ALLAN WILSON CENTRE
FOR MOLECULAR ECOLOGY AND EVOLUTION

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BIODIVERSITY A CENTURY LONG NATIONAL SCIENCE CHALLENGE

In the 2010 novel *Freedom*, by American author Jonathan Franzen, well meaning, faithful Walter sits in his car making "mental tallies of what had gone wrong in the world in the hours since he'd awakened in the Days Inn. Net population gain: 60,000."

"New acres of American sprawl: 1,000. Birds killed by domestic and feral cats in the United States: 500,000. Barrels of oil burned worldwide: 12,000,000. Metric tons of carbon dioxide dumped into the atmosphere: 11,000,000. Sharks murdered for their fins and left floating finless in the water: 150,000." And it's not even lunchtime.

But aren't we all now immune to, and helpless in the face of, the relentless statistics about the loss of biodiversity? We shed quiet tears at the poignant closing remarks of David Attenborough in his TV programmes about the impending annihilation of those beautiful, strong and yet vulnerable, creatures, but have refocused on what to wear the next day by the time we've brushed our teeth. Not because we're necessarily stupid or shallow. What, after all, can we do about it at 9:30pm on a Tuesday night, when we have work the next morning.

But instead of focusing on the loss of biodiversity, let's think about what we've gained. It could be so much worse! Think of the many scientists – over 100 in the Allan Wilson Centre – who every day work on understanding and ensuring a future for our plants and animals, including *humans*. (We seem to forget that the loss of biodiversity may well include us.) There's Thomas Buckley, tracking and recording every shaky move of our charismatic stick insects; Alexei Drummond and team, identifying hundreds, actually thousands, of unique (and many hitherto unknown) native species in just a few square metres of soil on Hauturu/Little Barrier Island, to inform conservation practice; Charles Daugherty and Nicky Nelson repopulating the mainland with tuatara after decades of painstaking work in the lab and on Stephens Island; Kristina Ramstad focusing on the genetic variety of Little Spotted Kiwi, now flourishing in Zealandia; and Ian Jamieson, patiently tackling the challenge of re-establishing populations of native birds, including the pre-requisite eradication of predator populations. Their jobs are a far cry from those of other New Zealanders, no more or less important. But they can help us understand what we seem to have forgotten – how dependent we all are on the rest of nature. We perch, precariously, atop this marvelously interwoven edifice.

The announcement on 30 April of the Government's National Science Challenges, which include biodiversity and biosecurity, and the additional millions attached, gives us hope that research in this area will continue, be expanded, and respected as the foundation for positive and cost effective action on the ground.

For the scientists of the Allan Wilson Centre, every day is Biodiversity Day*.

Saving the birds: Associate Professor Ian Jamieson

As it should be for all of us. A Biodiversity Century is what we need.

** 22 May is International Day for Biodiversity*

By Glenda Lewis

INSIDE THIS ISSUE

MARCEL MEDRANO - WHEN PIGS GO WILD

Throughout the nineteenth century, domestic pigs of European and Asian origins were released into the wild in several areas, including the sub-Antarctic Auckland Islands, on the mainland within New Zealand and also Australia and the Americas.

AWC PhD candidate Marcel Medrano is taking advantage of the natural replicated experiments that the different pig populations provide to examine the underlying genetic nature of the feralisation changes.

In several cases the pigs managed to survive in their new environments, forming populations that are still present today. But these wild pigs are often quite different to their domestic ancestors, most obviously in their morphology - typically having narrow heads and long snouts, and in many ways more closely resembling wild boar than domestic pigs.

The process by which domesticated animals adapt to a new life in the wild is known as 'feralisation' and there are examples of this occurring worldwide in several different species. While in some ways this resembles a return to the original wild state of the animal it has been shown that the reversion is not complete, as essential characteristics of domestication, for example, a smaller brain size, often remain unchanged. What is of particular interest in an evolutionary sense is the speed of the changes - as shown by the rapid morphological and physiological changes some pig populations have undergone in less than two centuries.

