Newsletter of the ANU COLLEGE of SCIENCE

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SCIENCE WISE

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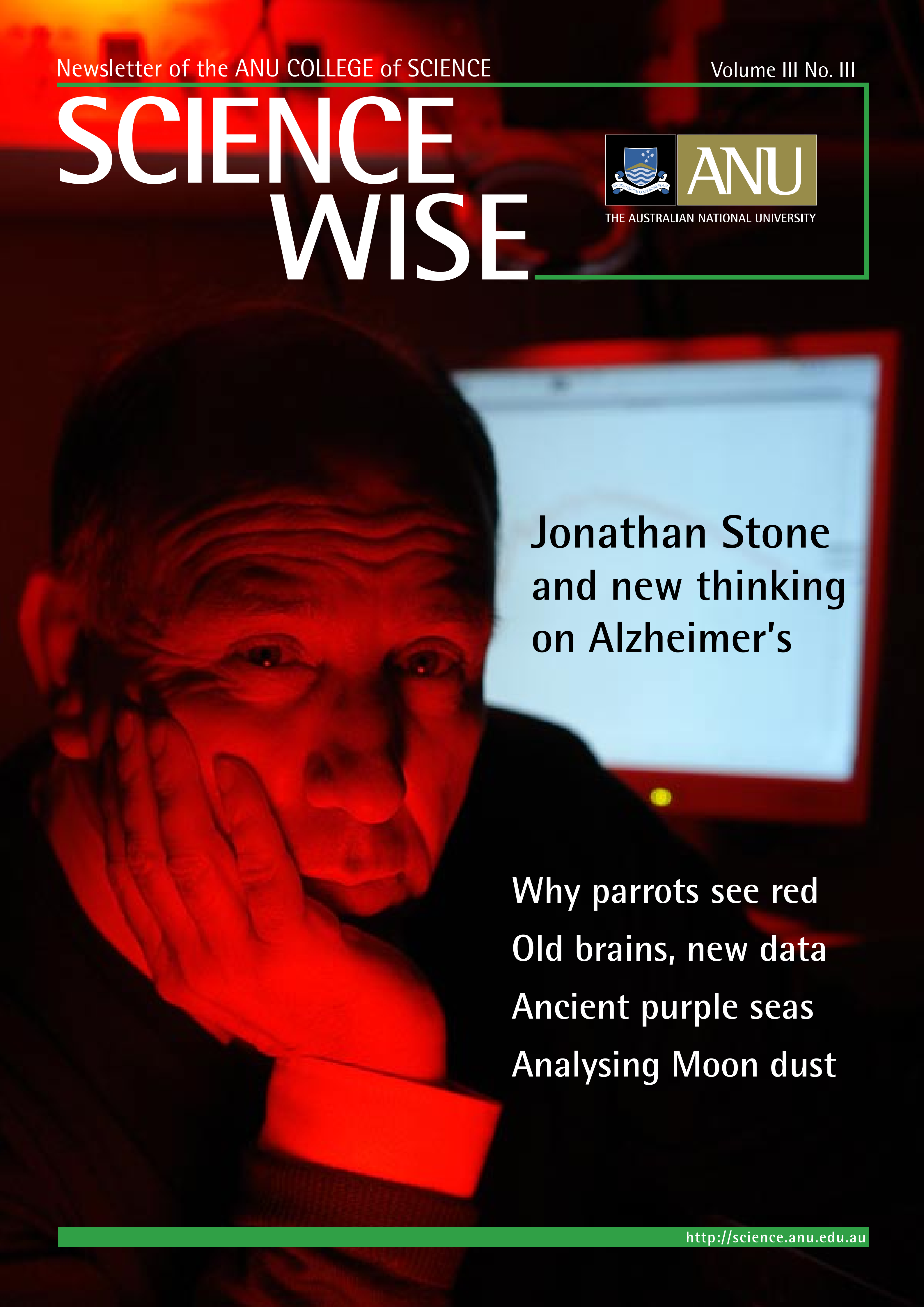

Jonathan Stone and new thinking on Alzheimer's

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Ancient purple seas

Analysing Moon dust

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Cover image:

Professor Jonathan Stone is the Director of the Research School of Biological Sciences and a leading proponent of a new approach to Alzheimer's (see story on page 3).

Photo by Tim Wetherell.

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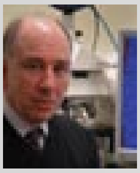
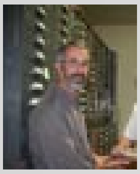
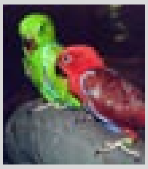
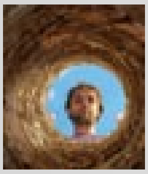








As Australia's national university, ANU has always been held in high regard by the Australian Academy of Science, the nation's scientific brain trust. This has been well illustrated in recent months with the election of a senior ANU scientist as the Academy's new President, the conferral of several awards to ANU researchers and the election of two ANU academics as new Fellows to the Academy. Details are presented below.

LAMBECK AS NEW PRESIDENT

Professor Kurt Lambeck, Professor of Geophysics at the ANU Research School of Earth Sciences (RSES) has been elected to lead the Australian Academy of Science, Australia's senior organisation of research scientists and technologists. He succeeds Dr Jim Peacock who completed his four-year term in May.

