The new award recognises distinguished research in the mathematical sciences by a researcher under 40 years of age, in one of three fields on a rotating basis: pure mathematics; applied, computational and financial mathematics; and probability theory, statistical methodology and their applications. Dr Henderson won his medal for research in pure mathematics.

From 2011, the Australian Academy of Science are offering the Christopher Heyde Medal annually to outstanding early career mathematicians who are residents in Australia.

"This is a great honour and I'm very pleased that the Australian Academy of Science has chosen to reward my research," Dr Henderson said.

"I was quite surprised, since I'm only 34 and I thought it would go to someone closer to the age limit.

"Since most researchers in my area are either overseas or here in Sydney, I don't often get a sense of how my work is viewed by the Australian mathematical community as a whole, so this recognition is very gratifying."

The latest honorific medal to be added to the Australian Academy of Science’s annual awards honours the contributions to mathematics made by Professor Christopher Heyde, who was the Foundation Dean of the School of Mathematical Sciences at the Australian National University, and Professor Emeritus of Statistics at Columbia University, New York.

"I'm on the Council of the Australian Mathematical Society, which has awarded an annual medal for young researchers for the past thirty years, but the Australian Academy of Science hasn’t had one for mathematics until now. It’s great that the late Christopher Heyde, who did so much for the mathematical sciences in this country, can be remembered in this way.

"I hope that the Heyde Medal will become a major indicator of the work being done by young Australian mathematicians and statisticians, like the Pawsey Medal in physics."

Dr Henderson works on geometric and combinatorial aspects of representation theory.

"When we talk about a ‘group’ in mathematics, we mean a collection of operations which preserve something. For example, in chemistry, if you have a molecule which has some symmetry, then there are rotations and reflections and so on which leave the molecule unchanged, and those form a group. In algebra, if you have a function involving several variables, then there may be some permutations of the variables which leave the function unchanged, and those form a group. These groups come with a kind of multiplication, because you can do one operation and then a second one, and that whole process is a third operation in the group," said Dr Henderson.

"My research is in representation theory, which studies how to represent one of these abstract groups of operations by a concrete collection of matrices of numbers, so that the multiplication is just the standard multiplication of matrices. These representations are very useful for calculations relating to the original molecule, or function, or whatever it may be; they're also needed to describe the states of various particles in quantum physics. But it can be hard to find representations, and there are some basic classes of groups where we still don't know them all after more than a hundred years of searching," explained Dr Henderson.

"My main contribution has been describing some new representations of old groups. The idea is that even if you start with the first kind of group - the symmetries of a molecule or other geometric object in ordinary space - there may be some group of the second kind, defined from a function or collection of functions, which has the same multiplication law. Once you know that, you can look at a different geometric object, the set of solutions when you equate all the functions to zero; the functions may involve many variables, so this solution set may live in some very high-dimensional space.

"Then there's a trick you can use, called homology, to produce matrices from this solution set and get a representation of your original group. This idea goes back decades, but what I've done is to find various new ways to make it work," said Dr Henderson.
High school students create new Facebook

BY JOCELYN PRASAD AND RACHEL GLEESON

High school students from across Australia presented four alternatives to Facebook in their final day at a University of Sydney summer school.

They developed social networking sites as part of the National Computer Science School (NCSS), an annual event held at the University in January. Functions presented on the sites included the ability for users to stay anonymous, and to collaborate on shared projects.

The summer school is run each year by Dr James Curran and Dr Tara Murphy from the School of IT to get school students thinking more about careers in IT and to complement a high school syllabus wanting in relevance.

“Although IT now permeates our everyday lives, it still suffers from an image problem," says Dr Curran.

“NCSS is about giving school students a peek into the opportunities and excitement the industry holds.

“We’re also trying to demystify IT. While much has been made of the genius behind the likes of Facebook and Twitter, their success is partly a matter of timing.

“The principles behind these sites are something you’d learn as an undergraduate IT student.”

Other challenges faced by students who attended the ten-day school included programming robots to perform a rescue and return to their starting point doing a victory dance.

Seventy three students took part in this year’s NCSS. They presented their sites to judges, sponsors and parents on 11 January.
We humans have been digging up dinosaur bones for thousands of years. But it’s only in the last few centuries that we have recognised them as the bones of dinosaurs.

Only just lately have we understood that birds are dinosaurs. Indeed, it was only as recently as the 1980s that we began to understand how a small asteroid was involved in the extinction of the dinosaurs (at least, the ones that were not birds).

