pheno

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ALLAN WILSON CENTRE

INSIDE THIS ISSUE

New Director takes the helm

In late 2009, Charles Daugherty became the Director of the Allan Wilson Centre. Charles is Professor of Ecology and Assistant Vice-Chancellor (Research) at Victoria University of Wellington, where he has worked since 1982. Charles has published over 140 papers in genetics, ecology, evolution, and conservation biology. His work has contributed to the conservation management of high profile native species, such as kiwi, parakeets, and reptiles. He was made an Officer of the New Zealand Order of Merit (ONZM) in 2005 for his work in conservation of tuatara. Here Charles describes his aspirations for the Allan Wilson Centre.

The English biologist Richard Dawkins recently described evolution as *The Greatest Show on Earth*. Researchers in the Allan Wilson Centre bring state-of-the-art mathematical and genomic tools to bear on understanding how the greatest show on earth has played out in our part of the world, creating the flora and fauna of modern New Zealand and the Pacific. Elsewhere in this newsletter you will read about some of the exceptional achievements of our researchers in 2009, and I am confident that 2010 will continue to see exciting discoveries arise from their work.

As Director, my challenge is to ensure that we take this new knowledge one step further – to use it for the benefit of New Zealand's people and our future. In 2010 the Allan Wilson Centre will focus ever more strongly on informing the people of New Zealand and the Pacific about the biological history of our region – how is our land different, unique, and so special? How did the history of human migration and settlement affect the plants and animals of our land? How can we ensure that the biological resources of our land are best developed? And how can we contribute to present management of these resources to ensure that our biological wealth prospers and is available to benefit future generations?

We will achieve this by sustaining the flow of new knowledge to all New Zealanders. This means especially that we connect to schools and teachers at all levels so that the next generation of New Zealanders understands our special land better. It means that we connect with Maori and Pacific peoples, with conservation managers, and with medical researchers, because increased knowledge of our flora, fauna, and microbes can lead to better understanding of ourselves and ways we can help create a better future for our country. And as always, we will focus on our post-graduate and post-doctoral students, who are the emerging generation of researchers and our future leaders.

New Fellow of the Royal Society of New Zealand

Allan Wilson Centre Investigator, Professor Hamish Spencer, has been elected as a Fellow of the Royal Society of New Zealand. Spencer is a world renowned theoretical population geneticist best known for his work on genomic imprinting.

Spencer works on the evolutionary and population-level consequences of genomic imprinting – an unusual form of gene expression in mammals and other groups whereby paternally and maternally inherited alleles are expressed differently (often one copy is completely silenced). The evolutionary consequences of phenotypic plasticity are also a research area.

Election as a New Zealand Fellow is an honour given to top scientists for showing distinction in pure or applied research or in the advancement of science and technology.

Professor Spencer can be contacted on hamish.spencer@otago.ac.nz

Young scientist wins major award

Newly appointed Centre Principal Investigator Dr Thomas Buckley has been awarded the New Zealand Association of Scientists Research Medal. This medal is given to a scientist under the age of 40 for outstanding fundamental or applied research.

Buckley's research focuses on systematics, biogeography, speciation, molecular evolution and phylogenetic methods. His study organisms include stick insects, cicadas, fungus-feeding beetles, tortricid moths, earthworms, wetas, onychophorans and terrestrial molluscs.

He is particularly interested in the biogeographic origins of the New Zealand biota and evolutionary processes within New Zealand. His interests in systematics also include taxonomy where he is revising the New Zealand stick insect fauna using morphology and genetics.

Newly developed research directions include transcriptomics and functional genomics of adaptations to environmental stress in stick insects.

Dr Buckley can be contacted on buckleyT@landcareresearch.co.nz

ALLAN WILSON CENTRE

NEWS


David Bryant


Thomas Buckley


Alexei Drummond


Nigel French


Nicola Nelson


Charles Semple


Jon Waters

Centre research programme strengthened – seven new Principal Investigators appointed

As part of the ongoing process of development of the Allan Wilson Centre investigator pool, the Director of the Allan Wilson Centre recently announced that seven Centre Associate Investigators had been invited, and had accepted, principal Investigator roles in the Centre.

