pheno

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ALLAN WILSON CENTRE

INSIDE THIS ISSUE

Welcome to pheno

AN ORGANISM'S PHENOTYPE is the outward expression of its genetic material (genotype) and the impact that the environment has on that genotype. You could say that a phenotype is what you look like; your genotype is what's inside. We'd like *Pheno* to be the outward expression of what we are doing inside the Allan Wilson Centre for Molecular Ecology and Evolution. Through *Pheno*, we'll introduce you to our researchers and their work and we'll keep you up to date with our involvement in New Zealand schools and society. We'll send *Pheno* to you twice a year – once at the beginning of school term one and once at the beginning of term three.

Since the Allan Wilson Centre was founded in 2002, Professors David Penny and Mike Hendy have served as its co-directors, providing insight and inspiration to faculty, staff and students. After six years, the pair will be able to put their energies back into full-time research and hand-over the reins to a new director. Following an international search, the Centre has chosen Paul Rainey, Professor of Evolutionary Genetics at Massey University's Albany campus, as its new director. Prof Rainey will assume his appointment on 29 October 2008 and, on behalf of the Allan Wilson Centre, we would like to welcome Prof Rainey to the role. You can read more about Prof Rainey on page three of Pheno. We would also like to express our gratitude and thanks to Professors Penny and Hendy for six years of hard work! ■

We welcome your suggestions and input and invite you to contact Susan Adams, Executive Officer and Business Manager on 06 350 5448 or s.i.adams@massey.ac.nz.

ALLAN WILSON: Evolutionary

NEW ZEALAND-BORN Professor Allan Wilson (1934 – 1991) revolutionised the way we study how life on earth evolved. *Allan Wilson: Evolutionary* is a documentary film produced by George Andrews, one of New Zealand's most respected documentary producers. This 40-minute high definition documentary on New Zealand's greatest scientist since Ernest Rutherford is now available on DVD. Within days of its distribution, Allan Wilson:Evolutionary was snapped up by Films for the Humanities (www.films.com), one of the largest distributors of educational films in the United States.

Here's what Films for Humanities has to say about the documentary:

"Allan Wilson, a groundbreaking researcher and a lightning rod for controversy, revolutionized science and galvanized the scientific community through his quantitative biochemical approach to the history of evolution. Drawing upon the insights and recollections of those who knew Wilson best, this program—narrated by paleoanthropologist Tim White, co-discoverer of the hominid "Lucy"—correlates milestones of his remarkable career with his enduring contributions that range from molecular phylogenies of multiple species to an understanding of mechanisms underlying the mode and tempo of organismal evolution. Commentary by David Wake, professor emeritus of zoology at the University of California, Berkeley, and many others is featured." ■

To purchase a copy in New Zealand, please contact Susan Adams on 06 350 5448 or s.i.adams@massey.ac.nz

ALLAN WILSON CENTRE

NEWS

KEALL AWARDED FOR WORK

FLAWLESS AND innovative animal husbandry techniques with tuatara have earned Allan Wilson Centre's biology technician Sue Keall the Animal Technician's Award for 2008 by the Australian and New Zealand Council for the Care of Animals in Research and Teaching.

Keall has been responsible for care of tuatara at Victoria University since 1991. Numbers of tuatara in the colony have varied from as few as five to several hundred and Keall has cared for hatchlings, juvenile and adult animals, and has also been responsible for the incubation of eggs from both captive populations and wild populations threatened with extinction.

Professor Daugherty, director of the University's tuatara biology and conservation programme, says Keall has led the improved husbandry of tuatara at institutions in New Zealand and overseas—in particular at the San Diego Zoo—and that her work has been essential to ongoing research programmes aimed at ensuring the future of tuatara. Additionally, she has worked tirelessly to educate New Zealanders on the significance of conservation using tuatara as a flagship species. ■

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Weaving tikanga
and technology together

More than 120 Maori resource managers and scientists gathered for a three-day hui to discuss the potential impacts of biotechnology and nanotechnology on Maori tikanga (culture) and kaitiakitanga (guardianship)

TIKANGA AND TECHNOLOGY: *A New Net goes Fishing* was the name of the hui held at Island Bay's Tapu te Ranga marae and Te Papa Tongarewa from 30 April. The hui was hosted by the Environmental Risk Management Authority of New Zealand (ERMA NZ) and sponsored by the Allan Wilson Centre for Molecular Ecology and Evolution and GNS Science.