But now it seems that Jack Horner has made one third of all dinosaur species extinct. This Jack Horner is John ‘Jack’ R. Horner, the American palaeontologist. (Not the Jack Horner from the nursery rhymes that date back to 1725.)

As a separate issue, Jack Horner was the person who almost certainly proved that dinosaur mothers looked after their eggs, instead of just laying them and walking away in a callous reptilian manner.

Back in 1978, he was working at the quaintly named Egg Mountain in the Badlands of Eastern Montana in the USA. Now it’s amazing how lucky you become if you work hard, and Jack Horner was lucky enough to discover complete nests of dinosaur eggs.

These nests held both dinosaur eggs and baby dinosaurs.

The babies and eggs belonged to a new duck-billed species. Since he had discovered them, he could name them. He called the species Maiasaura. This comes from the Greek, and means ‘good mother lizard’.

He reckons that the newly hatched dinosaur babies must have been very vulnerable, and so the babies totally relied on a parent (probably the mother) hanging around the nest, like birds do today.

Firstly, the parent had to protect the unhatched eggs from predators.

Secondly, the parent had to feed the babies until they were strong enough to feed themselves, and survive on their own. This probably happened when the babies had reached at least twice their birth weight.

And Dr Horner’s brand new theory is that, in at least a few dinosaur species, their appearance changes dramatically as they grow into adults. He picks triceratops as an example.

Triceratops was one of the last of the dinosaurs. They roamed the Earth some 65–68 million years ago, and are one of the most commonly found dinosaur fossils. In North America, they make up over 80 per cent of the large dinosaur bones found in the last 5 million years before the great dinosaur extinction.

Their skulls were among the largest ever for a land animal — up to two metres long. The skulls were remarkably sturdy and strong. In fact, more skulls than other bones of triceratops have survived.

Triceratops were a few times bigger than a rhinoceros: up to nine metres long, three metres high and 6–12 tonnes in weight.

Triceratops had two very obvious and recognisable features: a set of horns, and a rather fetching frill (or bony shelf) around the back of their neck.

As well as the two big horns that erupted out of their foreheads just above the eye sockets, they also had one smaller horn on the centreline, near the tip of their very long nose.

Now according to Jack Horner’s theory, the big horns usually pointed backwards, but only when they were a juvenile.

He then claims that as an adult, the horns changed direction. Not only did the horns point forward, but they became flattened as well.

If he’s correct, this means that another dinosaur species, currently called Torosaurus, is not a different species. Instead, it’s just a grown-up triceratops. Torosaurus looked like a triceratops, only bigger.

The triceratops frill was usually solid, but about half the frills found so far have two thinner areas. These thinner areas are where the torosaurus dinosaur usually had holes.

Jack Horner reckons the frill started out as totally solid in the juvenile dinosaur, and then gradually got thinner as it got older, until as a mature dinosaur, it developed some holes.

Torosaurus dinosaur skulls do look remarkably similar to triceratops, with three horns and a large frill behind the neck. The horns usually point forwards. The frill usually has two holes.

So was a triceratops actually just a younger torosaurus? Maybe!

If Jack Horner’s theory turns out to be correct, we will lose some species of dinosaurs. Some pairs of different dinosaur species might get re-classified as the juvenile and adult forms of the one single dinosaur species.

At a rough guess, Jack Horner reckons that we might lose about one-third of dinosaur species.

But in reality, it’s not a real extinction. It’s just a re-classification.

What is real is the extinction of all the non-bird dinosaurs, and also the asteroid that hit the Earth 65 million years ago.
Solar energy research wins $967K

BY KATYNNIA GILL

A team of solar energy researchers led by Dr Tim Schmidt, from the School of Chemistry, has been awarded a $487 584 grant from the Australian Government’s Australian Solar Institute.

Dr Raphael Clady, part of the solar research team, has also been awarded an Australian Solar Institute Postdoctoral Fellowship. Minister for Resources and Energy, Martin Ferguson AM MP, announced the Institute’s round 2 grants, four Postdoctoral Fellowships and four PhD scholarships on 29 November 2010.

The Australian Solar Institute will provide $21.6 million funding for 14 solar energy research projects under Round 2 of the grants program.

The team led by Dr Tim Schmidt also includes Professor Maxwell Crossley and Associate Professor Sebastien Perrier, all from the School of Chemistry at the University of Sydney.

