



- Dissecting the cause of devil facial tumour disease
- Education and collaboration with e-tools
- X-ray tomography goes nano
- Elegant efficiencies – how termite wings stay dry

RESEARCH

## A devil of a disease



### AMMRF @ SARF

Tasmanian devil facial tumour disease (DFTD) is decimating devil populations across large areas of Tasmania. The disease was first sighted in 1996 and causes cancerous lesions around the mouth that develop into large tumours of the face and neck. It is always fatal and has depleted approximately 80% of the devils in Tasmania. Such rapid devastation calls for a strong and committed research program to understand the rapid spread of this baffling disease and so there is a great deal of work being done to tackle the problem.

The unusual thing about DFTD is that it is a contagious cancer. This occurs by the direct transmission of cancerous cells from animal to animal through biting. Because of the general lack of genetic variation within the population, there appears to be reduced immune recognition of the foreign cells when they invade the bitten animal, allowing them to survive. Some hope, however, is now on the horizon, stemming from the observation that a population of devils in western Tasmania appears to be disease free, which might imply resistance or simply that the disease has not yet reached this population. Another, possibly related, observation, that affected devils carry an inverted chromosome, could also shed light on the difference between the two populations and suggests a possible

mechanism of disease susceptibility. The rearrangement of a whole section of chromosome could be disrupting the function of nearby genes, possibly affecting immune responses.

Robyn Taylor, of the Tasmanian Government's Save the Tasmanian Devil Program (STDP), is very passionate about these cute, noisy creatures. She is determined to put her knowledge of molecular science to good use in the quest to prevent their extinction from the wild, where they are a vital part of the natural Tasmanian ecosystem.

Robyn is assisting Anne-Maree Pearse and Kate Swift, also from the STDP, with the investigation of the inverted chromosome. She visited the AMMRF at the University of Adelaide in March to micro-dissect devil chromosomes by laser capture microscopy. The work is part of a Linkage Project with Dr Jeremy Austin of the University of Adelaide and A/Prof. Katherine Belov (voted Australia's favourite scientist at the 2009 Eureka prizes) of the University of Sydney. The dissected sections of chromosome that Robyn has prepared allow a targeted approach to the construction of DNA probes to help understand the impact of the inversion on devil susceptibility to DFTD.

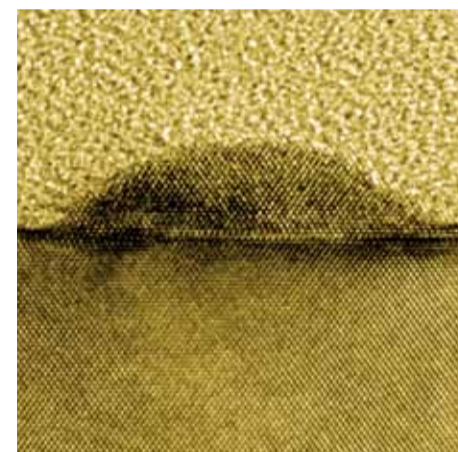
Down the line, this research could lead to a breeding program introducing normal chromosomes back into the current devil population with the aim of increasing population immunity to the tumour cells. ■

## Creating a positive spin on electronics

### AMMRF @ UQ

Currently, transistors are made of semiconductors that control the charge of electrons. Creating a semiconductor that takes advantage of the magnetic properties (spin polarisation) of electrons as well as their charge at room temperature would be a huge step forward in semiconductor electronics. Having it integrate with current semiconductor (CMOS) platforms would also be necessary for large-scale practical device applications. Information storage currently uses metal-based magnetic devices, whereas information processing uses semiconductor devices. The exchange of information between these two separate systems is energy and time consuming. With magnetic semiconductor-based spintronics, data manipulation and long-term storage can be achieved in one computer chip, rather than separately in a central processing unit and a hard drive as is practiced at present.

