



Seven super science students at Sydney

By Katynna Gill



Seven super students who scored a UAI of 100 in their Higher School Certificate have enrolled in the University of Sydney's combined science and medicine degree, starting in March.

The super science students come from a mix of state and private high schools: Kin Lam, Alex Stoyanov, Joshua Lau and Karen Lee all attended James Ruse Agricultural High School; Ronald Fung attended Sydney Grammar School; Pok Wong attended Sydney Technical High School; and Chao Wang attended Shore – Sydney Church of England Grammar School.

All seven hope to become doctors, with some hoping to also be involved in scientific research at some point in their careers. Kin said, "I hope to have a career as a practising medical specialist and/or be involved in medical research. I am interested in medical research areas involving chemistry and mathematics, but it's too early to really decide on a focus since my interests change all the time."

Pok has similar ambitions: "I am hoping for a career in medical

research, as well as clinical practice as a doctor. I am currently considering many pathways, but I hope to work at the intersection of science and medicine allowing me to cross-pollinate the two and ultimately give the best patient care."

Joshua said, "In the future, I hope to be a doctor and possibly specialise in a certain area, although at the moment I am uncertain which area that will be. Through the course of my studies at the University of Sydney, I'll investigate different specialisations."

Choosing to study in the combined science and medicine degree at the University of Sydney, the super seven will first complete their undergraduate science degrees, then continue on to the prestigious four year graduate medical program.

Six of the students have chosen the Bachelor of Science (Advanced) degree, and Karen has chosen the Bachelor of Medical Science degree. This unique combined degree program, which allows students to gain a strong foundation in the sciences before moving onto medicine, has been offered since 2005.

Celebrating Success, Thursday 22 May 2008

Each year, the Faculty of Science takes the opportunity to acknowledge the outstanding team of researchers and teachers that make Science at Sydney a major contributor and competitor in the global scientific community and the producer of the next generation of science leaders in Australia. Guest

speakers will include Professor Margaret Sheil from the Australian Research Council and Ms Deborah Smith from the Sydney Morning Herald.

For more information about **Celebrating Success** please contact Ms Trixie Barretto: trixie@science.usyd.edu.au



Combating drug resistance in Golden Staph

By Carla Avolio

*There are few disease-causing bacteria that modern science hasn't yet beaten, but amongst these *Staphylococcus aureus*, or Golden Staph, has proven to be a formidable challenge. In recent decades, a drug resistant strain of *S. aureus* known as MRSA (methicillin-resistant *S. aureus*) has emerged as a major pathogen, possessing a broad ability to infect and a seemingly endless capacity to evade virtually every antibiotic thrown at it. MRSA and other drug-resistant 'superbugs' have spread around the world at alarming rates, and for medical researchers at the University of Sydney, the race to control them begins with understanding how they became so deadly to begin with.*

S. aureus causes a number of diseases, ranging from skin problems like boils and impetigo to life-threatening infections such as pneumonia and meningitis. By releasing toxins into food and the blood, it can be a cause of food poisoning and the highly lethal Toxic Shock Syndrome. While the MRSA variety does all of these things, its true threat lies in its striking ability to acquire resistance to new antibiotics. "Bacteria are masters of adaptation" says Dr Slade Jensen, who researches MRSA at the University of Sydney's Molecular Genetics Laboratory. "The development of antibiotic resistant strains of bacteria is a major healthcare problem around the world." It is this deft ability to evade our best medical innovations which has made MRSA a global threat and has kept researchers in a medical arms race trying to keep it at bay.

The history of MRSA begins as early as the 1940s when it was discovered that penicillin - the first antibiotic developed - was highly effective in treating staphylococcal infections. Shortly afterward, penicillin-resistant strains of *S. aureus* began to emerge in hospitals around the world. In the early 1960s a new class of penicillin antibiotics was developed, starting with methicillin, which proved active against these penicillin-resistant strains. Once again, it was only a matter of time before *S. aureus* adapted to methicillin-type drugs, and MRSA was born. Today MRSA is a global problem. Hospitals in particular are hotbeds of infection, and patients with surgical wounds and implanted medical devices are at particular risk. The treatment of choice (and one of the only antibiotics available to treat MRSA infections) is vancomycin, however, true to form, vancomycin-resistant strains of *S. aureus* have begun to emerge.

Dr Jensen and colleagues have been studying MRSA in the hopes of understanding how it develops resistance to antibiotics.