AWC PhD candidate Marcel Medrano is taking advantage of the natural replicated experiments that the different pig populations provide to examine the underlying genetic nature of the feralisation changes. Marcel joined Professor Neil Gemmell's lab in the Department of Anatomy at the University of Otago in 2012. Before coming to New Zealand, Marcel lived

AWC PhD candidate Marcel Medrano

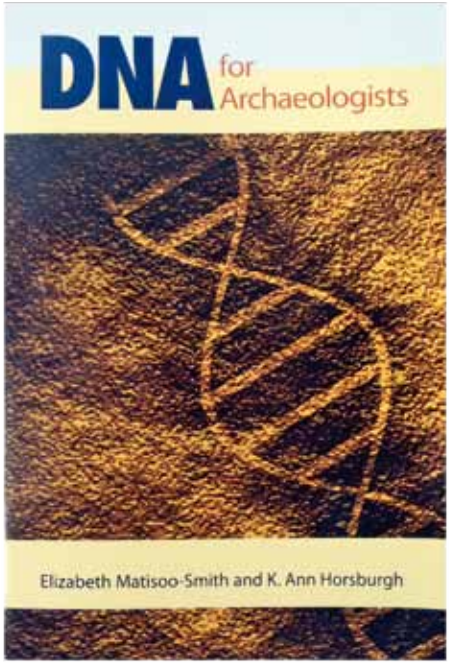
in Germany, and his previous work includes a masters' degree looking at sex determination in the honeybee.

Marcel's project will use samples and data from several of the different wild pig populations, and reference data from domestic pigs and wild boar, to look for evidence of the mechanisms driving the changes from the domestic forms to the feral phenotype. Marcel plans to combine population ecology methods with genetic techniques, including DNA-chip assays and the construction of gene regulatory networks, to investigate several key questions. These include finding out whether populations in different regions have undergone the same, or different, independent genetic alterations to converge on similar feral types, and determining the nature of the underlying genetic changes triggering the phenotype changes. The results of Marcel's work are also likely to shed light on the important, but as yet little-known, genetics of domestication.

Picture courtesy of Ben Stassen

DNA TOOLS FOR ARCHAEOLOGISTS

Allan Wilson, the NZ-born scientist for whom the Centre is named, was a pioneer of the field of molecular anthropology - taking new tools and knowledge from genetics and using these to investigate the human past. AWC Principal Investigator, Professor Lisa Matisoo-Smith, of the Department of Anatomy at the University of Otago, has recently co-authored the first textbook designed to introduce the concepts and methods of molecular anthropology to archaeologists.



As the authors state: 'archaeologists and molecular anthropologists are natural allies in our attempts to understand the past' - but it can be difficult for archaeologists to interpret and assess genetic research results, which are generally published in technical biological journals. *DNA for Archaeologists* (Left Coast Press, Walnut Creek, California) by Lisa and Dr Ann Horsburgh bridges this divide. It describes the power and pitfalls of anthropological DNA research, identifies key applications of genetic techniques for archaeological studies, and outlines the best practice methods for ancient DNA sample recovery from excavations.

DNA for Archaeologists begins with chapters describing DNA itself, and common methods used in molecular anthropological studies, including an overview of the different challenges presented by work with ancient DNA. Following this, case studies illustrate different areas of research - from hominin origins and relationships to human population histories and human impacts on other animals and the environment.

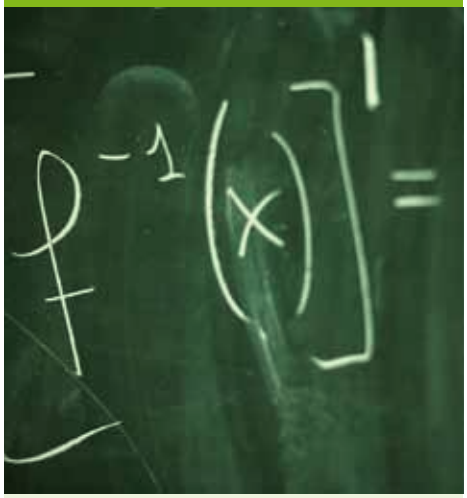
Molecular anthropologists Lisa and Ann are particularly well-suited to presenting this topic as both have a great deal of experience in working with DNA in collaboration with archaeologists. Ann is a Research Fellow in the Department of Anatomy at the University of Otago and an Honorary Research Fellow in the School of Geography, Archaeology and Environmental Studies at the University of the Witwatersrand. Her work focuses on using DNA, ancient and modern, to unravel the complex history of cattle domestication in Africa.