The fundamental research project is called ‘Upconversion of the solar spectrum for improved PV energy conversion’ and will be additionally supported by the NSW Government through its Science Leveraging Fund.

“Our project grant recognises the advances made in the last few years in our spectroscopy laboratory. The funding will significantly advance our technology towards more efficient solar energy harvesting,” said Dr Schmidt.

“Most commercial solar cells are limited to absorbing particles of light above a certain threshold energy. This causes their energy conversion efficiency to be limited to about 33% under standard illumination. Our research will develop a coating for solar cells which can harvest the sub-threshold light,” explained Dr Schmidt.

“By joining the energy of two low energy particles together, the material will re-radiate the light into the solar cell above the absorption threshold. Doing this raises the energy conversion efficiency limit considerably.

“Cells with thresholds corresponding to 620nm light - reddish-orange light - have their efficiency ceiling doubled. By raising the ceiling, the project aims to bring about 10% improvements in real cells within three years,” said Dr Schmidt.

Other participants in the project include Imperial College, London; UNSW; the University of Adelaide; and the Helmholtz Centre for Materials and Energy, Berlin. The University of Sydney project comprises a total cash budget of $811 000, with Sydney and other partners contributing an additional $1 million in-kind contributions.

“We’re also really pleased that one of our postdoctoral researchers was successful in winning one of only four Australian Solar Institute Postdoctoral Fellowships. Raphael’s three-year postdoctoral fellowship will allow him to continue to make fantastic experimental contributions to solar energy projects around the world,” said Dr Schmidt.

“He will be performing ultrafast spectroscopic experiments on a range of new generation solar energy materials to track the degradation and processing of energy on the femtosecond timescale.”

Minister for Resources and Energy, Martin Ferguson AM MP, said investment in solar energy is a key part of the Australian Government’s vision for a low-emissions economy.

“The global use of renewable energy is predicted to triple by 2035 and these investments position Australia to take advantage of this growth,” said Minister Ferguson.

The Australian Solar Institute grants support Australian researchers in solar photovoltaic and concentrating solar thermal technologies. The Institute helps to retain Australian solar expertise and develop the next generation of Australian solar researchers.

The Australian Solar Institute is part of the Government’s $5.1 billion Clean Energy Initiative, which includes the Solar Flagships Initiative.

It’s life, but not as we know it

BY DR NICK COLEMAN - FIRST PUBLISHED IN THE DAILY TELEGRAPH ON 4 DECEMBER 2010.

Bacteria are the true rulers of the Earth.

Their numbers, activities and diversity are far greater than any other group of organisms and they have an amazing capacity to make a living in the most unlikely environments.

Bacteria that tolerate high concentrations of toxins, like arsenic, are not unusual and have been long studied for their possible role in cleaning up contaminated sites.

Bacteria that can ‘breathe’ using arsenic compounds instead of oxygen are also known, although these are rare and only found in environments very rich in arsenic, such as Mono Lake in California, USA.

The new NASA results are revolutionary because they show that functional DNA and other cellular components can be made using arsenic instead of phosphorous. And further, living things can thrive in the absence of phosphorous, previously thought essential for all life. The significance of this finding for the existence of life on other planets is threefold.

Firstly, it demonstrates the incredible ability of life to adapt to apparently inhospitable environments.

Secondly, it shows planets lacking phosphorous can still potentially support life.

Finally, it makes us rethink questions such as: “What is life and how will we recognise it if we find it elsewhere in the galaxy?”

Dr Nick Coleman is a lecturer in microbiology in the School of Molecular Bioscience at the University of Sydney. His research is in the area of microbial biotechnology.
You get an explosion of light and matter - ISS2011: Light & Matter, to be precise.

This July the School of Physics is hosting the 36th International Science School for high-school students. Talented young minds from across Australia will meet peers from China, Japan, Malaysia, Singapore, New Zealand, Thailand, the UK and the USA for a fortnight of science talks, experiments, activities and excitement.