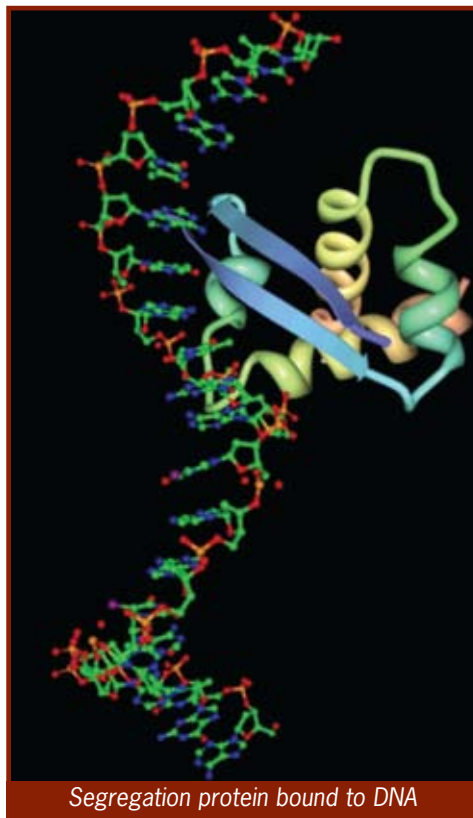
Understanding how this works may provide clues as to how to beat MRSA at its own game.

Horizontal gene transfer, or HGT, is a process by which bacteria exchange genetic material, such as DNA. In contrast to vertical transmission, in which genes are inherited from parent to offspring, HGT allows genes to be transferred between individual organisms and even between different species. HGT rarely occurs in eukaryotes such as mammals (for example, we can't easily swap our eye colour with a friend's), however in bacteria HGT is an important mechanism for drug resistance. According to Dr Jensen, "Strains commonly become resistant by acquiring pre-existing resistance determinants from the bacterial gene pool through horizontal gene transfer," which basically means that if one bacterium happens to have resistance to a particular antibiotic, the gene for that resistance may be picked up by other bacteria, leading to the spread of antibiotic resistance and eventually to the emergence of superbug strains like MRSA.

HGT is facilitated by mobile genetic elements. One type of mobile genetic element is called a plasmid, which is essentially a ring of DNA separate from the main bacterial chromosome. The link to MRSA and other superbugs is that genes for antibiotic resistance are often contained on plasmids, and thus can be swapped with other bacteria through HGT.

Dr Jensen and his colleagues Professor Ron Skurray, Dr Neville Firth and Dr Anthony Brzoska have been collaborating

with researchers at the University of Texas and recently revealed some exciting insights into how plasmids, such as those encoding drug resistance, are maintained in a bacterial cell population. As Dr Jensen explains, "We have recently determined a key structure of the DNA segregation mechanism of an *Staph. aureus* multi-resistance plasmid. This work revealed the structure of a protein-DNA complex called the segrosome, which is required for the movement of DNA in dividing cells to achieve faithful inheritance of genetic information - a process that is fundamental to all living things". Their work has shed light on how plasmids are passed from one cell to another, and Dr Jensen believes that understanding this has important implications for finding new tools to fight superbugs like MRSA. "Our research may provide opportunities for the development of targeted interventions to disrupt plasmid carriage and reduce the incidence and spread of antimicrobial resistance within healthcare facilities," said Dr Jensen. While it looks as if the arms race with MRSA will continue for a long time to come, perhaps it won't be much longer before we once again have the upper hand.



Segregation protein bound to DNA

From algae to parasites: new 'missing link' species found in Sydney Harbour

By Katynna Gill

It's not often that brown algae is considered exciting or revolutionary, but Associate Professor Dee Carter from the School of Molecular and Microbial Biosciences at the University of Sydney and her former PhD student, Robert Moore, have found a new species of single-celled brown algae that is an evolutionary missing link.

The new marine species, named *Chromera velia*, was found living in Sydney Harbour and turns out to be the closest living photosynthesising relative to a group of parasites called Apicomplexa. The Apicomplexa are a significant group of parasites, as they cause malaria and other diseases that kill and disable millions of people every year.

What makes this new species special, is that it is the missing link between photosynthesising algae, which use the sun's energy to make food, and the parasitic Apicomplexa, which use the cells of their host organism to obtain food. *Chromera velia* has a unique genetic feature in the *psbA* gene, which has been found only in the largest group of Apicomplexa, indicating how closely related the algae species is to the parasites.