Professor Lambeck, 64, was elected to the Academy in 1984. He has been at the ANU since 1977, including 10 years as Director at RSES. His principal research areas have included climate and environmental sciences, geophysics and space science. His current research focuses on the interactions between ice sheets, oceans and the Earth, as well as the rise and fall of sea levels and their effect on human civilisations.

Professor Lambeck's research has been recognised in Australia and overseas. In addition to being the recipient of many prestigious international awards, he is a Fellow of the Royal Society of London and a Foreign Member of the Netherlands Academy, the Norwegian Academy, Academia Europea and the Académie des Sciences, Institut de France.

Professor Lambeck has extensive links with the international scientific community having held research positions in Europe and the United States. He has, for many years, represented Australia on numerous international committees including the Intergovernmental Panel on Climate Change and the Antarctic Science Advisory Committee. He was Foreign Secretary for the Academy from 2000-04.

"It's a great honour to have been elected President of the Australian Academy of Science," says Professor Lambeck. "I will be working hard during the next four years to advance science at all levels – through school programs, at universities and, importantly, in the development of the careers of Australia's young scientists.

"I will be promoting Australian science in the international scientific arena and putting science into Australia's foreign policy. Science is global and Australia needs to expand its presence in international science to secure our social, economic and environmental future."

ANU WINS ACADEMY AWARDS

As one of his final official duties as outgoing Australian Academy of Science President, Dr Jim Peacock gave out a series of awards in May to scientists from across Australia as national recognition for their research. ANU was well represented.

"These prestigious awards not only promote the high calibre of scientists we have in Australia but also highlight the positive benefits that science provides," said Dr Peacock.

Dr Peacock said one of the highlights of the ceremony was awarding the Academy Medal to Professor Mike Gore from the ANU Centre for the Public Awareness of Science for his outstanding contribution to science, in particular through the establishment of Questacon.

"Professor Gore's dedication to science education, through Questacon, has brought the excitement and wonder of science to countless children and adults across Australia," said Dr Peacock.

Other ANU researchers receiving awards included:

Professor Jenny Graves (Research School of Biological Sciences) who received the Macfarlane Burnet Medal for her highly acclaimed international reputation for her work in mammalian genetics and comparative genomics on Australian marsupials and monotremes.

Professor Barry Ninham (Research School of Physical Sciences and Engineering) who received the Craig Medal for his pioneering work in molecular self-assembly and non-electrostatic interactions between molecules.

Assoc Professor Michael Sherburn (Research School of Chemistry) who received the Le Fevre Memorial Prize for developing powerful new methods to achieve efficient chemical synthesis. His research group created superbowl-container molecules to capture and release drugs and chemicals.

Dr Mahananda Dasgupta (Research School of Physical Sciences and Engineering) who received the Pawsey Medal for her development of theoretical models to describe quantum tunnelling of composite objects and designing experimental particle detection equipment.

TWO NEW FELLOWS FROM ANU

Each year the Australian Academy of Science elects 18 new Fellows to join its ranks. Election to the Academy is an honour and recognises a career that has significantly advanced, and continues to advance, the world's scientific knowledge. In March, the 2006 list of Fellows was announced and two of these prestigious positions went to ANU researchers:

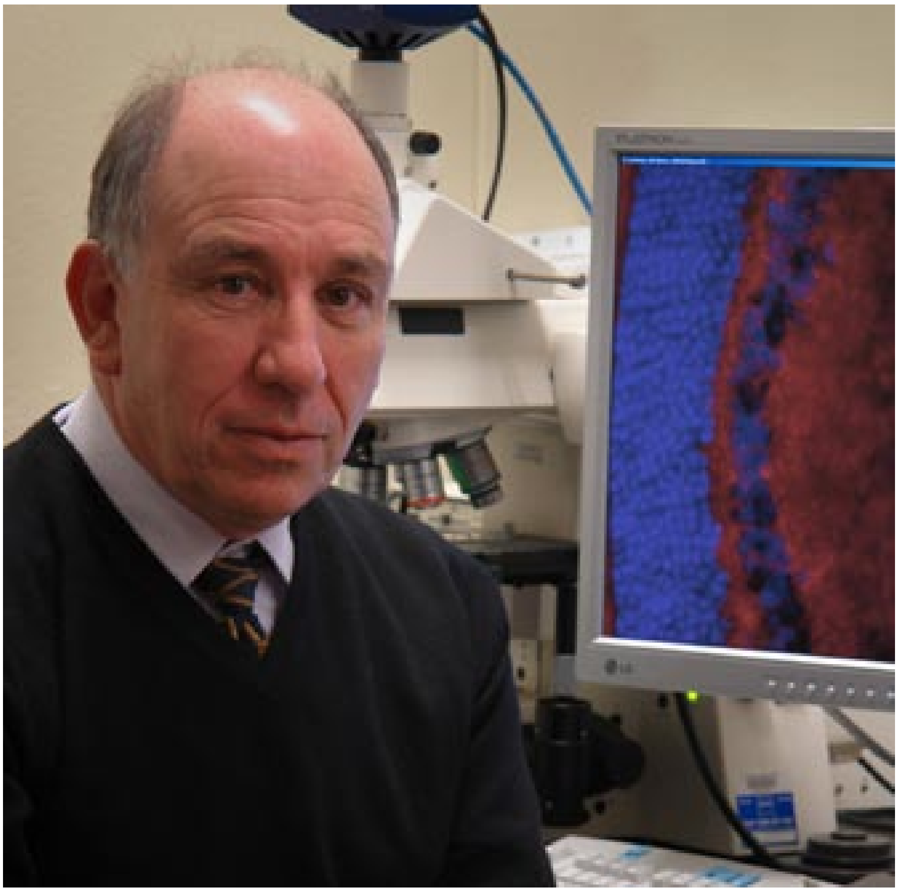
Professor David Hinde is based in the Department of Nuclear Physics, Research School of Physical Sciences and Engineering. He has developed novel experimental equipment and techniques allowing the elucidation of the time-scale involved in heavy ion reactions. His work has led to a significant change in our knowledge of nuclear dynamics, resulting in a redirection of international research.