Co-organiser Dr Kristina Ramstad, a postdoctoral fellow in the Allan Wilson Centre, says that this is the first time ERMA has partnered with research institutes such as the Allan Wilson Centre and GNS in response to calls from members of ERMA's Maori National Network to learn more about new and emerging technologies.

Allan Wilson Centre investigators discussed a range of biotechnology research being undertaken in New Zealand. Postdoctoral researcher Hilary Miller presented a session on 'low-risk' genetic modification and associate professor Lisa Matisoo-Smith talked about work the centre is doing to track Pacific migrations. Senior lecturer, Nicky Nelson and Glenice Paine, Te Atiawa ki te Tau Ihu, presented a talk about tuatara conservation research.

Providing a lay-person's explanation of nanotechnology and the opportunities and challenges it poses was also addressed. The regulation of nanotechnology and the issues faced when regulating new and unique materials and products created by material that have been manipulated down to the nanoscale (1/100,000 the width of a human hair) and the potential impact (both positive and negative) of nanotechnology for Maori knowledge, tikanga and kaitiakitanga were covered.

Dr Ramstad says the hui aligns with the Allan Wilson Centre's commitment to engage with Maori and iwi about science and research. "These are fantastic opportunities for Maori communities and scientists to learn from one another and to discuss how our views of science and conservation are similar and also differ," she says. ■

To purchase a copy of the DVD and associated teacher resource, please contact Dr Kristina Ramstad on: 04 473 7443 or by emailing Kristina.ramstad@vuw.ac.nz

our new director

Professor Paul Rainey will become the AWC director on 29 October 2008

PAUL RAINEY is Professor of Evolutionary Genetics at Massey University's Albany campus where he leads a team researching themes that cover evolution, microbiology, genetics, ecology, parisitology and biochemistry. Internationally recognized for his research on evolution, Paul lists close to a hundred papers published in various scientific journals and the results of some of his work are incorporated into undergraduate textbooks. He edits several major scientific publications including the Proceedings of the Royal Society, London, Series B, and the international research forum Ecology Letters.

Gaining his PhD at Canterbury University, Paul moved to the United Kingdom where he worked as a post doctoral research fellow at Cambridge and Oxford, eventually joining the faculty of the University of Oxford in 1996. In 2003 he returned to New Zealand where he took up the Chair of Ecology and Evolution at the University of Auckland's School of Biological Sciences, although he retained a fractional appointment at the University of Oxford as International Professor of Biology. He moved to the NZ Institute for Advanced Study & Institute for Molecular Bioscience at Massey University in 2007. As well as his work there, Paul also holds the positions of Visiting Professor at Stanford University where he is Co-Director of the Hopkins Microbial Diversity Programme and Adjunct Senior Researcher at the Swiss Federal Institute for Aquatic Science & Technology. Elected to the Academy of the Royal Society of New Zealand in 2007, he was recently appointed as a Principal Investigator at the Allan Wilson Centre where he is the Director-designate.

For Paul, time away from the laboratory means an opportunity to play the piano, paint watercolour landscapes, garden, enjoy wine (not just the drinking of it, he says, but its diversity and social history), walk in the hills around his home and read voraciously. A small wooden yacht he has been planning to build for some time has been put on hold in favour of the construction of a Great Barrier bolthole where he escapes for family weekends as often as possible. ■

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our new principal investigator

In May, Doctor Richard Newcomb joined the AWC team and HortResearch became a partner institution

RICHARD NEWCOMB is the Science Leader for the Molecular Olfaction group at the Horticulture and Food Research Institute of NZ (HortResearch) in Auckland where he heads a team that includes 12 PhD students. His work there focuses on the flavour compounds produced in fruit and how odours are detected by insects and humans – in other words the evolution of the sense of smell. Insect research concentrates on odorant and pheromone production in the light brown apple moth. In addition to his work at HortResearch, Richard holds an honorary post at the University of Auckland's School of Biological Sciences where he teaches molecular biology and evolution.

