MARSDEN FUND

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UPDATE

Marsden celebrates 10 years

Sir Ian
Dinner at Te Papa. Photo: James Gilberd.

The Marsden Fund is now 10 years old. The Fund was announced in the 1994 Budget but it wasn't until November of that year that the Minister of Research, Science, and Technology, Rt Hon. Simon Upton, gave it a name and appointed the Committee to run it. The inaugural Marsden Fund Committee was chaired by Sir Ian Axford, and included Professors Carolyn Burns, Dick Walcott, George Petersen, and Roy Kerr, and Drs Garth Carnaby, Roger Slack, and Janet Davidson. The first round of competitive bidding was in 1995, when funds totalling nearly $6 million were up for grabs. The Fund grew rapidly for a couple of years, and has grown steadily ever since. This year, nearly $40 million was allocated to new projects.

Professor Diana Hill took over from Sir Ian as Chair of the Fund and served for nearly 7 years, during which time the Committee was transformed into a Council, and a Fast-Start funding category was introduced. Since mid 2005, Dr Garth Carnaby has chaired the Fund.

The Fund celebrated its tenth anniversary at the Science Honours Dinner, held in mid November at Te Papa. The Marsden table included all three Chairs of the Fund, along with former and present members of the Council, and Marsden staff. It was particularly fitting that Sir Ernest Marsden's son, Dr Tim Marsden, attended and also presented the Marsden Medal (on behalf of the New Zealand Association of Scientists) to this year's winner, Dr Kevin Tate.

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From the Minister – Hon. Steve Maharey

A milestone like turning ten is a good opportunity to revel in just how many Marsden funded projects have contributed significantly to New Zealand science, global knowledge and the wellbeing of New Zealanders.

When much of the media publicity for scientific and technological research tends to concentrate on ideas that have commercial potential or health benefits, we should not overlook the fact that many of those ideas would not have seen the light of day had it not been for the 'blue skies' research of the type funded through the Marsden Fund.

Marsden Fund projects reward excellence of the research and researcher. They are not only held in high regard in New Zealand, but are well-known internationally. It is pleasing to hear so many examples of top researchers being lauded on the international stage.

Two examples of note are:

In 2004 Professor Paul Callaghan was awarded the prestigious Ampere Prize for his work (funded by Marsden) on nuclear magnetic resonance imaging. He was the first scientist from outside Europe to win the award.

Minister of Research, Science, and Technology, Hon. Steve Maharey.

In June 2005, Associate Professor Richard Blaikie was included in *New Scientist*'s timeline – A Brief History of Negative Refraction. His work demonstrates a technique to focus light more tightly, overcoming the barrier to further miniaturisation of silicon chips. On that list, his name stands alongside the likes of French scientist and mathematician Rene Descartes, Dutch mathematician Willebrord Snell, and Scottish physicist James Clerk Maxwell.

Coming from a social science background, I am also intrigued by Marsden Fund projects that explore New Zealand history and culture, including work by linguists on the origins of New Zealand English, using broadcasting archive material of people born as early as the 1870s.

At its inception, the size of the Marsden Fund was $5.574 million. Next year the Marsden Fund Council will allocate just over $38 million. As Minister of Research, Science and Technology, I will continue to support the pure 'blue skies' research funded through the Marsden Fund. I recognise its importance in transforming New Zealand into a dynamic, knowledge-based economy and society and demonstrating our excellence on the international stage.

Congratulations on the first 10 years of the Marsden Fund. May there be many decades more of the Marsden Fund and the fascinating and varied research it supports.

Ten years on – Rt Hon. Simon Upton

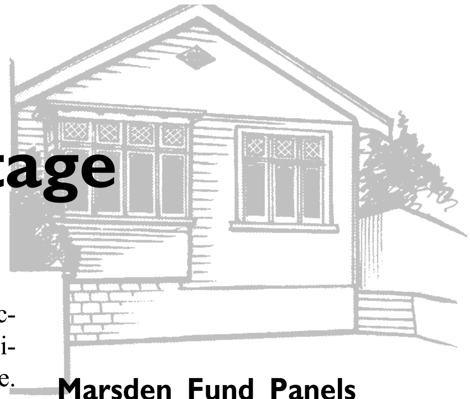
Ten years on, the Marsden Fund has become the most respected and 'established' part of the New Zealand science system. It was born at the end of a particularly cataclysmic era of upheaval in the way we fund and organise public science in New Zealand. It would be a rash person who claimed that the Marsden Fund has become such a settled part of the landscape that it is immutable. But it's about as close as you can get to that. Structures and institutions come and go. But the need for a dedicated, 'blue skies' fund catering for the very best researchers is beyond debate and I can imagine no politician who would seriously question whether this was a wise use of resources.

If only it had been as easy to establish the Fund in the first place! In truth, it was probably only when contestable, output-based funding had been instituted that the critical need for something like the Marsden Fund became clear – at least to political eyes. There is a certain hubris about believing that bureaucrats (on behalf of politicians) can 'purchase' science. The Marsden Fund was an implicit admission that no bureaucratic system can gravely buy the alchemy that flows from first class brains with hunches.

Of all the initiatives I was associated with during the 1990s, the Marsden Fund is the one in which I take the most continuing pleasure. Trawling through the list of grants since 1995 I am delighted that we have managed to solicit such a range of proposals from such a wide cross section of our research community. I can't wait to see what the next ten years brings forth.

Rt Hon. Simon Upton, Minister of Research, Science, and Technology from 1990–1996, and currently Chairman of the OECD Round Table on Sustainable Development.

News from Marsden Cottage



by Dr Don Smith, Manager, Research Funding

Tenth anniversary

Since the first funding round was held in 1995, the Fund has become an important part of New Zealand's research scene. 875 projects have received funding and over 1,500 researchers have been principal or associate investigators on Marsden projects. Some of these people and their projects are highlighted in this issue of Marsden Update. Another important contribution the Fund has made has been in supporting the training and career development of new researchers. This includes 340 postdoctoral fellows and more than 500 postgraduate researchers.

A special privilege for the Fund this year was to be able to invite Dr Tim Marsden and his wife, Dr Adair Marsden, to be our guests of honour at the Royal Society's 2005 Science Honours Dinner. Dr Marsden is the son of Sir Ernest Marsden after whom the Fund is named. Dr Marsden presented the Marsden Medal on behalf of the NZ Association of Scientists to this year's recipient, Dr Kevin Tate. It was especially heart-warming to note how many of the recipients of awards at this year's Science Honours Dinner had been supported by the Fund.

The Fund is in good shape. It has grown from $5.5 million in its first year to over $38 million this year and continues to receive strong support from the government. We look forward to the next 10 years.

Applications for 2006

The next funding round sees the introduction of a new system for making preliminary proposals called Proposals On-Line. A web portal has been created through which applicants can prepare and submit electronic versions of their proposals. Paper versions will still be required, but fewer copies than in the past. The deadline for preliminary proposals is 9 February 2006. The new system will allow the assessment of the preliminary proposals to be completed earlier than previously and give those who are invited to submit full proposals more time to prepare their applications. Information about Proposals On-Line and guidelines for preliminary proposals are available from research offices at institutions, from the Marsden Fund office and are on our web site: www.rsnz.org/funding/marsden_fund/

Other documents relating to the process such as information on full proposals, guidelines for panellists and referees, and the list of panellists for 2006 will be on the web site from mid December.

There are no changes to the rules for applications for 2006 other than the preferred size range for proposals to the Mathematical and Information Sciences panel being increased slightly. There are also some minor layout changes to the application documents, so please be sure that you consult the latest version of the guidelines if you are intending to apply.

Marsden Fund Panels

The continued interest in the Fund from the social sciences has led to the establishment of a new panel for 2006 and a redistribution of some of the panel responsibilities. Proposals relating to research into law and some cultural studies subjects will now be handled by the Humanities panel and the new Economics and Human & Behavioural Sciences Panel will be responsible for proposals relating to economics; education; psychology (experimental, cognitive, neuro-); cognitive science; linguistics; archaeology; anthropology (other than social anthropology) and demography. All the remaining social science subjects will remain with the Social Sciences panel.

Christmas Greetings

The Marsden Fund staff wish you all a very good and satisfying year in 2006.

