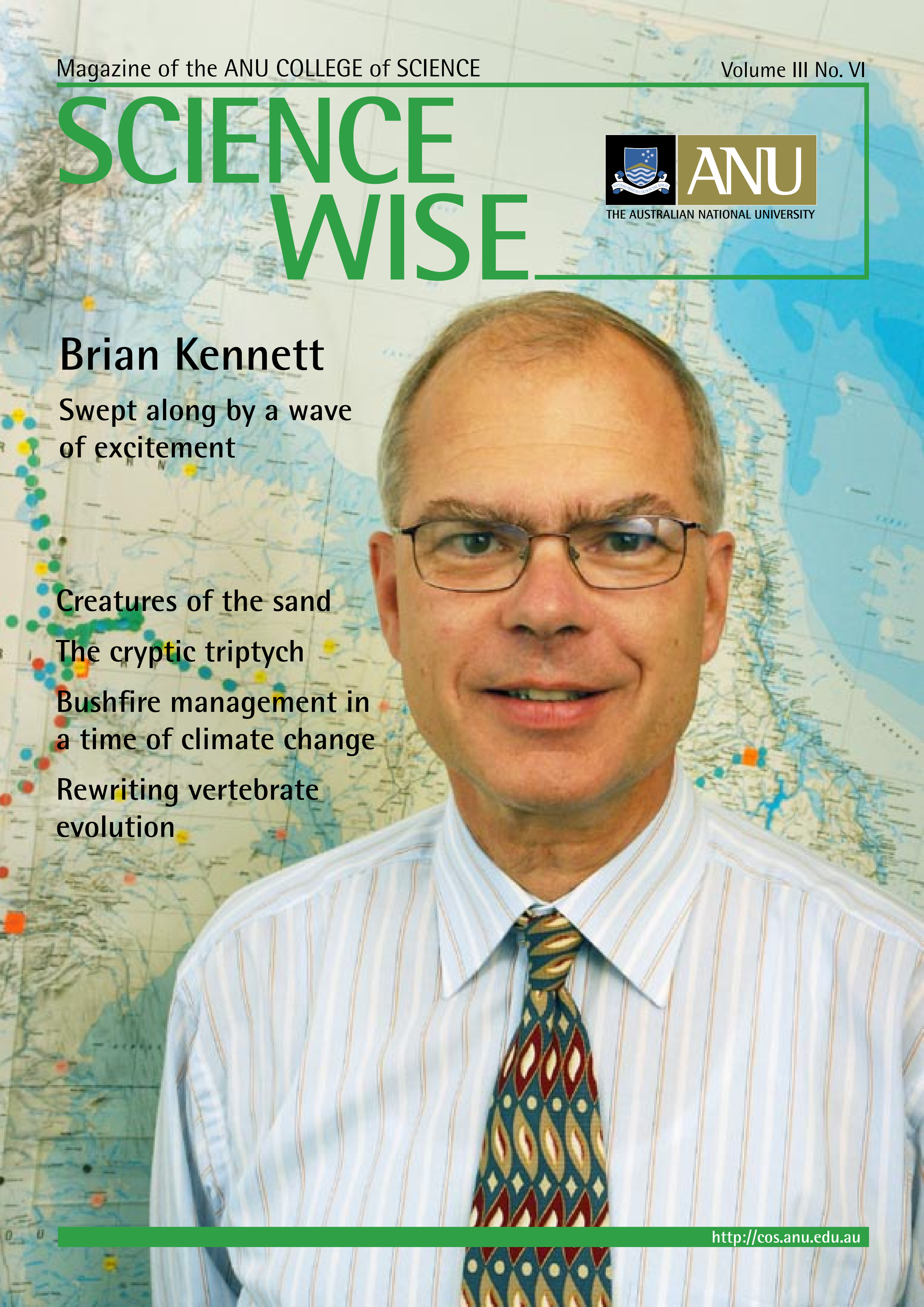
Magazine of the ANU COLLEGE of SCIENCE

Volume III No. VI

SCIENCE WISE

THE AUSTRALIAN NATIONAL UNIVERSITY



Brian Kennett

Swept along by a wave of excitement

Creatures of the sand

The cryptic triptych

Bushfire management in a time of climate change

Rewriting vertebrate evolution

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Cover image:

Professor Brian Kennett is a world expert in seismology. He now takes up the directorship of the Research School of Earth Sciences.

(See page 3 for more details.)

Photo by Tim Wetherell.

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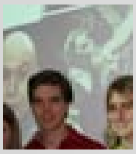

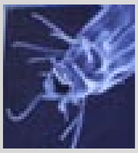

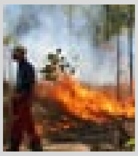

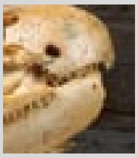

SCIENCE WISE NEWS

MAPPING THE BEE GENOME

The genomic sequence of the honey bee – the fifth and most sophisticated insect to be sequenced yet – has been completed by a group of international scientists, including a pioneering team at The Australian National University.

"The sequencing of the honey bee genome will provide an avalanche of insights into insect biology and the genetic basis of social behaviour in insects. You could say we've hit the honeypot," lead ANU investigator, Dr Ryszard Maleszka, said.

"Study of the genome is set to benefit human health, medicine and nutrition in areas such as venom toxicology, parasitology, and allergic and infectious diseases, the enhanced pollination of food plants, and the accelerated delivery of biological control of pests, among other areas."

The honey bee, or Apis mellifera, is a member of one of the largest orders of the insect world and has long been an important subject for study by scientists, particularly because of its complex social organisation and small but sophisticated brain. The sequencing of its genome has already yielded new findings.

Scientists are buzzing at the discovery that the honey bee genome is the closest yet to that of mammals of any insect so far sequenced, indicating it may have evolved differently.