Richard chose to study for his PhD at the Australian National University in Canberra but came home to Auckland to begin his academic and research career. From 1999 to 2002 he led a Plant Health and Development Group at HortResearch, developing the largest fruit gene database in the world which determined the role of genes in fruit development, health, flavour and pest and disease resistance. Since then he has been a visiting Fellow at CSIRO and Yale, a speaker at many international conferences, a published author in various international scientific journals and was recently appointed a Principal Investigator at the Allan Wilson Centre. He is a member of the Marsden Fund panel and the New Zealand representative for the Genetics Society for Australasia.

Richard lists his out-of-hours relaxations as music (once a member of a band, he still plays keyboard), tennis and enjoying the great outdoors in the Waitakeres where he lives. ■

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The 2008 New Zealand Biology Olympiad team (l-r) Ben Paterson, silver medalist, Kings College; Jessica Shailer, bronze medalist Palmerston North Girls High School, Chloe English, bronze medalist Christchurch Girls' High School; Amanda Deacon, bronze medallist, Burnside High School.

Biology Olympians Bring Home Medals

NOT ALL THE Olympic news in 2008 came from Beijing. In July, four of New Zealand's brightest biology students competed in the Biology Olympiad in Mumbai, India, winning one individual silver and three individual bronzes. The team, pictured above, was chosen through a rigorous selection process over the course of seven months that began last July.

In order to expand their biology knowledge from the high school level to the equivalent of second-year University, Olympians attended a ten day biology camp, took advantage of local teachers and mentors, spent countless hours on individual study and, like all serious Olympians, put their social life on hold.

For Palmerston North's Jess Shailer, it was the first time she had travelled further away than Australia and the work and sacrifices were worthwhile. While Shailer is thrilled with her bronze medal, she found the cultural exchange the most amazing part of the trip. "It was amazing to meet all the different people from the different cultures," she says. "Being in the dining room and hearing all those different languages and accents was just so cool."

On the way to Mumbai, Shailer, along with her team mates Ben Paterson, Chloe English and Amanda Deacon and their coaches, Dr Angela Sharples, a biology teacher at Rotorua Girls High and Dr Steve Chambers, a lecturer at Unitech, spent four days in Singapore brushing up on biology and enhancing their knowledge.

In Mumbai, a total of 220 students from 55 countries participated in formal opening ceremonies, cultural exchanges and then got down to business, faced with five hours of written theory examinations on one day and four hours of practical examinations on another. In total, 23 gold, 47 silver and 68 bronze medals were awarded.

The Allan Wilson Centre helped train the students and assisted with the cost of attending the Olympics. Susan Adams, the Centre's business manager, is a member of the New Zealand committee seeking to bring the International Biology Olympiad to New Zealand in 2011. ■

Notes from our Teacher Fellow

Chris Corser is a Biology teacher from Ngatawa School and one of this year's 52 New Zealand Science, Mathematics and Technology Teacher Fellows. Established in 1994 by the Government and administered by the Royal Society of New Zealand, the teacher fellow programme offers primary and secondary teachers of the sciences, mathematics, social sciences and technology the opportunity to improve their teaching through experience in technological or scientific practice. Chris is spending her year at the Allan Wilson Centre's Palmerston North site.

I HAVE ALWAYS been interested in evolutionary concepts. I am also, having experienced a few of my own, very keen on sailing voyages. Thinking about the lives of those people navigating across great tracts of seemingly featureless ocean, in search of a "home" strongly fuels my imagination.

The first objective for my teacher fellowship work at the Allan Wilson Centre (AWC) – researching and reporting on the migratory patterns of groups of Polynesian people from South East Asia – ties these two interests together.

The biologists at the AWC work with mitochondrial DNA (mtDNA) which is inherited through the egg and passed down the generations from mother to offspring. Unlike nuclear DNA, which is inherited from both parents and changes through recombination, there is usually no change in mtDNA from one generation to the next. Consequently, mtDNA can be assessed for slight changes, or mutations, giving a measure of "relatedness" between individuals and between species. For example, few or no changes in the variable part of two people's mtDNA mean they are probably quite closely related whereas many changes indicate that they are distantly related.