The new Principal Investigators are Associate Professor David Bryant, Dr Thomas Buckley, Associate Professor Alexei Drummond, Professor Nigel French, Dr Nicola Nelson, Associate Professor Charles Semple and Associate Professor Jon Waters.

Bryant is based at the University of Auckland and his research focuses on the mathematical, statistical, and computational aspects of evolutionary biology. Much of his work has been concerned with phylogenetics and the reconstruction of evolutionary history. More recently he has started investigating areas of cross-over between phylogenetics, population genetics and geography.

Buckley, a scientist at Landcare Research, is particularly interested in the biogeographic origins of the New Zealand biota and evolutionary processes within New Zealand. He is involved in a range of conservation genetics projects on highly threatened invertebrates including terrestrial molluscs, tusked and giant weta.

Drummond is at the University of Auckland. His research program is centered around statistical models and algorithms for population genetics and molecular evolution. He is also specifically interested in virus evolutionary dynamics and developing new models for studying phylogeography.

French, based at Massey University in Palmerston North, trained as a veterinarian and epidemiologist and currently specializes in research and training in molecular epidemiology, food safety and the control of infectious diseases. French is actively involved in the development of surveillance tools for infectious diseases of both humans and animals.

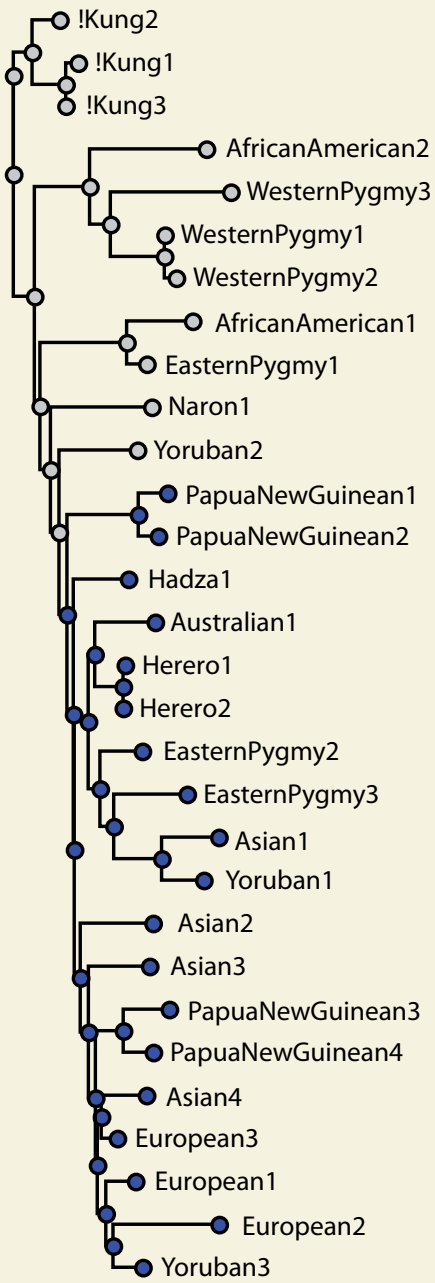
Nelson undertakes her research at Victoria University of Wellington where her current research projects look at how reptiles with temperature-dependent sex determination cope with global warming, the conservation techniques for reptiles and also how mate choice, mating systems and disease affect the fitness of reptiles.

Semple, of the University of Canterbury, has research interests in combinatorics, algorithmics, and computational biology, particularly phylogenetics and matroid theory.

At the University of Otago Jon Waters uses genetic tools to answer fundamental questions in evolutionary biology. He pioneered the use of river capture as a means of calibrating molecular clocks. He recently initiated a novel direction in marine phylogeography using DNA techniques to test the evolutionary and ecological importance of kelp-rafting in the marine environment .

All the new Principal Investigators bring strong research credentials and a history of supporting the wider aspects of Allan Wilson Centre work.

RESEARCH



Show Me! What's the evidence for an African origin for humans?

Dr Howard Ross, Associate Investigator in the Centre at the University of Auckland asks... Have you ever wondered how scientists find the answers to big questions, like where did humans come from? In the 1980s, Allan Wilson and several colleagues wanted to determine whether modern humans are descended from archaic humans who were dispersed widely across Europe, Asia and Africa or from just the archaic humans living in Africa. They concluded that we all share a common ancestor in an individual woman living in Africa about 200,000 years ago. This "African Eve" conclusion changed our understanding of ourselves and our history.