The main feature of the ISS is always the series of talks by leading scientists, and this year the students will meet Sir John Pendry of Imperial College, London, renowned for his work on invisibility cloaks. This isn’t some mere Harry Potter-esque magic show: Sir Pendry works with metamaterials, so carefully engineered that they have bizarre properties - including invisibility! Then students will get a glimpse of the very earliest moments of the universe after the big bang with Professor Allan Clark from the University of Geneva. Professor Clark works on the ATLAS detector Large Hadron Collider in Switzerland, the world’s largest particle accelerator, where particles collide at energies higher than we have ever seen on earth to explore the very smallest scales of matter. Dr Christine Charles, head of ANU’s Plasma Research Laboratory, will introduce the students to the most abundant form of material in the universe, the stuff of stars and the beautiful northern and southern lights: plasmas. She will show the vast range of plasma applications, from fluoro lights to microchips, hydrogen fuel cells and even plasma space engines.

The talk series will also feature home-grown researchers from the University of Sydney. Professor Ben Eggleton will talk about his team at the Centre for Ultrahigh Bandwidth Devices for Optical Systems, who are creating fibre optics and light-based computers for the future of communications and IT. Geoscientist Dr Jo Whittaker will show how her work on plate tectonics can reconstruct the shape of our world in the distant past. And in this, the International Year of Chemistry, Dr Deanna D’Alessandro will speak on doing her bit for the planet through research into 3D chemical structures that capture greenhouse gasses.

This is just a sample of the amazing research and inspiring scientists our ISS students will encounter at ISS2011. When they’re not absorbing science in the lecture theatre, the students will be running around campus with GPS units on a geosciences treasure hunt, or taking eye-popping images with the Australian Centre for Microscopy and Microanalysis, or designing airships, breaking codes and modelling power grids with the Science and Engineering Challenge.

And when they are done with science for the day, each evening they can take part in a wide range of social activities, from movie and games nights to the famous ISS Sydney Harbour Cruise.

Applications for the International Science School are open from February and close Friday 1 April 2011 - the application form and information kit are available from:

sydney.edu.au/science/physics/foundation/iss/iss.shtml

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A new era in dairy farming has been heralded with the revelation of the robotic rotary, a world first, developed by DeLaval in collaboration with the University of Sydney and Australia’s FutureDairy project.

Designed for Australian grazing herds with more than 300 cows, the robotic rotary automates most milking tasks, enabling the job to be performed as a background activity, without the presence of a human operator.

Chair of FutureDairy, Shirley Harlock, said the robotic rotary was a major step towards addressing two of the key challenges facing the industry - the availability of labour and the lifestyle associated with dairying.

"This is one of the most exciting developments that has occurred in the 40 years I’ve been dairy farming," Ms Harlock said.

"Although it won’t suit all dairy farmers, the robotic rotary offers considerable benefits in terms of enabling more flexible working conditions and improved lifestyle."

While automatic milking systems have been widely adopted overseas, their application on Australian farms has been slower, mainly because the technology was developed for European herds which are smaller, and housed indoors for most of the year.

FutureDairy research has proven that automatic milking systems can operate effectively in Australia’s pasture-based system, achieving both high pasture utilisation and acceptable AMS unit utilisation. However the available technology was best suited to herds of less than 300 due to capacity (number of cows that can be milked by each unit in a 24-hour period) and cost. The robotic rotary offers a better solution for larger Australian dairy herds.

A limited commercial release is planned for 2011 under the brand name DeLaval AMR (automatic milking rotary). The recommended retail price for the DeLaval AMR has not been announced yet but it will be competitive in the automatic milking segment for larger herds. It is likely to cost more than a conventional rotary with all the ‘bells and whistles’ but the running costs would be significantly lower because of reduced labour input.

The next step in Australia will be the installation of robotic rotaries on two commercial farms in 2011. These installations will be closely monitored and supported by DeLaval and the FutureDairy team. The experience provides the opportunity to identify issues and continue the development of the system in the ‘real life’ situation.

Although developed for Australian conditions, the robotic rotary is flexible enough to operate under a variety of dairying systems such as free-stalls and loose housing which are typical of overseas industries.

The potential value for larger herds overseas has already been recognised, with the DeLaval AMR will receive the prestigious 2010 Eurotier Gold Medal in Germany on 16 November 2010.
New research led by Associate Professor Ashley Ward, in the School of Biological Sciences at the University of Sydney, shows for the first time that larger social groups make faster and more accurate decisions. This crucial benefit may have been important in promoting the evolution of sociality, a strategy used by a huge variety of animals from ants to humans.

The study, published in the prestigious US journal *Proceedings of the National Academy of Sciences*, presented mosquitofish, *Gambusia holbrooki*, with a choice to swim down one of two arms in a Y-shaped channel. One arm contained a replica predator, while the other arm did not. Associate Professor Ward, with PhD student James Herbert-Read and other colleagues, found that larger groups of mosquitofish made the correct decision to swim down the predator-free arm more rapidly than smaller groups and individuals.