This is the basis for my work on Polynesian ancestry. By comparing mtDNA samples between different Polynesian people, my project can trace their movements.

I am putting into practice some of the techniques studied in Year 13 Biology. I began my project by extracting DNA from tissue or blood, practicing PCR (a technique which amplifies small defined portions of the DNA), visualising the PCR products using gel electrophoresis and sequencing these PCR products. Once the DNA is sequenced, I then compare the different genomes and find the mutations which characterise this group of people.

After the first few days, I began to get the hang of keeping a steady hand while using Gilson pipettes, of handling tiny tubes and even tinier amounts of solutions, and of operating the PCR machines. The DNA never ever looked as though it was in these solutions, but usually after gel electrophoresis, there they were - strongly fluorescing clean bands of amplified DNA!

The successful PCR products can then be sequenced, that is, I can set up the reactions which give the order of bases A,C,G and T's .The resulting data from the powerful sequencing machines is translated by the software into chromatograms - rows and rows of coloured peaks that correspond to the order of the bases. By comparing these readouts with one from a reference mitochondrial genome, I can spot the mutations. There aren't many, but here and there a T had become a G, or an A was now a C, or there was a deletion or an insertion.

The seven genomes being sequenced were from people from Kiribati, Fiji and Papua New Guinea (PNG) (and one from me, for added interest!). The mtDNA from each of the seven share the same haplotype – they are all Q2 – which is why they were chosen. Q2 haplotypes are more common in PNG people whose lineages date back many thousands of years before the more recently established Polynesian people.

The "express train" theory on Polynesian migration suggests that the original Polynesians migrated from the west, right past PNG and on into the Pacific Ocean where they discovered the islands that became their homes. There was no genetic mixing with PNG inhabitants. On the other hand, if Polynesians and PNG people share the same haplotypes, this does imply genetic mixing with PNG people before the great eastwards migrations on into the Pacific.

My task is to sequence some of these Q2 mitochondrial genomes (which have 16,000 bases each) and try to differentiate them further. Right now, I have seven almost completely sequenced genomes, but as luck would have it there are little gaps and 'holes' where a PCR product is short or missing or doesn't quite connect up with the next PCR product; the work goes on. I have to repeat and repeat the reactions until all the short pieces are sequenced clearly and each overlaps with the next. Only then can there be a "consensus" or final total readout of the 16,000 bases for each sample. We are getting very close to completion, but the odd gap persists. I'll have to sit down and think up a different approach, perhaps making a longer PCR product would be a start.

This is a remarkable and scientifically invigorating year for me. There are so many questions and intriguing attempts at answers outside the classroom walls and beyond the sound of the school bell. By actually practicing these techniques and learning about the applications and issues first hand, I hope to gain a much better appreciation of biotechnology. And, because another objective of the Teacher Fellow programme is to disseminate the knowledge I may gain during the year, it is an appreciation that could benefit others including the Biology students back at school. ■

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ALLAN WILSON CENTRE

PHENO FEATURE

Pacific focus

When the average holiday-maker puts on a snorkel and a mask and jumps in the crystal clear water around Fiji's islands, he or she is likely to admire not only the tropical fish, but also the marine sponges. That swimmer is unlikely, though, to be able to differentiate between one type of sponge and another – to the untrained eye, the sponges look pretty much the same.

BUT LOOKS can be deceiving and some Pacific sponges have unique compounds with antifungal, antibacterial and cancer cell line inhibitory properties. These compounds – Cribrostatins 3, 4 and 5 – are of the interest of international pharmaceutical companies, but only by examining the sponge's DNA can it be determined which sponges contain the compounds.

Figuring out which sponges in Pacific waters contain Cribrostatins is one of the research projects underway in collaboration between the Allan Wilson Centre and the University of the South Pacific.

Through its host Massey University, in 2003 the Allan Wilson Centre signed a memorandum of understanding (MoU) with the University of the South Pacific to establish a formal relationship through which research projects could be undertaken. The understanding also established research, education and training relationships between the universities.