Professor Susanne von Caemmerer is from the Molecular Plant Physiology Group, Research School of Biological Sciences. She is distinguished for her work on the modelling and experimental verification of photosynthesis, the carbon acquisition of plants, the biochemistry of carbon dioxide fixation and regulation of carbon dioxide diffusion in leaves.

Changing our thinking on Alzheimer's

by David Salt

There's a growing call from many scientists to reassess our approach to the degenerative brain disease Alzheimer's. The disease is associated with the formation of tiny plaques which form at sites of cell death in the brain. The prevailing theory is that these plaques both result from and cause the death of neurones which underlies dementia, as they contain a toxic protein called amyloid. The emerging counter view is that Alzheimer's is the result of microscopic bleeding in the brain, and that the plaques are the remnants of these bleeds.



Professor Jonathan Stone

"The plaques are probably inactive," says Professor Jonathan Stone, Director of the Research School of Biological Sciences at ANU. "Each is the tiny scar from a microscopic bleed in the brain. Each bleed is so tiny that by itself it goes unnoticed. However, over time, as more and more occur, the damage accumulates as nerve cells around these micro bleeds degenerate, and the symptoms of Alzheimer's gradually appear.

"Alzheimer's then is primarily a vascular problem, a condition driven by the breakdown of an ageing circulatory system."

Professor Stone is a neuroscientist who has been interested in the causes of Alzheimer's for many years. He says there is a growing body of evidence points to the vascular origins of the disease but that a key piece of research supporting this hypothesis has only recently been published. This was provided by Professor Stone's colleague, Dr Karen Cullen, a neuroanatomist from the Bosch Institute at Sydney University. She has shown that each plaque has a broken capillary running through it with signs of bleeding in it. This applies to all plaques whether from young brains where plaques are uncommon, or from old brains where they were numerous (and dementia had been observed). Every plaque, she found, was the site of a small bleed.

Dr Cullen and Professor Stone published these findings late last year in *The Journal of Cerebral Blood Flow and Metabolism*. Additional supporting evidence was that 'clean-up' cells which cluster around broken blook vessels to prevent further damage were found around the sites of the injured vessels. They also found that iron-rich compounds derived from blood were also found in the plaques. The plaques also contained clotting and serum factors that occur in brain tissue only where there has been a bleed.

Adding to this is a significant amount of epidemiological evidence suggesting a vascular connection with Alzheimer's. Therapies that improve cardiovascular health are known to delay the onset of Alzheimer's. It's been known since the 1980s that anti-inflammatory drugs taken for other conditions such as arthritis are highly protective against Alzheimer's. Statins taken to reduce cholesterol and artherosclerotic degeneration of vessels have also been shown to be protective against the disease, and controlling high blood pressure reduces the rise of Alzheimer's in people aged 65 and over. Regular exercise and the Mediterranean diet, both known to have benefits for vascular health, also appear to delay the development of Alzheimer's.

"The risk factors for Alzheimer's are the same as for cardiovascular disease," says Professor Stone. "High blood pressure is bad, exercise is good, low blood pressure is good, low blood cholesterol is good, low artherosclerosis is good. Even without Dr Cullen's detailed and extensive neuropathology, that's enough to make you think that these dementias have a vascular origin."

However, Stone and Cullen's findings and the epidemiological evidence have yet to change the mainstream medical view, which still holds Alzheimer's to be a neurological disorder rather than a vascular disease. The bulk of the current research into Alzheimer's

"Once you realise that it's a vascular disease you stop trying to cure it because you can't – once things happen, they happen. It's like a stroke, you can't reverse it but you can work to prevent it. "

is aimed at finding a cure to the amyloid plaque but to date results have been extremely disappointing.

"All the effort going into drug design that attempts to restore the brain's function isn't working," observes Professor Stone. "Once you realise that it's a vascular disease you stop trying to cure it because you can't – once things happen, they happen. It's like a stroke, you can't reverse it but you can work to prevent it. Our efforts should be directed towards prevention and we should be looking at treatments that stabilise blood vessels."

Professor Stone believes Alzheimer's is an important and growing problem because it's a disease associated with growing old and we live with an ageing population. It raises questions about the limits to ageing.

"As we've kept the other organs going we've run into the limits of the brain," he explains. "Are the limits of the functional life of the brain set by the stability of the neurones or are they set by the stability of the blood vessels that supply the brain? I think that in the case of people suffering from Alzheimer's type dementia it's the stability of the blood vessels that is the limiting factor."

