ScienceWise

SCIENCE MAGAZINE OF THE AUSTRALIAN NATIONAL UNIVERSITY
- January / February 2009

THE AUSTRALIAN NATIONAL UNIVERSITY

Volume 6 No. 1

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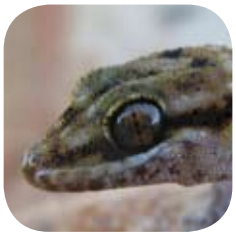
Science Magazine of the Australian National University



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Cover Image Mitzy Pepper

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The Editor's Corner

More like a sponge cake than the Queen Mary

Dr Tim Wetherell

Amongst the stories in our first 2009 edition of ScienceWise we take a brief look at some Australian geckos that are capable of parthenogenesis or asexual reproduction. In effect, some members of this species have the built in ability to clone themselves.

Given the enormous efforts most animals go to in order to attract a suitable mate - fancy feathers, elaborate dances, learning to play the guitar - one might wonder what nature was "thinking" when it "invented" sexual reproduction. Why don't we all use parthenogenesis? I guess the answer lies in the fundamental laws of physics and the very nature of life on earth.

The thing is, billions of years ago single celled organisms mostly did reproduce asexually. Sexual reproduction itself evolved, so it must have offered an advantage. Today we believe that advantage comes from the fact that mixing your genes with those of other members of your species frequently introduces what biologists call heterosis or hybrid vigour. Organisms that are a product of both parents have double the genes to choose from and often (though not always) express a batter pick of genes than could be found in either parent.

Another important point is that life on Earth isn't static. The climate changes as do the plants and animals any organism has to share its environment with. Most individuals of a species don't express the less desirable recessive genes buried deep in their DNA. But such genes and the odd individuals that do express them, give a species variability than can be crucial to surviving changes in habitat.

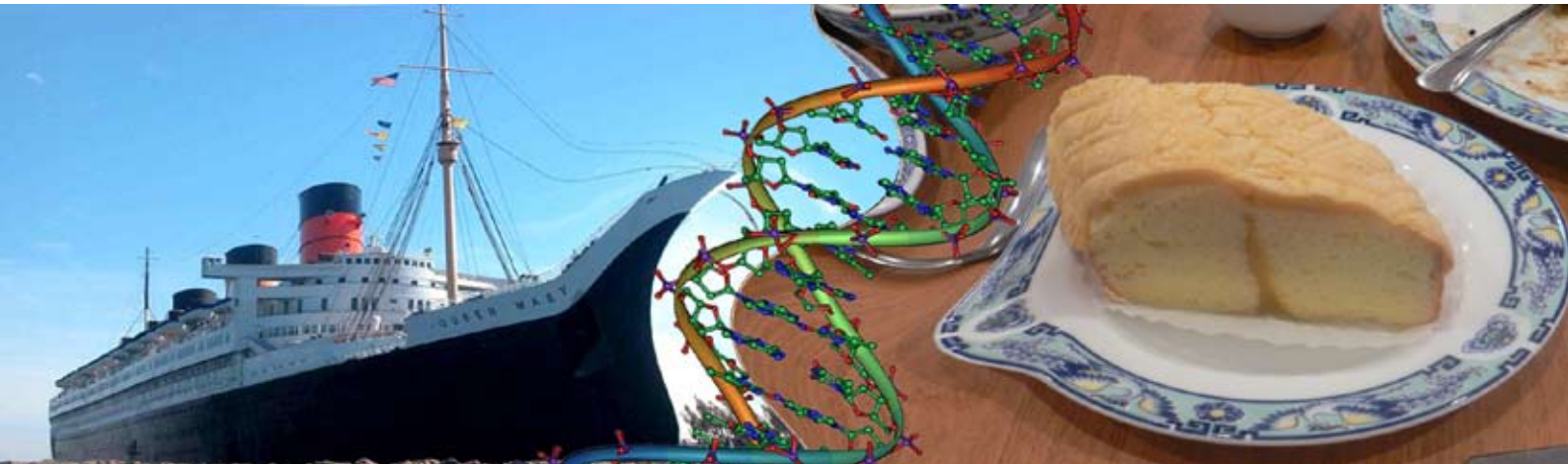
For example, as the world stands; if you were a diminutive tiger only 10cm tall, you would be at a disadvantage because you'd only be able to bite a gazelle on the ankle. But if suddenly all the large prey animals disappeared (maybe because the strange looking primates you've occasionally seen, begin to fill the atmosphere with CO_2?) Then it's your lucky day. You can hunt mice and survive whereas the large "normal" tigers can't. This kind of diversity, variability and adaption is the engine room of evolution.