Following the MoU, the AWC ran a workshop in molecular biology and one in bioinformatics at USP. From 2003 to 2005, the AWC helped fund a number of research visits for USP staff and students to the AWC and AWC researchers and staff were hosted by the USP.

It was important, says AWC Principal Investigator Professor Peter Lockhart, to work with staff and students in Fiji; the programme, he says, would only be successful if it was driven by their interests, not the interests of researchers or funding bodies in New Zealand. During the development of the programme, says Lockhart, it also became apparent that merely bringing Pacific Islanders to New Zealand for training wouldn't work; scientists would become highly skilled but would have no opportunity upon return to use the knowledge they had gained.

Consequently, studies were begun to investigate the potential of developing molecular systematic studies at USP and, in 2005, a proposal by biology staff was made to USP to purchase equipment for a molecular biology laboratory on the USP campus. In 2006, a proposal by the AWC that would help establish a postgraduate group in molecular systematics at USP was funded by the New Zealand Overseas Development Fund as a subcontract to Landcare Research. This grant operates over a 3 year period and is for approximately $750,000. The molecular systematics budget has funded direct costs (USP lab refit, consumables, USP student stipends, sequencing, costs of travel and accommodation of Pacific and NZ staff and students) and overheads at USP and Massey University for administration costs; AWC staff involved in the project provide professional time at no cost.

The new laboratory was opened in May 2007 and weekly meetings through video were held between New Zealand co-supervisors and members of the USP lab. It became apparent late in 2007 that more assistance would be needed in order to develop confidence in the USP students. Richard Winkworth, Peter Lockhart's first Massey PhD student, who completed postdoctoral studies at Yale University in the US and in Brazil, was hired to fill a short-term role and has since accepted a three year lecturing contract at USP.

In addition to marine sponge research, projects currently underway include understanding the origins and diversity of Fijian endemic birds; understanding the origins and evolutionary patterns of Fijian long-horned beetles; understanding the effective conservation and monitoring programs for the Fijian frogs; understanding the genetics of invasive ants; understanding the molecular biology of the indigenous cutnut; and understanding the distribution and species diversity of root knot nematodes, a type of plant root parasite. ■

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A Billion Bases

WE MIGHT think climate change is a modern problem, but much of New Zealand's flora has been through it before. Many plant groups came here by transoceanic dispersal and individual plants diversified during centuries of climate change that followed their arrival. In order to understand the genetic process underlying that diversification involves using gene sequencing technology – the same technology that was the used in the Human Genome Project.

Gene sequencing can be done using two different methods: Maxam-Gilbert sequencing (chemical cleavage method) or Sanger-Coulson sequencing (the chain termination method). Sanger-Coulson is the method used by the Solexa Genome Analysis System, which was installed in December 2007 at the Allan Wilson Centre.

The Solexa is sometimes called "the billion base box", because it can generate up to 1 billion bits of genetic information in a single run – a process that takes over three days.

Professor Peter Lockhart says its greatest value in a country like New Zealand isn't to do with sequencing genomes, but with developing molecular markers and doing expression studies. It's particularly good, he says, at giving a quantitative measure of the extent to which different genes are turned on and off.

Messenger RNA (mRNA) is a molecule of RNA that translates DNA's genetic code into the amino acids that will make a protein. It, therefore, serves as a template for protein synthesis and, consequently, the mRNA that is present determines how much – and what – protein is made.

"Solexa technology can count the number of messenger RNAs that you have for a particular gene so you can get a quantitative measure of how much of a particular protein is being made, and work out the extent to which particular biochemical pathways are turned on or off - and so how processes might be different in different cells, tissues or organisms," explains Lockhart.

"You use the sequencing technology to sequence all of the genes being expressed in particularly interesting plant groups and then you use that database as a reference for measuring which genes are being turned off and on within different species of those groups."

Lockhart has been using the Solexa to investigate what has driven the diversification of species in New Zealand alpine plants during periods of climate change. Understanding what happened to the plants in previous change periods will give an indication of how they might respond to future changes. As well as investigating the origins of alpine plants, Lockhart is also using the technology to develop a methodology for studying a wide range of organisms – both animals and plants.