"It appears that the honey bee genome evolved more slowly than those of the fruit fly and malaria mosquito and consequently contains versions of some important mammalian genes that have been lost from these other insects," Dr Maleszka said. "Why this slower evolution occurred, and whether it's related to the honey bee's sophisticated social structure, will be a fascinating area for further research."

NEW FACILITY FOR STROMLO

October saw the opening of the first new major facility at the Mt Stromlo Observatory since the bushfires of 2003. Known as the Advanced Instrumentation and Technology Centre (AITC), the facility contains state-of-the-art laboratories for research and development of new technologies, and a large Integration Hall for assembling instruments for telescopes.

ANU Vice-Chancellor Professor Ian Chubb said the AITC opening heralded a new era for ANU participation in the international development of large astronomical instrumentation.

"This new facility goes beyond simply replacing lost buildings, extending the capacity of the University to play a key role in some of the most exciting and visionary international projects in astronomy, including the Giant Magellan Telescope," Professor Chubb said.

Research School of Astronomy and Astrophysics (RSAA) Director Professor Penny Sackett said the AITC cemented Australia's participation in front-line international astronomical research.

"It's essential that Australian researchers have access to the best facilities in the world to participate in the global effort to better understand the Universe around us. This facility keeps Stromlo, which has always been at the forefront of astronomy and its instrumentation, on the map, and allows us to play an important role in future developments.

"Every new generation of telescopes demands more complex and efficient instruments. This centre means that Stromlo will long have the facilities to play a role in the development of new technology."

MORE SEX = HEALTHIER BABIES

A team based at the School of Botany and Zoology (BoZo) has for the first time proven that promiscuity increases the survival rate of offspring in an animal species.

"Scientists have developed many theories to explain why some female animals have multiple sex partners: whether it's trading sex for food and protection, dealing with infertile males, or avoiding the negative effects of inbreeding in species that can't recognise their relatives," team leader Dr Diana Fisher said.

"Another theory is that mating with multiple males would result in sperm competition. This means that males with the strongest sperm are more likely to become sires and father better quality offspring."

The researchers found the first compelling evidence for this sperm competition theory among brown antechinuses, a mouse-sized marsupial common in the forests of south-eastern Australia.

The team brought male and female antechinuses into captivity for the mating seasons. Some females were only allowed one mate, while others had three. Groups of three males were mated (one at a time) with three different promiscuous females, so that paternity tests could reveal their success at sperm competition.

"In one year, we released families back into the wild when the babies were still in the mother's pouch," Dr Fisher said. "The result was that survival of babies with promiscuous mothers was almost three times as high as those in the monogamous group."

"The next year, we kept families in captivity until the babies were almost weaned. Again, babies of promiscuous mothers did much better. Paternity tests showed that the sperm of some males were far more successful than others, and, most important of all, that babies fathered by these males were twice as likely to survive."

The research team also included Professor Andrew Cockburn, Mike Double and Michael Jennions from BoZo, and Simon Blomberg from the Centre for Resource and Environmental Studies.

Swept along by a wave of discovery

by David Salt

Seismology is the study of how shockwaves generated by earthquakes move through the Earth. By recording and interpreting these waves we can extract powerful insights on the structure of our planet, detect nuclear weapons tests, better understand earthquakes and, in some situations, provide some warning of imminent tsunamis. Professor Brian Kennett has devoted most of his professional life to the study of seismology and is regarded as one the world's leading experts.

His leadership in this field has won him numerous awards, including the Adams Prize of the University of Cambridge (1983), the Jaeger Medal of the Australian Academy of Sciences (2005), the Murchison Medal of the Geological Society of London (2006) and he will receive the Beno Gutenburg Medal from the European Geosciences Union in April 2007. He was made a Fellow of the American Geophysical Union in 1987, a Fellow of the Australian Academy of Sciences in 1994 and a Fellow of the Royal Society, London in 2005.

Now, after more than two decades of leading the science of seismology at the Research School of Earth Sciences (RSES), he steps forward to take up the directorship of the school.

Professor Kennett's career in seismology began with a PhD in Theoretical Seismology from the University of Cambridge in 1973. Following this he spent the next couple of years researching at the University of California, San Diego and then returned to Cambridge to lecture in the Department of Applied Mathematics and Theoretical Physics.

"I came from a physics background with an interest in wave propagation," says Professor Kennett. "I was also very excited by the earth sciences, and these two interests came together for me in the form of seismology.

Professor Brian Kennett is one of the world's leading seismologists. (Photo by Tim Wetherell)

"My early work was relatively theoretical and looked at the propagation of seismic waves. This focus shifted somewhat when I came to Australia in 1984 to take up the role of Leader of the Seismology group at RSES. I became involved with leading an observational program of seismology which was concerned with various aspects of understanding the three dimensional structure of the Earth.

"The theoretical tools were not there when I started my career and we've developed them since. Using these tools we've put a lot of effort into building three dimensional models of what's beneath the Australian region, and trying to understand the way the Earth works by looking at images of the whole of the Earth's mantle."

While the basics of seismology have been understood for centuries, the science has really blossomed over the past 50 years thanks to increases in computing power and the need to monitor nuclear testing.

"The basic mathematics underpinning seismology was developed in the 19th century," explains Professor Kennett. "The general concept was reasonably well understood in terms of the major phenomena by the last world war. However there have been huge advances in technology and what's possible with seismology since then. The main impetus behind this was the desire to monitor underground nuclear explosions. The American government poured a lot money into the program, and the quality of instrumentation that we use today, being both portable and high fidelity, can be traced back to this time.