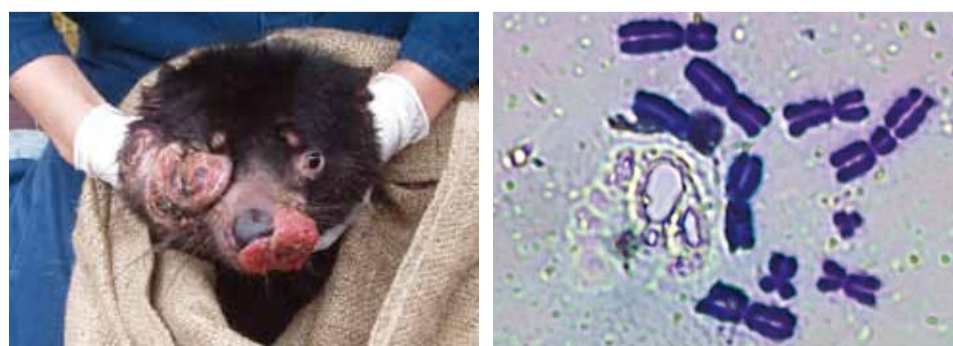
Prof. Jin Zou and Dr Yong Wang from the University of Queensland (UQ), Prof. Kang L. Wang and Dr Faxian Xiu from the University of California at Los Angeles and Dr Ajey Jacob from the Intel Corporation in Santa Clara have published their latest research in *Nature Materials*. They describe the successful fabrication of a new class of magnetic semiconductor quantum dots that take advantage of electrons' charge and spin to combine electronic and magnetic properties. In particular, they showed that the magnetic properties of the quantum dots could be controlled by changes in electric field at ambient temperatures, making it possible to build practical spin devices (or 'spintronics').



Quantum dot on a silicon substrate.

Characterising the dots' structure and understanding how the components are distributed was wholly dependent on the microscopy carried out in the AMMRF at UQ. The dots are composed of 95% germanium and 5% manganese. They are 30 nm in diameter and sit just 8 nm high on a silicon substrate. Prof. Zou says, "The key was getting just the right concentration of manganese mixed in with the germanium matrix of the quantum dot. Manganese has characteristics that, in combination with other semiconductor atoms in the right concentration, allows magnetic properties to be achieved."

The small size of the dots will enable electronic devices to be made smaller, thereby reducing variability and allowing the possibility of constructing nonvolatile logics for substantial power savings when systems are in standby mode. Eventual spintronic devices will have applications in nearly all fields, especially as spintronic-based computers would be smaller and faster and would consume less energy. ■



A devil with DFTD (left) and laser capture microscopy of devil chromosomes (right).



## EXECUTIVE DIRECTOR'S COLUMN

Microscopy and e-research? These powerful research-enabling tools interest many scientists and engineers and also have their own burgeoning research discipline. I get excited when the integration of particular ideas, tools and technologies come together to enable new research possibilities. My colleagues and I at the AMMRF believe that the nexus between microscopy and e-research does just this. Through the excellent work of Prof. Tim White and A/Prof. Allan Jones, present and past chairs of the AMMRF's e-research committee, we are learning about the need for good governance, management and stewardship in the fledgling Australian e-research community, which are important given the hundreds of millions of dollars of federal investment in this area.

There are many definitions of e-research. This is no surprise – we are familiar with the scramble to define nanotechnology, biotechnology and the like. Nevertheless, it is valuable to define its scope and the AMMRF understands e-research as encompassing high-performance computing (HPC), online collaboration and training tools, and data issues such as storage, curation and sharing. I feel that the connections of all three areas with microscopy are strong, and relevant to our user community. It is a fact that many microscopy and micro-analysis experiments do not always yield unequivocal results directly from the instrument. The experimental data often need to be compared to the results of computer-based simulations that 'trial' particular structures and compare the fit to experiment – a common technique in scientific research. Increasingly, the scale of systems requiring simulation is enormous, giving rise to problems of great complexity. Greater availability of HPC will allow microscopists to close in on that much-sought-after unequivocal result.