Lisa's research uses evidence from ancient and modern human and animal DNA samples to look at questions in Pacific prehistory. A recent focus of her work has been looking for evidence of Polynesian seafarers reaching, and settling in, South America. This has involved several trips to Chile and fieldwork with local archaeologists to recover samples to test for signs of Polynesian ancestry. Closer to home, in October last year, Lisa, Ann and other team members announced their success in recovering DNA from the remains of some of the first settlers of New Zealand (~750 years old), as part of the Wairau Bar Kōiwi Research Project, a joint initiative between Rangitane iwi, the Canterbury Museum and the University of Otago.

Lisa's research uses evidence from ancient and modern human and animal DNA samples to look at questions in Pacific prehistory.

Professor Lisa Matisoo-Smith collecting ancient DNA samples from an archaeological excavation

The Mathematics of Life Poster Competition



The New Zealand Association of Mathematics Teachers has organised a national poster competition to celebrate 2013 Year of Mathematics of Planet Earth. The topics vastly broaden appreciation of the role of maths in – well, almost everything.

The Allan Wilson Centre is sponsoring the theme for Years 7 and 8: The Mathematics of Life.

This theme asks students to think of what mathematics may relate to an understanding of Life on Earth, including:

- The mathematics of languages: how many languages are there, how many languages are being lost each year, how do people communicate in Facebook, how do words evolve, what are the main languages in the world and how are these changing, how are these ideas described by mathematics?
- The mathematics of DNA, population genetics, phylogenetics.
- The mathematics of populations: how do populations vary, what about human numbers, fish numbers, rabbit numbers, etc? How do we know how many wild dolphins there are about the New Zealand coast? How do algae blooms form?
- The mathematics of evolution: extinctions, speciation, evolutionary game theory, how many people believe (do not believe) in the theory of evolution and how does this vary in different countries?

The competition has great prizes, so encourage students to go to *www.nzamt.org.nz/2013-maths-quest-poster-competition* and *www.allanwilsoncentre.ac.nz* for more information.
Entries close 7 June.