"*Chromera velia* does photosynthesise, but it has lost one of its photosynthetic pigments – the chemicals which allow the sun's energy to be trapped and transformed into sugar in the algae. Many Apicomplexa, such as the species which causes malaria, have an organelle in their cells that is really similar to the chloroplasts in photosynthesising species, such as algae and plants," explained Dee.

Chloroplasts are where photosynthesis goes on in algae and plants, while parasitic Apicomplexa have an unpigmented chloroplast-like organelle called the apicoplast.

"Malaria treatments often target the apicoplast in the invading Apicomplexan cells, so not only is our new species important from an evolutionary perspective, it can also potentially be a surrogate host for developing anti-parasitic drugs," said Dee.

"For researchers working on treatments for diseases caused by Apicomplexa, the parasites are difficult to work on as they need

to be grown in living host cells, whereas *Chromera velia* can be grown simply in the lab. *Chromera velia* is closely related to the parasites, so it could be a good model to work on in developing treatments."

Finding an evolutionary missing link is a rare and exciting discovery. This newly described species indicates how photosynthesising algae evolved into the fully parasitic Apicomplexa, with their left-over chloroplast remnant indicating their evolutionary past as algae.

"*Chromera velia* can tell us something about how these parasites, which were in fact once algae themselves, evolved.

The Apicomplexans are now the only group of organisms that we can say with certainty transitioned from photosynthesising algae to parasites."

"It will be very interesting to see where *Chromera velia* fits on the spectrum from symbiont to parasite, since it was found living in corals and is photosynthetic, but has lost one of the normal photosynthetic pigments. It might be at the evolutionary stage of losing photosynthesis on its way to becoming parasitic," said Dee.

Dee's former PhD student, Robert, found the new species while researching algae that inhabit corals and allow them to grow. Their research focuses on understanding the lifecycle and biodiversity of algae living in corals, as they are very important for reef conservation.

"Robert had a few samples from Sydney Harbour and thought he would keep other algae that he came across apart from the ones we were studying. One of these turned out to be *Chromera velia*! It was thanks to Robert's scientific curiosity and his perseverance growing the algal culture that this discovery was made," said Dee.

The discovery of *Chromera velia* was published in the journal Nature in February 2008.

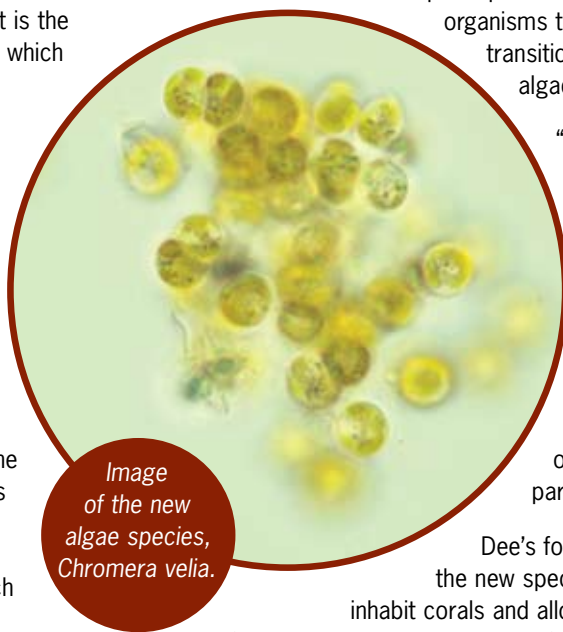


Image of the new algae species, *Chromera velia*.

Rosemary Hafner, 1953 - 2008

Rosemary Hafner was an inspiration to many. Not only was she a pioneer in science education and an active science enthusiast, but to many a close friend. She had a long distinguished history in science education through her work with the Board of Studies and the Australian Science Teachers Association.

Rosemary was also a judge for the University's Sleek Geek Science Eureka Schools Prize and approached the competition with a great enthusiasm for the communication of scientific ideas and a keen interest in the students' interpretations. Rosemary will be greatly missed.

SMALLmatters – Exploring the World of Microscopy

By Jude Philp

Celebrating the Golden Jubilee of the University of Sydney's Electron Microscope Unit

This year, the Electron Microscope Unit (EMU) is teaming up with the Macleay Museum to celebrate 50 years of making advanced microscopy techniques available at the University of Sydney.