So given that sexual reproduction is great for evolution, why would cloning not be a good selfish strategy for a particular animal? The answer to that comes from physics. The second law of thermodynamics tells us that the entropy of an isolated system always tends to increase. In plain language this means that when you copy something over and over mistakes inevitably occur and the resulting disorder just gets worse and worse over time. Eventually your cloned DNA would become riddled with errors and quite useless. You'd also be competing with other animals around you that were constantly evolving and improving and pretty soon you'd feel very much like last year's model.

Entropy is also one of the major theories to explain human aging. As cells repeatedly replicate errors occur and bad things happen. Sadly despite the claims of cosmetic manufacturers, this isn't an easy thing to fix because the human body isn't just one big porridge of cells. Our bodies also have mineral deposits like bone and connective collagen fibres holding us together. So as structures like the skin sustain and repair damage they slowly drift further and further from their "intended" shape.

One of the key things here is that our DNA isn't a blueprint for our body in the way the plans of the Queen Mary describe the structure of the ship. It's much more like a recipe for a sponge cake. So much flour, so many eggs, mix and bake at this temperature for this time. Your DNA tells a cell how to divide up into an embryo and eventually end up as you. But DNA isn't something cells in your adult body can refer back to see if your nose is still the shape it should be.

I suppose this is why nature doesn't create complex animals and maintain them in perfect repair indefinitely. The process just doesn't work that way. Which from our perspective as individuals is kind of a pity really! Then again, perhaps if nature did work that way, we'd all still be single celled amoebae and wouldn't be reading Sciencewise.



Gecko researcher with a taste

PhD candidate Mitzy Pepper sheds light on gecko evolution in the Pilbara

The remote Pilbara, with its ancient rocks and arid landscapes is not the first place you would look for a classical violinist. But it's here, amongst some of the oldest rocks on earth, that ANU's Mitzy Pepper, a PhD student, gecko researcher and professional violinist, is continually drawn. "It's just got the most amazing landscape, I did a geology degree", she says "and the geology up there is fantastic, it's just so old and unique".

Mitzy is just one of many young researchers in the Botany and Zoology (BoZo) department of the ANU, discovering more about our unique and diverse Australian flora and fauna every day. And in the previously research-neglected Pilbara, Mitzy is doing just that.

Mitzy first discovered her love for the Pilbara when she took part in a six-year biological survey to discover and document the flora and fauna of the Pilbara. Costing over 12 million dollars, the survey was funded by the Western Australian Department of Conservation and Land Management with the assistance from the Western Australian Museum.

"I'm looking at an area where very little genetic research has been done before; we've only just done the survey to find out what biodiversity exists there".

Mitzy Pepper in the lab

Mitzy is using this iconic Australian backdrop to map the evolution of the local geckos. "The Pilbara has a huge diversity of geckos," she explains. By analysing geckos DNA, Mitzy is using genetics to map the geckos' family tree and finding out how the environment has moulded their evolution.

Now half way into a three year PhD, Mitzy's current project is continuing on her honours work on Pilbara geckos. In 2006,

A typical day of fieldwork in the Pilbara, working with Department of Environment and Conservation (DEC)

for the classical

Ben Knox

Mitzy, along with Paul Doherty and Scott Keogh, published a journal article describing how the Sand-plain gecko (Diplodactylus stenodactylus) has two distinct populations, one that lives in the Pilbara and prefers hard rocks and one that lives outside the Pilbara and prefers sandy habitats.

After her success in mapping the Sand-plain gecko genetic history, Mitzy felt too many questions were left unanswered and returned to the Pilbara to see if these results were consistent across other gecko species in the region.

Mitzy's research has already uncovered a number of new species of gecko previously unknown to science. "These lizards haven't been studied at the same level as birds for example" she explained. "When you're looking at a lizard that hasn't been studied at a molecular level before, if it has a wide range over a large area, it is unlikely that it will all be one species".

However, it is not all rocks and geckos for this young doctorate hopeful, Mitzy is also an avid violinist and plays in a number of quartets. "I had a big decision to make when I came to university," she says. Torn between music and science, Mitzy was able to study both by doing a combined Bachelor of Arts/ Bachelor of Science degree. That way she could keep playing her violin as part of her arts degree while studying geology and geography at the same time.

Now in her spare time, Mitzy teaches violin and plays at functions to earn money. "Most people here (at ANU) tutor students or mark papers, but I get to go and listen to little kids playing violin which is quite pleasant". When asked if she would like to further her classical music career when her research is finished, Mitzy says, "I'm really enjoying doing it just as a hobby, it's way more fun this way"

A Sandplain gecko (Lucasium stenodactylum)

The gecko girls

Adapted from an article by Mitzy Pepper

Australia's only reptile capable of asexual reproduction

The Bynoe's gecko (Heteronotia binoei) can be found ranging over many of Australia's different landscapes. While some other species of gecko are specialised to live in particular habitats, such as on rocks, up trees, or on sand dunes, Bynoe's gecko is a habitat generalist, happy to live just about anywhere. But one location it's especially fond of is man-made rubbish dumps.