Online-collaboration tools are also of great interest to microscopists. At the AMMRF, we have over 2,800 users and the need to streamline the process of training and instruction is increasingly important. Effective online tools, which allow users to understand the principles and concepts of microscopy as well as conduct 'virtual' experiments, can maximise the effectiveness of our valuable instrument time. Moreover, we seek to build collaborative capacity during microscopy experiments – having experts synchronously examine data online directly from a microscope enables full interdisciplinary research.

Finally, the issues arising from huge data sets are becoming ever more pressing with more tomography and multi-dimensional experiments making e-research tools an essential component of our future research toolkit. ■

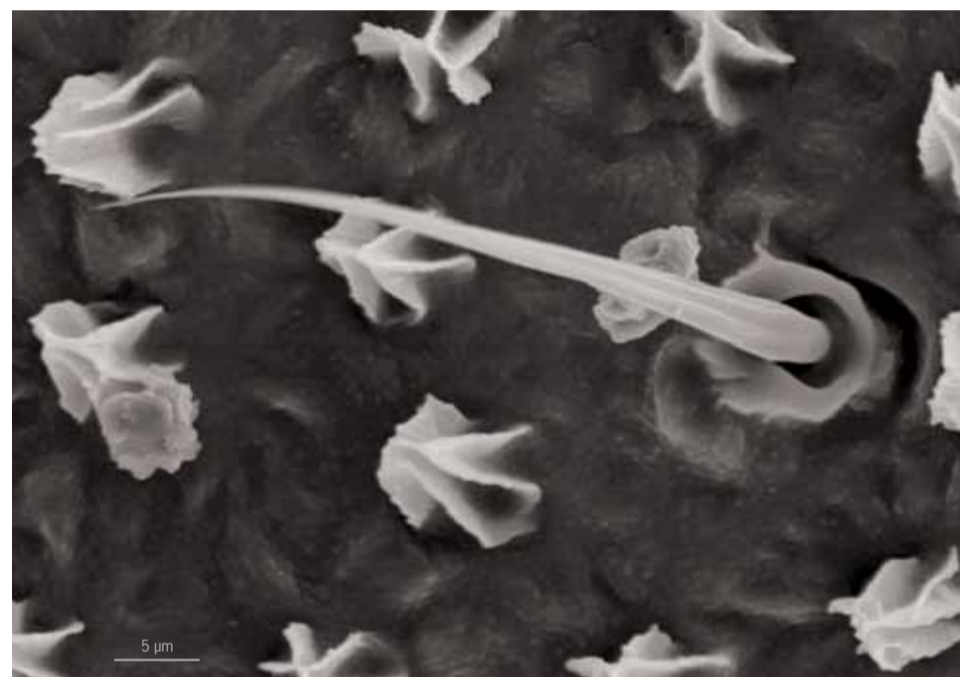
Regards,  
Simon Ringer, Executive Director & CEO

## RESEARCH

## Learning from nature – water-repelling termite wings

## AMMRF @ UQ

The strange phenomenon of termites that choose to fly in the rain has led to the discovery of a micro- and nano-architecture that efficiently acts to repel water. Many species of termites tend to fly in the rain or during storms, usually when they are establishing a new colony. This is thought to help them to avoid predators and to be sure that there will be mud available for establishing a new nest.



Water-repelling hair and star-shaped domes on the surface of a termite wing.

A collaborative project among Dr Gregory Watson, Dr Jolanta Watson from James Cook University and Dr Bronwen Cribb from the AMMRF at the University of Queensland has discovered that termites' wings are ideally structured to repel water, providing high repulsion for minimal weight gain. The work was published recently in *ACS Nano*. By using a variety of microscopic techniques available at the AMMRF, the team has found that these termite wings are covered with many thousands

of long, grooved hairs that can support water droplets up to about 10 microlitres in size. Interspersed between the hairs, approximately 10 micrometres apart, are smaller parabolic, star-shaped domes that repel the smaller water droplets. The top surfaces of these domes also have even smaller scale structures to further minimise water adhesion. Combining these structures has allowed the termite to maximise the water-repelling properties of its wings while keeping additional weight to a minimum, an important outcome for an insect that is not a strong flyer.