"The next step that was really required was developing the capacity for large-scale data collection. In 1960 there were 400-500 seismological observatories around the globe. Now there are 4000 or 5000 observatories that are regularly reporting to international agencies.

"The availability of global communications and access to the Internet has also made an astonishing difference in the development of modern seismology. The data from a very large number of stations around the world is collected within a few hours at a central point in Seattle, and it's then available worldwide. So, for example, the information from the Sumatran earthquake was available within a couple of hours."

While Australia does not experience a large number of earthquakes, Professor Kennett believes the work of his group has made an important international contribution to the international study of seismology.

"RSES is the only centre in Australia that does what might be described as structural seismology using earthquakes to describe the structure of the Earth" he says. "The group of four staff, including myself, has achieved an international recognition on a par with much larger countries. What we've done here is recognised at an international scale.

"One of the reasons for this is that we've had a whole continent to work with and we've concentrated our efforts on Australia whereas many of our international colleagues tend to look overseas for their research opportunities. I suppose the tendency has been for seismologists to go where the earthquakes are. In Australia we've had earthquakes all around us rather than being the location of a lot of earthquake activity, so we've approached seismology in a slightly different way.

"In most parts of the world seismometers are installed where you have earthquakes because you want to study the earthquakes. Australia has had a limited number of earthquakes and consequently the permanent stations weren't there. Studying this continent has involved going out and deploying portable stations to obtain information from places where there are no previous recordings.

"In the last 10 years we have set up over 150 sites where we've put in very high quality stations and another couple of hundred where we've been using equipment designed to pick up high frequency waves rather than low frequency waves which gives us more detailed structure in a more limited area."

Professor Kennett is quick to point out that it's not just in seismology that RSES is highly rated.

"RSES ranks very highly internationally," he explains. "The various imperfect measures that we have of international recognition put us in the top ten earth sciences department in the world. Which is quite an achievement because we don't have components that many of our competitors have.

"I think the secret of our success is probably the sheer diversity of backgrounds and talents that we bring to bear. We have everything from theoretical physicists through to people trained as geologists and geochemists. We have many strands of different activities. Those strands interact and people talk to each other often bringing different strengths to a problem. You don't necessarily see this in other institutions.

"We're big enough to provide the range of disciplinary strengths. But we're not so large that we've got separated into separate departments. One of the ingredients of our success is that it's been a non-departmental school. We have research groups that interact with each other but there are no hard boundaries, and that has been a very important part I think of how the school operates. When we contemplated organisational change we consciously avoided the term 'divisions' because we didn't want to create them."

In a similar vein the College of Science is attempting to maximise the strengths of the university by better integrating the teaching and research strengths across the campus. Research schools and faculty departments are seeing greater interaction on a number of fronts. Professor Kennett believes that relations between RSES and the Department of Earth and Marine Sciences, DEMS (formerly the Department of Geology) have always been positive but that this can be developed even further within the College of Science.

"We've had good relations with DEMS for a long time. Initially they were very separate because the research school and the department covered very different topics. When we were set up we made an effort not to duplicate what was being done.

"Now we have two joint appointments, we recently invited the DEMS staff to join our academic forum and I've been having quite close interactions with the acting Head of DEMS to get a concerted approach on the way we bring resources to bear on certain issues. There are also external groups like the CRC for Landscape Environments and Mineral Exploration which we both have involvement with, and these things require close interaction.

"In addition to this, one activity that has taken place within the College of Science has been the development of a geoscience strategic plan. This has been created as a cooperative effort between the department and the research school. That has been a constructive process and I hope a good sign of things to come."

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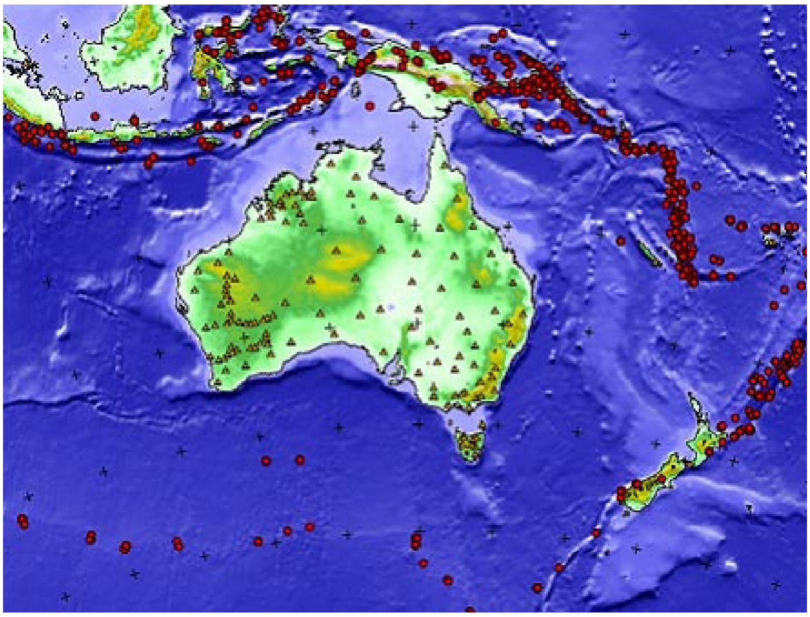

As continents go, Australia is seismologically quiet. However, major earthquakes are taking place all around us. By monitoring the shockwaves radiating out from these events it's possible to extract valuable information about the structure of the planet underneath us. The map indicates the distribution of regional earthquakes (red dots) used in recent studies of the 3-D structure of the Australian region as recorded at the seismic stations (yellow triangles) most of which were portable stations deployed by the Research School of Earth Sciences.