So, when it comes to the belief that you can keep your mind in good shape by keeping the brain active, he's a bit guarded.

"It's more important to keep your body active and your blood vessels in good shape. Like everyone else, I like to think that if I could just keep solving crosswords till I'm 103 I'll be doing the right thing but I actually fear that if I don't look after my blood vessels I won't be fine. To that end I watch my diet, exercise as best I can and, for good measure, take a mini-aspirin every day whenever I remember."

As with many causes he has taken on in his career, Professor Stone is prepared to stand up and be heard on the vascular connection with Alzheimer's even if it goes against mainstream thought.

"The current approaches are simply not working. However, if we could only delay Alzheimer's in people for a year, or five years or 10 years, then it would make an enormous difference to human suffering."

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The mind in question

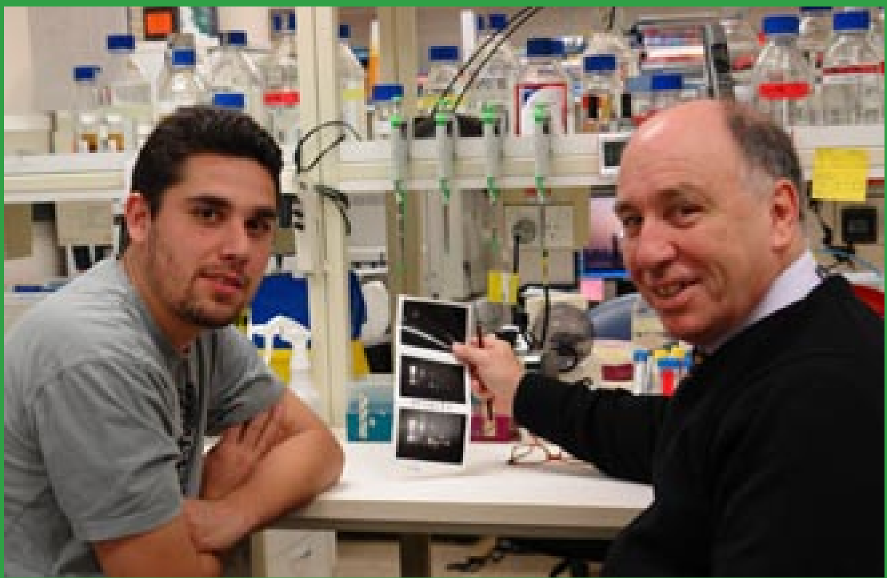
Professor Jonathan Stone is a neuroscientist whose principal interest has been in the visual pathways. His early work included the development of the whole-mount technique of retinal analysis, analyses of retinal receptive fields, and analyses of the topography and naso-temporal division of the retina. In the 1970s he was a research fellow at the John Curtin School of Medical Research where he continued his research on the retina, discovering a new class of cell in the retina and developing an explanation of how the retina sends information to the brain. He showed that different types of ganglia went to different areas of the brain. This led to the concept of parallel processing in which the three basic types of information (colour, shape and motion) are separated in the retina and sent through parallel pathways to the visual cortex.

In 1976 he moved to the University of New South Wales where his research interests shifted from the study of parallel processing to the development of the brain. His next appointment was as Challis Professor of Anatomy at the University of Sydney (1987-2003). Here he worked on the interaction of neuroglial cells during the stresses of birth, particularly focusing on types of blindness that result from the degeneration of photoreceptor cells.

Professor Stone was appointed Director of the Research School of Biological Sciences (RSBS) at The Australian National University in 2003. At ANU his research has focussed on the stability and degeneration of the central nervous system, including dementia and a group of inherited eye diseases that affect the retina.

"It's a privilege to be director of a such a distinguished school as RSBS," says Professor Stone. "We're strong in many areas of bioscience and, in particular, the areas of plant science, animal genomics and neuroscience where we're really setting the standard. Of course, a large part of our strength lies in our interactions with other areas at ANU, in particular with various departments in the Faculty of Science and the John Curtin School of Medical Research. The College of Science and the College of Medicine and Health Sciences have an important role in ensuring these interactions are fruitful and ongoing.

"My role as director at RSBS is not so much to direct the research but to build the infrastructure so that top quality research can be carried out, to maintain an atmosphere of goodwill and mutual support among our people, and to effectively deal with problems as they arise. To draw a analogy with the brain and its blood vessels, as director my role is not to control how the brains in my school 'think' but to provide them with a healthy infrastructure that will nourish and vitalise their 'thinking' well into the future."



Professor Stone with PhD student Riccardo Natoli, who is working on the effects of increased oxygen on the development of the retina. (Photos by Tim Wetherell)

Secrets of the strong room

by David Salt

Deep in the Geology Building of the Department of Earth and Marine Sciences (DEMS) lies a small, fire-proof, armoured vault. The walls of this strong room are lined with steel drawers filled with carefully packed treasures from our planet's long and rich biological past. There are trilobites, brachiopods, echinoderms and a range of other fossilised forms, many of which are the precious 'type' specimens on which these extinct animals were originally described. While these are precious in their own right, what makes the room's collection unique and priceless is the extensive collection of Devonian fish from around Australia.