From the Chair – Dr Garth Carnaby

The community we live in today is the result of transplanting cultures from the Pacific, Europe, Asia, and elsewhere to our physically isolated location. In the humanities and social sciences, there are many new 'big questions' to be asked and researched about the evolution and diversity of our multiple cultural identities. There are many aspects of our unique local environment and society which we are intensely curious about. Equally many of us aspire to a wealthy and informed first world lifestyle, one which is intimately connected globally to emerging scientific and technological knowledge.

Ours is a small economy and we depend heavily on access to discoveries and knowledge created elsewhere as well as here. It is not enough that our best brains are just aware of the issues and discoveries at the frontiers of modern science. It is through the active participation in and contribution to global scientific endeavour by our best researchers, that New Zealand can expect to remain intimately involved, and hence achieve a fully competent modern society.

The size of the Marsden Fund, and the public nature of its funding, demand that only the very brightest can be supported by it, to do such wholly undirected research. That is why there is such a demanding and competitive application system, with selection based on an international peer review process overseen by leading New Zealand researchers.

Despite these constraints on scale, a decade of growth in the Marsden Fund has transformed the scope of New Zealand's research culture and provided the seeding funding for many researcher inspired initiatives which are now regarded as mainstream areas where New Zealand has recognised international leadership.

Sir Ernest Marsden – a remarkable life in science

The Marsden Fund takes its name from 'Ernie' Marsden, the founding secretary of the DSIR in 1926, and a scientific leader whose lively imagination and new and provocative ideas epitomises what the Fund stands for. This article tells his story.

In 1909, the life of a 20-year-old physics undergraduate at Manchester's Victoria University changed forever after he came under the wing of the New Zealand experimental physicist Ernest Rutherford, a recently appointed professor of physics.

The young man's name was Ernest Marsden, the son of a Lancashire cotton weaver, whose academic abilities saw him winning scholarships, first to grammar school, and then to university.

Marsden was in the final year of his degree course when he went to work with Rutherford's research assistant Hans Geiger, who was undertaking experiments for Rutherford on alpha particle scattering from thin foils.

Marsden's subsequent finding that a few of the particles bounced right back came as a complete surprise, overturning current ideas of the structure of the atom. Rutherford was stunned and delighted at this result, helping inspire his subsequent nuclear model of the atom, in which most of its mass is concentrated in a minute, positively charged central nucleus. To quote Rutherford: "I suggested to one of my students, E. Marsden, that it would be of interest to examine whether any alpha particles were scattered in a backward direction from a metal plate. I did not have any good reason to expect a positive result."

Ernest Marsden, BSc (1st class Honours), Victoria University, Manchester (circa 1909).

The publication of Geiger and Marsden's findings that year can now be seen as one of the great moments of 20th century physics, making their names known to scientists worldwide. Marsden, meanwhile, completed his BSc with first class honours and, after a brief period as a lecturer at Imperial College, London, continued to work with Rutherford.

In 1914, on the recommendation of Rutherford, Marsden was appointed professor of physics at Victoria College of the University of New Zealand. He arrived here in May of the following year, and quickly volunteered for war service with the NZ Expeditionary Force, later serving in France with the Royal Engineers. He received a Military Cross for his war service.

Back in Wellington, Marsden carved out a reputation as an energetic and inspirational lecturer, and undertook a range of research into radioactivity and new areas of local interest, such as cosmic rays, electrical induction, and fossil fuel efficiency. He showed early evidence of his considerable skills as a persuader by successfully lobbying for a new physics laboratory.

In 1922, the 33-year-old physics professor surprised his academic colleagues by taking up the position of Assistant Director of Education in the Department of Education. A Royal Commission on University Education with Marsden as secretary led to the establishment of Massey University College.

The Lancashireman remained active in science circles and sat on many committees and inquiries on both education and research. A local reorganisation of science based on a British model later saw him appointed secretary of the Department of Scientific and Industrial Research (DSIR). At the time he took it over, DSIR had barely two dozen staff drawn from various Government departments and was constrained by a biological/geological bias.

An early survey that Marsden led into the country's research needs identified a range of serious problems in agriculture and food processing. Among these were bush sickness, poor baking quality in flour, and deterioration in chilled meat and fruit exports.

'Ernie' Marsden spent the next two decades building the superstructure of the new department. He well understood that in 1920s New Zealand, the imperative was bringing science to the nation's farmers. He got busy, helping set up many DSIR divisions such as Grasslands, Crop Research, Entomology, Plant Disease, Botany, Fruit Research, and the Soil Bureau.

With his help, some parts of the early DSIR, such as the Dairy Research Institute and the Wool Research Organisation, became independent research organisations, jointly funded by industry and government. He showed remarkable proficiency at gaining outside funding and getting Government to match it.

After the 1935 election, he was able to expand the DSIR's role in carrying out state-funded research as part of a highly publicised mission to 'put science into NZ industry'. The war years saw Marsden increasingly involving himself in defence work. He travelled to London early in 1939 for briefings on radar, a new technology he felt New Zealand could assist in.

Homegrown radar sets later become part of a range of scientific projects fostered here as part of the war effort. He made many visits to the northern hemisphere during the war years, keeping up to date with scientific and technological developments.

Just four months after his 1947 election as president of the Royal Society of New Zealand, Marsden made another of his unconventional career shifts when he returned to London as New Zealand's scientific liaison officer. This role saw him becoming an ambassador of science for the country – making contacts, collecting information and serving on international committees.

Biographer Ross Galbreath comments: "He now dominated New Zealand science to an extent unequalled since James Hector in the 1870s."

But his ties with New Zealand remained strong. On turning 65 in 1954, he returned to Wellington to retire, remaining busy with work on Royal Society of New Zealand advisory committees, such as the Committee on Atom Bomb Test Fallout. He also returned to research on radiation – 45 years after his great breakthrough in Manchester.

Ernest Marsden's remarkable contributions to science – and to his adopted country – were recognised by many honours. He received a fellowship of the Royal Society of London in 1946, and was made a Knight Bachelor in 1958.

Confined to a wheelchair in 1966 after a severe stroke, Sir Ernest Marsden died at his home in Lowry Bay, on the shores of Wellington harbour, in 1970.

Reprinted from *Marsden Update*, Volume 14, December 2000 (edited by Redmer Yska).

A son's personal perspective

Dr Tim Marsden, son of Sir Ernest Marsden, reminisces about his father

Tim Marsden, a retired GP and son of Sir Ernest Marsden, has fond memories of his childhood, and interesting stories to tell about his father. "He was a good father," he said, "although he was very busy, he cared for my sister and me." Father and son enjoyed many of the usual activities fundamental to a New Zealand childhood. "He took me to football matches, and fishing," he recalled. Ernest's mathematical knowledge also proved useful to his teenage son. When Tim was 15 years old, he remembers being assigned a difficult series of mathematical problems for homework one night. After struggling with the first equations for quite some time, in exasperation, he went to his father for help with the remaining one. "He had it solved in about one minute," said Tim, "and it was a very difficult one too."

Drs Tim and Adair Marsden. Photo: James Gilberd.

Tennis was another activity that Sir Ernest enjoyed, as well as trips to the family beach house at Raumati South, on the Kapiti coast, which the family purchased around 1930. "He and some friends each bought sections, one street back from the beach,' said Tim. "Each one cost only 25 pounds, or $50! My father enjoyed going up there. He used to take us frequently to

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How does evolution work?

The research of Professor David Penny

He is sometimes known as 'Mr Marsden', and with good reason. Professor David Penny, Research Director of the Allan Wilson Centre for Molecular Ecology and Evolution, and Professor of Theoretical Biology at Massey University, has been a principal investigator on no fewer than eight Marsden grants for his research in the field of theoretical evolution – more than any other researcher to date.

Professor Penny's research interests are wide-ranging, involving numerous collaborations with scientists from New Zealand and around the world. Each project involves tackling some aspect of the evolutionary history of life, and all are interesting and important in their own right. However, at a higher level, David Penny and his colleagues are trying to answer one of the biggest questions of all: are the genetic and ecological processes we can study in the lab and in the field (microevolution) sufficient to explain all of macroevolution?

The processes involved in the evolution of life have long been the subject of scientific debate. Most evolution is thought to occur through gradual, small-scale changes, known as 'microevolution'. The fossil record, however, has been interpreted to show evidence of a number of mysterious, major evolutionary changes, which appear to have occurred in geologically short time spans. Known as 'macroevolution', two classic examples of this are the extinction of the dinosaurs and rise of the mammals, and the evolution of the human brain. These events are so dramatic that they have led some evolutionary theorists to suggest that 'everyday' evolutionary processes are not enough, and that something much more major must have occurred. But is this the case?

