Magazine of the ANU COLLEGE of SCIENCE

Volume IV No. V

SCIENCE WISE

THE AUSTRALIAN NATIONAL UNIVERSITY

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Cover image:

Arthur Murgatroyd working as a student volunteer in an ANU wildlife survey that explores the connection between fire management and biodiversity in the mallee.
(photo by Annabel Smith)

THE AUSTRALIAN NATIONAL UNIVERSITY

In This Issue

NEWS For the very latest news from ANU see http://info.anu.edu.au/mac/Media/Media_Releases/

The Editor's Corner - The Infinite Atmosphere Theory

Dr Tim Wetherell

During a total lunar eclipse, the moon can turn a deep coppery red at totality. In the middle ages, this "blood moon" was seen as an omen of disaster. Of course in more enlightened times we have a far better explanation for the reddening of the lunar disc at totality. We understand it in terms of atmospheric lensing and scattering of the blue component of sunlight by the dust and gasses in the air. It's all about the earth's atmosphere and nothing to do with prophesy.

As science makes more and more progress towards understanding natural things like the earth's atmosphere, I think there's a tendency to forget the awesome power that they posses. It's almost as though they become specimens in jars, understood, catalogued and for the most part, totally harmless. This is largely how we've treated the atmosphere over the last century. Ten kilometres up multiplied the surface area of the earth makes a gargantuan volume of air. At the human scale, essentially an infinite volume. So if you pour a few cubic metres of this or that into it, the effect is a few divided by infinity - in other words absolutely nothing at all. The problem with this arithmetic is of course that the number of humans on the planet is also becoming quasi-infinite, and as any good mathematician will tell you, infinity over infinity is an undefined quantity.

I don't think there's a simple answer to climate change but what I am sure of is that science and technology will have to play a central role in both fully understanding the problem and creating appropriate solutions. It would be terrible to see superstition proved right about the "blood moon" - even though it would be for all the wrong reasons. And perhaps equally terrible to see our response to the situation driven by modern superstitions rather than well grounded scientific reasoning.

Total lunar eclipse of August 2007 photographed from Canberra

During a lunar eclipse the shadow of the earth falls across the face of the moon. It's a beautiful sight but it's also filled with interesting physics. At the start of the eclipse the earth blocks one side of the sun's disc but not the other. This results in a partial shadow, known as the penumbra. As the earth moves further across, it begins to block all the sunlight creating a full dark shadow - the umbra. The shape of the umbra is graphic evidence that the earth is round.

Another interesting phenomenon is the changing colour of the moon during the various stages of the eclipse. The Earth's atmosphere scatters blue light far more than it does red light. During the day, the scattered blue photons enter our eyes from every possible angle, which is why the sky appears bright blue. However all this blue light lost to scattering results in the remaining sunlight appearing more red. This effect is at its greatest at sunrise or sunset because when the sun is on the horizon, its light has to pass through far more air than when it's directly overhead. The exact same thing happens to moonlight, often causing the rising moon to appear orange. Notice how in this time-lapse of the eclipse, the moon appears orange then yellow as it's rising behind the gum trees.

Another less obvious effect comes into play due to the curvature of the earth and the changing density of air with altitude. This causes the atmosphere to act like a very weak lens bending any light that passes through it. As a consequence of this, there is a slight apparent flattening of the sun or moon when near the horizon. Lensing also results in the refraction of a small amount of sunlight into the earth's shadow. Because this refracted light has passed through the atmosphere at very shallow grazing angles, the scattering effect is especially strong, colouring the light red. During a total eclipse, the moon's face is partially lit by all the sunrises and sunsets on earth put together.

Camping with Snakes

- David Salt

Dr Don Driscoll is looking for volunteers to sleep out in the wild this summer, and handle snakes and spiders (and other interesting animals). If you're interested, drop him an email.

"Some people may think that this is a strange way to spend part of your summer break," says Dr Driscoll. "But volunteers who have helped us in the past say they have the time of their lives. What's more, for anyone with an interest in Australia's biodiversity, this is an invaluable experience. You'll gain practical knowledge and field skills that look great on your CV if you're hoping to work in conservation in the future."