But, how did Wilson and colleagues reach this conclusion? Wouldn't you like to sit alongside these scientists as they performed their analyses and pondered the problem? Now you can. Ross have developed a web site called *Recreate the Research* (www.allanwilsoncentre.ac.nz/teachingResources/RTR/) that lets you see some of Wilson's data, and perform some of the same analyses as he did. Then you have an opportunity to assess the results and reach a conclusion.

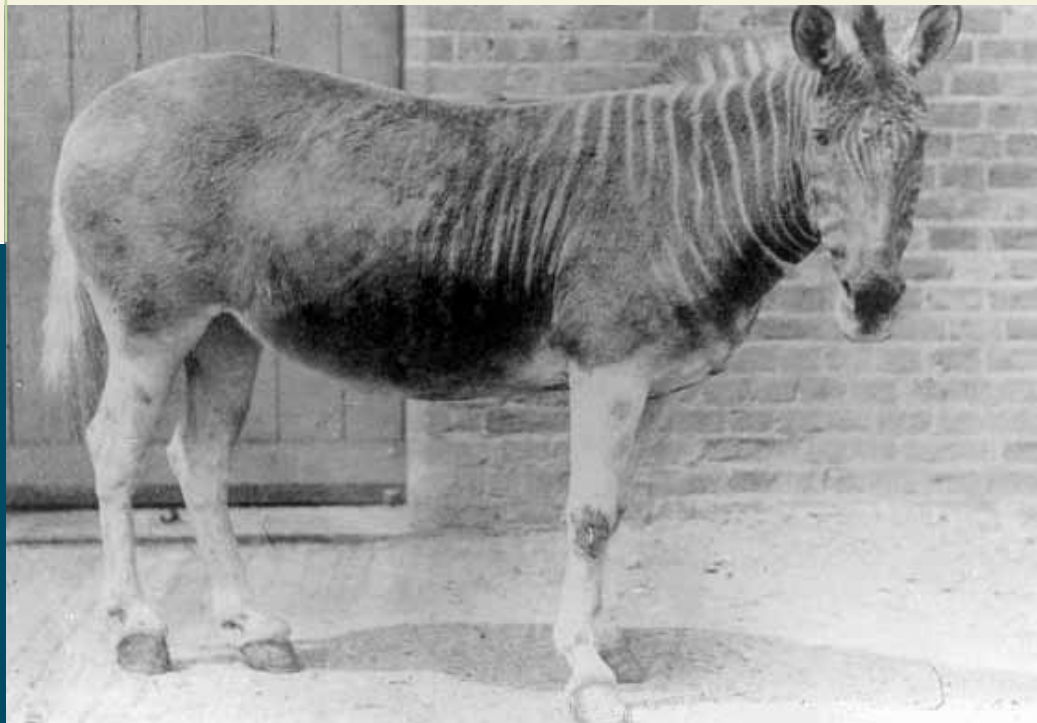
Recreate the Research guides you through Wilson's famous studies on the time and location of human origins. It follows the structure of a real science research project:

- What are the major hypotheses? What predictions are made by each hypothesis? How will we be able to decide which hypothesis is supported by the results?
- What samples are required? How do we obtain data from the samples? How do we analyse the data?
- What results are obtained from the analyses? Do the results support one or the other set of predictions? What can we conclude about which hypothesis is supported?

To answer the research questions, you will estimate and interpret phylogenetic trees and estimate the age of the common ancestor of modern humans. To perform the analyses, you will use some of the actual data from Wilson's studies and free versions of software tools, such as Geneious and FigTree, used today by scientists studying these topics.

Recreate the Research also contains a smaller case study that introduces you to Wilson's attempt to determine the identity of the quagga, an extinct mammal from South Africa resembling both zebras and horses. This was the first study to use ancient DNA, extracted from a preserved museum specimen.