The ability to produce efficient water-repelling surfaces is essential to many industrial applications, from medical diagnostics to large-scale anti-fouling surfaces. Therefore, understanding how nature has created its own efficiencies will be extremely valuable to innovation in the design of new types of water-resistant surfaces. Biodiversity provides ready-made reservoirs of useful molecules and structures that, when understood and harnessed, can inform modern innovation. ■

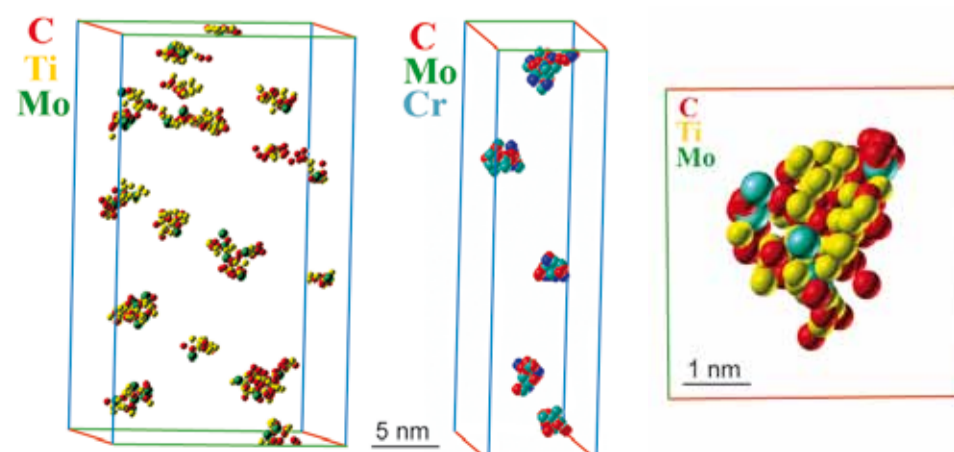
## ACCESS

## Wollongong access agreement renewed

University of Wollongong researchers are regular users of the AMMRF and the university has recently renewed its access plan to continue this relationship. The arrangement is based on subscriptions through which they have purchased almost 400 hours of beam time to access flagships and other instruments. The researchers, who use the AMMRF facilities at the University of New South Wales and the University of Sydney, are active in many areas of innovative research such as intelligent polymers, better steels, superconductors and

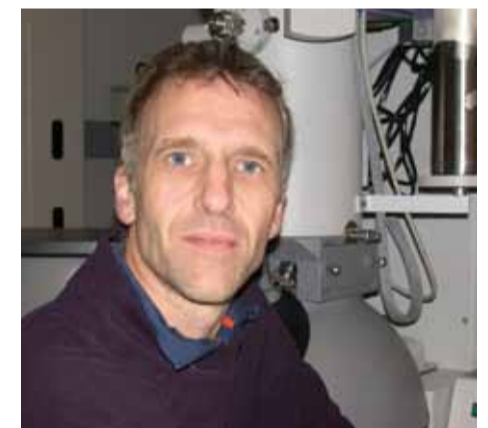
anti-cancer chemistry, all of which benefit enormously from the diverse range of microscopy and microanalysis techniques available. New collaborations and publications have resulted from this access and this can only be enhanced by continued interactions.

General manager of the AMMRF, Dr Miles Apperley says, "This continues the long-standing relationship with the University of Wollongong and we are looking forward to continuing to assist their researchers to achieve world-class research outcomes." ■



Atom probe tomography from a joint project between Prof. Elena Pereloma (University of Wollongong) and Prof. Simon Ringer (The University of Sydney).

## Research excellence rewarded



Prof. Rob Parton, Deputy Director of the AMMRF at the University of Queensland, recently received the NHMRC Achievement Award for having the highest-ranked project grant out of the 683 grants announced in the last round of awards. He won a \$588,500 grant that will be used to investigate ways of treating prostate cancer by suppressing the secretion of a protein called caveolin. This protein is normally embedded in the cell surface but in aggressive forms of prostate cancer, it is secreted from the cancerous cells and promotes the progression of the disease.