A PhB festival of ideas

by David Salt

There aren't many places you'd hear talks by researchers on such a broad range of topics such as superdeformed nuclei, styles of empathy, circle packing, the genetics of biofilm formation, the Eureka Effect on the musical brain, self-avoiding walks and the chemical lies of *Chiloglottis*. And this was just a small selection of the presentations at this year's PhB Annual Conference.

In addition to the sheer diversity of research on display, the conference was noteworthy for many reasons. First, the presenting researchers were all undergraduates studying for their Bachelor of Philosophy (Honours) (PhB) in the Faculty of Science. Second, the conference was organised by the students themselves.

"I think this year's PhB Conference reflects a growing sense of community among the PhB students," says Mr Nathan Deutscher, a third year PhB student and one of the organisers of this year's event. "This is the second time we've organised the conference and we're hoping it will become an annual meeting. Interest continues to grow and this year we had more people wanting to present than we had time available."

The PhB is an exciting research-focused degree that's now been running for four years at the ANU. The degree is for ambitious students wanting to study at the highest level. Every student receives intensive individual attention from an academic supervisor and are given options to participate in research throughout their degree. To remain in the degree program students need to maintain their grades at the highest level.

"The work load can be tough," says Mr Deutscher. "But the rewards are many in the form of opportunities to undertake research. Though even that is a bit daunting at first because it's up to you to seek out your own research and to make your own contacts. With time you get more confident and before long you develop a real taste for the research."

Mr Deutscher lives in Melbourne and he chose to move to ANU because of the research component offered as part of the PhB experience.

"I was also keen to come to ANU because of its strength in astrophysics," says Mr Deutscher. "When I was looking ahead at a career in science, astrophysics was the area in which I was interested and, of course, ANU had Mt Stromlo.

Nathan Deutscher chose ANU for the research.

"However, I found that my interests changed over the course of the degree. I'm still very much interested in the physics but now I'm also drawn to maths."

Part of his conversion stems from his research experience in the Department of Applied Maths.

"I was working with Dr Vanessa Robins on modelling complex three-dimensional networks, as you might find in oil-bearing rock," he explains. "We were looking at the phenomenon of percolation and how the behaviour of the network changes dramatically when a certain degree of connectivity is achieved. It's enormously exciting to be involved in research that's generating novel results."

He's also keen to share this excitement with others, as are many of his fellow students. And it was this sentiment that led to the organisation of the PhB conference.

"It's fantastic to see the younger students coming through and be just as excited by what they're researching," comments Mr Deutscher. "And it's great to hear about the sheer diversity of work that PhB students are engaged in.

"Our conference is an important focal point for the PhB program, one that we expect will only grow in years to come. This years event was organised by a team of four. In addition to myself there was Frank Cai, Melissa Tacy and Ruth Mills. The presentations were judged by independent outsiders, and prizes for best talks went to Ruth Mills for her work on 'chessboards and self-avoiding walks' and Matthew Pollard for his presentation on 'stock markets and heterogeneous agent models'."

Are scientists mad? This was the question posed by Mr Craig Cormick (far left), keynote speaker at this year's PhB Conference. Mr Cormick is Manager of Public Awareness for Biotechnology Australia and his presentation looked at Hollywood stereotypes of scientists. On his right are the organisers of the conference. They are (from the left): Melissa Tacy, Nathan Deutscher, Ruth Mills and Frank Cai.

"One of the aims of the conference was to dispel myths about what scientists are like so it seemed appropriate to begin the conference with a presentation on the stereotypes," says Mr Deutscher.

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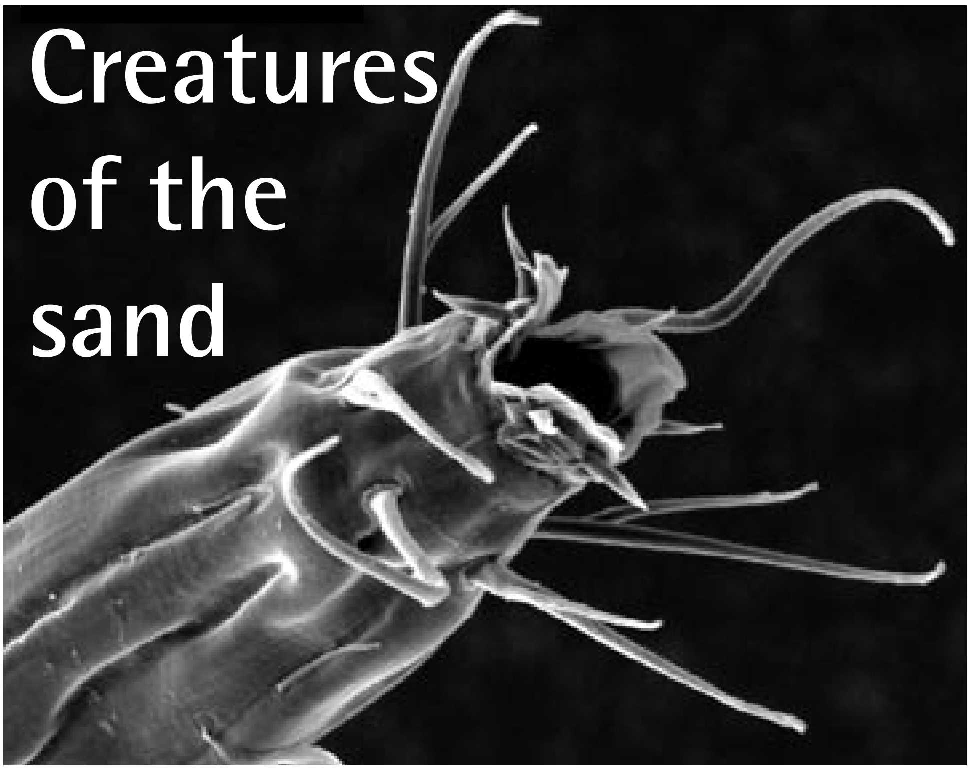
Creatures of the sand



by David Salt

The worm pictured above looks like it belongs in a sci fi horror flick but it actually originated from a sandy beach down at Broulee on the south coast. It's named *Enoplolaimus* and it's just under a millimetre in length. *Enoplolaimus* is a nematode (sometimes called roundworms) and this particular form hasn't been given a species name yet.