In 1958, the University established the EMU underneath the Bank Building on Science Road, installed a Siemens Elmiskop 1 as its first electron microscope and appointed Dr D Gordon Drummond as the first Electron Microscopist. Over the next 50 years, of course, things changed dramatically. Today, with more than 40 staff, the EMU incorporates the **Australian Key Centre for Microscopy and Microanalysis**, is headquarters of the **Australian Microscopy and Microanalysis Research Facility** and is a node of the **ARC Centre of Excellence for Design in Light Metals**. No longer dealing solely with electron microscopy, the comprehensive capabilities of the Unit include microscopes and other instruments that make use of electrons, ions, light and lasers, x-rays and scanned probes to understand the structure and composition of materials around us and even inside us.



Image by Anne Simpson

Scanning electron micrograph of the reproductive palp of a male huntsman spider.

To celebrate this remarkable facility and the enormous research output that it enables, Macleay Museum curators Jan Brazier and Jude Philp have been working with Uli Eichhorn and Peter Hines of the EMU to put together the *SMALLmatters* exhibition. *SMALLmatters* will probe into the world of modern microscopy, highlighting the research and the technology of the Unit through stunning images and some inspiring hands-on activities for kids.

Keep an eye on Sydney University Museums' website (www.usyd.edu.au/museums) for further information about the exhibition and associated talks, lectures, fun days and behind-the-scenes tours.

For those interested in the somewhat older history of light microscopy, there will also be a smaller exhibition featuring some of the Macleay's historic collection, including a facsimile of Anton von Leeuwenhoek's famous simple microscope of the 1660s and a carousel device used in the University in the 1880s to allow students to see a number of microscope slides without touching a single item.

To find out more about the EMU in the meantime, their training, services, and research programs and the upcoming Jubilee Conference go to www.emu.usyd.edu.au

SMALLmatters exhibition: 1 August 2008 – 20 January 2009

EMU Jubilee conference dates: 3–5 December 2008 (details to be announced shortly)

Multimedia resources for school teachers

By Jacqueline Hayes

The Physics Education Research group at the University of Sydney has spent 18 months putting together a DVD and website covering key topics in the year 11 and 12 physics syllabus. The DVDs containing educational and entertaining films will be arriving at schools along with the next issue of COSMOS magazine.

Teachers, science communicators, physics academics, university students, and online learning specialists from the University of Sydney and high schools around New South Wales created over 50 multimedia resources. Under the title AMPS – Australian Multimedia for Physics Students – they tackled some of the problematic topic areas in year 11 and year 12 physics.

The videos are short and snappy – designed to be watched in sequence. After years studying design principles in multimedia, the Sydney University Physics Education Research group got it

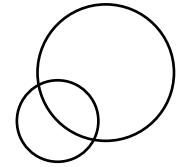
right. These videos are designed to increase student retention compared to more traditional video styles.

From power stations to university laboratories, from Dr Karl to the top professors in Australia, the team behind AMPS is excited to be bringing this science into classrooms across New South Wales. Common student misconceptions are addressed, and lesson plans are provided to make them easy to use.

On the website, teachers will find the films in the resources section. Lesson plans group the resources together along with suggestions to work through the ideas. The DVD and website were created with funding under the Australian School Innovation in Science, Technology, and Mathematics (ASISTM) initiative.

Visit the AMPS website: www.hscphysics.edu.au

Dr Karl Kruszelnicki's Great Moments in Science



X-Chromosome

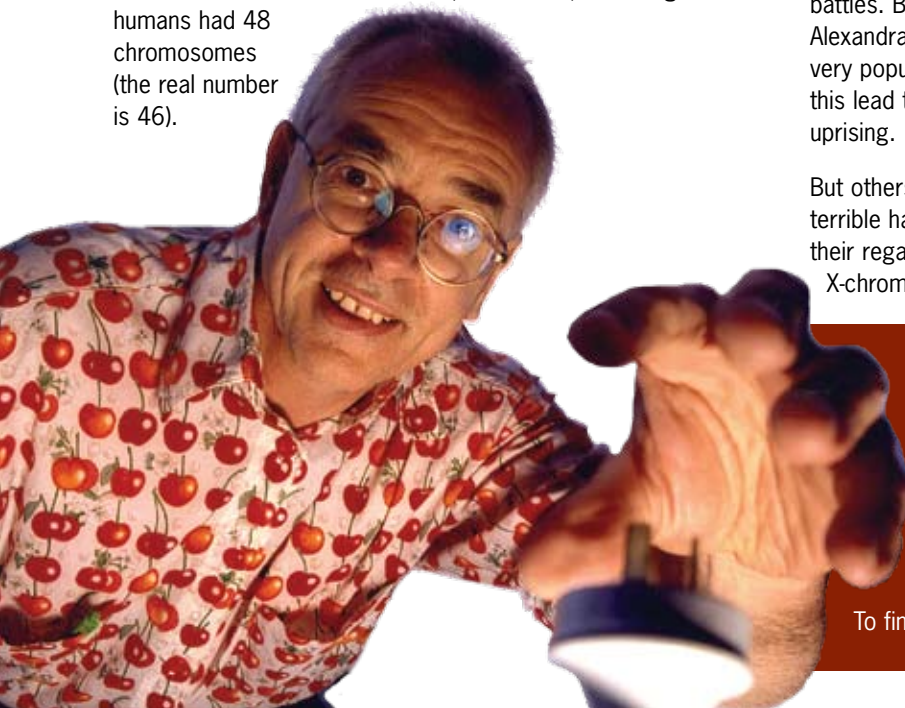
Back in the Old Days before research into cloning and stem cells, most people didn't know much about genetics and DNA. But they had a vague impression that there was something called the "X-chromosome" and it was called that because it looked like the letter X. Well, that's not the case, but just as an aside, the X-chromosome did help give the world Communism.