The Bynoe's gecko is of special interest to reproductive biologists because some populations of Bynoe's consist entirely of females; identical, genetic clones of one another reproducing without the need for males. The phenomenon is called "parthenogenesis" and comes from the Greek parthenos, "virgin" and genesis, "creation".

While parthenogenesis is not uncommon in the wider biological world (lots of plants do it, some insects do it, and some fish do it too), Bynoe's gecko is the only Australian reptile known to reproduce in this way. The parthenogenetic geckos evolved when two genetically distinct groups of Bynoe's came into contact and bred, and through a twist of genetic fate ended up with three sets of chromosomes rather than the usual two.

The Bynoe's gecko (Heteronotia binoei)
Photography: Matthew Fujita

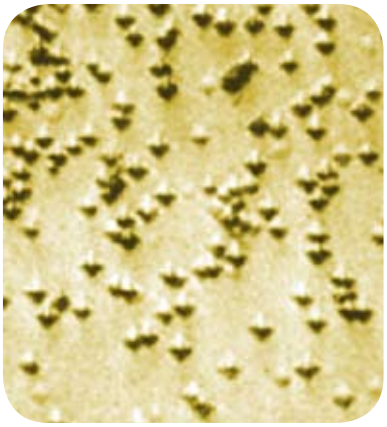
Keeping track of the damage

Tim Wetherell

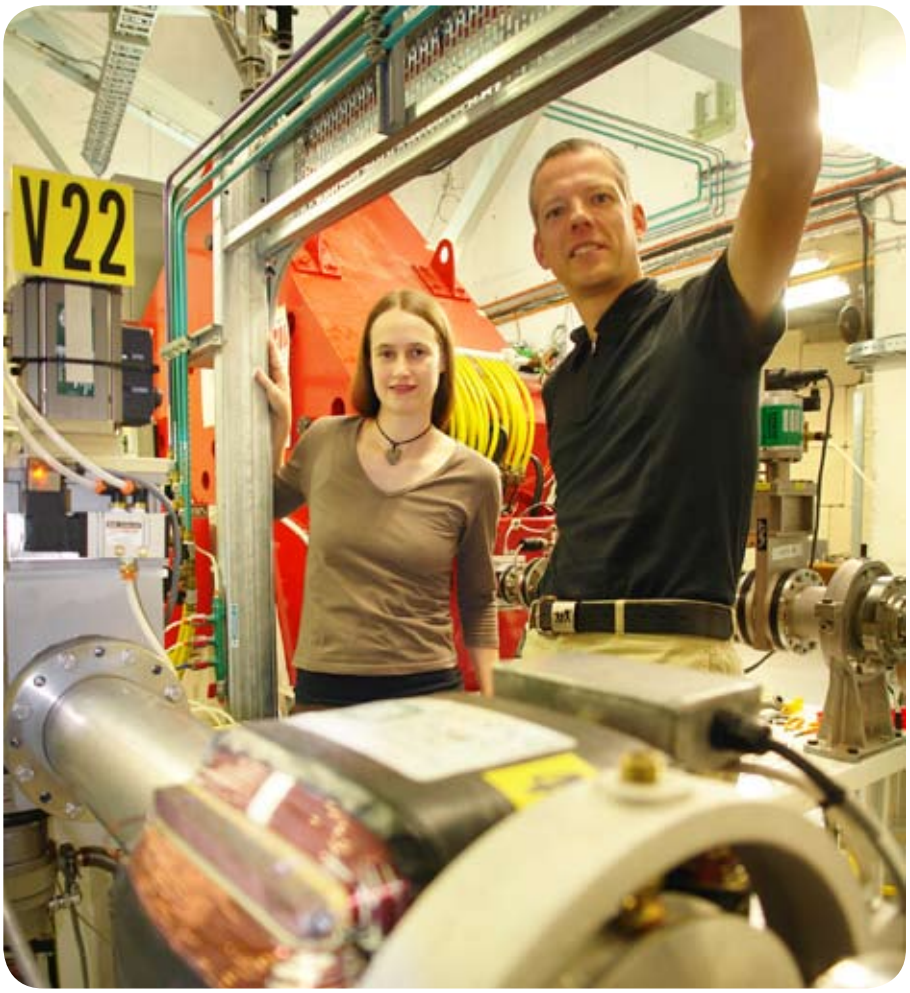
Scientists resolve long-standing mystery of ion-solid interactions

Silica (silicon dioxide) is the most abundant mineral in the earth's crust and consequently is a core component in many rocks. It's quite common for such rocks to also contain natural traces of materials like uranium that undergo slow radioactive decay. This radioactivity produces energetic particles that smash through the surrounding silica creating tracks of localized damage in their wake.