The work is being carried out on the Eyre Peninsula of South Australia over this summer break. And it's all for an important cause.

"Our volunteers will be helping with a wildlife survey that explores the connection between fire management and biodiversity in the mallee," explains Dr Driscoll, a Research Fellow working on ecological synthesis at the Fenner School of Environment and Society.

"Fire plays a critical ecological role in the extensive mallee ecosystems of Australia," he says. "However, in fragmented agricultural landscapes fire regimes have been altered. When it comes to fire management, the predominant practice is simply fire suppression, but this could eliminate species that are dependent on fire. Occasionally fire suppression fails, leading to the complete incineration of small bush remnants. This could eliminate species that depend on long-unburnt habitat.

The Eye. Thorn Tailed Geckos Strophurus assimilis, have eyes that need to be seen to be believed.

"So, we're interested in finding out how many species are threatened by this fire-suppression / incineration cycle? How important is it to implement management burns in remnant mallee ecosystems? We aim to resolve this key question through the mallee fire project.

"The fire project will also shed new light on our understanding of post-fire succession. Succession theory provides an important framework for predicting species' responses to disturbances like fire. Our research project will test and further refine succession models, making it easier to predict how species might respond to novel fire scenarios."

Nephrurus stellatus, the starred knob-tailed gecko is a prodigious burrower and is most commonly captured after recent fire.

Although venomous, the desert banded snake Simoselaps bertholdi is harmless and rarely bites when handled. (photo by Annabel Smith)

Volunteers will be working in remnant patches of eucalyptus mallee scrubland on the Eyre Peninsula in South Australia. They'll be monitoring sites for reptiles, beetles and small mammals. Some sites have been recently burnt, others are long unburnt, and some have been experimentally burnt. By examining a broad range of species in these different treatments, Dr Driscoll and his colleagues expect to develop robust approaches to fire management.

"There are several important questions that our ongoing research will address," he says. "How low do population sizes drop in the first two years after fire? Succession models predict that this is the time when population sizes should be smallest, and therefore, when populations face the greatest risk of extinction. Ongoing monitoring after recent experimental fires and wildfires will answer this question.

"Do early successional species recolonise burnt areas from adjacent unburnt areas or from within the unburnt habitat? Using grids of traps across burn boundaries, we'll discover if species recover after fire by recolonising from unburnt areas. If they do, then implementing long thin burns would enhance the rate of colonisation.

"The data we've collected so far indicate that research into the implementation of fire mosaics to accommodate fire-specialist species is a priority because some species have opposite responses to fire."

Dr Driscoll is running field trips to the Eyre Peninsula in December, January and February this coming summer. Food and transport is provided, and no experience is required.

"Volunteers can expect to get dirty, handle animals they've never seen before and discover ecosystems that most Australians don't even know exist," says Dr Driscoll. "It's just too good an opportunity to pass up."

Places are limited so, if you'd like to learn more, contact Dr Driscoll today.

don.driscoll@anu.edu.au

Simoselaps bertholdi, the desert banded snake.

What a CLAM can do for your local waterway

- Tim Wetherell

Coastal lakes form at the mouths of many of Australia's rivers and streams when wave action forms a sand bank between the river mouth and the ocean. Over time these sand banks can isolate the lake system from the sea forming a lagoon. Periodically when river flows or tides are high, the sand bank is breached creating a brackish mixing of sea and river water. This all creates a unique environment in which many species of flora and fauna thrive including some of very high economic value such as oysters. However increasing pressure on water resources coupled with demand for urban development is beginning to take its toll on these delicate ecosystems. Local councils often find themselves in the difficult position of having to make decisions on development approval based on minimal quantitative information. The same situation often hinders environmental restoration programs where there is a desire to make improvements but limited resources. In such situations it's often far from obvious where those resources are best spent. In an ideal world, it would be possible to fund an extensive research program into every such river system then having gathered data for many years, make appropriate decisions. However, in the real world this is a luxury councils rarely have. Decisions need to be made quickly and all too often the only information to base them on is qualitative local knowledge and "gut feelings."