The quest to solve this mystery is behind every aspect of Professor Penny and his colleagues' diverse research. "It is a big question, so we have to divide it into smaller ones", he explained. "All of our projects contain examples where people have claimed that microevolution is not sufficient to explain the macroevolution that occurred."

One of their most intriguing projects has been to investigate what makes us human, genetically speaking. The human species and, in particular, the human brain, is often considered an evolutionary phenomenon, leading some to assume that a major event must have occurred in order for humans to exist. But is there actually anything in our genetic makeup that could not have arisen by everyday evolutionary processes? One way to answer this is to see what separates us from our closest living relative, the chimpanzee, by comparing the complete genomes of the two species. The results of this research are proving fascinating, and support the microevolution hypothesis. "Humans are different from chimpanzees based on a series of small changes, not anything large, dramatic or unusual," said Professor Penny.

A second interesting project is the investigation of the evolutionary events surrounding the extinction of the dinosaurs, 65 million years ago. Known as the K/T (Cretaceous/Tertiary) boundary, the exact series of events that occurred during this time has always been somewhat of a mystery. The popular view is that dinosaurs were flourishing until the end of the Cretaceous when, suddenly and unexpectedly, they became extinct as the result of the impact of a large meteorite. With the extinction of the dinosaurs, mammals and birds could then diversify and occupy the vacant niches left behind. But was this really what happened?

"The meteorite impact is totally real," said Professor Penny, "but did this actually wipe out the dinosaurs?" To answer this issue, the team is building evolutionary trees of both birds and mammals to see just when they began to diversify into the main groups that exist today, and are conducting a detailed examination of dinosaur fossil data. The project involves the generation of a large amount of new information, including complete mitochondrial genomes of birds and mammals and an improved database of fossil records, and then a major analysis.

So far, the results suggest that birds and mammals appear to have diversified *before* the K/T boundary, and that dinosaurs and pterosaurs also began to decline well before this. The evolution of the main mammalian groups appears to have occurred over tens of millions of years, and by normal evolutionary genetic mechanisms. The dinosaur fossil data appears to show that all small dinosaurs had in fact already disappeared before the meteorite impact. This is exactly what would be predicted if there was competition between small dinosaurs and early mammals. As a result of this research, Professor Penny believes there is almost no chance of the impact being the ultimate cause of the dinosaurs' demise.

Another ongoing project is to investigate the origin of the eukaryotic cell – the name given to all cells that contain a nucleus. Eukaryotic cells make up the bodies of all animals, plants, and fungi. The standard model is that the eukaryotic cell arose through another dramatic evolutionary event: the fusion of an archaeon and a bacterium. This model suggests that bacteria are one of the most ancient organisms on Earth, and are simple in structure because they have never developed the complex structures seen in more 'modern' forms of life. Now, however, this idea is being challenged.

Professor Penny is exploring the idea that eukaryotes may not be fusions, but could, in fact, be *ancestral* to bacteria. Genetic examination of bacterial and eukaryote genomes do not show the expected evidence that a merger has occurred, and seem to support the idea that eukaryotes are the older form of life. David Penny suggests that bacteria, far from being primitive, are actually refined and simplified, perfect for the job they do. "They're the racing cars of the biological world," he joked. "They are really specialised for one job. They do it brilliantly and they do it fast."

Finally, one of Professor Penny's newest projects is to investigate an evolutionary phenomenon known as the Cambrian explosion, which occurred 545 million years ago. Fossil evidence from this time appears to suggest that over a geologically short period of time – 5 to 10 million years – a very large number of diverse body plans evolved. It is known that many

Professor David Penny.

genes are involved in body development, so how did the process happen so fast? This is another apparent example of macroevolution at work, and Professor Penny and his colleagues are aiming to find out just what occurred.

David Penny believes that his team's research will ultimately show that small-scale evolutionary processes are in fact enough to explain most of the major evolutionary events that have occurred in the past. In keeping with his other projects, he has his own theory to explain why many scientists believe in catastrophes and large and dramatic events. "I think humans have been evolutionarily selected to be aware of potential disaster. That's why scientists go for disaster scenarios first," he said. "Looking for a catastrophe is a very human way of thinking. But once we see there are alternatives, we can test them." He believes scientists should be willing to admit when a theory is past its use-by date, and likes to apply this approach to his own work. "I like to use theories like a carpenter uses tools, and use a better tool if it comes along. It's a win-win situation if you are wrong because you get something new. We're using theories to see if we can think of new ideas. In practice, however, you do get attached to your theories – but we must be cured of that."

Professor Penny says that the Marsden funding he has received has been extremely valuable in helping his research to move ahead. "We're doing the big questions that we have to take in little bites," he explained. "Within each project there's a lot of work – computing, sequencing, and mathematics. We have a very skilled group, but only since we've had the Marsden Fund have we been able to do the lab work to get the data to help test the ideas."

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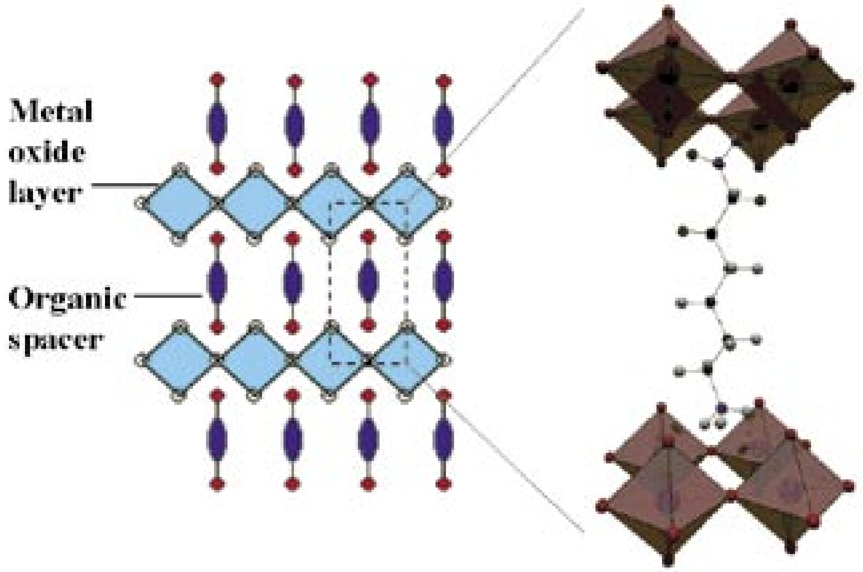
David Penny was interviewed by the editor of Marsden Update, Anna Meyer (pictured). Anna has a PhD in science communication from the Australian National University, and an Honours degree in genetics and biochemistry from Massey University. She is the author of the popular science book, *Hunting the Double Helix: How DNA is Solving Puzzles of the Past.*

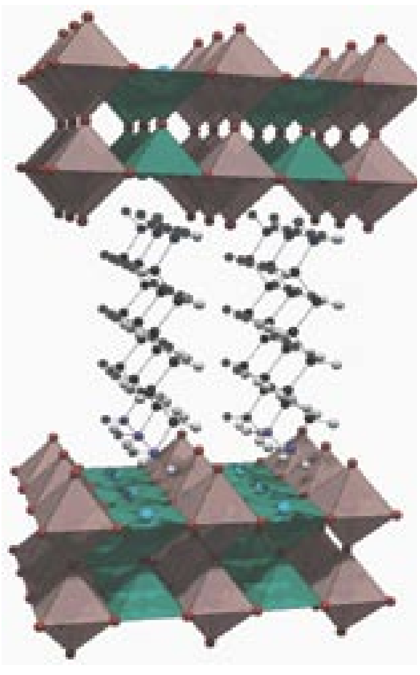
Ladders and layers – organic-inorganic hybrids

There is a basic division in nature between living and non-living, and it is a similar situation in the chemical world, too, where there are two separate groups: organic and inorganic. Organic compounds are generally produced by living things, and are made up of a basic skeleton of carbon and hydrogen, whereas inorganic compounds are generally produced by non-living natural processes. Sometimes, however, these two basic classes of compounds come together, to form substances known as organic-inorganic hybrids. These interesting materials are present all around us, from the makeup of mammalian bones, to the lustrous shells of shellfish.