The tracks are too small to see directly but because the damage changes the local structure of the material, such tracks serve as a seed point for certain chemical etches. Suitably etched samples show tiny cone shaped pits in the surface that are visible in a powerful light microscope. Geologists have used this etch pit technique for many years to study the density of tracks. Their interest stems from the fact that knowing the number of tracks in a material and the amount of radioactive material present, you can gain information about the age and thermal history of the rocks. High temperature anneals out the damage so a rock with high uranium content and few pits must have been heated in the relatively recent past.



Conical etch pits seeded at high energy ion damage sites



Dr Patrick Kluth and Claudia Schnohr amongst the steering magnets of the 14UD accelerator at The Australian National University

However, it's not just geologists that have an interest in the interaction of energetic ions with solids. An improved knowledge of such interactions is also pivotal to emerging technologies such as nanofabrication, nuclear waste management, fusion power and long distance space travel. The problem to date has been that remarkably little is known about such ion track damage in solids. The traditional etching technique reveals the number of tracks but removes the tracks themselves, so tells you little about the underlying material science.

This lack of detailed information has created debates and arguments amongst scientists for more than 50 years. However, a research team from The Australian National University led by ARC Australian Research Fellow Dr Patrick Kluth has recently solved the mystery.

Dr Kluth explains, "The exact nature of ion track damage has been very difficult to determine because the tracks are only a few tens of atoms in diameter with often only subtle differences in structure to the surrounding material. A lot of times we are getting localized disorder in a material that is itself highly disordered."

To generate the ion tracks in a controlled manner, the researchers have used Australia's largest and most powerful accelerator, the 14UD at ANU where they bombarded amorphous silica targets with very energetic gold ions.

Keeping track of the damage... continued

In the world of subatomic particle interactions is very different to our experience of collisions in everyday life. If you're throwing rocks at a tin can the likelihood of you scoring a hit depends on your aim and the size of the can. So long as you aim doesn't falter the likelihood of scoring a hit doesn't change with the speed of the rock. However in the microscopic domain, this common sense no longer holds. The velocity and thus energy of subatomic particles has a large bearing on the likelihood of them hitting each other. This counter intuitive situation arises because the particles aren't really colliding like two solid objects; rather it's their wave functions that are interacting. And wave functions are diffused through local space and time. To keep things convenient, scientists still express the likelihood of two particles colliding in terms of a collision cross section. Bigger cross-section, better chance. The only tricky thing is that this collision cross section changes as the particle energy changes. It's like your tin can getting smaller as the rocks get faster.

For this reason, ions of different energy interact with different components of the target material. Very energetic ions from either natural radioactive decay or the powerful accelerator are very unlikely to collide with the nuclei in the target, as the collision cross section for this interaction is essentially zero at these velocities. This means that the ion loses energy by interaction with the electrons of the host material, not the atoms. The result is a sudden and massive local heating along the ion's trajectory by several thousand degrees. This causes a violent expansion of the silicon dioxide reducing the density along the core of the track and compressing the material in the surrounding cylinder. The area is so localized that the subsequent cooling down is almost instantaneous, preventing the material from returning to its original structure. The net result is a tunnel shaped shock wave frozen in time.

The big breakthrough came with design of high-resolution x-ray scattering experiments to study the structure in the ion tracks. The tracks in the silicon dioxide are amorphous ¬ meaning the crystal lattice structure has no long-range order. However the target silicon dioxide also has an amorphous structure. "It's very hard to see tracks of new disorder in an already disordered material." Dr Kluth explains, "the new measurements, however, enable us to resolve the small density changes in the ion tracks which has not been possible by other means before. We are now confident that we can apply this method to resolve the structure of ion tracks in wide variety of other materials as well."

A crucial aspect for the measurements is that the accelerator-irradiated material differs from naturally occurring silica in one very important way. All the ions from the accelerator were travelling in exactly the same direction when they created tracks. This means that all the damage tracks are parallel. This is vitally important because it makes x-ray analysis viable. To obtain a suitable bright monochromatic x-ray source, the scientists travelled to Chicago to use the Advanced Photon Source synchrotron at Argonne National Laboratory.

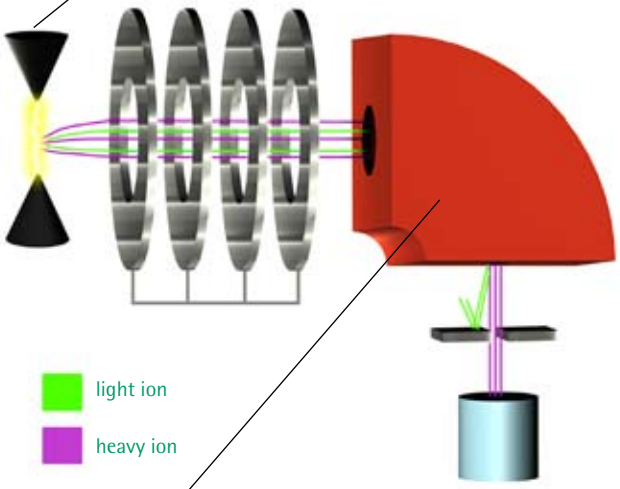
In a natural sample with tracks at random angles, a beam of x-rays is scattered in a different direction by each track resulting in a blurring of the scattering signal. However when the tracks are all parallel each one scatters x-rays in the same direction reinforcing the signal. "What we see in a case like this is a clean superimposition of the signals from each track."