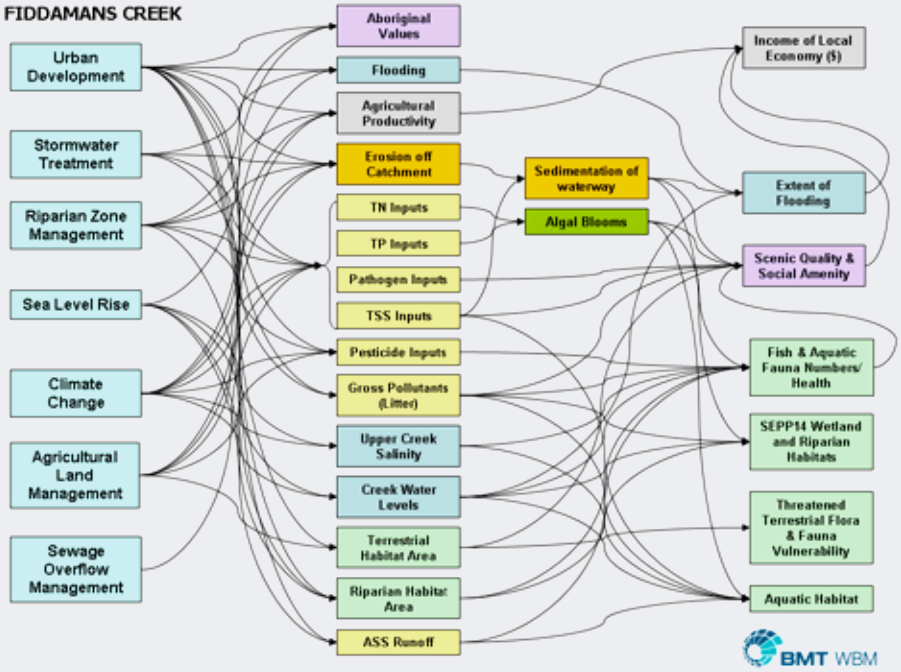
Robert Quirk - Tweed Valley sugar cane grower and recognised world leader in best management practice of acid sulphate soils, takes CLAM researchers Dr Rebecca Letcher and Dr Jenifer Ticehurst on a tour of his farm

However, a group of researchers from the ANU Integrated Catchment Assessment and Management Centre (iCAM), and the former NSW State Department of Natural Resources (now the Department of Environment and Climate Change, DECC) have developed a modelling approach and software tool that may help change all this. CLAM, the Coastal Lake Assessment and Management tool is the brainchild of Dr Rebecca Letcher, Dr Jenifer Ticehurst and Dr Wendy Merritt. The CLAM software allows users to enter data into a complex, yet flexible model of the entangled web of interrelated factors that contribute to the health of a particular coastal water system. But what's really special about CLAM, is that it's based on Bayesian logic processes. The practical upshot of this is that it can accommodate both hard quantitative data and expert and local knowledge into the same model. This has been central to the success of the system because it allows decision makers to take advantage of the huge body of qualitative knowledge that often exists in local communities. Because the system draws on this local knowledge and participation, it fosters a sense of inclusion amongst stakeholders which in turn often smooths the process of change.

CLAM has multiple levels and multiple functions ranging from easily accessible archiving of local knowledge and research data to extrapolations of various future scenarios. For example, by entering in factors affecting catchment condition such as urbanisation or local vegetation, CLAM can output the likely consequences to all the facets of the water system. The system is easily updated to include the latest data and is also accessible enough to allow back tracking from predicted outcomes to reveal the assumptions that underlie them.