Prof. Parton led the team that discovered this link between aggressive prostate cancer and caveolin and will be continuing to work on understanding the implications of the association. He also won an NHMRC Excellence Award in 2007 for having the top-ranked program grant, and was awarded a \$4 million Australia Fellowship in 2009 by the Australian Research Council for other aspects of his work on caveolin. ■



## E-RESEARCH



## New e-tools ease the load

The AMMRF is taking advantage of opportunities to develop and implement an array of e-research tools to further enable and facilitate research done through our facility.

A team of experts in research-led teaching from six universities within the AMMRF was recently successful in an application to the Australian Learning and Teaching Council for funding to develop an integrated range of virtual microscopy tools. They will support a national blended-learning approach in microscopy that will cater to the increasing numbers and diversity of students who require education and training in microscopy. These tools will be openly accessible by educators around the country.

Complementing this is the Technique Finder, a addition to the AMMRF website, currently under development. It will help potential users identify techniques available through the AMMRF that are relevant to their research questions. The information is technique, rather than instrument, focused and will be accessed through a simple interface based on the types of experiments that the researcher wishes to perform.

Two other tools support those users already deeply into their research projects. The first of these is the Data Management System (DMS) to support data and metadata capture from instruments, data transfer between nodes and to federated data repositories. Increasing amounts of highly complex data, that also require multiple post-acquisition processing steps, are being collected from modern, high-end instruments often in collaborative, multi-institutional projects. The DMS is currently under development and will allow data to be moved between analytical platforms and will enable multiple individual researchers to access the data.

Last, but certainly not least, is the Biosecurity Collaboration Platform (BCP), about to be installed at CSIRO's Australian Animal Health Laboratory (AAHL). The collaborative platform will provide a shared workspace for viewing of scientific data and other resources in real time. The BCP will provide a vital link from within AAHL's high-biocontainment facility to those outside. This collaborative tool will improve communication and decision-making capabilities, particularly in disease outbreak situations when time is of the essence. ■

## TECHNOLOGY

## What is X-ray nanotomography (nano-CT)?

X-ray nano-CT takes X-ray tomography into new realms at the sub-micrometre scale. It is a non-destructive technique, because its aim is to image internal structure without the need to section or otherwise damage the specimen. This ability to see into the specimen is not limited to one particular view – X-ray nanotomography is naturally three-dimensional in its context – so the resulting data may be viewed and/or re-sliced at any angle to see the features of most interest.

The technique allows internal structural detail to be imaged either as 2-D slices or as 3-D rendered volumes. With specimen thickness in the order of 200  $\mu\text{m}$ , 3-D sub-volumes of 64  $\mu\text{m}$  cubed or 16  $\mu\text{m}$  cubed can be imaged at resolutions of 150 nm or 50 nm respectively.

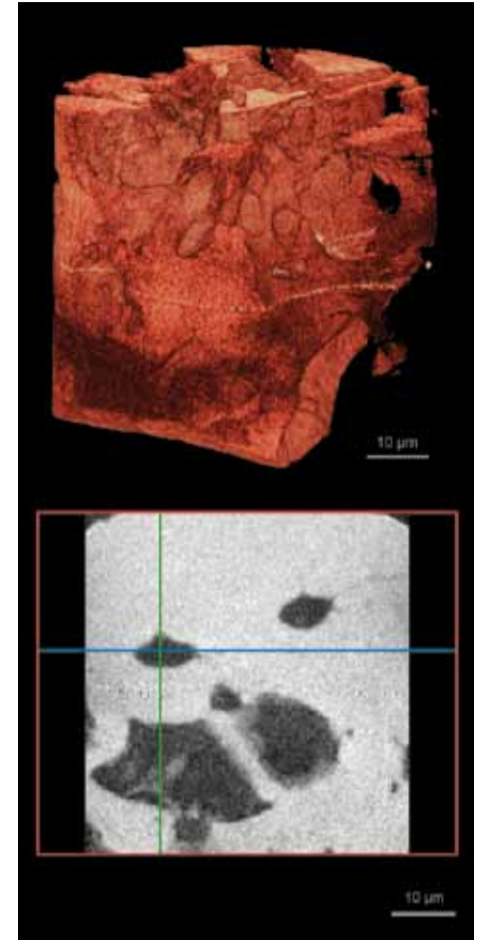
Although functionally similar to microtomography, the higher resolution achieved in nanotomography demands that particular attention be paid to the alignment of the projection images that are acquired as the specimen is incrementally rotated over 180° in steps of between 0.1° and 1°. To facilitate this alignment a 3  $\mu\text{m}$  gold particle is placed on the specimen and subsequently used as a fiducial marker for correction of spatial misalignments. Following