Over the past three years, a research team, led by Professor Jeff Tallon and drawn mainly from Industrial Research Ltd and Victoria University, has been conducting research to create novel hybrid materials, learn more about their fascinating properties, and to explore their potential uses in electronic and magnetic devices.



Schematic diagram of an organic-inorganic hybrid oxide. The tungsten atoms are surrounded by octahedral cages of oxygen atoms.



Structure of a 50% tungsten, 50% copper layered organic-inorganic hybrid oxide. The metal oxide forms in a double layer, creating ladders of copper oxide (green square pyramids) and tungsten oxide (maroon octahedra).

The research focusses on a new type of highly unusual organic-inorganic hybrid, which consists of alternating layers of organic and inorganic sheets. The organic part is based mainly on amines (compounds containing NH_2 groups), which include substances such as nicotine, morphine, heroin and caffeine. The inorganic layer consists of tungsten oxide.

It was proposed that, in this material, the rigid inorganic layer could provide the complex electronic properties that are found in metal oxides – properties that lead to phenomena such as magnetism or superconductivity. Such materials can usually only be made at very high temperatures (>900°C) leading to difficult and expensive manufacturing processes. The organic molecules, on the other hand, would bind the layers together, provide mechanical flexibility, and control the electronic communication between the inorganic layers. Taken together, these properties could mean the materials have a variety of uses in electrical and magnetic devices. Most importantly, these hybrids self assemble into their complex structure at room temperature, making for potentially cheap and flexible manufacture.

One of the aims of the project was to explore the possibility of fine-tuning some of the useful properties of the oxide sheets, by varying the length and composition of the organic layers. Amines come in a large variety of shapes and sizes, and each could lend slightly different properties to the hybrid material, which could lead to a variety of novel features and applications. The research team, which included postdoctoral fellow, Dr Shen Chong, and Dr Bridget Ingham (who completed a PhD during the project), has succeeded in preparing many of these hybrid compounds, each of which has subtle differences in the organic layers. They have also used combinations of different type of metals within the tungsten-oxide layer. Depending on the combination of molecules, different physical and chemical structures were obtained.

The most interesting of the substances that the team produced is a class of compounds where the tungsten atoms are partially substituted with transition metals. Transition metals include elements such as copper, zinc, iron, cobalt and manganese. When half of the tungsten atoms are replaced by transition metal atoms, the transition metals form one-dimensional magnetic 'ladders', separated by non-magnetic ladders of tungsten oxide. Such materials are exceedingly interesting because they combine one-dimensional objects (the ladders) with two-dimensional oxide layers, to form a three-dimensional network of ladders and layers. Physics in one or two dimensions is different from physics in three dimensions, leading to many interesting effects. Small changes in pressure, temperature, or magnetic field can cause the material to lurch from being an insulator, to a metal, a magnet, or perhaps even a superconductor. The researchers' novel materials provide an ideal set of model compounds in which to investigate these effects.

The compounds can also be made into thin films. This means that there is the possibility to use the materials in devices such as sensors, transistors, or memory storage devices. So far, the group has successfully fabricated and tested a field-effect transistor, a key device used in electronics and computer technologies.

These studies have deepened our knowledge and appreciation of the architecture of these interesting substances. The versatility of these materials, and their structural variation, make them a rich source of new physics and promising technologies.

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Kapiti Island, where the fishing in those days was brilliant. On one occasion, he and Dr Mick Watt, our neighbour and, at that time, Director General of Health, lit a small fire to help clear their sections. They put it out, or so they thought, and went for a walk up the beach. Black smoke soon indicated the whole hillside was alight. Fortunately, at the time, there were no houses nearby, and I think all they received was a small rebuke from the local volunteer fire department."

Although very young at the time his father was a working physicist, Tim recalls that Ernest always spoke with admiration about his time with Rutherford. "Rutherford was like a God to him – he greatly admired him," he said. Tim remembers meeting Rutherford in person when he was about nine years old, when the scientist was a dinner guest at their home. "He was a big, tall man," he recalled. Tim also enjoyed the company of Rutherford's brother, Jim, who taught Tim how to catch trout.

The First World War was a worrying time for the Marsden family, as it was for most families at the time, and its effects were felt by Sir Ernest even after it had ended. "The war was quite unsettling for my father", said Tim. "It was a huge interruption for people's lives. After the war, he was restless, and found it difficult to settle."

Fortunately, Marsden used this restlessness to his advantage, and become heavily involved in the development of the fledgling DSIR. The post-war years were a very busy time for New Zealand science, and the DSIR in particular. "After the war, New Zealand was opening up, and the DSIR had a great diversity," said Tim. "My father enjoyed the travel involved. He used to ring my mother and say: Pack me a bag, I've got to go straight away to Auckland or Christchurch, etc. In those days, there was no air travel and all was done by train or ferry. He led a very busy life, and he enjoyed the excitement of it."

Ernest Marsden's work meant that he had close involvement with Parliament, and Tim recalls as a teenager picking his father up from work there. Sir Ernest was friendly with Prime Minister George Forbes, and travelled to England with him. Tim recalls that his father got quite a surprise when Labour was elected in 1935. However, as it turned out, the DSIR benefited from this turn of events; "they got a good deal from Labour".

Late in 1939, Ernest returned from the UK after doing a crash course in radar, but was disappointed when the Armed Forces chiefs did not want to know about it. So, early one morning, he and Charles Watson Munro (later Professor of Physics at Monash University in Melbourne) went up Mount Victoria, in Wellington. They knew the ship *HMNZS Achilles* was coming into port that morning so, even though it was pitch dark, with their radar set, it was easy for them to track *Achilles'* exact course and time of entry. "Father that morning presented the data to a defence meeting. At first, they accused him of having an informer on board, but this was soon disproved and the acceptance of the new technology was confirmed."

Sir Ernest's working life was certainly not without its share of amusing incidents. One of these involved the family dog, Bunny, who Marsden often took to work with him at Parliament, where the pet became very well known. One day, during the term of the second Labour government in the late 1950s, Bunny found and chased a rat through the corridors of Parliament. Unfortunately, this activity happened in front of the Prime Minister's wife, Mrs Nash, who sustained a terrible fright. Fortunately, no real harm was done.

After retirement, Marsden continued to stay involved with science, and became very interested in the radioactivity in various tobaccos from around the world, and spent much time measuring the levels. He had a theory that the emissions from the active smoke punched minute holes in cell walls, allowing carcinogens to enter and trigger the development of lung or bladder cancer.

Science has continued to be a theme in the latest generations of the Marsden family. "Our son, Alastair, was born in 1957, the year the Sputnik was launched," said Tim. "My father, who seemed very fond of him, always called him 'young Sputnik'. Alastair is now an Associate Professor of Commerce at Auckland, and he has a son, Hamish, who was born on 19th February, 1998, exactly 109 years after his great grandfather. Hamish is already showing a great affinity with maths, and solving quite difficult sums in his head, to the wonder of his teacher and the other kids. Hopefully, the genes are filtering down!"