The unique type specimen (12cm lower jaw) of *Metaxygnathus*, Australia's first land vertebrate

Dr Gavin Young (left) with colleague Professor Ken Campbell examine the exquisitely preserved fossil skull of *Griphognathus whitei*, a 375 million year old lungfish found at Gogo in the Kimberleys. New techniques such as X-ray computer tomography are providing fresh insights on the internal structure of these fossils (see Old brains, new data) and are helping to rewrite traditional views of vertebrate evolution.

"The Devonian Period lasted from 415 to 360 million years ago, and is known as the Age of Fishes," says Dr Gavin Young, a visiting fellow at DEMS and an expert on Devonian fish. "It was a time in which vertebrates evolved the structures that enabled them to colonise the land, and fossils from this period hold enormous interest for biologists interested in the evolution of vertebrates.

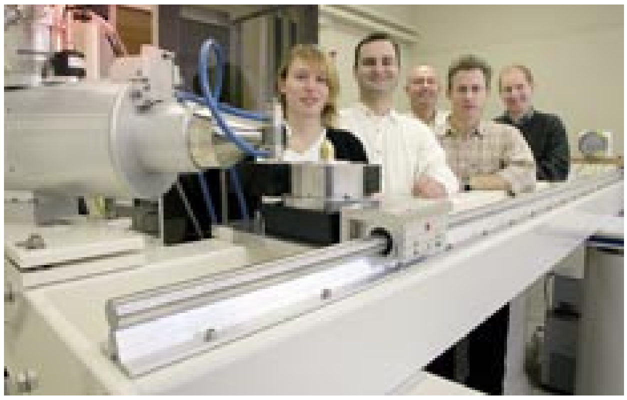
"There are two sites around the world that are especially noted for the richness of their Devonian fish fossils, and they're both in Australia – Gogo in the Kimberleys, and Lake Burrinjuck, on Canberra's very door step. If our strongroom is special for anything it's this reference collection of fossils from these two sites. These include hundreds of fragile Devonian fish specimens in which the skull and braincase have been completely removed from the limestone rock by the painstakingly slow process of acid etching."

It's not just the detail of some of the specimens but also the fact that they were collected in the southern hemisphere that holds significance. Back in the Devonian, Australia was part of the super continent Gondwan. Some palaeontologists believe there is evidence to suggest Gondwana was where the fish evolved into the land dwelling tetrapods, though the more widely held view is that this happened in the northern hemisphere.

"The trouble is that Gondwana is a pretty large piece of real estate, and there aren't as many scientists exploring this ground compared to Europe and North America," says Dr Young. "Consequently it is relatively unexplored, and what we have uncovered is often overlooked by our northern brethren.

"Earlier this year, for example, there was much fanfare made over the discovery of a fossil fish from the Canadian Arctic that was supposedly caught 'in the act of adapting towards a life on land'. The finding, which appeared in *Nature*, is no doubt an important discovery because the fins on this animal were evidently modified to support the animal off the ground. However, this creature is a fish – it does not have legs.

"Not mentioned in the published reports is the fact that at about the same time that this newly discovered fish was around in the north, animals with legs – tetrapods – were already walking around in south-eastern Australia. The incontrovertible evidence comes from fossil tracks in Devonian rocks at Genoa River just across the NSW/Victoria border in east Gippsland, and now on display in Museum Victoria.



The X-ray computer tomography facility at Applied Maths (Research School of Physical Sciences and Engineering). (Photo by Tim Wetherell)

"To date, only one bone of a tetrapod has ever been found in Devonian rocks of Gondwana - a lower jaw from an animal called *Metaxygnathus*. This unique specimen was found near Forbes and is held in the DEMS strongroom. It was described as an amphibian by my colleague Professor Ken Campbell in 1977. After 20 years dismissing this as merely the jaw of a fish, European experts finally conceded in 1997 that it was definitely the jaw of a tetrapod.

"These southern hemisphere records confuse the simple scenario of a well-documented evolutionary series from fish to amphibian, based on northern hemisphere fossils," says Dr Young. As a result they are conveniently overlooked. In the *Nature* article various fish fossils are compared with the most complete remains of Devonian tetrapods (from East Greenland), and assembled to suggest a series of 'intermediates' in the form of the skull, and development of the limb bones.

"Apart from the geological evidence of our southern hemisphere fossils, there are various unresolved problems in the morphology of the fossil remains – for example, the radically different braincase structures between the presumed fish-like intermediates and the early tetrapods.

"Recently we have been investigating such questions at ANU using X-ray CT scanning techniques on a remarkable lobe-finned fish specimen found only last year by Tim Senden on a collecting expedition to Gogo. This was led by the co-leader of our project, Dr John Long (Head of Science, Museum Victoria). The X-ray CT facility at the Department of Applied Maths is one of the best facilities in the world for such work.

"Indeed, we have various new lines of evidence supporting our view that the traditional story about northern hemisphere evolution of first land animals may not be correct."

The unfolding story of life on Earth has come a long way in recent years, but it's a sure bet there are several new chapters waiting to be told based on the fossils of the DEMS strong room.