alignment of the projection image series, the projection data are subsequently converted into a stack of axial slices and viewed in 3-D.

Specimen preparation is a critical part of this process, with samples of somewhat less than 0.5 mm being mounted on steel pins for scanning. Typically a low-resolution micro-CT scan will be done as a preliminary assessment to establish the orientation of the sample and find regions of interest for the higher resolution nano-CT scan.

Scan durations are long, ranging from 12 hours for a simple preliminary scan to up to 168 hours (one week) for a very high-quality scan. In addition to the standard X-ray absorption mode of operation, the scanner can also be used in a phase-contrast mode that provides further enhancement of structural details, particularly at material boundaries.

The AMMRF's new X-ray nanotomography system is located at the Australian Centre for Microscopy & Microanalysis at the University of Sydney, and it is the only one of its kind in Australia. If you are interested in using the instrument please contact A/Prof. Allan Jones, ph. 02 9351 7587 or email [allan.jones@sydney.edu.au](mailto:allan.jones@sydney.edu.au). ■



Top: 3-D reconstruction of an otoconia, a biomineralised structure in the inner ear. Bottom: 2-D section of the otoconia showing internal pores.

## RESEARCH

## World first – ancient DNA isolation from fossilised eggshells

## AMMRF @ UWA

In a world first, an international team, led by Dr Michael Bunce of Murdoch University, including researchers from Australia, the UK, Denmark, NZ and the USA, has successfully isolated ancient DNA from the fossilised remains of eggshells from extinct birds.

The work, published in the *Proceedings of the Royal Society*, has generated considerable excitement. DNA was extracted from fossilised eggshells up to 19,000 years old. Although

used for a variety of dating techniques ancient eggshell was not previously considered to be a source of DNA.

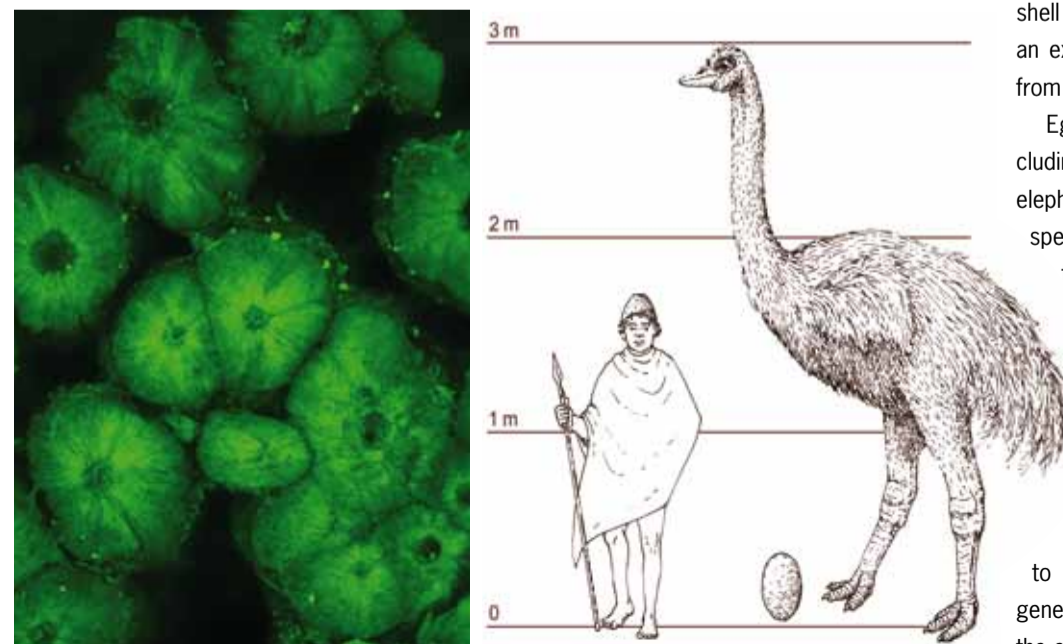
"We were really surprised to discover that ancient DNA is well-preserved in fossil eggshells", explains doctoral student Charlotte Oskam, who carried out some of the research. "Researchers have tried unsuccessfully to isolate DNA from fossil eggshell for years – it just turned out that they were using a method designed for bone that was not suitable for fossil eggshell."