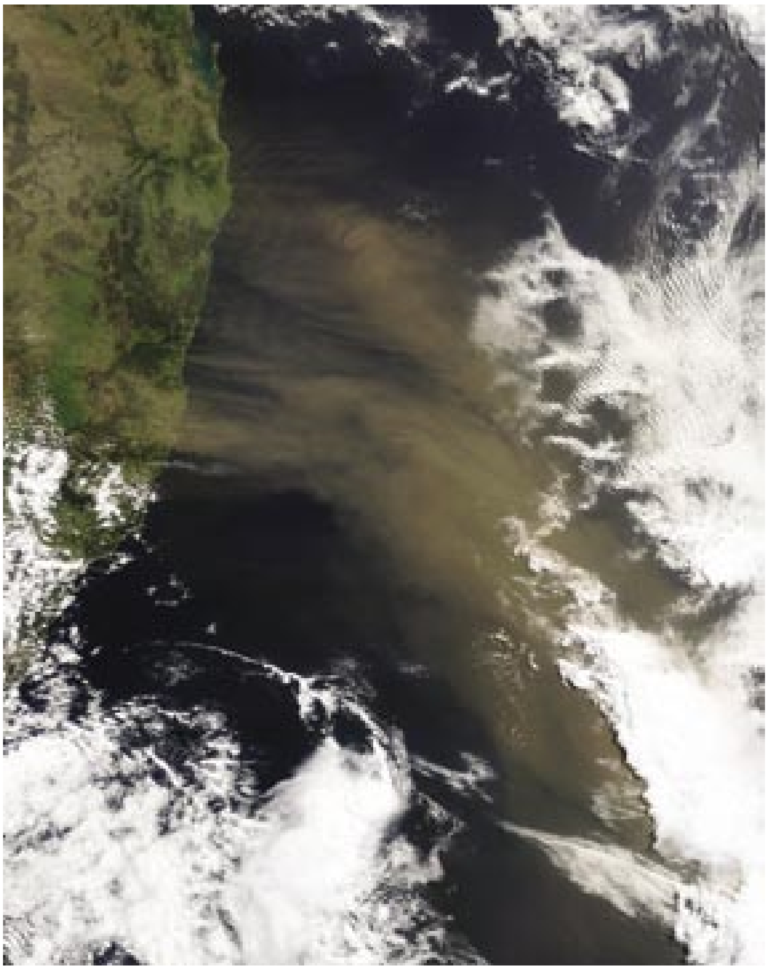
Outback dust and ocean blooms

Every decade or so, there is a fall of pink snow on the Southern Alps. The colour is due to the red and orange iron oxides that blow across in dust from the Australian outback. In a large dust storm, an incredible 5 million tonnes of soil can leave Australia, and be wind-transported over 3,000 km to the Southern Alps – and beyond.

Interestingly, these iron-rich dust storms may also have an effect on the growth of our ocean plants. Large parts of the Southern Ocean are naturally low in iron, and this limits the growth of microscopic marine plants, known as phytoplankton. However, satellite imagery has shown that occasional, unexplained, phytoplankton blooms occur in the Southern Ocean. Experiments have shown that adding dissolved iron directly to the ocean also causes a transitory 'bloom' of phytoplankton. Could these mysterious blooms, therefore, be due to iron fallout from big dust storms?

A key issue is to discover just how much iron from the dust storms can actually be used by the phytoplankton. Traditionally, it has been assumed that if the mass of soil contained in a dust-storm and the iron content of the soil are known, then it should be easy to work out how much iron was delivered to the phytoplankton. However, deep-sea sediments from the Tasman Sea contain plenty of iron rich dust, showing that not all iron is captured by plants before sinking. This indicates that the solubility of the iron is also an important factor.

With the help of a Marsden grant, the Centre for Physical and Chemical Oceanography (a joint venture between NIWA and the University of Otago), has brought together a team to study this in more detail. It is led by Professor Keith Hunter from the Department of Chemistry at the University of Otago and Dr Philip Boyd from NIWA, with collaboration from Dr Grant McTainsh at Griffith University, Brisbane, and postdoctoral fellow Dr Doug Mackie from the University of Otago.



A front of dust, stretching from Sydney to Brisbane, leaves the coast of Australia at 60 km/h during a large storm in October 2003 (Image courtesy of NASA).

Dr Mackie has been simulating how the dust gets processed in clouds, to establish what factors influence the extent to which iron gets dissolved from the dust. It turns out that there are three reservoirs of iron in the dust: very easily extractable, extractable, and difficult to extract. The precise proportion of each is not easily predictable, and depends on several factors, including grain size and pH during cloud processing. These factors themselves are variable; for example, grain size can change during a dust-storm, through abrasion as grains bang into each other and fracture.

Most previous studies have used Saharan or Gobi dust collected after transportation in the atmosphere, and data from this has been extrapolated to the Southern Ocean. However, Australian dust differs in several important respects, like the relative proportions of the different iron oxides. Also, dust collected after transportation has already undergone atmospheric processing. To minimise the effects of these factors in the simulations, Dr Mackie has been manufacturing dust using soil taken from a region in the Outback that produces dust-storms. The resulting 'artificial dust' is similar to some real dusts, especially regarding the rate at which each reservoir of iron is dissolved. This is assisting in working out the exact mechanism of how the iron dissolves. Knowing this will allow more precise calculations for the form in which iron is delivered to the surface layers of the oceans – the first step in determining the effect on marine life.

The next phase of the project will involve adding dust samples to lab cultures of phytoplankton, to find the extent and rate of uptake of each reservoir of iron. Ultimately, this research could help explain one of the ongoing mysteries of our oceans.

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Modelling the human lungs

The human lungs are incredibly complicated structures, consisting of thousands of airway branches and blood vessels, and millions of air sacs. Having a detailed computer model that could be used by researchers to investigate the structure, function, and mechanical stress of the lungs would be extremely useful in studying lung disease such as COPD (Chronic Obstructive Pulmonary Disease).

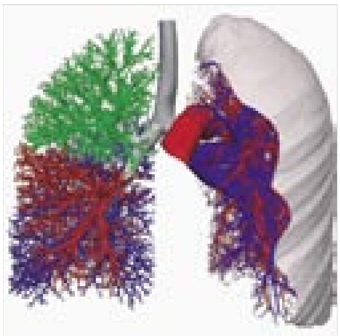
Dr Merryn Tawhai and Professor Peter Hunter, from The University of Auckland's Bioengineering Institute, recently completed a three year Marsden-funded research project to develop just such a model. The research built upon their experience in developing detailed mathematical descriptions of other anatomical structures, such as the heart and the musculo-skeletal system, and in using equations to describe physiological function.

Using a combination of medical imaging and specially designed computational mathematics, Dr Tawhai and Professor Hunter developed new methods to create mathematical models of the complex branching airways, their associated arteries and veins, and the soft tissue of the lung. The techniques are the only published methods to date that produce models with accurate relationships between the lungs, the airways, and blood vessels. The techniques can also be applied to model the lungs of other species, such as sheep.

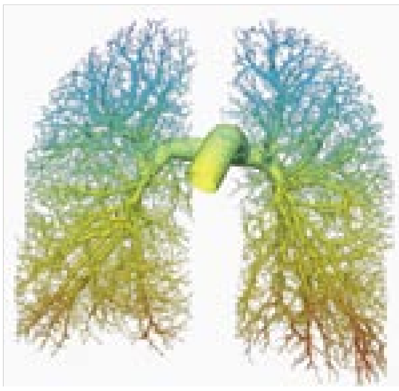
Predictions of arterial and venous blood flow in the completed model have highlighted the significant role of vascular branching in determining blood flow to the tissues of the lung. At a smaller scale, blood flow was also investigated through the lung's microcirculatory system. This involved the development of detailed models of its dense capillary network, and the solution of a system of equations that describes the relationship between factors such as air and blood pressure, individual capillary size, and their effect on blood cell velocity and distribution.

The model has a variety of potential uses. For example, modern medical imaging provides high resolution data that could potentially identify early changes in blood flow as a marker of disease, but a difficulty is that a large variation in blood flow is typical of the normal, healthy lung. A significant challenge, therefore, is to differentiate between normal and early disease-related patterns of blood flow. This demonstrates the importance of using computational techniques to understand complex function, particularly as the organ progresses from health through the various stages of disease. The modelling framework developed during this project is uniquely placed for application in this area.

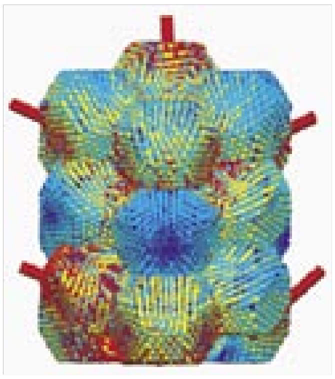
The research has resulted in 12 international journal publications to date, and has led to follow-on funding, through Dr Tawhai's collaboration with the University of Iowa, in two major research projects supported by the U.S. National Institutes of Health. Dr Kelly Burrowes completed her PhD on developing and analysing the models of blood flow.



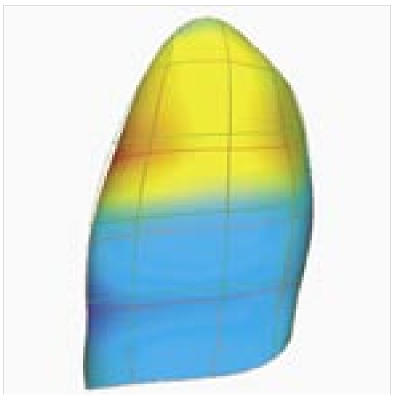
Human model airways in the right lung (right upper lobe in green, right middle lobe in red, right lower lobe in blue), and model arterial (red) and venous (blue) trees in the left lung, surrounded by a computed tomography image of the lung.