There's a whole world of tiny organisms that make their life in between grains of sand. They are referred to as the meiofauna, and Dr Warwick Nicholas, a Visiting Fellow at the School of Botany and Zoology, has been documenting them for many years.

"Since I retired in 1991 I have been systematically examining the meiofauna of Australian estuaries and beaches," says Dr Nicholas. "No one has previously done this systematically in Australia, although it has been well covered in other parts of the world. Most Australian species are new to science. The fauna includes copepods, turbellaria, ostracods, archiannelids, tardigrades and acarina, but by far the most numerous are nematodes."

The image show here was prepared using a scanning electron microscope (SEM) at the ANU Electron Microscope Unit (EMU). Preparing soft and delicate forms for the electron microscope takes a bit of effort because they are scanned in a vacuum. First, Dr Nicholas prepares his specimens by re-suspending a sample of sand in tap water.

"I then collecting the meiofauna it contained on a 60 micron mesh sieve and back wash in sea water into a petri dish," he explains. "The sample is fixed in 5% formalin in sea water, and then the desired specimens are picked up with a micropipette under a binocular microscope. The selected specimens are washed in distilled water and placed individually in a drop of water on a 10 cm diameter copper disc.

"The drop is frozen by placing the disc on a metal stand cooled with liquid nitrogen. The disc then goes into the EMU freeze drier overnight. Double-sided adhesive tape is affixed to SEM metal stubs and the nematodes or other meiofauna are picked up with a fine needle under the microscope and placed tail down on the adhesive tape. The stub, with specimen in situ, is coated with gold/ palladium in the EMU coating unit, then examined in the SEM."

Besides displaying such an evocative form, the image of ***Enoplolaimus*** is also significant in that it was one of the first captured by the EMU's new Field Emission Scanning Electron Microscope. The new machine is a Hitachi 4300 Schottky Field Emission SEM and is expected to be become one of the workhorses of the Unit.

"The Hitachi 4300 FESEM is a fabulous new addition to the EMU," says Dr Sally Stowe, Coordinator the of EMU. "It's a simple, robust and wonderfully flexible machine that will be serving many of our users needs over the coming decades. When fully configured it will incorporate a cold stage, cathodoluminescence detector and energy dispersive X-ray facility.

"One of the aspects that makes it particularly suited to imaging intricate specimens like these nematodes is its ability to operate with a relatively poor vacuum around the subject being scanned. Traditionally SEMs operate in a high vacuum making specimen preparation extra tricky. The Hitachi 4300 is more forgiving. Also, because it's a poor vacuum you don't get so much charging of the fine structures like the feelers around the nematode's mouth. In our older SEMs these feelers would usually have been glowing brightly often making it difficult to record the image."

Besides working on the taxonomy of Australia's meiofauna, Dr Nicholas has also been investigating the ultrastructure and ecology of nematodes. While the work makes a valuable contribution towards understanding a little known aspect of Australia biodiversity, it is entirely self-funded.

"This work would be quite impossible without the support of Sally and the staff of the EM unit," says Dr Nicholas. "It's a great facility making an important contribution to a wide range of research being undertaken across the campus."

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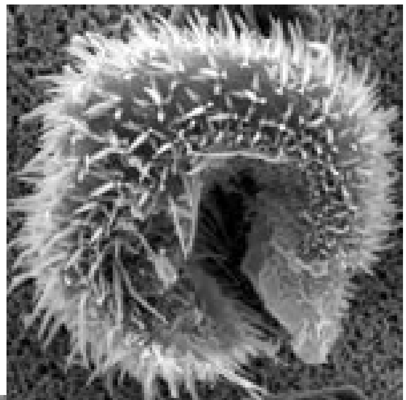

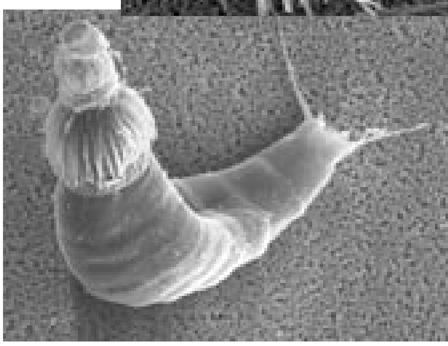

Other examples of the mieofauna collected by Dr Nicholas.

The cryptic triptych

by David Salt

The 13th of October may have been a black Friday for some, but for staff and students in the Research School of Physical Sciences and Engineering (RSPSE) it was a day of celebration. Not only was it 'Founder's Day', an annual celebration of RSPSE's founder Sir Mark Oliphant (see page 11), but it also saw the opening of the long awaited refurbishment of the Le Couteur Building.

Part of the refurbishment involved the construction of a link building to the main Oliphant Building. Besides providing a spacious new common room for students, the Le Couteur Link Building is also the setting for a dramatic new three-piece art work (pictured above) by resident artist and communicator Dr Tim Wetherell.

Known simply as the Triptych, Dr Wetherell attempted to capture many of the themes being worked on at RSPSE.

"The triptych presents a landscape of physics being practised at many scales," says Dr Wetherell, who originally trained in physics. "This ranges from the subatomic up to the intergalactic.

"The first panel reflects the topics of nanotubes and microfluidics. The middle panel incorporates complex surfaces, quantum dots, models of turbulence and is dominated by a giant orange ball representing the Sun. The third panel embodies notions of fractals, mathematics and themes of complexity.