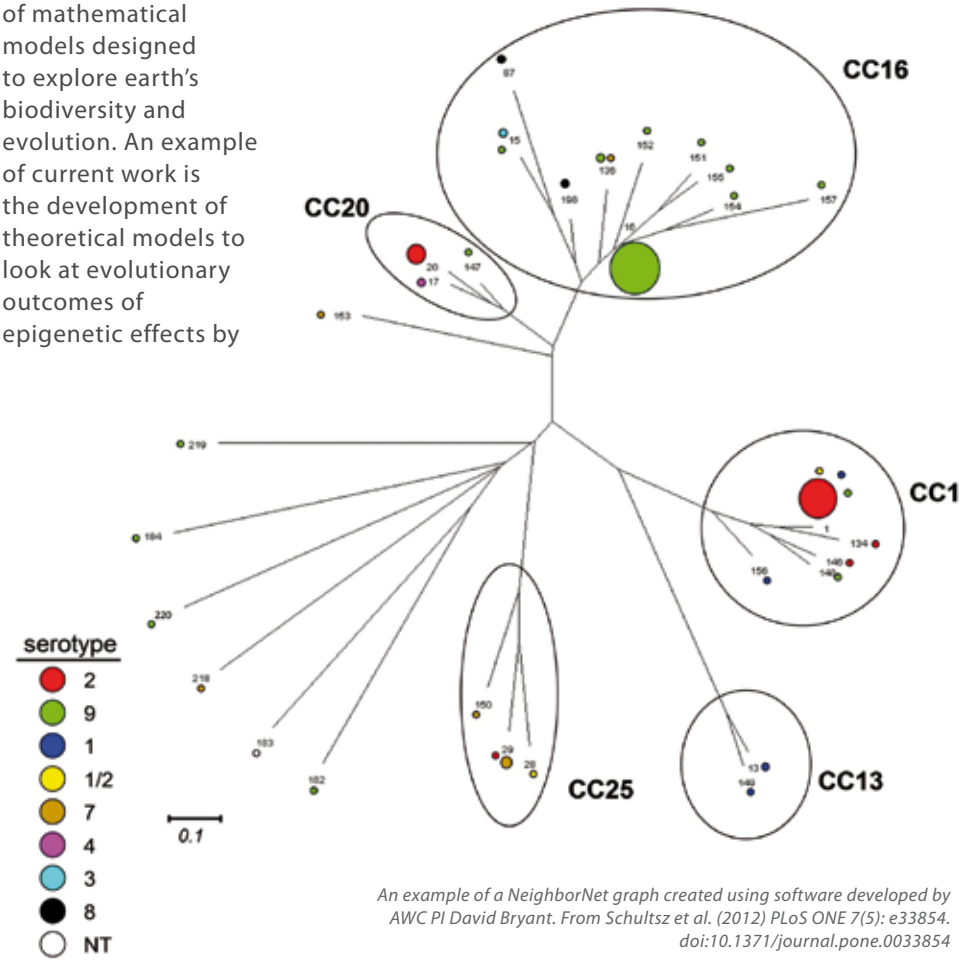
MATHEMATICS OF PLANET EARTH

This year more than 100 scientific societies, universities, research institutes, and organisations from all over the world have banded together to declare a special year for the Mathematics of Planet Earth (MPE2013), under the patronage of UNESCO.

The goals of MPE2013 are to raise public awareness of the role mathematics plays in our understanding of dynamic earth processes: the geophysical processes in the earth's mantle; the atmospheric and oceanic processes that determine our weather and climates; the biological processes involving living species and the human processes of finance, agriculture, water, transportation, and energy.

A major enduring strength of the Allan Wilson Centre (AWC) is the collaborative network that has been established between leading New Zealand researchers in biology and mathematics. AWC researchers are at the forefront of the invention and application of mathematical models designed to explore earth's biodiversity and evolution. An example of current work is the development of theoretical models to look at evolutionary outcomes of epigenetic effects by AWC Director, Professor Hamish Spencer, and his group at the University of Otago.

Other investigators within the Centre are working on the creation of new theory and software designed to keep up with the masses of genetic data now available and the increasing sophistication required of models as our knowledge of evolutionary processes grows (Associate Professor David Bryant, University of Otago; Professor Alexei Drummond, University of Auckland; Professors Charles Semple and Mike Steel, University of Canterbury). Doctoral students and postdoctoral fellows play a major role in the research of the Centre, and in this issue we take a quick look at two mathematics-based projects in progress.



An example of a NeighborNet graph created using software developed by AWC PI David Bryant. From Schultsz et al. (2012) PLoS ONE 7(5): e33854. doi:10.1371/journal.pone.0033854

The problem of direct ancestors in sampling

Dr Alexandra (Sasha) Gavryushkina moved to Auckland from Russia last year to begin a PhD project in Professor Alexei Drummond's group at The University of Auckland. Sasha brings particular strengths in mathematics to her PhD research, having previously completed a PhD in pure mathematics from Novosibirsk University in Russia.

Sasha's project focuses on finding solutions to the problems raised in phylogenetic analyses if samples include individuals who are direct ancestors of others within the sample. A growing trend in recent phylogenetic analyses has been to take samples of molecular data at different time points and analyse these together; this approach is particularly well-suited to analyses of ancient DNA and also to research on rapidly evolving pathogens.

At present, researchers can use phylogenetic software programs, including BEAST2 (the popular Bayesian evolutionary analysis software created by Alexei and colleagues), to perform the analyses on this 'serially sampled' data. But the models that are used within the software do not account for a special type of event - that of sampling direct ancestors. This can be a significant problem, as when the population size is small or the fraction of individuals sampled from the population is large, it is possible that the sample includes individuals that are direct ancestors of others within the sample.