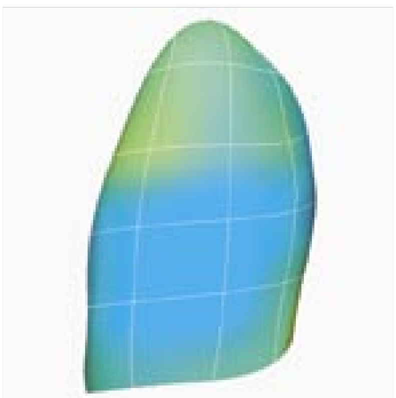


Blood pressure in the arterial tree. Pressure increases moving down the lung (with gravity).



Blood 'flow' through a single alveolar sac, the site of gas exchange in the lung. Several capillary networks thread the 19 alveoli in the sac. Highest flow is in red, and lowest in blue: preferential flow pathways are visible.





Pleural pressure (pressure on the membrane around the lung) at total lung capacity calculated from a model of lung soft tissue mechanics. The left image is for the vertical lung exposed to normal gravity, and the right image is for zero gravity.

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Genetic investigation of mass strandings of pilot whales

Professor Scott Baker (on the left) and the team – Dr Rochelle Constantine, Marc Oremus, and Debbie Steel (on the right).

Aristotle first reported on the mass stranding of whales and dolphins in 350 BC, commenting that this behaviour seemed to have "no apparent reason". More than two thousand years later, the phenomenon is still a mystery. Why do large groups of highly intelligent animals, in perfect health, end up stranded on the shore, certain to die? Even more mysterious, why do they often intentionally restrand after being refloated during rescue attempts?

As well as providing a compelling problem for humane management, mass strandings provide an important opportunity to improve our understanding of the social structure of the species involved in these events. Indeed, mass strandings almost exclusively affect species that form large cohesive social groups in the wild, such as sperm whales and pilot whales.

With the support of the Marsden Fund and the Whale and Dolphin Adoption Project (WADAP) fund, a team led by Professor Scott Baker, from the School of Biological Sciences at The University of Auckland, has been using DNA to investigate mass strandings of the long-finned pilot whale (*Globicephala melas*), the most common species involved in strandings in New Zealand, and around the world.

A decade of collaboration with the Department of Conservation and the Museum of New Zealand Te Papa Tongarewa has provided a database comprising more than 300 samples, representing 35 separate stranding events of long-finned pilot whales. By investigating genetic relatedness within and between mass strandings from around New Zealand, the team is beginning to gain unique insight into these tragic events.

Previous genetic studies of the social organisation of long-finned pilot whales have hypothesised that the species may live in extended matrilineal societies, where females and males remain with their mother, presumably for life. As a result, even pods made up of several hundred individuals are thought to be descended from a single female. Under this matrilineal hypothesis, the phenomenon of mass stranding could be explained by the urge to help close relatives. Maybe these whales simply refuse to give up on their associates, whatever happens to them, because these associates are actually close maternal relatives.

Professor Baker and his team's genetic investigation, however, reveals some contradictions with this previous work. By comparing sequences of the maternally inherited mitochondrial DNA from mass stranded whales, the researchers discovered that, at least some of the time, unrelated families of long-finned pilot whales stranded and died together. This finding discounts the hypothesis that large pods are always composed of maternal relatives and that the urge to assist close relatives is the single explanation for mass stranding.

Another interesting finding comes from a detailed study of a particular mass stranding on Stewart Island in 2003, where 122 whales died. Through the efforts of members of DoC Southland, samples were collected from all individuals, and the age, sex, and position on the beach of each whale was mapped. This showed that, contrary to a common expectation made during rescue attempts, females with their dependent young were not found to have stranded close together but, instead, were found widely separated along the beach.

It is not yet known if the observed separation of close kin is a cause or a consequence of stranding. However, this disruption of kinship bonds could help explain the behavioural distress of stranded individuals. More importantly, it may help explain the tendency of many whales to restrand even after being refloated.

The research team hopes that in future strandings, it will be possible to collect genetic samples from all individuals in a pod, and more detailed observations of behaviour. They also plan to begin sampling pods of pilot whales at sea, during more natural social interactions. With this information, it may at last be possible to begin to explain the enigma of 'death on the beach'.

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Decade of discovery

Red coral (*Errina novaezelandiae*), photographed in Fiordland by Stephen Wing.

2005 marks the 10th anniversary of the Marsden Fund. In its first decade, the Fund has supported a fascinating and diverse range of projects, which have resulted in a wide variety of intriguing discoveries. Some of New Zealand's top researchers have been strongly supported, helping them to create leading-edge new knowledge, to build their careers and international reputations, and to foster the next generation. Here, we present a sampler from the research from the first 10 years of the Fund.

Measuring the Earth's Wobble

The Canterbury Ring Laser project involves sending laser light in both directions around a rectangular path, allowing parts per million changes in the rotation of the Earth to be measured. This has culminated in the recent observation of a wobble in the Earth's axis of less than 1 m at the poles.
(*Marsden Update*, No. 31, June 2005)

Marine Ecology of Fiordland

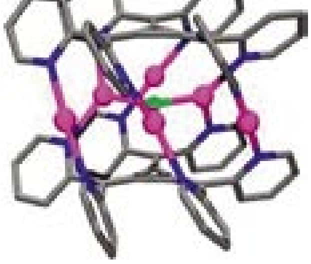
In the environmental area, Marsden funding has been supporting Dr Stephen Wing in his investigations of the marine ecology of Fiordland, particularly food webs and the dispersal of marine organisms. Along with work funded by the Ministry for the Environment and the Ministry of Fisheries, this has directly informed a management strategy for the Fiordland area, which has become enshrined in law as the Fiordland (Te Moana o Atawhenua) Marine Management Act 2005.

Using Maths to Study Evolution

Professors Mike Steel and Mike Hendy have made outstanding contributions to the mathematical theory which enables scientists to decipher the web of biological relationships from genetic sequences. More recently, they have been joined by Dr Charles Semple who, with Mike Steel, has published the first textbook on the construction and analysis of evolutionary trees from genetic data. The success of these three researchers has attracted at least one outstanding mathematician, Dr David Bryant, back to New Zealand, and to success in the latest Marsden funding round.

Silver Platter

Professor Peter Steel's research group at the University of Canterbury has made a variety of new organic molecules and used metal atoms to glue these together to make new discrete and polymeric supramolecular assemblies. For example, PhD student Chris Sumby managed to sandwich six silver atoms (pink) in a planar array within a complex organic framework – a nanometre-sized 'silver platter'.



Investigating Soft Materials

The research of one of New Zealand's foremost scientists, Professor Paul Callaghan, has been consistently supported by Marsden over the last decade. Paul Callaghan is an authority on nuclear magnetic resonance imaging, a technique which provides information on the position and movement of atoms. Marsden has supported his investigations of the flow of soft materials, complementing FRST funding on other aspects of his work. The quality of this research not only enhances New Zealand's scientific reputation, but also feeds into industrial processes of national importance.

Professor Michael Walker.

Professor Paul Callaghan.

Predicting Volcanic Eruptions

New Zealand is a superb natural laboratory in which to study earthquakes, volcanoes and plate tectonics. By observing how seismic waves moved through the ground around Mt Ruapehu before and after the 1995–1996 eruptions, Dr Martha Savage and her research team have discovered a possible technique to predict when future eruptions may occur. The technique is based on the effect on the waves of tiny cracks in the earth that change in size and direction as volcanic stress increases.

Navigation of Migratory Animals

How do migratory animals navigate? Professor Michael Walker and his colleagues have demonstrated that the magnetic sense of trout and pigeons is based on very small crystals of magnetite in the nose or beak of the animal. They have also shown that homing pigeons navigate by detecting changes in the strength of the Earth's magnetic field. This work is a significant advance towards understanding the navigational feats of migratory animals. The research has led to 3 publications in *Nature* since 1997, the most recent of which has been selected by "Faculty of 1000" as one of the most important papers in biology.