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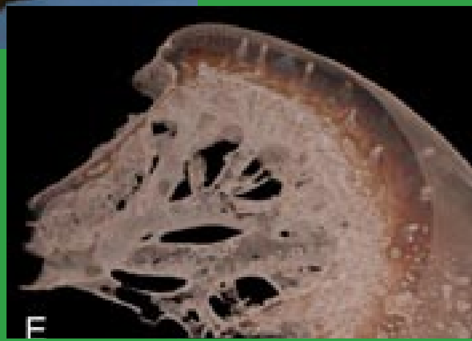
Dr Gavin Young discusses the largest Devonian fish skull ever found at Lake Burrinjuck (around 45cm long) with Dr Tim Senden, a physical chemist who is now working with the palaeontologists on new ways of extracting information from the fossil collection.

Old brains, new data

X-ray computer tomography is allowing the internal structure of fossils to be visualised in fine detail. The skull of the 375 million year old fossil lungfish *Griphognathus* (left) was scanned to reveal an intricate network of tubes and openings (below) under the bony surface of its snout. (Image of skull courtesy of Dick Barwick)



X-ray computed tomography has proven to be a big winner in deciphering the 3D structure of fossils that are hundreds of millions of years old. Computer tomography (CT) uses X-rays to image slices of a sample and then a computer to stitch these slices together to build a 3D model of its structure. The Department of Applied Maths (at the Research School of Physical Sciences & Engineering) designed and built its own X-ray CT facility.

"Our X-ray CT facility is one of the finest around," says Dr Tim Senden, a Research Fellow at the Department of Applied Maths. Dr Senden played a key role in developing the facility. "When it comes to mapping the fine structure of complex materials over length scales of microns to millimetres there are few other facilities that can match our capacity.

"The facility has been used to characterise a diverse range of structures and materials. For example, it's been applied in a wide ranging investigation on the nature of oil-bearing rock. Many of the rocks we've examined have contained a number of fossils but up until recently the focus has never been on providing information on the fine scale structure of those fossils. However, that all changed several months ago when Dick Barwick from DEMS approached our group to see if we might be able to help map out the internal structure of several lung fish fossils they had."

"The vertebrate head has developed over some 500 million years of evolution," says Dr Young. "Of all the complex structures biology has provided, the evolution of the vertebrate brain and its sensory organs is perhaps the most enigmatic. The fossil record occasionally provides us with a chance to trace this evolution but the finer detail of the internal structures of these fossils are fiendishly difficult to unravel. We have the specimens, so now it's a matter of finding ways of understanding their internal detail.

"The new data we're generating will radically change views on the evolutionary relationships of the major groups of jawed vertebrates. It's an exciting time to be involved in this work."

And the enthusiasm is not just being felt by the palaeontologists.

"This is some of the most exciting work I've been involved with," says Dr Senden. "To see how intuitive these gentlemen are with these fossils, and to witness the thrill they get when we reveal new detail in these treasures is tremendously rewarding."

And it seems that the seeds of interest that have been planted through this collaboration are yielding some interesting fruit. Dr Senden is now working with some of Australia's other top palaeontologists on a range of fossils including the earliest known animals in the form of the Edicaran fauna and the world's earliest mammals.

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The lobe-fin *Gogonasus* is the best preserved member of the evolutionary branch leading to the first tetrapods. (Image courtesy of John Long)

Why parrots see red

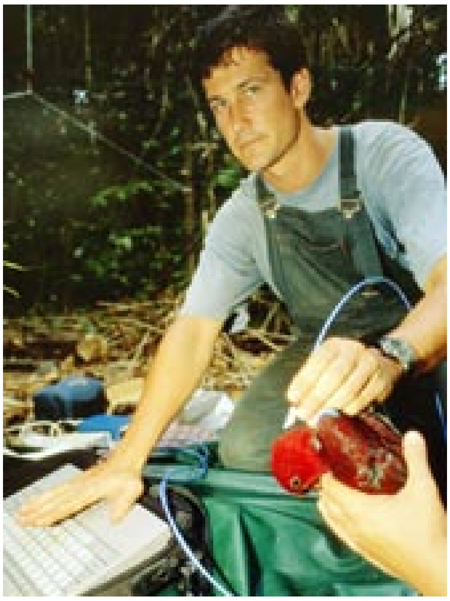
by Tim Wetherell

The general principle in competitive sexual selection is that the sex that invests least in the rearing of offspring has the most energy to spare for beautification and display. Animals of the 'drab' sex select mates from the 'beautiful' sex based on their looks and competitive behaviour. This principle can be seen in many species of birds such as the Mallard duck where the male is brightly coloured while the female is dull brown. Of course, it's not always the male that is beautified, but the general rule in bird beautification occurs in either one gender or the other, not both. The Eclectus parrot (*Eclectus roratus*), however, is an exception. Found in the rainforests of north eastern Australia and Papua New Guinea, the Eclectus parrot is unique in the animal kingdom as both the males and females are beautified in strikingly different ways. The two are so different that scientists thought them to be completely different species until they were seen mating.

Studying the Eclectus parrot offers scientist Dr Rob Heinsohn, from the Centre for Resource and Environmental Studies, a fascinating opportunity to explore evolution working in an unusual way. However, observing the parrot up close is not as straightforward as it sounds. As well as only being found in remote and inaccessible areas, these rare parrots live in hollows in the highest trees of the rainforest canopy and almost never visit the forest floor.

Male and female specimens of the Eclectus parrot. Their colouring is so different they were at first thought to be different species.