AMMRF researchers at the University of Western Australia used microscopy to reveal that the DNA is distributed throughout the eggshell matrix. Consequently, the team was able to optimise the DNA-extraction technique to the specific characteristics of eggshell and was able to extract significantly larger amounts of the ancient DNA than can be extracted from other types of material. It appears that the structural features of eggshell are particularly conducive to the preservation of DNA and to keeping bacterial contamination at bay. There was found to be 125 times less bacteria in the eggshell than in fossilised bones, making eggshell an excellent option for the extraction of DNA from extinct birds.

Eggshell from a variety of bird species including the extinct moa from New Zealand, the elephant bird from Madagascar and museum specimens of Australian emus and owls was tested for the presence of preserved DNA.

The DNA was preserved well enough to enable some DNA sequence information to be collected.

This work will allow much more extensive genetic characterisation of historic collections and fossilised fragments of eggs, making it possible to unravel evolutionary processes and link genetic information to changes in diets and in the environmental conditions in which the birds lived. The technique could also be relevant to conservation and forensic applications. ■

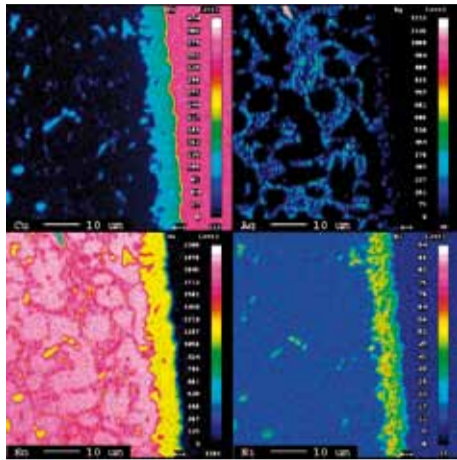


The intense green dots show the location of DNA within the eggshell of an extinct moa (left). The extinct elephant bird from Madagascar (right).



FROM THE NODES

Exchange yields results



AMMRF @ UNSW

As a result of Prof. Paul Munroe's teaching and research links with the University of Malaya, postgraduate researcher See Leng Tay recently completed an exchange visit to the Electron Microscope Unit at the University of New South Wales. Her research program is in analysis of nanostructured solder materials designed for applications in the integrated circuits of electronic devices. See Leng made the most of her opportunities, intensively investigating the relationship between the chemistry and microstructures of solder materials made of tin, silver and either nickel or cobalt. The absence of lead makes these materials more environmentally friendly than conventional solders.

See Leng's study helped her understand the formation mechanism of the intermetallic compounds through the diffusion behaviour of the solder elements within the copper substrate and in the solder itself. Depending on the composition and post processing, the elemental distributions vary as is shown in the concentration map (above) acquired with an electron probe microanalyser.

The researchers are using these data to enhance the mechanical properties of these next-generation solders for optimal performance in electronic devices. ■

International experts share their knowledge

AMMRF @ SARF/USYD

Prof. John Vickerman and Dr Peter Frederik (pictured with Define Cheng), both renowned experts in their fields, have been sharing their knowledge and skills with the AMMRF.