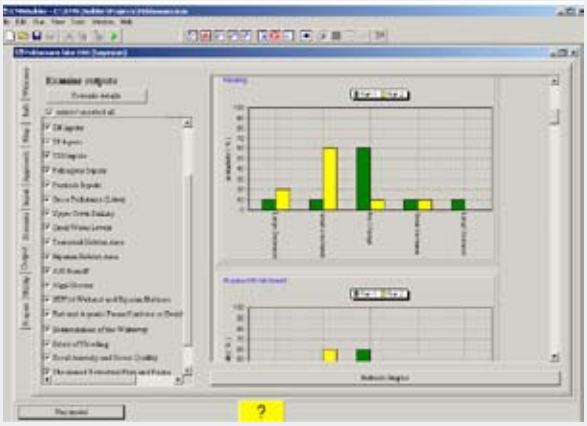
28 CLAMs have so far been developed in collaboration with NSW State Government agencies, local councils, and catchment management authorities. The system has proved so successful that a training and accreditation system has been developed under the auspices of ANU-Enterprise. This allows users to train on the system and gain accreditation allowing them to independently build CLAM models of particular water systems.

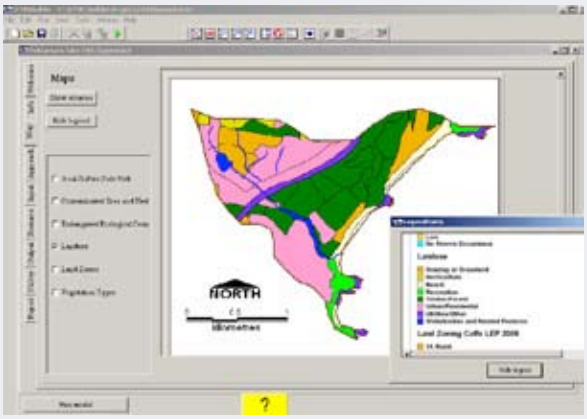
CLAM's contribution to the conservation and improved sustainability of coastal lakes has been recognised by Environs - the Local Government Environment Network. The recent Northern Rivers Catchment Management Authority CLAM project was granted an award for "Outstanding Sustainability Partnership" and "Outstanding Sustainability Leadership." The CLAM Coordinator, Naomi Brydon, accepted these awards at the Local Government Sustainable Development conference dinner on Tuesday, 11 September this year.



Above: the complex web of interacting factors that clam uses to generate predictions about future conditions in the waterway such as salinity, flow rates and biodiversity. The system also serves as a very user friendly cross referenced repository for local knowledge of the system.

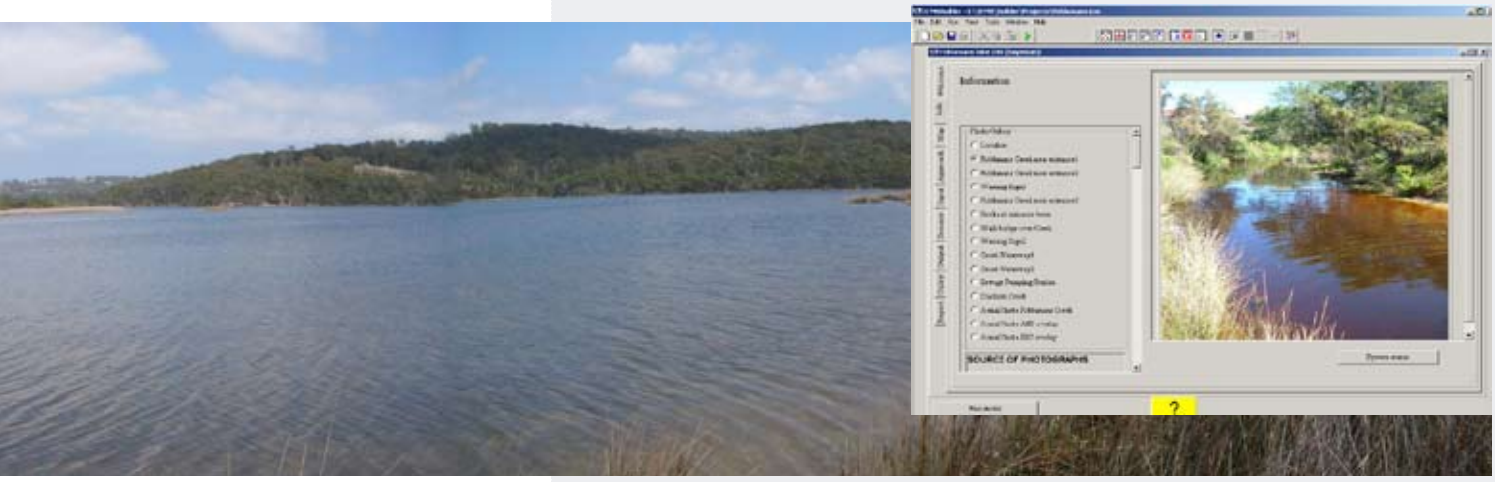
To the right are various screens from the system detailing local information recent trends and various predicted future scenarios .