How Limestone Forms

Limestones were traditionally thought to have formed solely in warm, shallow tropical seas. However, most of New Zealand's limestone deposits were created in cool sea water. A Marsden-funded team, led by Professor Cam Nelson, has studied in detail the limestone ridges in the eastern North Island, using the different layers to decipher sea-level changes and discover more about how sands are transformed into limestone. The team's observations revealed that the limestones are typically built up by repetitive units, each from a few metres to about 15 metres thick, which vary systematically in their properties from bottom to top. The study has shown the fundamental importance of sea-level change in controlling not only the large-scale features of the cool-water limestones, but also the way the grains of carbonate are bound together.

Studying an Ancient Extinction

Dr Bruce Hayward, a paleontologist based in Auckland, has studied fossil shells from single-celled animals called foraminifera, from samples of mud drilled from the ocean floor by the Ocean Drilling Programme in 1998. This programme is funded by a consortium of about 20 countries. This research has uncovered a major deep-sea extinction episode that occurred within the last one million years, during the Ice Ages. The research indicates this event was far more significant than previously reported.

Arrival of Kiore

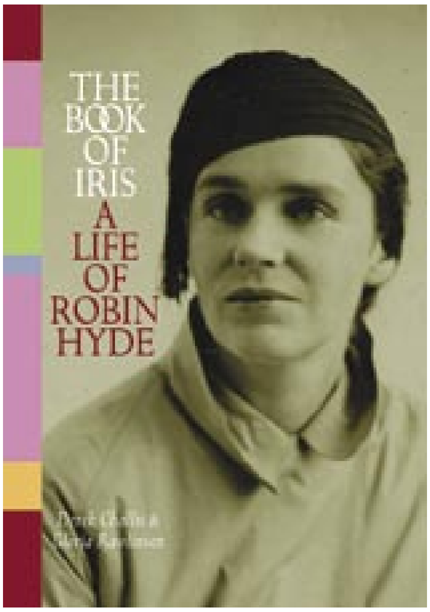
The kiore, or Pacific rat, spread throughout the islands of the Pacific with voyaging humans, tagging along as a stowaway in Polynesian canoes. Because of its close association with human migration, knowing the time of the earliest presence of the kiore in New Zealand can help to pin down the date that people first arrived here. Dr Janet Wilmshurst has found seeds gnawed by kiore, and has determined their age by radiocarbon dating. Her results to date are consistent with the kiore being in New Zealand for no more than 800 years.

Origins of New Zealand English

The Origins of New Zealand English project, which has received sustained funding, has used unique archival resources to trace the origins and development of New Zealand English. Using the Mobile Disc Unit archive of the New Zealand Broadcasting Service, and other sources, they have found that the "colonial twang" can be heard in people born as early as the 1870s, and that it emerged faster in areas where there was a mixture of people from different places. Using the same resource, the change in pronunciation in Maori over time is now being tracked.

Learning How the Brain Responds to Rewards

Human behaviour is shaped by reward. Marsden-funded research by Professor Jeffrey Wickens, Dr John Reynolds, and Dr Brian Hyland from the University of Otago focuses on the response of the brain to reward. They have shown that dopamine, a reward chemical in the brain, primes the brain for learning. These findings have implications for a range of disorders, including hyperactivity, addiction, Parkinson's, and schizophrenia. Dr Reynolds, who is working on a rare type of brain cell involved in reward-related learning, was the first New Zealander to be awarded a prestigious Brain Research Young Investigators Award in 2004.



Biographies

Marsden funding has led to some highly-praised books. *The Book of Iris*: *a Life of Robin Hyde* by Derek Challis and Gloria Rawlinson, was a finalist in the Montana New Zealand Book Awards in 2003. The following year, *Long Journey to the Border*: *a Life of John Mulgan* by Vincent O'Sullivan, was also a finalist. And *The Trial of the Cannibal Dog*: *Captain Cook in the South Seas* by Anne Salmond, won the 2004 Montana Medal for Non-Fiction, with the judges saying that "Salmond is a consummate storyteller and this book, as well as being in the very first rank of historical scholarship, is quite riveting."

Professor Dame Anne Salmond.

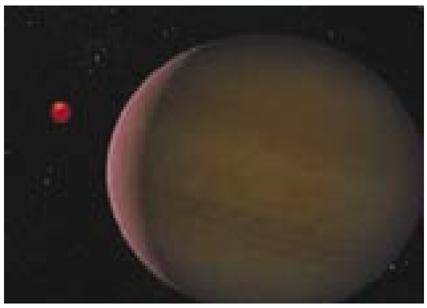
How Does Hearing Develop?

How does hearing develop and how is it regulated? Research by Associate Professor Gary Housley at The University of Auckland is addressing these questions. His team is studying the cochlea, the part of the inner ear that converts sound into signals which are sent to the brain. They have developed a technique that, for the first time, allows the sensory cells of the cochlea and their connections to be examined. Using this technique, they have identified and characterised the nerves and chemicals which convey these signals to the brain, and have shown that neurons also have an input into the sensory cells which can change hearing sensitivity.

Planet Hunting

The Microlensing Observations in Astrophysics (MOA) project, funded almost continuously since 1995, bases its observations on the bending of light proposed by Einstein. The MOA group is the first to use this technique to discover extrasolar planets.

Artist's impression of one of MOA's discoveries, a Jupiter-sized planet orbiting its parent star, a red dwarf. The planet is 17,000 light years away, the most distant known planet.



Gathering field data from the Mackenzie Basin.

Information for Wind Farms

To obtain maximum benefit from wind power, it is important to select sites that, collectively, provide a continuous supply of electricity. A 1996 Marsden project, led by Professor Andy Sturman and aimed at understanding the afternoon winds in the Mackenzie Basin has led, in the last year or two, to advice on regional wind patterns for an electrical generation company planning wind farms.

Studying Memory Development

Two University of Otago child psychologists, Professor Harlene Hayne and Dr Elaine Reese, have studied aspects of memory development in children. Professor Hayne has investigated the reasons why we all suffer from childhood amnesia, the inability to recall experiences from our infancy and early childhood. In a complementary study, Dr Reese has discovered that parents can strongly influence the development of this memory – those who converse with their children in a more reflective style help children to develop a better memory and a better understanding of themselves and others.

Patrick Read, 20 months, discovers his reflected self. Self recognition is important in developing the ability to recall earlier parts of one's life.

Studying Multiple Sclerosis

Associate Professor Geoff Krissansen has led a team which has played a major role in unravelling the process by which the body's own immune system can attack the nerve fibres of the brain and spinal cord, causing the debilitating disease, multiple sclerosis. This has led to the development of an antibody-based treatment, which has the potential to relieve suffering in human MS patients.

Syft Technologies

Syft Technologies Ltd makes sensitive mass spectrometers which have numerous applications including medical diagnostics, environmental monitoring, biosecurity, explosives detection, and petroleum exploration. This industry has arisen from sustained Marsden funding to investigate the chemistry that occurs in the atmospheres of planets and moons, and also in interstellar clouds, the enormous clouds of gas that exist between the stars.

Studying Fertility

Dr Ken McNatty and Dr Jennifer Juengel have received Marsden funding to investigate proteins that may affect ovulation and fertility in mammals. This research arose from prior observations of sheep that showed a high incidence of multiple births over a number of years; the researchers then went on to show that mutations in the genes that encode these proteins caused the increased rates of multiple births. The Marsden-funded research has led to the development of a vaccine that can be adjusted so that sheep either increase their ovulation, or do not ovulate at all. This has implications for the control of fertility in a number of mammals, including humans.

Dr Jennifer Juengel and Dr Ken McNatty.

Diseased Arteries

Disease-prone thickened artery walls contain fewer fibres of the protein elastin, and increased levels of cholesterol binding molecules. Associate Professor Mervyn Merrilees has been investigating the mechanism by which a particular gene, called V3, can lead to these changes. They have carried out experiments in which the effect of the V3 gene has been nullified, creating arteries enriched in elastin. The team has further funding from three medical charities to continue the work, which has implications for the treatment of atherosclerosis and lung disease.

Marsden researcher, Professor Murray McEwan (on the left) and Geoff Peck, Chief Operating Officer of Syft Technologies Ltd.