Other projects currently being run on the system include studies on the origins of life and microbial evolution. Lockhart expects the Solexa to draw wide interest from New Zealand scientists involved in applied agricultural, medical and basic research. Its huge sequencing capacity means multiple samples can be run at the same time, which speeds up the process and makes it less expensive.

"Imagine a glass slide with eight lanes on it," Lockhart says. "In one lane on the Solexa you get much more information back. If you were a biologist and you could put ten experiments in one lane, then it becomes really, really cheap."

"We make every attempt to keep costs as low as possible and annually reassess our pricing structure taking into account the previous period's throughput," says the centre's business manager, Susan Adams. "Any profits are reinvested in the service."

One of the biggest problems in getting the Solexa up and running has been dealing with the sheer volume of data it generates. The centre has recently bought three large-capacity servers to handle the data and further down the track, Lockhart says, people will be able to work with the results on their laptops. ■

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Visit the Allan Wilson Centre at
http://awcmee.massey.ac.nz

CONFERENCES

The Allan Wilson Centre will be hosting the following conferences:

ANNUAL AWC RESEARCH MEETING

Date: October 29 – 31, 2008
Location: Rugby Institute, Massey University, Palmerston North
Enquiries: s.i.adams@massey.ac.nz

BIOED CONFERENCE 2009

Date: February 12-17 2009
Location: Convention Centre, Christchurch, New Zealand
Enquiries: awc@massey.ac.nz

PUBLICATIONS

The following publications are some of those that have been authored by members of the Allan Wilson Centre during 2008.

Please visit http://awcmee.massey.ac.nz/publications.htm to view these and prior publications. The website also includes a listing of book chapters and book reviews by members of the Allan Wilson Centre staff.

- Penny D., White WT, Hendy MD, and Phillips MJ. (2008). A bias in ML estimates of branch lengths in the presence of multiple signals. Molecular Biology and Evolution 25 (2): 239-242
- Gruenheit N, Lockhart PJ, Steel M, Martin, W. (2008). Difficulties in testing for covarion-like properties of sequences under the confounding influence of changing proportions of variable sites. Molecular Biology and Evolution 25(7): 1512-1520.
- Steel M, and Rodrigo A. Maximum likelihood supertrees. Systematic Biology 57(2): 243-250.
- Howe CJ, Barbrook AC, Nisbet RER, Lockhart PJ, and Larkum AWD. The Origin of Plastids. Philosophical Transactions Of The Royal Society B-Biological Sciences 363 (1504): 2675-2685
- Morgan-Richards M, Trewick SA, Bartosch-Haerlid A, Kardailsky O, Phillips MJ, McLenachan PA, and Penny D. Bird evolution: testing the Metaves clade with six new mitochondrial genomes. BMC Evolutionary Biology 8, Article Number: 20.

FEATURED PUBLICATION

IN THE MARCH 2008 issue of *Plus*, Mike Steel, director of the Biomathematics Research Centre at University of Canterbury and a principal investigator of the Allan Wilson Centre for Molecular Ecology and Evolution, co-authored "Reconstructing the Tree of Life." *Plus* is an internet magazine which aims to introduce readers to the beauty and the practical applications of mathematics and is part of the Millennium Mathematics Project, a long term national initiative based in Cambridge and active across the UK and internationally. Steel is co-author of the book Phylogenetics, which presents the mathematical foundation of phylogenetics.

RECONSTRUCTING THE TREE OF LIFE

by Daniel Huson, Vincent Moulton and Mike Steel, assembled by Marianne Freiberger

Next year is a great one for biology: not only will we celebrate 150 years since the publication of On the Origin of Species, but also 200 years since the birth of its author, Charles Darwin. And two important anniversaries these are indeed: Darwin's theory of evolution through natural selection revolutionised vast swathes of human thought, from hard science to religion. Recent advances in genetics have lent a whole new dimension to Darwin's basic tenet, and furnished it with a vast body of evidence...

...At the heart of evolution lies a beautifully simple mathematical object: the evolutionary tree. The quest to understand it has spawned recent collaborations between mathematicians and biologists and thrown up simple mathematical questions that look like they should have been answered centuries ago. In this article we look at a few of these.

To read the entire article, go to: http://plus.maths.org/issue46/features/phylogenetics/index.html