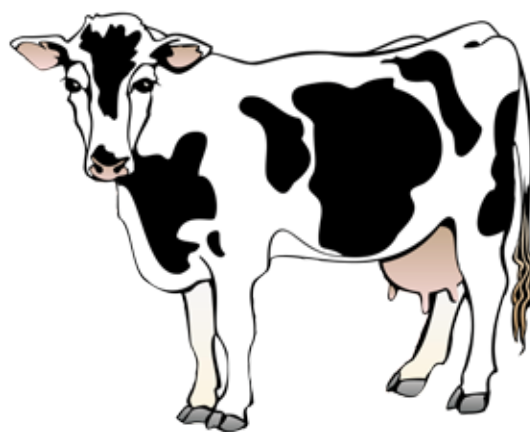
Rietveld refinement of neutron powder diffraction data from $\text{Ca}_3\text{CoNb}_2\text{O}_9$, collected on the HRPD at ANSTO

Improved milk products

The behaviour of milk proteins on drying and re-dissolution is important in the production of many dairy products. Dr Andrew Jackson and Professor John White of the Australian National University, in collaboration with Dr Tim Wooster and Dr Maryann Augustin at Food Science Australia (a division of CSIRO), are engaged in an ongoing effort to understand such behaviour. A better understanding of these processes should allow manufacturers to develop powdered milk products with improved handling properties.

As part of their research they have been studying the effect that chemically attaching sugars to the proteins has on their properties in solution, by using the natural reaction that gives rise to the crust on bread.

The small angle neutron scattering facility at ANSTO has allowed them to examine the way that molecules structure themselves, on the nanometre scale, as the proteins aggregate when dissolved in water. They have seen that the presence of bound sugar changes the aggregation behaviour and, with further investigation, this may prove to be beneficial in the production of powdered dairy products.



AINSE Winter School 2005

The School continues to be a most valuable AINSE activity for the promotion of research opportunities at ANSTO to prospective research students. One student is selected by the AINSE councillor at each of the 38 member universities.

The program is interdisciplinary and although it is clear from some comments that some students feel challenged at being taken out of their physics or chemistry comfort zone, the variety of experiences, both in the formal classes and through working with other students is an important part of the School experience.

Changes in topics occur from year to year. A session on radiation safety was introduced in 2005 by ANSTO Safety and Radiation Services. In this experiment the students were introduced to ways of localising a source of radiation and determining the risk posed by the source as well as the effectiveness of various shielding materials in . We are very grateful to the staff of ANSTO's Safety and Radiation Services, Frank Harris and Athena Prib for their help.

With the new accelerator on line, the ion beam analysis experiment was revised to involve surface analysis using Rutherford BackScattering and SIMS.

The AINSE Postgraduate Scholars, Susan Pearce (ADE), Cat Kealley (CUR), Angus MacGregor (ADE), and Leigh Sheppard (NSW) and Adam Fischmann (MON), made a very important contribution to the School as demonstrators, role models and through the presentations on their research. They are warmly welcomed by the students and the Winter School and AINSE are very grateful for their commitment to the School.



Dr Gerald Laurence, Winter School Convenor in front of the entire group.

Students

Details of the students and their broad disciplines are given below.

The total number exceeds 38 because 8 students were doing a double discipline major.

The gender ratio was exactly 1, with 19 females and 19 males.

Each year the mix of students is different. Chemistry dominated the School this year while student numbers in environmental areas slightly exceeded those in engineering.

This year the following students attended

Name	Uni	Name	Uni	Sum	No
Andrea Young	ACU	Suzannah Lyons	MUR		
Samuel Stranks	ADE	Llewellyn Clack	NCT		
Jeremy Currie	AKL	David Kruss	NSW		
Akimui Nakamura	ANU	Kristy Anderson	CDU		
Rob Buchholtz	BAL	Jacques Bothma	QLD		
Naomi Matthews	CAN	Anthony Musumeci	QUT		
Tiffany Cripps	CBR	Matthew Field	RMI		
Michelle Stewart	CQU	Stacey King	SCU		
Ben Ramsay	CSU	Catriona Wimberley	SWI		
Shane Lawrence	CUR	John Yeh Truong	SYD		
Brett Logue	DEA	Ian Little	TAS		
Sean Stankowski	ECU	Rachelle Levingston	UNE		
Katya Igorevna	FLI	Sarah Carter	USA		
Edmund Burt	GRI	Adam Blazak	USQ		
Elizabeth Fellows	JAM	Nazareth Sevazlian	UTS		
Sarah Hagerty	LAT	Anne Dinh	UWA		
David Byrne	MAC	Tamae Fukumoto	UWS		
Sarah Buckley	MEL	Aida Zilic	VIC		
Dilani Kahawala	MON	Leena Burgess	WOL		
				Sum	46

Discipline	No
Biology	3
Chemistry	17
Engineering	5
Environment	7
Medical Sciences	4
Physics	10

Special Speakers

The School had the benefit of three talks by outstanding speakers. The address by Professor John White, President of AINSE on the issues raised by human cloning led to the most lively and vigorous discussion ever heard at a Winter School. Dr Lynn Dennison, Manager of Air Quality for Environment Victoria linked her doctoral research in radiation chemistry to environmental issues in Mozambique. The students' visit the OPAL neutron beam hall was preceded by a talk by OPAL project manager Mark Summerfield.