Statistical models have been developed to account for this type of event, and implementation of these models will help us to determine how important these models are and how much evidence of direct sampling the data contains. All of this requires new mathematical models, theory and algorithms as the existing phylogenetic tools cannot cope with the ancestral samples. Sasha's project aims to develop methods to incorporate these new probabilistic models and new tree structures within the BEAST2 software, and test these new methods by performing analyses on real data.

Applying applied maths to genetics

Advances in genetic technologies have led to a massive increase in the amount and scope of data, as well as to the sophistication of models. Gordon Hiscott, an Allan Wilson Centre PhD student supervised by Associate Professor David Bryant, of the Department of Mathematics and Statistics at the University of Otago, is focusing on models used in population genetics, a field in biology which studies the genetic makeup of populations of organisms. Gordon is from Canada, and his PhD work follows an MSc degree undertaken at Simon Fraser University in Vancouver.

There is a huge array of mathematical techniques and theory for dealing with physical models, applied to problems ranging from engineering to biophysics to finance. An objective of Gordon's project is to determine how best to take the techniques and theory from these areas of applied mathematics and use them to work with genetic models in population genetics. The project involves researchers from pure maths, applied maths, statistics and physics, and will enable large data sets, for example those being produced by AWC colleagues studying aspects of our native flora and fauna, to be analysed with greater precision.

Teaching suggestions

- **In the October 2011 issue of Pheno,** Professor Mike Steel described the types of maths used by biological researchers today, and areas that are likely to see growth in the future: a useful resource for secondary and tertiary students considering a career in biomathematics. Back issues of Pheno can be downloaded from our website: *www.allanwilsoncentre.ac.nz*
- **MathsReach** (*www.mathsreach.org*) has several short videos of NZ mathematicians discussing their work, including the AWC's Professors Charles Semple and Mike Steel.
- **Professor Mike Steel** talks about maths, biology and evolution in series 2, episode 9 of the TVNZ 7's 'Ever Wondered' series (*http://tvnz.co.nz/ever-wondered/s2-e9-video-4426539*)
- **Curriculum Links:** Nature of Science - Understanding about Science (all levels)

WHAT CAN MOTHS TEACH US ABOUT EVOLUTIONARY BIOLOGY AND ATTRACTION?

Speciation is an important process that has produced the biodiversity we see all around us. In New Zealand we are proud of this biodiversity and wish to maintain it and the ability of biological systems to keep producing new biodiversity. So what mechanisms have produced this vast array of life forms? What are the processes involved and how can we study them?

Principal Investigator, Dr Richard Newcomb, Plant & Food Research

Within the scientific community most of our efforts to date have focused on the biogeographic factors that have impacted the evolution of new species, such as plate tectonics, mountain building, and sea level changes, not to mention the ecological factors, such as climate change and food abundance. The dominant theory currently is that as species evolve locally to new conditions they split from ancestral populations to form a new species. However we know very little about how changes at the DNA level might be involved in this process.

New Zealand has a great diversity of moths (but not so many butterflies). While there is some diversity in shape and size there is even more when you begin to look more closely. Moths use specific blends of aroma compounds called sex pheromones to communicate between males and females. In most species the females produce a specific blend of aroma compounds within specialised glands in their abdomen. At night females emit these volatile pheromones from their abdomen in a behaviour known as 'calling'. Males of the same species detect these pheromones using specifically tuned receptors within sensory hairs on their antennae. Only males of the same species are attracted and in many cases different species can vary purely on the chemistry of the sex pheromone they use, otherwise they are identical.

For pest species, understanding the chemical makeup of these pheromones has allowed the development of lures to monitor pest populations and control tactics such as mating disruption, where pheromones are released into the environment to confuse the males and inhibit their ability to find females. Understanding how these chemical communications change, however, can also provide insight into how new species evolve. The dilemma is though, how do new species evolve when both males and females need to change elements of their mate recognition system, with females presumed to evolve first to produce a new blend and males evolving a modified detection system? And what are the underlying mechanisms involved?