To study the parrots Dr Heinsohn had to spend months at a time living in a makeshift shelter in the remote rainforest. By day he would wander the dense forest floor with an expert ear tuned to the birds distinctive cry. Having located a nest, he would then don climbing gear, shoot a grappling line up the 100 metre tree and climb the enormous trunk. Once in the treetops, Dr Heinsohn was able to take blood samples from the chicks so that when back in the lab, he could perform DNA analysis to establish which birds were mating with which - essential information for biologist trying to understand sexual selection.



Dr Rob Heinsohn measures the light coming off the parrot's feathers.

However, the mating habits of the birds are only half the story. The other important question was why the birds had evolved the particular display colour schemes in both males and females. To measure this in an objective manner, Dr Heinsohn used a spectrophotometer to map the wavelengths of light that the feathers reflect. This is an essential step because bird eyes are quite different to human eyes in that they see much further into the ultraviolet than we do. It's important to know what one parrot looks like to another parrot.

After years of study and numerous gravity defying visits to the upper rainforest canopy, Dr Heinsohn and his co-workers were able to build up a fascinating picture of the life of these extraordinary birds.

The parrot is only found in the tops of the tallest trees. in the rainforest, so to study them requires good climbing skills.

Suitable nest hollows for the birds are very rare. The female birds are fiercely competitive over available sites. A typical female Eclectus parrot spends as much as 11 months of the year at home defending her nest site from other females. Of course the only way she is able to do this is if a male bird will feed her, and the only way to persuade him to do that is to have his chicks - or at least make him believe the chicks are his. To achieve this, her plumage adaptation is a bright conspicuous red – attractive to males whilst aggressive to other females. Because she spends most of her time in the relative safety of the nest, her bright plumage doesn't make her especially vulnerable to predators such as kites and hawks.

The male, on the other hand, has quite a different problem. He must fly far and wide to gather food for the female and their chicks, but he must also be able to compete for her attention and intimidate other males once back at the nest site. He is able to achieve this with some remarkable colour chemistry in his plumage. When viewed from above - as it would be seen by a predatory hawk - the bright green bird is very hard to spot against the lush canopy below. But once back at the nest entrance against the tree trunk, he becomes highly conspicuous to his partner and other male birds.

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Reading the Sun in the Moon

by David Salt

What's the chemical make up of the Sun and the proto-planetary soup that gave birth to our solar system? These are burning questions in astrophysics and the earth sciences, and part of the answer is believed to lie in samples of soil collected from the Moon by Neil Armstrong back in 1969.

Why would you look to the Moon when you're trying to understand the composition of the Sun?

"We can't get samples directly from the Sun," explains Dr Trevor Ireland from the Research School of Earth Sciences. "However we can infer its composition by looking at lunar samples, which are believed to reflect its composition. This is because lunar soil contains oxygen isotopes 'implanted' by solar winds carrying elements blown out from the Sun."

To date, the isotopic composition of the Sun has been inferred for some elements from lunar samples, but not for oxygen because of its high abundance in lunar minerals. However, a new analysis using the Sensitive High-Resolution Ion Microprobe (also known as the SHRIMP) has been able to get an accurate measurement of the solar oxygen isotopes in iron metal grains. These metal grains have very low intrinsic oxygen and so the solar wind implant dominates the signal from these grains.

Dr Trevor Ireland, seen here holding a meteorite, has long been fascinated by the chemical composition of the early solar system. Using the SHRIMP to decipher the isotopic composition and age of meteorites, lunar soil and solar wind, it's possible to build a model of how the Solar System and our planet formed.

In particular, researchers hoped to find evidence for either of the two reigning theories about the Sun's composition. According to one theory, the Sun has a similar oxygen composition to the planets and meteorities. The other theory suggests it has enriched levels of the isotope oxygen-16.

However, rather than producing a result that supported one of the theories, their analysis came up with something neither of them predicted – it has lower levels of oxygen-16 than expected (and the oxygen signal is dissimilar to bodies like the Earth and meteorites).

"We found that the oxygen isotope levels did not agree with either a planetary composition or the oxygen-16 rich composition," says Dr Ireland.

"The oxygen isotopes are telling us that the mix of components in the Sun is different to that in the planets, particularly in regard to the amount of dust versus gas that comprises the Sun versus the planets."

"This was a completely unexpected result for us," says Dr Ireland. "Our Sun is not the Sun that we thought it was.

"The finding also suggests that the Sun somehow ended up with a different composition from the cloud of dust and gas that preceded it."

The results, which were recently published in *Nature*, come at an interesting time for studies on the composition of the Sun. Between 2001 and 2004 a NASA space probe called *Genesis* has been collecting samples of solar wind. The probe crashed down to Earth in 2004 but its precious cargo of solar particles was retrieved. Those samples are now being sorted and catalogued and will soon be available for analysis.

An artist's conception of the *Genesis* probe with solar wind collectors deployed. (Courtesy of JPL/LMA)

"In many ways, our measurements on the lunar samples were our first attempt at scoping the experimental difficulties we might have in measuring the *Genesis* samples," says Dr Ireland. "As it turns out, the analysis we have undertaken using the SHRIMP has proved to be very successful.

"The real question our finding raises is why this solar composition appears unrelated to the composition of the planets, the largest rocky bodies in the solar system, or to refractory inclusions from meteorites which have been regarded as solar condensates. Further study of samples from the *Genesis* mission may have the answers."