"Apart from solving a long-standing mystery in materials science, these findings have significant potential impact for interplanetary science. In space, equipment is exposed to very high energy cosmic radiation and the response of materials to that is important in designing reliable electric components."

Aerial photo of the Advanced Photon Source at Argonne National Laboratory. Image courtesy of Argonne National Laboratory

A closer look at the 14UD accelerator

Ions are produced by heating a chosen source material in an electric arc. A series of charged plates with central apertures electrostatically attract and accelerate these ions into the central core of the accelerator which is kept at high vacuum to avoid collisions with air molecules.



The first steering magnet deflects the charged particles according to the Lorentz force equation
F = q (v x B) Where v is the velocity vector B is the magnetic field vector and F is the resulting force vector.
From Newton's famous F = ma equation, the acceleration a charged particle (ion in this case) experiences depends on both its mass and the charge it carries.
A heavy ion is thus bent less than a light one and a doubly charged ++ ion is deviated more than a singly charged one of the same mass.
In effect this smears out the beam by deflecting the light ions more than the heavy ones. If a slit is placed at the output and the field is correctly adjusted, the magnet assembly can select only ions of a given mass (element) and charge to pass through into the main accelerator tank.

Once they leave the upper steering and mass selection magnet, the negatively charged ions are strongly attracted to the 14 million Volt positive potential at the centre of the accelerator and gain huge speed and energy as they hurtle towards it. Of course if they were simply allowed to pass through and exit the other side they would loose all this energy as they approached the bottom of the tank because the centre electrode's potential would attract them back. To overcome this, a microscopically thin layer of gold foil is placed near the centre electrode. As the ions pass through the foil at great speed many of their outer electrons are stripped off leaving them positively charged. This makes the positive 14 million volts on centre electrode highly repulsive to them and causes them to further accelerate towards the bottom of the tank.

The massive charge at the centre of the accelerator is built up using long rotating chains with links made of alternate insulating and conducting material. These transfer frictional electrostatic charge to the centre of the accelerator tank. The principle is exactly the same as a common Van De Graaff Generator except that in this case, the potential at the accelerator centre reaches 14 million Volts.

Because air breaks down at about 30,000Vcm^{-1} the tank has to be filled with a special insulating gas called Sulphur hexafluoride. At a pressure of six atmospheres this gas has sufficient insulation to prevent arcing between the 14 million Volts of the centre electrodes and the tank wall.

Another steering magnet at the base of the tank changes the ion beam direction to horizontal and enables it to be directed to a variety of targets and experiments.

Playing with fire

David Salt

Taking the guesswork out of fire mosaics

Fire is one of our more visible land-management tools. Most of the time its sole objective is fuel reduction for asset protection, but fire management also has important implications for biodiversity conservation. Frequent fire and the complete suppression of fire have both been implicated in species' declines.

With fire benefitting some species, but having detrimental effects for others, the obvious solution is to maintain a mosaic in which there are areas burnt at different times in the past. But what is the appropriate range of times-since-fire? Do burns of similar age need to be next to each other to allow colonisation, and what's the appropriate size of the management fires? Currently there are no answers to these questions, and so designing fire mosaics is guesswork, with no guarantee that it will meet conservation objectives.

Dr Don Driscoll at the Fenner School for the Environment and Society is working to fill these knowledge gaps. Along with colleagues at Flinders University, Wollongong University, the NSW Department of Environment and Climate Change and the SA Department of Environment and Heritage, he has designed a three-pronged research program to gather the necessary information.

"The first prong involves studying reptiles, birds and plants in the field," says Dr Driscoll. "Researchers will examine how wildlife use habitat, animal behaviour, reproduction and how survival is affected by the time since the last fire.

"Next, the researchers will take to the lab and use genetic methods to understand the dispersal of different species to discover if time-since-fire influences movement. Combined with direct evidence of dispersal in the field and demographic and habitat data, this will enable a description of the mechanisms that influence each species' response to fire.

"The third prong is still being planned, but will involve a post-doctoral research fellow doing computer simulation modelling using the detailed biological data that's been collected. With cleverly designed simulation models based on solid field

Fire management for biodiversity is set to become an increasingly important tool for land managers as climate change takes effect.

evidence about how the study system works, we will be able to model the responses of multiple species to contrasting fire mosaics. Our ambition is to be able to conduct virtual experiments that could never be done in the field because replication at the necessary scale is impossible and the duration of each experiment is prohibitively long."