To address this members of the Allan Wilson Centre at Plant & Food Research have been isolating the genes involved in pheromone production in females and pheromone detection in males from species of endemic New Zealand leafroller moths within the genera *Ctenopseustis* and *Planotortrix*. We have been using the recently developed suite of sequencing technologies which have speeded up the identification of the genes involved. One of the major differences between the pheromones used by these different species is the position of double bonds within the compound. The pheromone glands of these moths utilise a suite of desaturase enzymes to incorporate these double bonds. What seems to differ between closely related species is which of the desaturases is 'switched on or off'. So rather than evolving a whole new gene or type of gene the moths are merely changing which genes are expressed within the pheromone gland. But what is controlling the switching on and off? It turns out that it is other genes within the genome, so called regulatory genes. So at least in the females, regulatory genes are altering the pheromone blend. The question we are now attempting to address is whether gene regulation is also involved in the male side of the story.

By Dr Richard Newcomb

Female Black-lyre Leafroller Moth
Picture courtesy of Ken Walker, Museum Victoria

Teaching suggestions

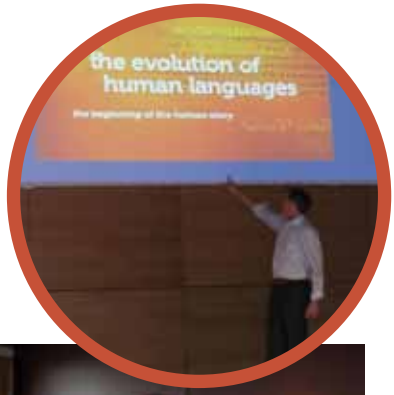
- **Curriculum links:** Living World - Life Processes Levels 6,7 - Evolution Levels 6,7
- **Radio interview:** *http://www.radionz.co.nz/national/programmes/ourchangingworld/20120823*
- **Open access publication:** *http://www.plosgenetics.org/article/info%3Adoi%2F10.1371%2Fjournal.pgen.1002489*

PROFESSOR MARK PAGEL: NEW ZEALAND VISIT

Recent Allan Wilson Centre guest lecturer, Professor Mark Pagel, made the most of his visit to see as many of our long-time residents as possible, including Takahē at Zealandia, and Yellow-eyed Penguins in Dunedin.

After a long and unusually sunless UK winter, he enjoyed the 30 degree heat in Gisborne, and being able to stride out on the exquisitely lonely beaches of Taieri Head. His lectures around New Zealand were extremely popular; the essential idea of language as an evolutionary tracer, akin to DNA, of how humans spread around the globe - intrigued audiences. His final message was sobering. The future for the world's 7000 or so languages is bleak, he predicts: "mass extinction" – and within a very short period of time.

A link to the recording of Mark's Wellington lecture is available at *www.allanwilsoncentre.ac.nz*



BUSINESS AND SCIENCE MEET TO VALUE NATURE

As the country's biodiversity champion, the Allan Wilson Centre will be supporting a landmark conference where business, science, national and local government will start working out how to factor the value of nature's services into our national accounts, products and services. Examples include water and air quality regulation, nutrient cycling, plant pollination, flood and erosion control and food, fuel and fibre.

This is now a matter of necessity for our survival and, from a purely expedient marketing standpoint, educated and concerned consumers around the world are demanding to know the provenance of goods, and methods and carbon content of production.

Valuing Nature: the economy and the environment will take place at the Embassy Theatre, Wellington, on 9 and 10 July 2013. Says AWC Emeritus Investigator, Professor Charles Daugherty, "this Theatre is the famous launch pad for great New Zealand creative endeavours." The Conference is being organized by Victoria University of Wellington, the NZ Government's Natural Resources Sector (a collective of 7 government departments), in association with the Sustainable Business Council. Keynote speakers include world expert on the economics of ecosystems and biodiversity (TEEB), Pavan Sukhdev, and Sir Robert Watson, Director for Strategic Development at the UK Tyndall Centre.

The Allan Wilson Centre will demonstrate its commitment to making its research meaningful and of practical use to New Zealanders by showing delegates the work it has been supporting in Uawa/Tolaga Bay, where restoration of biodiversity is uniting the community around a shared vision and clear plan for achieving it. The expected benefits include improved human health and wellbeing, new jobs, tourism, and improved land and forestry management. The plan being developed will be a useful model for other small coastal communities.

To find out more about the conference, go to *www.valuingnature.org.nz*

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