Every cell in your body (except for the red blood cells) carries DNA. The human DNA is a very skinny, and very long, molecule. The DNA in each molecule is a few billionths of a metre across, but if you stretch it all out, a few metres long. Our DNA is, among other things, an architect's plan that will make, and then maintain, a human being. Most of the time, the DNA exists in the form of a myriad of long slender filaments. This gives them a huge surface area, which makes it easy for the "machinery" in the cell to "read" the DNA to make proteins. These proteins could be insulin from your pancreas, enzymes from the cells in your gut to dissolve your food, or muscle in your muscle cells to move your arms, legs and eye-lids.

But whenever a cell is about to split into two more cells, the DNA will condense, for a brief time, into little clumps. A skinny strand of DNA gets wound into a coil, and that coil gets wound again, and so on. These clumps that appear when a cell divides are the famous chromosomes. They have a central point, and four arms – so they may seem to look a little bit like the letter X.

By the way, the number of chromosomes varies with the species – just 8 in the fruit fly, 46 in humans and hares, 48 in gorillas and chimpanzees, 104 in goldfish, and a massive 380 in butterflies.

Chromosomes were first seen in cells by the Swiss botanist, Karl Wilhelm von Nageli back in 1842. Chromosomes are really hard to see, but if you soak the cells with the right dyes you can then see these coloured bodies – hence the name, "chromo" meaning "colour" and "some" meaning "body". It took a long time to learn about our chromosomes – in fact, until 1955, we thought that humans had 48 chromosomes (the real number is 46).



They were all a big mystery until very recently, and the most mysterious of them all was the 45th chromosome. Part of this mystery was that it was somehow involved in diseases that were carried by females, but that didn't affect females – and yet, affected males. Very strange. These diseases included haemophilia, red-green colour blindness and Fragile X Syndrome (linked to mental retardation). For a long time, it was a big mystery just how this happened. In algebra, the symbol "X" stands for the unknown quantity, as in the X-Factor – and that is how the X-chromosome was given its name. If it was named after its shape, then all the chromosomes would be called "X".

And the Y chromosome? Well, it was pretty mysterious too, and "Y" is the next letter in the alphabet after "X", which is how the Y-chromosome got its name.

So what's the Communism link?

Well, it seems that Queen Victoria had a spontaneous mutation in her X-chromosome that could cause the bleeding disease, haemophilia. One of her children, Alice, carried this mutation in her X-chromosome, and passed it to her daughter, Alexandra. In turn, Alexandra married Nicholas Romanov, who became Czar Nicholas II of Russia. Her fifth child, and first son, was Alexis – and he suffered from debilitating haemophilia from an early age, not very favourable for the future Czar.

Now Nicholas II did have his fair share of worries. He had not been properly trained to be the Czar of Russia. For example, when approached by a respectful delegation of peasants and workers who asked for some reasonable constitutional reforms to improve their wretched lives, he made long-lasting enemies by angrily rejecting them. When in 1914, in Sarajevo, the Austrian Archduke Franz Ferdinand was assassinated, Austria declared war on Serbia. Czar Nicholas II, as an ally of Serbia, mobilized his army against Austria, thus bringing Germany, Austria's ally, into war against him. Not only did his army lose many battles, he then personally became its commander and lost even more battles. Being away from his palace in Moscow, he left his wife Alexandra in charge – but she had been born a German, not a very popular nationality in Russia at the time of World War I. All this led to enormous unrest, and ultimately, to the Bolshevik uprising.