More info:

www.clam.net.au



Seeing Faces:

Probing the underlying mechanisms of face recognition

- Tim Wetherell

B

Most of us have had the experience of seeing faces in clouds, tree bark and the shadows of spooky places. This is because our brains place a special emphasis on faces compared to most other visual stimuli. From an evolutionary point of view, being able to quickly recognise different faces is a huge advantage. If one rabbit looks the same as another to a caveman it really doesn't matter because he's going to chase them both with a big club. But when it comes to people, we have to be much more selective who we chase with clubs and who we invite in to share the rabbit stew. This vital face recognition task is performed by a specialised region of the visual cortex called the fusiform face area.

The ability to recognise faces and the cognitive and neurological mechanisms that underlie it, are the area of expertise of Dr Elinor McKone from the ANU School of Psychology. Her research group focuses on the process of face recognition, how this develops from childhood and conditions such as prosopagnosia that interfere with it. Regarding one aspect of face recognition currently under investigation, she explains that "there are two common mechanisms by which the human visual cortex recognises shapes, including those shapes that make up faces."

The first, multi-channel narrowband coding, involves having small groups of neurons that respond only to a narrow range within a particular type of visual stimuli. For example, when we judge the angle a straight line makes with the vertical, one group of neurons might be sensitive to lines at 0° to 4°, the next to 2° to 6°, the next to 4° to 8° and so on. Although there is some overlap, the ranges are narrow and a line at 45° will not stimulate any neurones in the first few sets at all.

The second mechanism, two-pool broadband coding, uses only two groups of neurons, but they are each sensitive to a vastly broader range of values. The brain then uses the ratio of the stimulation strength to judge the true angle. In colour for example, the neutral colour white might be coded by equal firing in sets of neurons tuned to red and green.

Knowing which mechanism comes into play for each aspect of face recognition is vital in developing an understanding of how the process works at a neurological level.

The obvious approach to studying such processes might at first sight appear to be some kind of brain imaging technique such as functional magnetic resonance imaging (fMRI). However although fMRI has contributed enormously to our understanding of brain function, the best spatial resolution that can be achieved is of the order of a couple of millimetres cubed. The individual neurons involved in face recognition are over a million times smaller than this, so despite the power of fMRI as a technique, there are many questions about neural coding it can't answer. In the case of the underlying mechanisms of face recognition, answering these questions requires some cleverly designed traditional psychological experiments.

One experimental technique used by Dr McKone's group works by taking advantage of a phenomena called an adaptation aftereffect. Adaptation is the process by which a repeated stimulus is gradually ignored. A perfect example of this is how after a while, we no longer hear a ticking clock. Our brains become used to the stimulus and learn to ignore it. A similar process can happen with various visual features used to recognise faces such as the placement of the eyes or the width of the face. If someone lives amongst people who all have wide faces they adapt to this and it becomes "normal." Then if they see someone with an average face it can look exceedingly narrow. The important thing about adaptation is that the effects it induces are subtlety different for each of the two neural selection processes.