Fire management for biodiversity is set to become an increasingly important role of land managers as climate change takes effect. The frequency of high fire-risk days is expected to increase, bringing with it more, and potentially larger fires. The modelling phase of the project will enable the researchers to examine the consequences of increased fire intensity, and they hope to tease apart the benefit for biodiversity conservation of contrasting management options in the face of climate change.

The first part of the research will examine how animal behaviour, reproduction and survival is affected by the time since the last fire.

"We also hope to examine the interaction of fire and habitat fragmentation," explains Dr Driscoll. "In fragmented landscapes, fire suppression is the dominant management regime and this may disadvantage fire-loving species. When remnants do burn, they are entirely incinerated, so any fire-sensitive species will not have the benefit of unburned refuges from where they can recolonise. Cycles of fire suppression followed by a large fire could therefore ratchet down biodiversity in fragmented landscapes. Using a combination of detailed field research and simulation modelling, we hope to identify management strategies that will maintain species diversity across the landscape."

An ACE in the hand

David Salt

Unravelling the biochemistry of nutrition

By understanding what's happening with rare human disorders we sometimes generate knowledge that's fundamental to how our bodies function. In so doing we can directly assist the handful of people suffering from that rare condition, and indirectly advance the broader field of human biochemistry. Such a situation exists with Hartnup disorder. It's a rare genetic condition that manifests itself mainly in children, and has symptoms of skin rash and neurological problems. What causes it is an impairment with the absorption of amino acids in the intestine. Researchers at ANU are studying this impairment and have recently made some significant advances in understanding the uptake of amino acids in the intestine and kidneys.

"Protein forms up to 20 per cent of our nutrition," says Professor Stefan Bröer, the biochemist leading the team doing the research at the ANU School of Biology. "Before it can be used by the human body, protein is split into its subunits called amino acids. The amino acids are then removed from the intestine by specialised cells which are endowed with a large number of molecular transporters that move nutrients from the intestine and into the cells.

"A few years ago we identified a new subfamily of these amino acid transporters that is responsible for the uptake of neutral amino acids in these tissues. Together with colleagues from ANU and Sydney University, we subsequently could demonstrate that Hartnup disorder is caused by mutations in one of these amino acid transporters so we're hopeful that our research will generate insights that will help with the treatment of this disease while, at the same time, advancing the whole area of amino acid uptake and kidney function. The kidney is also involved because these amino acid transporters also play an important role in the kidney in reabsorbing metabolites that the body needs to retain."

But the transporters are only half the story and Professor Bröer's team has recently demonstrated that for the transporter to be fully functional it needs another protein named ACE2 working with it. Scientists have suspected that the ACE2 protein plays a role in regulating blood pressure but this is the first time it's been implicated in digestion and the uptake of amino acids.

"The ACE proteins are involved in generating a hormone which regulates blood pressures," explains Professor Bröer. "ACE inhibitors are widely prescribed drugs that reduce the risk of heart failure and protect against the long-term effects of diabetes.

"Two versions of the protein are known: ACE1 and ACE2. ACE 1 is a very well known target for blood pressure regulation, and many people take drugs to lower their blood pressure by inhibiting this particular enzyme.

"More recently they discovered a second protein, ACE2; and it was found just by looking at the human genome. While it's known to be related to ACE1, no-one really knew what role ACE2 played though it was expected that it has something to do with blood pressure regulation.

"What my lab found was from a quite different direction. We looked at nutrient uptake in the intestine. We are interested in protein digestion, how it gets split into amino acids, and how these amino acids get taken up in the intestine.

"And what we've discovered is that the ACE2 protein plays an important role in both of these areas. It helps split proteins into constituent amino acids and it's an important partner to the amino acid transporters that allow those amino acids to then be taken up into the cells."

Professor Bröer's research has several implications. It provides a more detailed understanding of what drives Hartnup disorder, it suggests we need to be very careful if we consider using ACE2 as a target for blood pressure drugs because ACE2 plays an important role in nutritional uptake, and it suggests that there might be other approaches available for treating high blood pressure.

"One thing we're looking into is the link between amino acids and blood pressure," explains Professor Bröer. "New research on metabolites found in urine is suggesting that certain amino acids in the urine correlate with higher blood pressure. This ties in neatly with our studies on the connections with ACE2, amino acid transporters and blood pressure. In the long term it might result in a different way to treat blood pressure. Normally, when you talk about blood pressure you work on salt intake but maybe there are other approaches that focus on proteins."