“Social animals are frequently required to make collective decisions about such things as the timing and direction of group travel, the detection and avoidance of predators, or the location of food. We predict that groups of animals are more accurate in their decision making than individuals,” said Associate Professor Ward.

“In our study, we put animals in a really straightforward decision-making situation, where they could choose one of two options: one of which is ‘wrong’ and the other ‘right’. The wrong decision is to swim down the arm of the Y maze where a predator is concealed; the right decision is to take the alternative path,” explained Associate Professor Ward.

“Even though we used a replica predator, the fish couldn’t be certain of that – from a distance it looked like a predator. It’s better to be cautious and avoid something that might represent a threat, if you are able to detect that threat in the first place."

Using this set-up, the team investigated the two key parameters of decision-making: speed and accuracy.

“An optimal decision must be both fast and accurate. An accurate decision that is slow may be good in some respects, but if a predator is around, it might come too late. Similarly, a rapid but inaccurate decision is clearly far from ideal,” said Associate Professor Ward.

The team tested the decision making speed and accuracy of mosquitofish in the Y maze as singles, pairs, or in groups of four, eight or 16.

“What we found is that as group size increases, fish in these groups make both faster and more accurate decisions. Their decision-making becomes more and more efficient as the size of their social group increases,” explained James Herbert-Read.

“Groups of eight and above showed almost 90% accuracy, meaning that nine times out of ten they avoided the predator, whereas single fish managed only about 56% accuracy,” said Mr Herbert-Read.

“Remarkably, we found that improvements in accuracy start even in groups of two fish and then accelerate rapidly.

“In addition, the fish in the larger groups typically made their decision in less than half the amount of time than that taken by fish on their own.”

Why did the mosquitofish do so much better at avoiding predators in groups compared to when by themselves?

“The answer seems to lie in the greater vigilance of animals in groups and their correspondingly greater ability to detect a threat. In addition to this, once one individual has spotted the threat, the information is transmitted rapidly throughout the group. We don’t know exactly how they communicate this – we assume it is to do with their behaviour, which may change once they detect a potential threat,” said Associate Professor Ward.

So while fish on their own may often have simply failed to detect the threat, leading to their overall lack of accuracy, larger groups were extremely good at detecting the threat, acquiring and using the available social information and ultimately avoiding the predator.

“We haven’t seen any previous studies that examine how decision making efficiency – that is both speed and accuracy of decision making – changes with group size in any animal, so this finding that fish living in groups benefit from these dramatic improvements is a first,” said Associate Professor Ward.

“Given that so many animals of all different kinds live in groups, we speculate that this crucial benefit may have played an important role in the evolution of sociality.”
The call was made as part of the recent global soil carbon summit held at the University of Sydney, with the support of the United States Studies Centre’s Dow Sustainability Program and the University’s Faculty of Agriculture, Food and Natural Resources.

Adjunct Professor in Sustainability at the US Studies Centre and summit convenor, Robert Hill said soil issues needed to have priority alongside climate issues.

“Australian agriculture is set to experience the destructive effects of ongoing climate change first and hardest. By improving the sequestration of carbon in soil to enhance soil security we can increase production and reduce carbon emissions at the same time. It is a win-win solution.”

Dean of the Faculty of Agriculture, Food and Natural Resources, Professor Mark Adams said soil security required increasing the quantity of carbon in soils through the adoption of sustainable farming practices. Improved soil security would underpin more sustainable food, water and energy production, at the same time as mitigating climate change.

According to the international experts, Australia is in a unique position to lead the effort to improve soil security with our agricultural sector among the world’s first to confront the challenges of climate change. The science and technology is already available for farmers to manage and increase soil carbon, but further support for the work is needed.

This summit, held in February 2011, marked the beginning of an international soil carbon initiative to improve understanding and raise awareness of soil security in Australia and around the world. It set four goals for future achievement:

• as a society we must recognise the fundamental importance of soil and soil carbon for food security and the survival and health of human populations
• soil issues must have priority alongside climate issues
• soil security will be achieved through soil carbon sequestration and optimisation for social, ecological and economic sustainability
• the science and technology is available for farmers to manage and increase soil carbon in accordance with their local situations, and they must be supported in doing so, through public policy and community recognition.

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