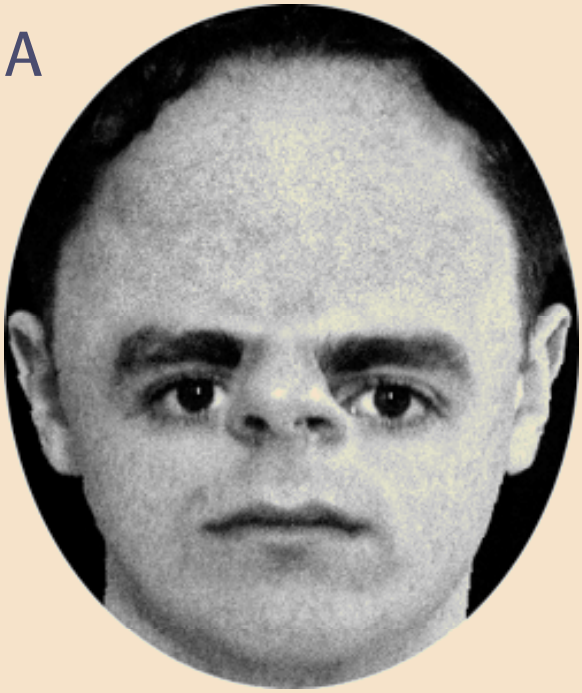
In two-pool broadband selection systems that use just two broad sensitivities, habituation to an extreme shifts all perception values, even those well away from the stimulus. In multi-channel narrowband selection systems, habituation to a particular value has very little effect on the same stimuli with a value well outside this range. You can test for yourself which mechanism is involved in recognising the width/length proportion of a face using the images to the right.

Researchers use tools like these to probe the mechanisms of many aspects of visual function. The group are also looking into how these mechanisms vary between looking at faces and other sorts of objects like horses and houses. Each test provides a vital piece of the jigsaw in piecing together a better understanding of how our brains work.

More info: Dr Elinor McKone

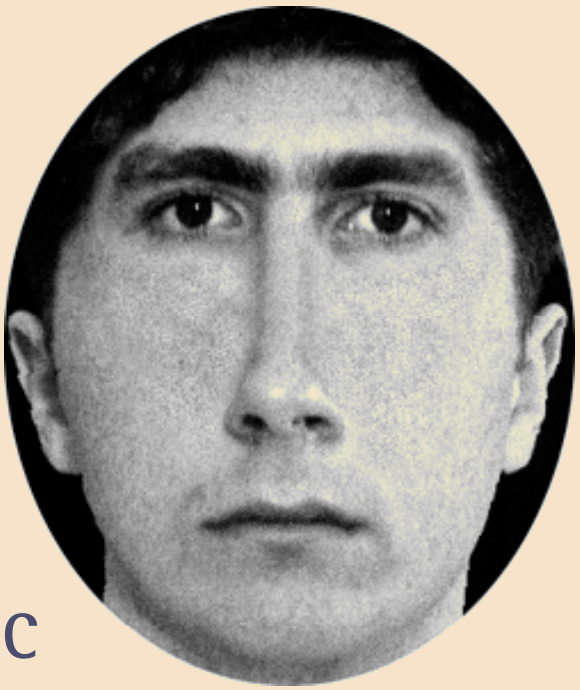
elinor.mckone@anu.edu.au

A



Try it for yourself

Study the face C (at the bottom of this page) for a full 30 seconds, then look at the face B (on the opposite page bottom left). Does it look unusually wide or unusually long? Leave the test for a couple of minutes to allow tour brain to renormalise. Now try the same thing but study A (the upper face on this page) for 30 seconds before looking at B. You'll probably see the opposite effect to before. Because exposure to a stimulus at one extreme has such a strong affect on the "normal" face, this test suggests that two-pool broadband selection is at work in face legnth recognition.



C

State of the Art Radiocarbon Dating facility Opens

- Stewart Fallon

Dr Stewart Fallon outside the cage that protects users from the high voltage used in the accelerator

The Research School of Earth Sciences (RSES) and the Research School of Physical Sciences and Engineering (RSPSE) have recently established a state-of-the-art particle accelerator – a Single Stage Accelerator Mass Spectrometer (SSAMS) for measuring radiocarbon in materials.