But others say that he and his wife were so pre-occupied by the terrible haemophilia of their only son, Alexis, that they failed in their regal duty to properly govern Russia – and that's how the X-chromosome gave the world Communism...

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11 June 2008 & 3 November 2008

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Dr Karl's Sydney Science Forum lecture 'Please Explain'

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To find out more visit www.science.usyd.edu.au/school/forum

Spotlight on: Geosciences

Associate Professor Dietmar Müller,
School of Geosciences

Reconstructing vanished oceans

Scientists from the University of Sydney and the Centre for Geodynamics in Norway have made the first comprehensive model of the Earth's sea level rising and falling over the last 140 million years, resolving a long-standing controversy over sea level fluctuations through geological history.

The group, led by Associate Professor Dietmar Müller from the School of Geosciences at the University of Sydney, has reconstructed the volumes of ancient ocean basins from the Cretaceous period until the present, in an article published in the journal *Science* on Friday.

"A global sea level rise of a metre, driven by slowly melting ice sheets, would have disastrous effects on at least 60 million people in coastal areas worldwide. But even larger sea level fluctuations have occurred in the ancient past, in 'hothouse' climates, when neither humans nor inland ice caps existed," explains Associate Professor Müller.

"Our goal was to understand these changes, as sea level fluctuations have been a driving force in the evolution of animals and plants, in climate change and biogeography," says Associate Professor Müller.

"By creating a detailed set of digital maps of ancient ocean basins we were able to show that cycles of mid-ocean ridge creation, evolution and destruction have profoundly effected shifting coastlines and inland seas through time."

The model is the first to comprehensively map the planet's oceans from the Cretaceous period, when Gondwana – the supercontinent that later broke up into Australia, Antarctica, South America and Africa – was intact. The Indian and Atlantic oceans were formed in this period.

"To give an idea of the time scale that our ocean basin model covers, it starts at the time when dinosaurs were at their most diverse, mammals were small and a minor component of animal life on Earth, and flowering plants were just spreading over the Earth," says Associate Professor Müller.

"If we project our model 80 million years into the future, we can predict that the sea level will continue falling by about 120 metres in the long run, through mid-ocean ridge destruction and the continuing ageing and deepening of the ocean basins," says Associate Professor Müller.

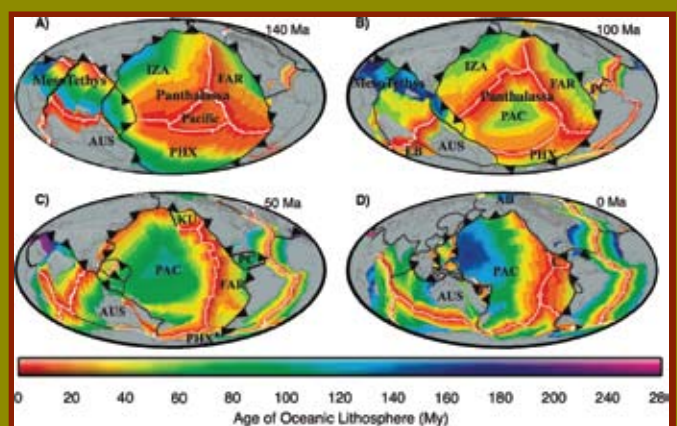
For the majority of Earth's recorded geological history, there were no inland ice sheets and it is quite likely that 80 million years into the future the world will be ice free again. The future looks likely to have a hothouse climate like in the Cretaceous 80 million years ago, when polar mean temperatures were over 14 degrees higher than today, compared to our currently frozen poles.

"Even if all present ice caps melt, causing a sea level rise of about 50 metres, the net result 80 million years from now would still be a 70 metre sea level fall, due to the unstoppable increase in ocean basin depths. It is a powerful reminder that, unlike greenhouse gas emissions, we can't control the planet's geodynamics," concludes Associate Professor Müller.

To see the animated model go to: www.science.usyd.edu.au



Sydney scientists Dr Maria Sdrolias and Associate Professor Dietmar Müller, with Dr Carmen Gaina from the Centre for Geodynamics, Norway



Snapshots from the first comprehensive model of the Earth's ocean floor through time starting from 140 million years ago, and showing the ocean floor at 100 million years ago, 50 million years ago and today.