This site gives non-scientists a chance to participate in real science and gain an understanding of how science is performed. Dr Ross can be contacted on h.ross@auckland.ac.nz



NEWS

Student talk gathers top prize

Beata Faller, a PhD student with Professor Mike Steel and Associate Professor Charles Semple at the University of Canterbury, has won the best student talk award at the Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (ACCMCC) held in Newcastle, Australia, 7-11 December, 2009. The talk was titled "Maximum-weight k-cardinality arborescence in vertex-weighted digraphs, with an application in conservation biology"

Genetic steps to adaptation

A research team, led by Professor Paul Rainey a Principal Investigator in the Allan Wilson Centre from Massey University,has observed the de novo evolution of bet hedging - a strategy that allows organisms to persist in the face of rapid and unpredictable environmental change - in experimental bacterial populations.

"We showed how evolution happens in real time," said Hubertus Beaumont, a former Marsden-funded post doc and now at Leiden University in the Netherlands.

Studies have shown bacteria and other organisms can switch back and forth between phenotypes to better survive in new environments. For instance, many bacteria switch their surface antigens when invading a host, so they can avoid being attacked, and certain desert plants are programmed to germinate seeds at random time intervals, increasing their chances of encountering rain. Beaumont said "This bet-hedging strategy is very simple, but captures the essence of evolution. Natural selection in these uncertain environments causes an organism to evolve protective traits." Exactly how such phenotypic adaptability emerges, however, was unknown.

In order to observe how bet-hedging evolves, the rerearch team observed *Pseudomonas fluorescens*, a common rod-shaped bacterium, in a new type of environment. They already knew that the bacteria grow well in a test tube that's shaken manually or in an incubator that allows oxygen to circulate in the culture. So instead of shaking the test tube, a condition to which the bacteria are well-adapted, the researchers watched the bacteria grow in non-shaken test tubes.

As expected, some of the bacteria adapted to the novel environment, forming colonies with an advantageous "wrinkly" morphology as opposed to the ancestral bacteria, which grew smoothly. The team identified these new colony types in the test tube and transferred them to fresh tubes, repeating this process 15 times to select for the new variations. Eventually, the bacteria evolved the ability to rapidly switch their phenotypes between the "wrinkly" and "smooth" cell-types to prepare themselves to cope with the different environments.

The phenotypic evolving occured rapidly, in the course of a just a few rounds of selection. As far as is known, this has not been observed before.

Jenna Gallie, another member of the group, then sequenced the evolved bacterial genome and found all the mutations that had arisen and that might have contributed to this new trait. The team identified nine mutations distinguishing bet-hedgers from their ancestors. They pinpointed one specific mutation as the one that allows the phenotype to switch back and forth between different morphologies, while the other mutations, they found, were essential for growing the new type of bacteria.

Richard Lenski, a microbial ecologist at Michigan State University who didn't participate in the research, says "This is a neat demonstration that the evolution of bet-hedging was contingent on other mutations that had occurred earlier in the lineage." These earlier changes improved the fitness of the bacteria at each stage. The results suggest that phenotypic switching is a strategy that can readily evolve and may help explain the earliest evolutionary solutions to life in fluctuating environments.

This research was the cover story in a recent issue of *Nature*, Beaumont et al. (2009) Experimental evolution of bet hedging. Nature 462: 90-93.

To learn more about this work please contact Paul on p.b.rainey@massey.ac.nz. or visit the Rainey Lab website: http://evolution.massey.ac.nz/rainey

Don't put all your eggs in one basket:

the theory of bet hedging explained

The theory of bet hedging was first mathematically developed by Daniel Bernoulli in 1738. The basic idea is simple - uncertain future conditions make conservative strategies beneficial. The phrase "Don't put all your eggs in one basket" is one example of a widespread but anachronistic reminder to spread risk.

Like investing in the stock market, evolution is a multiplicative process, not an additive one. Steve Stearns[1] illustrates this well....

"If a genotype has reproductive success that is twice the [population's] average in this generation and three times the average in the next, then its fitness [measured, as usual, relative to the population average] over those two generations is six times (2 × 3), not five times (2 + 3). If each of two children has three grandchildren, then there are six, not five, grandchildren."