"There are a myriad of intermeshing components running across the Triptych and I'm hoping anyone taking the time to study them will find new ideas and inspiration on repeated viewings."

The refurbished Le Couteur building will house Theorectical Physics and parts of Applied Maths. The building was named after Kenneth James Le Couter who was a Professor of Theoretical Physics at ANU from 1956.

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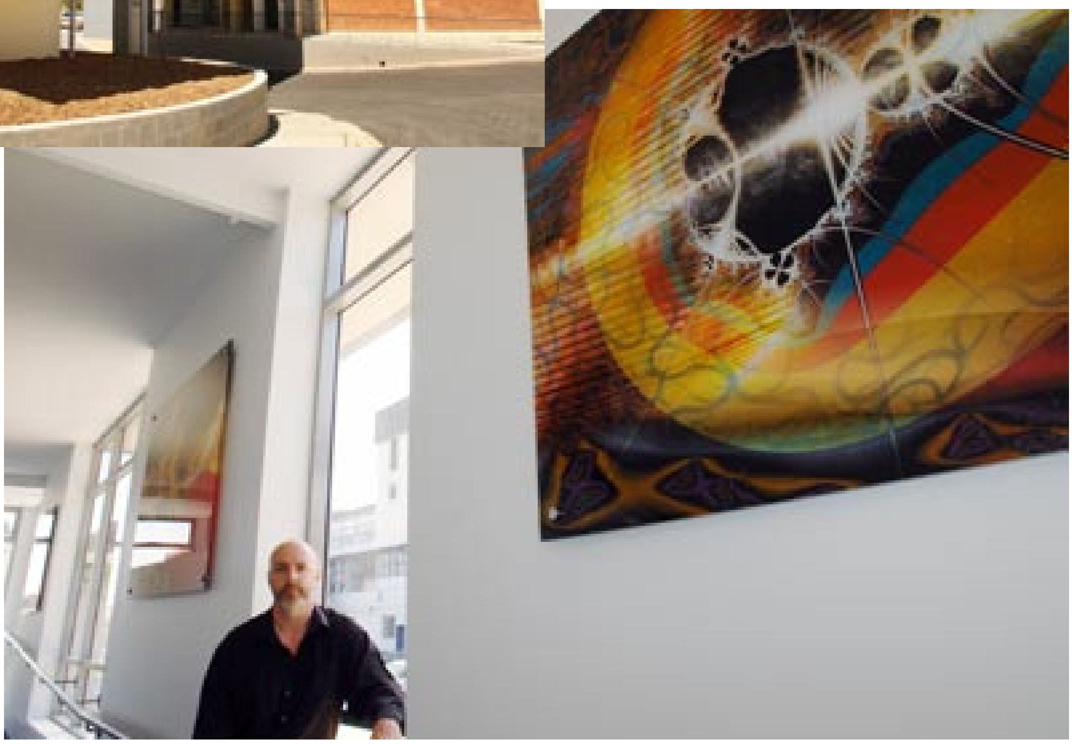
(Left) The elegant exterior of the new Le Couteur Link Building.

(Below) Dr Tim Wetherell stands with his latest melding of art and science, a panoramic Triptych of interwoven physics adorning the walls of the new Le Couteur Link Building.



Burning issues at ANU

By David Salt

Assessing the risk from bushfires is challenging at the best of times but the task is being made significantly more difficult by the prospect of climate change. What's an appropriate management response? Do we carry out more or less prescribed burning? Do we focus on managing fire ignitions? What's the cost of not doing anything to manage the risks? These are big and complex questions with enormous stakes, and there are no simple answers.

"It is not possible nor appropriate to try and fireproof the environment," says Dr Geoff Cary, leader of the ANU Landscape Fire Research Group based in the School of Resources Environment and Society (SRES). "It then becomes a trade-off amongst what can be done with limited resources, acknowledging that fire management isn't cheap.

"The Landscape Fire Research Group carries out a range of research using computer simulation models, statistical analysis of fire history and fire ecology field studies.

Computer simulation modelling provides a useful approach for determining what trade-offs exist between alternate fire management approaches and the long-term impacts of unplanned fires."

Dr Cary has developed a simulation program called FIRESCAPE that incorporates weather, terrain, fuel dynamics and fire behaviour, to model fire regimes and vegetation dynamics. It has been implemented and evaluated in a range of locations around Australia and overseas. This is a useful way of approaching the complex task of understanding the impacts associated with climate change, and it assists in better assessing the efficacy of managing the risk of fire to our economic and environmental assets. He also co-leads an international group of fire researchers who are comparing the behaviour of different landscape-fire-succession models, and has coordinated a major ANU Fire Forum that led to the publishing of the text *Australia Burning*. The expertise that he has gathered together in the Landscape Fire Research Group is starting to generate some real heat.

"We're one of the few fire research groups in Australia that have a modelling focus at the landscape scale, and our reputation for this work is growing," says Dr Cary. "We're currently engaged in many exciting collaborations with a range of partners. For example, the Australian Greenhouse Office has funded us to model fire regimes and carbon dynamics in the mountainous regions of south-eastern Australia. We've also been funded by the NSW Department of Environment and Conservation to explore alternative fire management strategies for the Sydney Basin. We're an associate partner in the Bushfire CRC working on 'Managing bushfire risk in a changing world'. Dr Karen King, a Postdoctoral Fellow in SRES, is funded by the CRC to undertake this work.

"Our growing links with various other groups working in these areas of bushfire science is testament to the importance of our research. This in turn reflects the quality of our people and the experience they bring to the group.