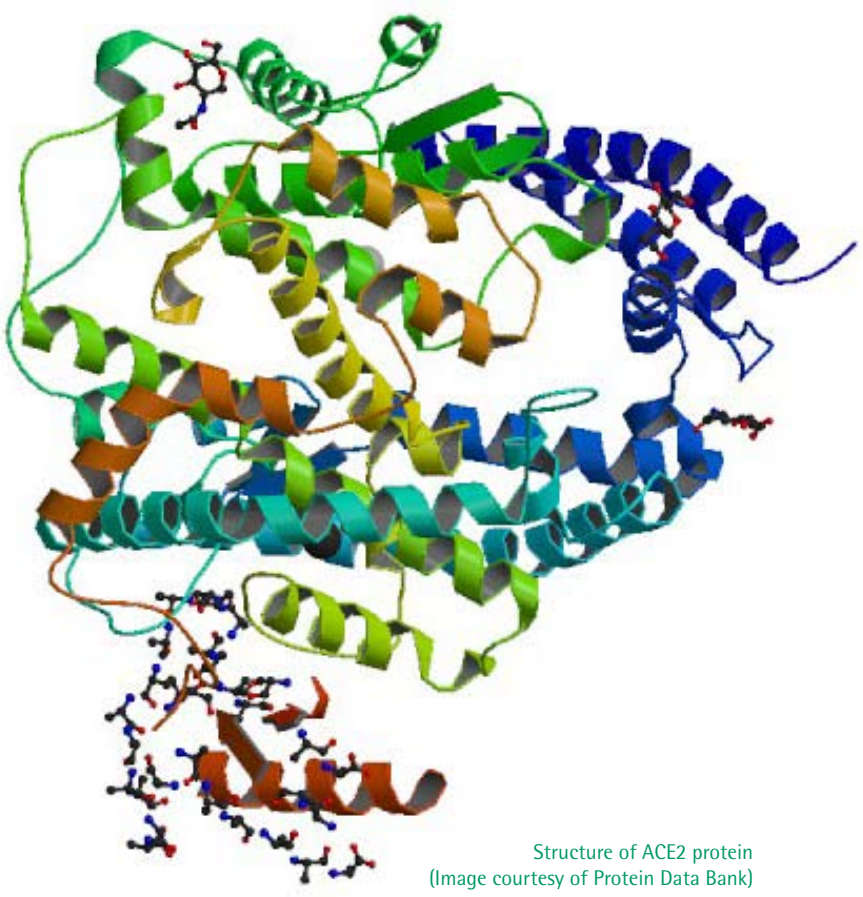
For now, the researchers are working to better understand the interactions between amino acid transporters and the ACE2 protein. Professor Bröer's lab has recently acquired a breeding population of 'knock-out' mice that have had the gene for one of the amino-acid transporters removed (or knocked out). These mice, then, are perfect models to study Hartnup disorder as they lack the same functionality as humans with Hartnup disorder.

Professor Stephan Bröer.

"The results of these studies will go beyond just assisting people with Hartnup disorder as it will help develop our basic understanding of intestinal and kidney function," says Professor Bröer. "These findings could have important implications for the way we treat common disorders such as diabetes and celiac disorder.

"I suppose my over arching interest is on how the human body works. When I'm teaching, this is the basic point I try to get over to my students – that we're trying to unravel is how the human system operate – the basic system that allows us to live and grow.

"The fascinating thing about this system is that as you focus down on the role played by individual proteins, you often discover they play multiple interacting roles. This is exactly what we've found as we've looked at the role of the ACE2 protein."



Structure of ACE2 protein
(Image courtesy of Protein Data Bank)