Carbon 14, also known as radiocarbon, is a radioactive form of carbon found in all living things. Simply being alive means you will have some in you. That is great news for scientists wanting to find out how old biological materials are because by measuring the amount of radiocarbon present in a sample it is possible to estimate how long that material has been around.

Living animals depend on carbon. Plants absorb it when they photosynthesise. Animals take it in when they eat the plants. Shellfish absorb it from the surrounding water and secrete it in their shells, and corals use it to build their skeletons. Throughout an animal or a plant's life it takes in carbon and stores it in its tissues. This stored carbon exists at the same ratio as the carbon in their surrounding environment that is roughly one atom of carbon 14 for every trillion atoms of normal carbon.

When the organism dies it stops metabolic activity and accrues no more carbon. This is when the radiocarbon clock starts ticking because over time the carbon 14 atoms decay but the normal carbon atoms stay the same. So the number of carbon 14 atoms decreases and the ratio of carbon 14 to normal carbon decreases in a predictable manner.

"At the moment there are only a few places in the world that are directly using CO2 samples for radiocarbon dating so our research will be at the leading edge," says Dr Stewart Fallon from the RSES.

SSAMS arrived at RSES at the beginning of 2007. Setting it up and getting it operational has taken several months and it was officially launched at the end of June.

For more information:

www.anu.edu.au/CSEM/newsletter.php

What's the difference between isotopes and ions?

Isotope ^{5}He
(One extra Neutron)

Atom ^{4}He
(Normal helium)

Isotope ^{3}He
(One less Neutron)

Ion He^{++}
(No electrons)

Ion He^{+}
(One missing electron)

Atom He
(Two electrons)
(Helium atom not an ion)

Ion He^{-}
(one extra electron)

An element is defined by its number of protons, for example any atom with two protons is called helium (He). Normal helium also has two neutrons and two electrons. Atoms with extra or fewer neutrons are called isotopes. Usually, different isotopes of an element have very similar physical and chemical properties. This is exactly the case with carbon. Carbon -14 is incorporated into living tissue in the same way as carbon -12.

Atoms with fewer or extra electrons are called ions. Ions carry a net electric charge so they accelerate in electric fields and can have quite different reactive properties to the equivalent neutral atom or molecule.

Ice Cream and Strawberries Under the Stars

- Scott Yates

Staff and students from the Research School of Astronomy and Astrophysics recently attended the Winter Night Markets, along with the staff from Chemistry who were making ice cream using liquid nitrogen (there was a very long line of children waiting patiently for their turn). Biologists were showing people how to extract DNA from strawberries and using a microscope linked to a plasma screen to display the results. RSAA set up the telescopes on the hill and had a table where we answered questions. The table was popular because there was a comptition to win an iPod provided by the College of Science marketing team. The rules were simple, we had a container full of lollies and all the contestants had to do was guess how many lollies there were. Lauren Keogh came closest with a guess of 148, the actual number was 145. Sara Kennedy came second with a guess of 150 and won the container of lollies. It was also an opportunity to pass on information on Tuesday's total lunar eclipse which took place in spectacular clear skies. If you were unfortunate enough to miss that event, you'll have to wait until December 2011 for the next total lunar eclipse visible in Canberra.

Relatively clear skies meant many folks, from very young to very old, were able to look at the Moon through the two portable telescopes we took along. Lots of questions were asked and lots of answers provided. The funniest question we had for the night was someone who had just looked at the moon through the telescope and asked "Is that real?" The most technical question was "How do you measure the lumens of each star?"

Interim Director Gary Da Costa came by to say hello and see how things were going. He was asked if he would fill in for someone manning a telescope so they could have a short break, well an hour later he was still there (oops, sorry Gary, although I did hear you were enjoying talking to people). Thank you to Emma Kirby, Helmut Jerjen and to everyone from the RSAA Student Outreach Group.

Above: the winter night markets.

Left: Lauren Keogh, expert lolly number guesser and winner of the ipod.

Below: how the waning half moon appears through a powerful telescope.

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