This means...

that the correct way to measure average returns is the geometric mean, not the arithmetic mean. The geometric mean is fairly easy to find: just multiply a genotype's fitness in generations 1 through n, and then take the nth root of that number. For example, the geometric mean of 3, 2, and 4 is the cube root of 24 (3x2x4), or about 2.88. Key properties of the geometric mean are:

1) It is always lower than the arithmetic mean. For example, the arithmetic mean of 3, 2, and 4 is 3, which is greater than 2.88. The amount that it is lower depends on how variable fitness is during the period in which it is measured. The more variable fitness is, the lower the geometric mean is relative to the arithmetic mean.

2) Genotypes with the highest geometric mean fitness will dominate the population over the long-term. Natural selection thus optimizes the geometric mean, not the arithmetic mean.

So, what does this all have to do with bet hedging? Qualitatively, bet hedging is defined as a trait that spreads risk, trading-off some potential short-term benefit for a long-term benefit. "Trading off" implies that a bet hedging trait is one that reduces arithmetic mean fitness but increases geometric mean fitness. To illustrate with an example: assume that for an annual plant, March 23rd is the single best day for its seeds to germinate. However, there is a small risk that there will be a severe frost that kills 95% of the seedlings that germinated that day. This event is rare enough to have little effect on the arithmetic mean, but it has a big effect on the geometric mean. A plant genotype that produces seeds which all germinate on March 23rd will have the highest fitness in the population until the year that early frost hits, but then that lineage will decrease drastically. If a plant were to leave seeds that germinate from March 15-30th, it is giving up some potential arithmetic mean fitness because many of its seeds are germinating at suboptimal dates, but by spreading risk it reduces variation in fitness and increases geometric mean fitness. This would be bet hedging.

Thus we arrive at the central problem with empirical bet hedging research: how do we know if a putative bet hedging trait evolved for the purposes of bet hedging? Simply observing that a trait is unexpectedly variable provides no evidence for bet hedging. One needs to show that the trait decreases arithmetic mean fitness, but increases geometric mean fitness.

As stated by Andrew Simons[2] "It is because of difficulties in characterizing the fitness effects of environmental variance over appropriate time scales that so little empirical work on bet hedging exists." A more subtle variation on the above question has to do with evolutionary dynamics: might a trait evolve for reasons other than bet hedging, then be maintained as a bet hedging strategy when conditions change? If only we had the complete history of an organism's evolution of bet hedging! Then we could actually answer the questions above...

Acknowledgements to Will Ratcliff for his blog at http://blog.lib.umn.edu/denis036/thisweekinevolution/2009/11/experimental_evolution_of_bet.html.

1 Stearns S. 2000. Daniel Bernoulli (1738): evolution and economics under risk. Journal of Biosciences 25:221-228...

2 http://blog.lib.umn.edu/denis036/thisweekinevolution/2009/04/optimal_bethedging.html

ALLAN WILSON CENTRE

RESEARCH

Taking the plunge:

New Zealand's diving skinks

Kim Miller, a recently graduated Allan Wilson Centre PhD, describes her work. This research was undertaken in collaboration with the Department of Conservation.

An animal's ability to escape predators influences its survival and fitness. Yet it is difficult to determine the importance of any one escape tactic without understanding how alternate strategies relate. Reptiles are remarkably adept escape artists, generally sprinting to cover before we see them.

New Zealand has more than 80 species of native lizards, yet a rustle in the grass or a tail-less present from the cat is the only contact most of us have with them. It's no surprise, then, that only a lucky few have even heard of the amazing diving abilities of some of these elusive creatures. At least three species of New Zealand's shore-dwelling skinks readily dive into seawater: the Fiordland skink, the shore skink and the egg-laying skink.

Skinks are generally well-adapted to diving, and over 25 species world-wide dive to evade predation. When diving to escape a predator, reptiles undergo elaborate physiological responses (bradycardia and cardiac shunts). Although not unique to reptiles, they are designed to slow the heart rate, reduce oxygen consumption, and maximise use of available oxygen. In essence, oxygen-poor blood from the right atrium, which is normally sent to the lungs, is recycled back to the muscles through arteries and capillaries. This "right-to-left cardiac shunt" allows leftover oxygen to be reused by the body instead of being exhaled.