"Our associates, working with us as SRES Visiting Fellows, are among Australia's foremost fire experts. Dr Malcolm Gill is Australia's leading fire ecologist, and Professor Ross Bradstock is head of the new Centre for Environmental Risk Management of Bushfires at the University of Wollongong. Associate Professor Rod Weber is a combustion mathematician with ADFA and Jim Gould, from CSIRO ENSIS, leads Australia's largest fire behaviour research group.

"Our students are leading the group's efforts in fire ecology and on analysis of fire history. Adam Leavesley and Carola Kuramotto are PhD candidates looking at the importance of fire regimes for birds in central Australia and rainforest in the Sydney region. Another is Lyndsey Vivian who is exploring the determinants of spatial variation of plant fire-response strategies in the mountainous regions of south eastern Australia. Nic Gellie is researching his Masters into the patterns of drought in Australia over the last one hundred years, and Amy Davidson's analysis of what determines patterns of fire frequency in the Sydney basin adds to a string of recent Honours theses.

"The Group is also a good example of cross-campus collaboration with the secondement of Ian Davies from RSBS. Ian is an expert ecological simulation modeller and he lends enormous strength to the team.

And the fruits of this research feed directly into a range of courses at SRES.

"There are only a small number of dedicated bushfire science courses in the country," comments Dr Cary. "We're one of them and our students are in the privileged position of seeing bushfire research in action. They also have the opportunity to participate in it, and several of our undergraduate students have gone on to do Honours and post graduate research projects with us. "

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Members and associates of the Landscape Fire Research Group looking at experimental field sites in Sydney with collaborators from the Bushfire CRC. Back row from left are Juanita Myers (SRES graduate now with the CSIRO ENSIS), Simon Travis (Uni of Wales), Kate Hammill (NSW Dept of Conservation), Rob de Ligt (SRES Honours graduate, now a research assistant with the group), Jim Gould, Dr Malcolm Gill, Professor Ross Bradstock, Matt Plucinski (CSIRO ENSIS). In the front row are Dr Karen King (SRES PhD student, now Postdoc Fellow), Amber Pares (SRES graduate, now PhD scholar at the Uni of Wollongong) and Dr Geoff Cary.

Gogo fish rewrites evolutionary history

by Tim Wetherell

The Gogo formation in the Kimberley region of Western Australia presents a unique snapshot of an ancient tropical reef that existed back in the Devonian Period some 370 million years ago. Back then the Kimberley region was under the sea. Today it lies high and dry, the reefs forming rocky limestone hills separated by black soil plains. The plains represent areas of deeper water between the reefs, where thick layers of mud accumulated on the sea bottom.

The warm seawater back then was saturated with calcium, and concretions of limestone would form around any small object lying in the muddy sediments, including the remains of ancient marine animals that settled to the bottom. Over the centuries the limestone accreted around these shells and bones forming little balls of rock that protected their contents from being crushed as the sediments were compacted.

In more recent times erosion has released these spherical limestone nodules to the surface, where they litter the black soil plains. And this has become a palaeontologist's lucky dip because around one in fifty of these nodules reveals a fossil when cracked open. Sometimes the fossils are common and well known. Sometimes they are truly remarkable.

When Dr Tim Senden from the ANU Department of Applied Maths, RSPhysSE accompanied Dr John Long, Head of Sciences at Museum Victoria and one of Australia's most experienced palaeontologist, on a fossil fishing expedition to Gogo no-one was expecting what they would bring home – one of the most remarkable fossils in recent history.

Towards the end of the expedition, Dr Senden, who was on his first serious fossil trip, found the skull of a fish poking out from an eroded nodule. It was the remains of *Gogonasus*, one of the rarest fishes found at Gogo. Only three incomplete skulls of *Gogonasus* had previously been found (and that's from thousands of fossil fish samples representing over 45 different fish species).

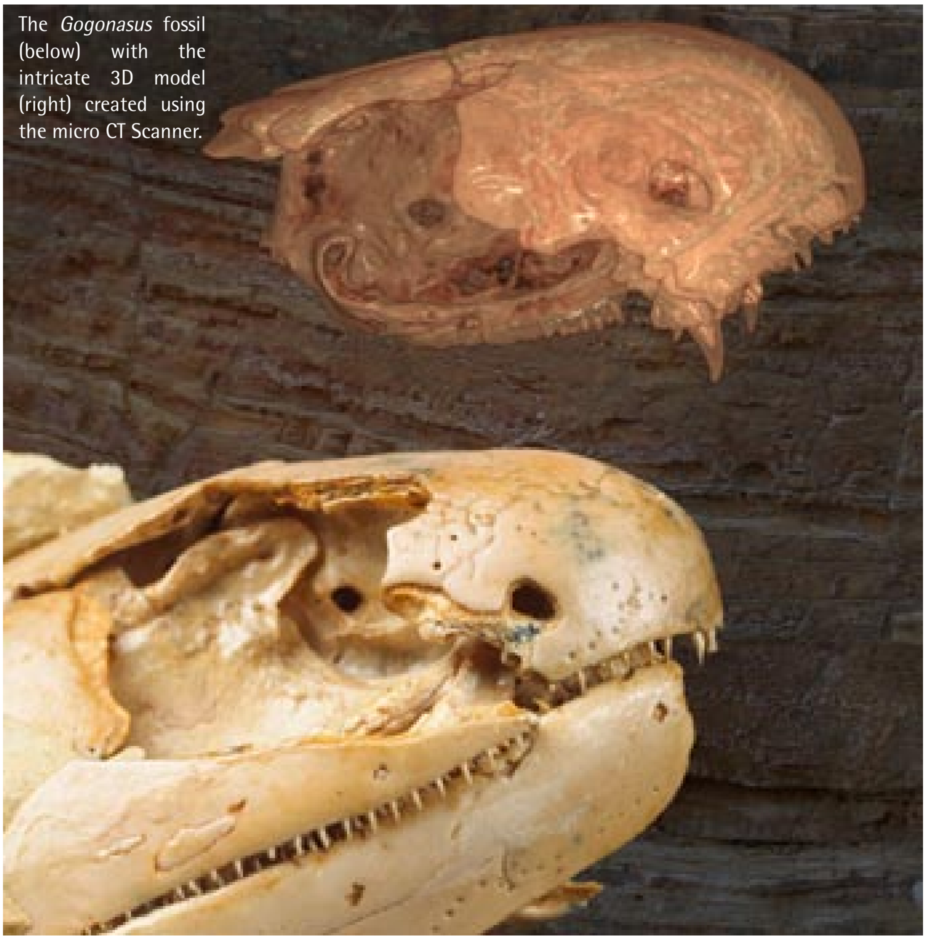
Gogonasus is the only known fish from this vicinity belonging to a major group called the tetrapodomorphs, an evolutionary branch that included early fish ancestors of the first four legged land animals, or 'tetrapods'.