Getting the words wrong

Tim Wetherell

New research suggests visual problems have a role in dyslexia

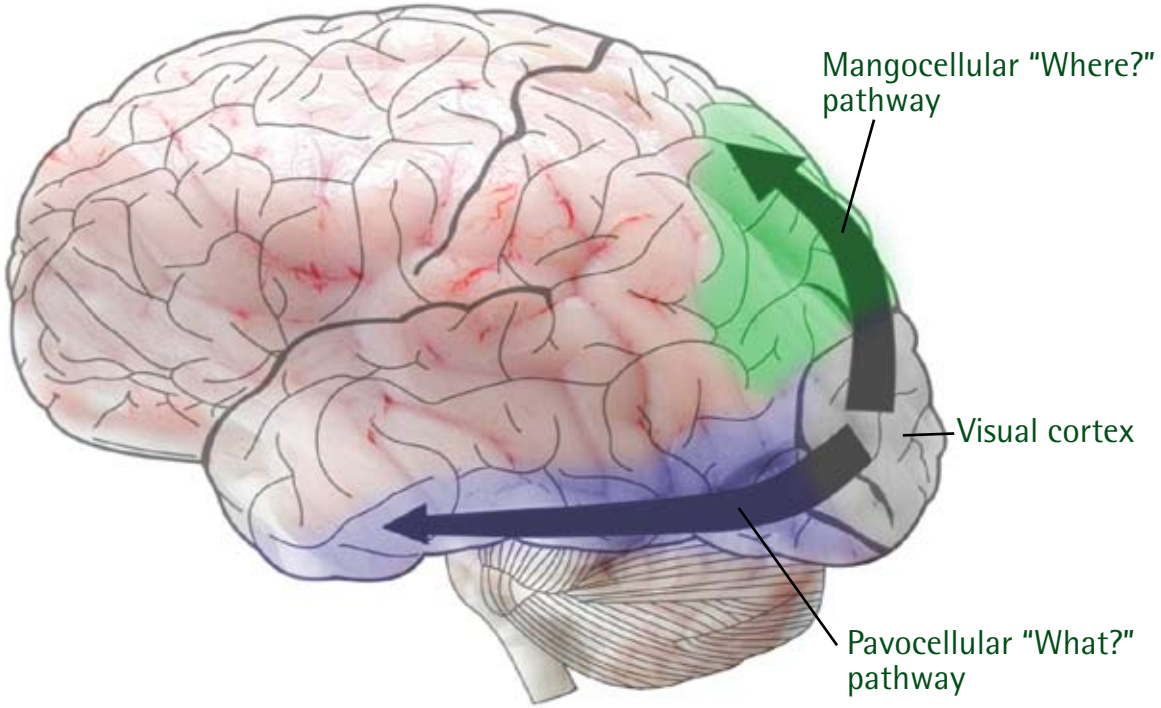
The first record of dyslexia as an identifiable condition came to light in the late nineteenth century amongst the many other medical curiosities that seemed to fascinate the Victorian imagination. Of course modern scientists realise that dyslexia is in fact quite common, many people being affected to a greater or lesser degree. It's also now known that there is a strong genetic component putting children of dyslexic parents at heightened risk. However despite many years of research and several significant breakthroughs, a complete model of the processes that underlie dyslexia remains elusive.

Dr Kristen Pammer from the ANU School of Psychology is currently leading a team of scientists trying to unravel at least one piece of this complex puzzle. "Traditionally dyslexia is seen as a phonics based problem, a difficulty in associating particular sounds with letters on a page. But whilst there is clearly a large component of photonics in dyslexia, our research has lead us to believe that there may also be subtle underlying problems in the dyslexic brain's visual processing systems."

Within the visual cortex there are two distinct processing pathways. The mangocellular pathway (also known as the dorsal stream due to its physical placement) deals with conceptualising the movement of objects and their position in space. For this reason it's sometimes nicknamed the "where" pathway. Leading to a different part of the brain, the pavocellular or ventral pathway is concerned with detailed visual information used for the recognition of objects. And can be thought of as the "what" pathway.

In terms of reading, the pavocellular pathway is vital for recognising letters and words but interestingly enough, it's deficiencies in the mangocellular pathway that seem to be related to reading difficulties. Dr Pammer explains "Its been known for some time that adults with dyslexia often do poorly on visual tasks designed to test the functioning of the mangocellular pathway. What we were unsure of is wether this was a partial cause of dyslexia or a consequence of failing to learn to read?"

In order to investigate this, graduate student Alison Kevan undertook a study of kindergarten children who hadn't yet begun to learn to read. The kids were selected from those who had a first-degree adult relative with dyslexia and so formed a "high risk" group. The researchers adapted the visual tests into a series of simple computer games that the kids would find fun. The first was a coherent motion test taking the form of a series of sheep moving round a field. The task was to detect when some of the sheep are moving in the same direction. A non-dyslexic adult can usually detect coherent motion



when about 20% of the sheep move synchronously, for a child it could be as high as 50%. However, in many children with a predisposition for dyslexia the number need to be much higher before they can recognise synchronised motion. This simple test was coupled with a number of other more complex games based on the visual frequency doubling illusion, to create a suite of specialised tests to probe the manogcellular pathway.

By following the progress of the children as they began to learn to read, the researchers found that those who did badly on the mangocellular pathway tests before they learned to read, also showed signs of dyslexia once they could read. This finding lends weight to the idea that inherent deficiencies in the visual cortex may be at least a partial cause for dyslexia rather than a consequence of it. But although the data correlation is excellent, Dr Pammer is cautious about jumping to conclusions. "Clearly phonemic problems are also a major factor, so I don't see our research producing a stand alone test for risk of developing dyslexia. They might however be useful as part of a broader series of visual and auditory tests used in the early diagnosis of dyslexia."

The team also hope that their work may help build a better understanding of the function and dysfunction of the brain. "Reading is a particularly interesting area of research because he brain has not evolved to read. It has specialised centres to deal with spoken language but in order to read, it has to recruit areas that have evolved for other purposes and build them into a network."

Dr Kristen Pammer

A simple computer based test may help identify easily signs of dyslexia

ScienceWise is published by the
Australian National University
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