To escape danger, egg-laying skinks (*Oligosoma suteri*) run to cover or dive into the nearest rock pool, staying submerged, and keeping their eyes open to follow movements above the surface. Knowing this, Kim Miller measured both sprint speed and dive duration of egg-laying skinks to determine the relationship between the two escape tactics. Animals vary a great deal in their diving ability, but average about 6-7 minutes per dive. A gravid female holds the record for maximum dive time: 20 minutes and 30 seconds!

In fact, gravid females dive longer than males and non-gravid females. These same gravid females are slower sprinters, which is unsurprising given the physical and physiological burdens of gravidity. However, gravid females may prefer diving to running when trying to escape a predator. If they change their behaviour, it will be difficult to interpret how natural selection acts on these performance traits during gravidity.

The egg-laying skink is currently classified as range restricted; it is difficult to find on the mainland, but are functioning parts of the coastal ecosystem on offshore islands. They provide valuable ecosystem services by consuming carrion and invertebrates, and are a rich food source for several species of birds ... that is, if they don't plunge into a rock pool first.

You may see lizards on the beach, but never try to make them dive. Many lizards seen on beaches around New Zealand, including common geckos, copper skinks, common skinks, and brown skinks, are not adapted to seawater. All reptiles in New Zealand are fully protected, so it is illegal to capture or harm them. Sit back and wait. You might just be lucky enough to see one take the plunge.

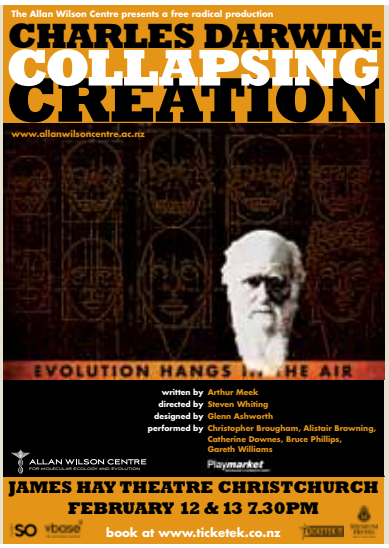
To learn more contact Kim.Miller@sci.monash.edu.au

Awards for *Collapsing Creation*

The Allan Wilson Centre is proud to be associated with ***Collapsing Creation*** a play that has won three awards. "Collapsing Creation" was commissioned by the Allan Wilson Centre and had its inaugural performance on 12 February 2009 at the BioEd 2009 Conference hosted by the Centre.

The play, about the struggles and genius of Charles Darwin, scooped a Wellington playwright an awards trifecta. Collapsing Creation, written by Arthur Meek, picked up the Peter Harcourt award for outstanding new playwright of the year at the Chapman Tripp Theatre Awards in Wellington. It also won outstanding New Zealand play of the year, and the Chapman Tripp award for best production.

When Collapsing Creation played at Downstage in Wellington last month, Dominion Post reviewer Laurie Atkinson called it "a tour de force, which, of course, could not occur without Meek's brilliant script".



Prestigious James Cook awards

James Cook Research Fellowships, administered on behalf of Government by the Royal Society of New Zealand, are awarded to researchers who are able to demonstrate that they have achieved national and international recognition in their area of scientific research. The Fellowships allow them to concentrate on their chosen research for two years free from administrative and teaching duties.

The Allan Wilson Centre is pleased to announce that James Cook Fellowships for 2010/11 have been awarded to Professor Pete Lockhart and Professor Mike Steel, both Principal Investigators in the Centre.

Steel said the fellowship would allow him time to research a fundamental question: "how far back in time we can hope to accurately trace evolutionary signal from genetic data?"

"The project is motivated by the inability of current methods to resolve some controversial ancient evolutionary events. These include the origin of metazoa, the origin of photosynthesis, and the relationship between the earliest life forms."

This project will involve joint work with other AWC investigators (particularly Pete Lockhart) and attempt to develop models for genome evolution more suited to next-generation sequencing technology.

A related project will attempt to predict how much genetic data would be needed to build a large and accurate "tree of life".

"Part of this project will require answering some purely theoretical questions about the performance of maximum likelihood estimation in statistics, in joint work with probability theorists in Israel and USA."