Further searching uncovered other nodules from the same animal providing what is the first complete tetrapodomorph skeleton ever discovered from Gogo. Tetrapodomorphs are interesting because they represent the very first steps that back-boned animals took to emerge from an aquatic existence onto dry land, ultimately evolving into all the amphibians, reptiles, birds and mammals. By studying the brain and sensory organs of these exquisitely preserved fossils, scientists can glean vital information about the evolution of vertebrate life on the planet.

One organ of special interest is the ear. Fish living in water have the semicircular canals of the inner ear, which are organs of balance, but no need for the middle ear. In a mammal the middle ear is formed as a series of tiny bones, called (after their shape) the hammer, stirrup and anvil bones, which transmit sound to the braincase from the outside. The first amphibians needed to adapt to the very different challenge of picking up sounds in the far less dense medium of air, by modifying some of the bones supporting the gill cover for this purpose.

By studying the ear structure of tetrapodomorphs, scientists can unravel the complex series of events that culminated not only in the development of modern mammalian ears, but also the complex brains that accompany them. The difficulty here is that the structures of the ear lay deep inside the bone of the animal's skull. Two-dimensional X-ray radiographs are of limited value and conventional CT scanners such as those used in hospitals, don't have anywhere near the spatial resolution to probe such tiny objects.

This is where the revolutionary micro CT scanner developed in the Department of Applied Maths really came into its own. This instrument is able to perform three dimensional X-ray scans of objects with voxel (3D pixel) resolution of two micrometres. To put that into perspective, this is almost as fine as detail that can be seen in the optical microscopes. Using the CT scanner, Dr Senden and colleagues were able to build up a perfect three-dimensional model of the



The *Gogonasus* fossil (below) with the intricate 3D model (right) created using the micro CT Scanner.

tetrapodomorph skull. This model reveals not only the middle ear, but nerves, blood vessels and various brain case structures vital to understanding the evolution of the complex brains required by land animals.

The 3D tomographical model produced by the CT scanner offers other exciting prospects too. Exact replicas can be directly printed into resin using rapid prototyping machines. This enables perfect replicas of the fossil to be created with both external and internal detail impossible to capture with conventional casting techniques. The computer model can also be used to create an animated creature. All the joints can be articulated in the virtual environment, enabling the scientists to test how the creature might have walked or swum, how its jaws moved and how it breathed.

The spectacular find and subsequent analysis has formed the basis of a recent article in the prestigious scientific journal Nature. It has also turned some aspects of accepted theory on evolutionary history on their heads. Because the Kimberley region can be so precisely dated, the group has been able to establish that the fish *Gogonasus*, with well developed bones inside the fleshy lobes of its fins, showed that precursors of the bones of the tetrapod limb were beginning to evolve some 30 million years earlier than had previously been thought.

The *Gogonasus* fossil was found by Dr Tim Senden (on the left). The skeleton was acid-etched from the rock at Museum Victoria, and then scanned by Dr Senden using the micro CT Scanner pictured here. Standing with Dr Senden is Dr Gavin Young. (Photo by Tim Wetherell)

The completeness of the skeleton has also enabled clear links to be drawn between this specimen and partial remains found as far away as Europe, Canada, and China. The wide distribution of these creatures lends weight to the possibility that amphibians may have emerged from the ocean, rather than evolving in localised fresh water deposits as some scientists had previously believed.

The *Gogonasus* research forms part of an ARC Discovery Project based at ANU and led by Dr Gavin Young from the Department of Earth and Marine Sciences. The CT Facility is also supported by the ARC and forms the central part of a large group working on computational interpretation of and simulation in 3D data of complex materials such as oil-bearing rocks, bone scaffolds and ink flow in paper.

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A good excuse for a celebration

by David Salt

Though Sir Mark Oliphant retired as Director of the Research School of Physical Sciences in 1963 he always maintained an active association with the research school he had established. In 1981, on the occasion of his 80th birthday, the school decided to honour Sir Oliphant with a day of celebration consisting of a morning of seminars and award presentations followed by a barbecue lunch for the whole School. And so the tradition of 'Founders Day' was born.

Every October on a date near Sir Oliphant's birthday, staff, students and friends of what is now the Research School of Physical Sciences and Engineering come together to tell stories about their science, reflect on the year that's been and let their hair down over a drink and a barbecue.

Pictured here are three Directors of the school swapping stories on Founders Day in 1984. From the left they are Sir Ernest Titterton, Professor John Carver and Sir Mark Oliphant. At the time, Professor Carver was the serving Director and it was he who instigated the tradition of Founders Day.

The photo was provided by the ANU Archives Program. For more info on the ANU Archives Program see www.archives.anu.edu.au/

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