Thanks

The Convenor of the Winter School and Scientific Secretary of AINSE record their gratitude and that of the students to the Board, the Executive Director and the staff of ANSTO for their generous contribution to the School. They thank all the ANSTO staff who gave so much of their time and talents in making the School a success.



Left to right: Dr Andrew Studer explaining the operation of AUSANS to Elizabeth Fellows JAM, Suzannah Lyons MUR, and Rob Buchholtz NCT

2005 Conferences & Workshops

AINSE conferences play a major part in the information exchange process for scientific and technological information, providing a forum for debate and an opportunity for young researchers to present their work. Participants from member organisations are assisted with travel and accommodation expenses and receive a discount on registration fees.

AINSE ran one international and three national conference in 2005. Two of the national conferences were part of the AIP National Congress.

International Conference on Neutron Scattering ICNS2005

The International Conference on Neutron Scattering was held at Darlin Harbour in Sydney on the 13-15th December 2005. It was underwritten by AINSE and was supported by ANSTO and ANBUG. There were 737 registered delegates from 38 countries. The oral program ran 4 parallel sessions involving 177 papers including 5 plenary and 6 keynote presentations. At the two poster sessions incorporated 600 posters were displayed.

There were 142 Australian delegates, which was the largest group at the conference.

On the Wednesday afternoon over 600 of the delegates were bussed to ANSTO for a tour of OPAL and the neutron scattering beam hall.

Student prizes

PANalytical prizes for the best 2 posters describing x-ray diffraction experiments Thomas Lenne from RMIT University and Jui-Ching Wu from National Tsing-Hua University Taiwan. Shirane-BNL Student Prizes were awarded to Ross Springell University College London, Kathleen Wood Institut Laue Langevin France, Mark Laver Institut Laue Langevin France, Morgens Christensen University of Aarhus Denmark. Tuerxun Wernisha from KEK Japan received the Oxford Instruments Superconductivity prize for the best poster describing work at low temperatures and/or high magnetic field.



Conference attendees in the OPAL neutron beam hall

14th Conference on Nuclear and Complementary Techniques of Analysis

Sunday 20 – Tuesday 22 November 2005, Te Papa Wellington , New Zealand

This is the first time this conference has been held outside Australia. We were delighted with the response from members when 89 abstracts from 25 institutions across Australia and New Zealand were accepted for presentation. This year there was a strong representation of research utilising synchrotron techniques and this is reflected in the inclusion of the word 'complementary' in the name of the conference. It remains AINSE's largest regular conference.

AINSE is grateful to the team at GNS Science who took a leading role in the organisation of this conference, and in particular to Freda Harrison who saw to much of the on-the-spot organisation.

19th Nuclear and Particle Physics Conference held in conjunction with The Australian Institute of Physics 16th Biennial Congress 2005

January 31 - February 4, 2005 at The Australian National University, Canberra

Of the 44 abstracts accepted 21 were oral presentations.

The balance between presentations was approximately 50% Particle Physics/Fundamental Interactions and 50% Nuclear/Applied Nuclear. Including Helen Quinn, 10 of the oral presentations for AINSE-NUPP were given by women with Helen Quinn from the Stanford Linear Accelerator Center presenting a talk on theoretical particle physics. Three AIP awardees were included in the sub-sessions: George Dracoulis, (Boas Medal), James Tickner (Walsh Medal together with Dr Brian Sowerby) and Mahananda Dasgupta (Women in Physics Lecturer). Keynote talks were selected to represent activity across the field: Phil Urquijo and Tom Atkinson from The University of Melbourne, Hugo Maier from Berlin/ANU, Derek Leinweber from University of Adelaide, David Hinde from ANU and Victor Flambaum from UNSW.

The AINSE-NUPP meeting had a ratio of oral presentations to submission of 0.47 compared to that for the whole Congress of 0.31. This decision resulted in 21 slots being allocated to the AINSE-NUPP meeting. The AINSE-NUPP committee chose to give preference to students and young researchers for oral presentations over more senior staff members. This decision was vindicated by the very high standard of presentation of most of the talks. The Congress organization ensured that the poster presentations were well attended and this aspect was also highly successful.

23rd Plasma Science Conference held in conjunction with The Australian Institute of Physics 16th Biennial Congress

January 31 - February 4, 2005 at The Australian National University, Canberra

The plasma community were allocated 10 slots for oral papers. Another 16 papers were presented as posters. A highlight of the plasma sessions was the presentation by Professor R Goldston from Princeton Plasma Physics Laboratory who gave an impressive overview of progress in the understanding of tokamak physics on the path to controlled fusion. Travel bursaries were provided to assist travel expenses for 14 students from 10 universities who attended this meeting.

International Conference Travel Scholarships

These scholarships are available to students and post doctoral fellows from AINSE member universities who wish to present their AINSE supported research at an international meeting which is being conducted outside Australia. Nine International Travel Scholarships were awarded during the year to the following students:

Cameron Barr from The University of Adelaide, Joanne Muller from James Cook University, John Daniels, Adam Fischmann and Anna Paradowska from Monash University, Manickam Minakshi, Murdoch University, Catherine Kealley from The University of Technology Sydney, Mark Waller from The University of Sydney, and Craig Sloss from Wollongong University.

For more information about International Travel Scholarships see our web site