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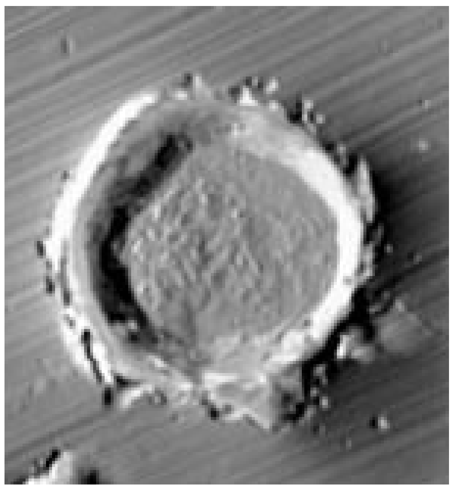

A scanning electron micrograph of one of the iron metal grains analysed from the lunar soil sample.

From purple soup to clear blue seas

by Tim Wetherell

The complex animals and plants that inhabit the Earth today represent only a tiny fraction of the history of life. For most of the last two billion years, the planet was entirely populated by simple single-celled organisms such as bacteria and algae. Although they may not appear outwardly spectacular their presence caused profound changes to the environment and laid the evolutionary foundations for the complex organisms of today.

However, getting information about these early organisms is difficult. Under some circumstances they can leave microfossils but their tiny size means it's rarely possible to derive much information from them. Chemical analysis of sedimentary rocks yields some data, but again the detail is lacking. Even recent advances in DNA mapping have little to offer to palaeobiologists because molecular clocks that predict the first appearance of organisms become increasingly unreliable as you go back millions of years.

To help fill in the gap, Dr Jochen Brocks from the Research School of Earth Sciences has been working on adapting a petroleum research technique. The method looks for lipids from the cell membranes of bacteria, some of which are both chemically stable and relatively indigestible. This means that they neither decay or are consumed by other organisms. Furthermore, the molecular structure of these "biomarker" lipids is closely linked to the bacterial gene sequences that create them. This means that even though you can't directly detect an ancient organism's DNA, you can deduce parts of its genome from the types of lipids it leaves behind.

The biochemistry is very complex and there are few convenient instances where a single lipid is species specific. However, by carefully correlating the ratios of the various lipids present, Dr Brocks has begun to build up a picture of the diversity and ecology of bacteria in billion-year-old oceans.

Not every oil-bearing sedimentary rock is suitable for this kind of study. Those rocks that have been pushed deep underground by subsequent geological forces get heated from within the earth. Once they reach 200°C, the biomarkers are destroyed and the information is lost, and this is the case with most sediments that were deposited in marine basins. However, there are some isolated regions such as the McArthur Basin in northern Australia where the rocks bearing

Dr Jochen Brocks peers down a hole left when a rock core is removed. (Photos by Tim Wetherell) the biomarker evidence have remained stable and cool for over a billion years.

Dr Brocks extracted oils from 1.6 billion year-old rock cores using organic solvents to isolate the chemical groups of interest. The samples were then analysed in a high sensitivity mass spectrometer. The process was complicated by the fact that as well as the biomarkers of interest, the samples contained millions of other hydrocarbons, oils and lipids.

A significant breakthrough occurred when Dr Brocks was checking that the distribution of biomarkers was uniform throughout a given date strata in the core samples. To his surprise he discovered that it wasn't. After an exhaustive study, he concluded there was contamination caused by modern oils which inevitably seep into the cooling water on drilling rigs or accumulate from airborne fumes on drill core material during years of storage. Once the effects of contamination were eliminated, the data pointed to a highly stratified proterozoic ocean with oxygen producing bacteria in the upper layers and the ancient purple sulfur bacteria in the deeper anoxic sulfidic waters.

Scientists already know that oxygen first accumulated in the atmosphere around 2.3 billion years ago. However, it took a lot longer for the sea to become as oxygenated as it is today. Some scientists believe this is because oxygen in the atmosphere remained too low to penetrate the deep oceans. Any oxygen was quickly mopped up by reactive iron emitted from volcanoes at mid-oceanic ridges in the deep sea. Dr Brocks believes that in this mid-proterozoic ocean current mixing may have created what he describes as a "marble cake" of sulfidic and oxygenated waters each with their own populations of bacteria exploiting the chemistry that suited them best.

It's still early days for palaeobio-geochemistry, but Dr Brocks is confident that we now have a better tool for probing life in Earth's early oceans. This should ultimately help us understand how the sulfidic purple soup of the mid-Proterozoic era became today's blue oxygen rich ocean teaming with complex and diverse life forms.

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Timescape

The year was 1963, and Canberra was growing from a country town to a major regional centre. Commonwealth Avenue Bridge had just been opened, Lake Burley Griffin was nearly finished and soon to be filled, and the city's population had broken 50,000 and was on the march to 100,000.

At ANU the R G Menzies Building and the J B Chifley Building, the University's two library buildings, were opened but the broader campus, as seen in this aerial photo taken in 1963, is quite removed from the ANU of 2006. Undergraduate courses had only recently begun (in 1960) and the landmarks that remained constant with today's time are the buildings of the four original research schools: The John Curtin School of Medical Research, the Research School of Physical Sciences, the Research School of Social Sciences and the Research School of Pacific Studies.

To help orient yourself, the main road running along the lower portion of the photo is Barry Drive meaning the dirt road running off it is today's main entrance. 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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