Prof. John Vickerman from the University of Manchester, UK, visited the AMMRF at the University of South Australia recently. He has had a long and distinguished research career in ToF-SIMS, being one of the pioneers in the design and application of modern multi-atom ion guns. These developments have markedly extended the analytical range of the ToF-SIMS, particularly into polymers and biological samples. Prof. Vickerman spent three days working with Dr John Denman on optimising the performance of the C<sub>60</sub> ion gun on the ToF-SIMS

flagship. It has already produced some excellent results in depth profiling of polymeric multilayer materials, only achievable with the C<sub>60</sub> gun, which is unique in Australia.

Dr Peter Frederik is a world expert in cryo-transmission electron microscopy and he holds honorary positions at Eindhoven and Maastricht universities in the Netherlands. As the inventor of the Vitrobot™, an important instrument used to prepare instantly frozen samples, he is the ideal person to help the AMMRF at the University of Sydney kick-start their capability in this area. He has been working closely with A/Prof. Filip Braet and Delfine Cheng to pass on his tips for getting reliable vitrification of diverse samples.

Thanks to both these visitors, the AMMRF can continually improve the services it offers to users in these areas. ■



OUT OF THE FRAME

Shooting star

AMMRF @ CSIRO

During April, Paul Monaghan from the AAHL Biosecurity Microscopy Facility (ABMF), an AMMRF Linked Lab, was competing in Brisbane and Coonabarabran as a member of the Great Britain Match Rifle Team. Paul immigrated to Australia last year, leaving the Bioimaging Group at the Institute for Animal Health at Pirbright in England to head up Advanced Light Microscopy within the high-biocontainment area of CSIRO's Australian Animal Health Laboratory (AAHL) in Geelong, Victoria.

With his specially made rifles only making it through customs in February 2010, Paul admitted to being out of practice for April's Woomera Match against Australia. To make matters worse, Paul strained a muscle in his back on the drive from Geelong to Brisbane and



then suffered a bout of food poisoning, which prevented him from shooting for a full day of competition. After much effort, Paul made it into the Woomera team of eight, shooting against Australia at targets 1200 yards away. Despite a valiant attempt by the Great Britain team, Australia won with a score of 1762, beating the Brits by just three points.

We wish Paul all the best in his next match rifle event. Hopefully he switches sides and competes for Australia! ■

The AMMRF is funded by



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STAFF NEWS

The University of Sydney

**Mr Steven Moody** has recently joined the ACMM at the University of Sydney as SEM Specialist. Prior to becoming a scientist, Steve worked in the entertainment industry in technical aspects of special events. He now holds a BSc in nanotechnology from the University of Technology, Sydney, and he is soon to submit his PhD thesis. Early in his studies, Steve developed a strong focus on electron microscopy and has acquired over five years' experience with a range of techniques including low-voltage STEM, ESEM, cathodoluminescence (CL) and e-beam lithography (EBL). He is looking forward to developing FIB expertise and supporting users in their research efforts. ■

The University of Western Australia

**Dr Tamara Davey** has recently joined the Centre for Microscopy Characterisation and Analysis at the University of Western Australia (UWA) to provide academic support for the centre's optical and microscopy instrumentation. Tamara is already familiar with UWA. She worked as a research assistant and then completed a PhD in Medical Science at the Centre for Orthopaedic Research at UWA, where she continued as a postdoctoral fellow. She has a strong background in molecular and cellular biology and brings a wide variety of skills to the position, including experience with X-ray micro-CT technology. She is looking forward to using these skills in her new role. ■

CSIRO

**Clare Holmes** is a new electron microscopy technician at the AAHL Biosecurity Microscopy Facility (ABMF), one of the AMMRF's Linked Labs. She has a BSc in Forensic Science and Chemistry from Deakin University in Geelong, and has worked as a Forensic Technical Officer at the Victorian Institute of Forensic Medicine, assisting in medico-legal autopsies in the mortuary. Clare also worked in conjunction with the Donor Tissue Bank of Victoria, retrieving donor tissue for transplants. She is a keen traveller and enjoys snowboarding and photography and also enjoys spending her free time training with the Geelong Roller Derby League. ■

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