Lockhart has been awarded his James Cook Research Fellowship to undertake research on the evolutionary ecology of New Zealand alpine plants. His studies will make use of high throughput DNA sequencing technology at Massey University to study gene expression and plant physiologies in closely related species found in different alpine environments.

With Associate Professor Mark Large, UNITEC, Lockhart is also co-writing a popular book for Craig Potton Press *If Plants Could Speak* to celebrate 100 years since Leonard Cockayne's book *New Zealand Plants and Their Story*.

Professors Steel and Lockhart can be contacted by email:
m.steel@math.canterbury.ac.nz
p.j.lockhart@massey.ac.nz

Marsden Successes

The Marsden Fund supports research excellence in science, technology, engineering and maths, social sciences and the humanities. In October 2009 the Marsden Fund Council announced its largest investment ever of $66 million. The money will support 111 world-class research projects from New Zealand's universities and Crown Research Institutes.

Researchers associated with the Allan Wilson Centre have been awarded just under $4 million to undertake projects over a range of topics; from how insects smell to Polynesian settlement in South America.

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ALLAN WILSON CENTRE

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Visit the Allan Wilson Centre at
www.allanwilsoncentre.ac.nz

ScienceOlympiaNZ
fostering academic excellence in science

Launch of Science OlympiaNZ

The Allan Wilson Centre is proud to be associated with Science OlympiaNZ, through its involvement with the New Zealand International Biology Olympiad.

Science OlympiaNZ is an umbrella organization that aims to foster academic excellence in science by bringing together the New Zealand Olympiad in Informatics, New Zealand Maths Olympiad Committee, New Zealand International Biology Olympiad, New Zealand Geography Olympiad, New Zealand Chemistry Olympiad Trust, International Young Physicists' Tournament NZ and Future Problem Solving New Zealand.

All of the programmes provide the gifted and talented students of New Zealand with student-centered learning. Here, teachers and students can discover the opportunities provided by science-related international competitions.

Science OlympiaNZ was launched on November 10 2009 at the Grand Hall in Parliament by its patron, Professor Sir Paul Callaghan, and the Honorable Heather Roy, Associate Minister for Education, Defence, and Minister of Consumer Affairs.

http://www.scienceolympianz.org.nz/

the ROYAL SOCIETY of NEW ZEALAND TE APĀRANGI

Royal Society of New Zealand Teacher Fellowships

Over the past six years the Allan Wilson Centre has hosted many teachers who have been awarded Royal Society of New Zealand Teacher Fellowships.

This Scheme, funded by the Government and administered by the Royal Society of New Zealand, offers primary, intermediate and secondary teachers the opportunity to improve their teaching through experience in technological, scientific or social sciences practice.

The scheme is open to fully qualified practicing primary, intermediate and secondary teachers whose work can be related to science, mathematics, social sciences and technology. Only New Zealand citizens or permanent New Zealand residents are eligible to receive a Fellowship.

If a year in a research environment appeals to you, and you would like to be hosted by the Allan Wilson Centre at any one of our host or partner institutions, please contact us and we will arrange to meet with you to discuss a possible project. Following discussions we will assist you to complete and submit the application form.

For more on the criteria and application process:
http://www.royalsociety.org.nz/Site/teachersstudents/Funding_for_teachers/

To initiate discussions regarding a project please contact Joy Wood on j.r.wood@massey.ac.nz

TEACHING RESOURCES

Over the years the Allan Wilson Centre has produced a number of resources that can be used in the classroom.

Allan Wilson Evolutionary: biochemist, biologist, giant of molecular evolution

This documentary film was aired on the Sky Documentary Channel during 2009. It profiles the remarkable career of Allan Wilson and explores the enduring impact of his ideas on anthropology, molecular biology and all the natural sciences. Duration: 40 minutes.

pheno

Back issues of *pheno* are available either in hard copy or online at
www.allanwilsoncentre.ac.nz

Biotechniques

This DVD demonstrates through explanations and animations the biotechnological techniques of DNA extraction, gel electrophoresis, PCR, restriction enzyme digestion, DNA sequencing, ligation and cloning, DNA chips and tissue culture.

There are also inumerable recorded lectures downloadable from
www.allanwilsoncentre.ac.nz

To receive your own copy of one of our resources please contact Joy Wood on j.r.wood@massey.ac.nz