Iron-Scavenging Bacteria

Associate Professor Iain Lamont's group has investigated a signalling pathway that enables a bacterium, *Pseudomonas aeruginosa,* to produce an iron-scavenger protein in the presence of low levels of external iron. The signalling pathway is regulated in a way that has never been seen before in bacteria, but has similarities with systems in more complex organisms. This increases knowledge of how bacteria cause infection.

Discovering a New Field

In 1996, Dr Robert McLachlan, a lecturer at Massey University, received his first Marsden grant, entitled "Unconventional methods and structures in numerical differential equations". This turned out to be the first grant anywhere in the world for a topic that was to become known as geometric integration. This is a field of mathematics which provides computational methods of solving equations that have been impossible to solve previously. It has a wide range of applications.

Mussel Glue

The glue that enables mussels to stick to rocks is a protein made up of a repeating chain of 10 amino acids. In a complex organic synthesis, Associate Professor Carol Taylor and PhD student Claudette Weir managed to make the 10 amino acid building block. The mussel protein is a proven adhesive in an unforgiving, saltwater environment. This synthesis will allow its properties to be explored in other contexts, such as skin wounds.

Preventing the Spread of Brain Damage

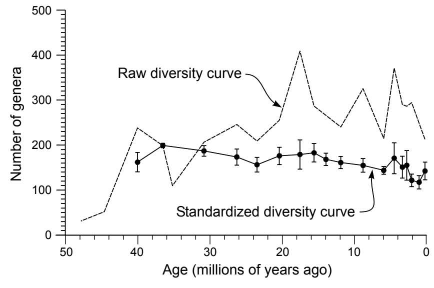
Marsden research has thrown up some chance discoveries. Professor Colin Green's group was studying the development of embryos when they accidentally discovered a way of preventing the spread of brain damage, following head injury. Their method is to limit the communication between cells, and they have subsequently found that this promotes wound healing in general. A company has been formed, discussions have been held with New Zealand Trade & Enterprise and Investment New Zealand, and commercial opportunities are being explored with overseas companies.

Leaves of the New Zealand horopito tree (*Pseudowintera colorata*) used by Associate Professor Gould to follow the production and scavenging of free radicals in situ. Photo: Kevin Gould.

Red Leaves, Deciduous Trees

Why is it that leaves are sometimes red, and why does New Zealand have so few native deciduous trees? Dr Kevin Gould (formerly at Auckland, now at Otago University) maintains that the red pigment in leaves – anthocyanins – protects the leaves from excessive sunlight; reduces the production of highly damaging free radicals; and mops up free radicals. Dr Matt McGlone has answered the second question: the temperate climate of New Zealand is such that neither evergreen nor deciduous trees are naturally favoured; rather, it is the poor soils in New Zealand which lead to evergreens – dropping leaves once every year is too wasteful when nutrients are in short supply. Both of these research projects attracted widespread interest from the public. For example, Dr Gould's findings were appeared in *New Scientist*, *American Scientist*, *New Zealand Geographic*, at least 11 international newspapers or on-line magazines, as well as on Australian television and New Zealand National Radio. The work also featured as the cover story of two international plant research journals.

Dr Roger Dungan measuring photosynthesis of evergreen wineberry (*Aristotelia serrata*) in the canopy of a forest in the Taramakau Valley, Westland.



Measure of biodiversity for the past 50 million years. The fossil record ("Raw density curve") has to be corrected for sampling biases, yielding the true biodiversity ("Standardized diversity curve"). The vertical bars indicate the uncertainty in the curve.

Is Biodiversity Increasing?

A team led by Drs James Crampton and Alan Beu has made a major advance in answering one of the fundamental problems in biology – is biodiversity increasing, or have we reached a limit to the number of species that can coexist? Using New Zealand fossil databases that are world renowned for their completeness, and molluscs as a proxy, they have shown that marine diversity around New Zealand has been more or less constant for the past 50 million years. The slight drop from a peak 20 million years ago may reflect the cooling of the oceans since that time.

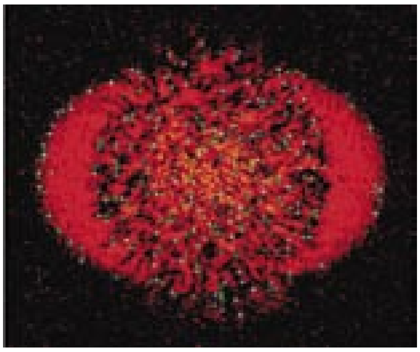
Programmed Cell Death

Dr Catherine Day from the University of Otago has been studying proteins which regulate programmed cell death (apoptosis). Cell death is vital for the human body; if cells do not die on cue, diseases such as cancer and autoimmunity may result. Dr Day's research has determined the structure and interactions of key proteins involved in cell death, and may ultimately lead to the development of new therapeutics.

Causes of Toxic Shock Syndrome

Dr Thomas Proft and Professor John Fraser have demonstrated that superantigens produced by bacterial infections are implicated in streptococcal toxic shock syndrome, and may be involved in other severe diseases such as necrotising fasciitis. A route for a possible vaccine has been identified.

Bose-Einstein Condensation



Slice through the centre of scattered atoms after the collision of two Bose-Einstein condensates. The crosses represent vortices that are indicative of the turbulent regime between the remnants of the two condensates.

Following the pioneering work in quantum optics of Professor Crispin Gardiner and the late Professor Dan Walls, the Marsden Fund has strongly supported this field and the related topic of Bose-Einstein condensation, in which atoms lose their individual identities at ultra cold temperatures. One focus has been the development of an atom laser, for which Professor Gardiner and Professor Rob Ballagh have made important theoretical contributions and Associate Professor Andrew Wilson was one of the first in the world to provide an experimental demonstration. In the main, however, the groups led by these researchers have increased understanding of the basic physics of these condensates, a prerequisite for any application of this remarkable state of matter.

Flexible Enzymes

As part of a Marsden project, an international research group headed by Professor Roy Daniel investigated how the flexibility of enzymes relates to the way they function. They carried out a parallel study of enzyme dynamics (how they move) and enzyme activity (how they work). They were able to show that the fastest motions that take place within enzymes are not needed for catalysis.

Hair in Health and Disease

A team of Marsden researchers studying the structure of hair in health and disease, led by Professor David Parry, has made a world breakthrough by successfully figuring out the arrangement of the molecules found in filaments of hair. This will permit an understanding of the origin of some hair diseases, such as bamboo hair, in which the strands develop a nodular, segmented appearance.

Rere Atu, Taku Manu!

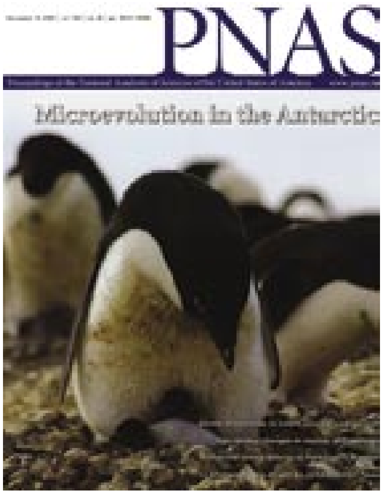
From the 1840s and into the twentieth century, Maori-language newspapers were published by government, churches, Maori, and Pakeha philanthropists. They are rare as a long record of Maori language in print, vivid in picturing Maori society and New Zealand history, and remarkable for Maori opinion. But they have been little used. With the Alexander Turnbull Library as the host organisation, and a research team led by Professor Ngapare Hopa, Dr Jane McRae, and Jenifer Curnow, the Maori-Language Newspapers Project aimed to promote use of the papers and to reveal the new and varied information they offer. One of the results was *Rere atu, taku manu!* (Fly out, my bird!), published by Auckland University Press. This book has 12 articles on various aspects of history, language, and politics, based on information from the newspapers. The final chapter describes a superb Internet resource that has become available as a result of the project.

Innovative Cancer Treatments

Professor Bill Denny is leading a team which received Marsden funding to carry out fundamental work on prodrugs, chemicals which can selectively kill cancer cells but not affect neighbouring healthy cells. The team has synthesised a range of these prodrugs. Their Marsden-funded project has led on to a patent application and further work funded by HRC and NERF.

Studying a Syphilis Cure

Professor Brian Nicholson and Professor Hugh Morgan are investigating the chemical structure and mode of action of Salvarsan, an arsenic compound that was introduced in 1910 by Paul Ehrlich as a highly successful specific cure for syphilis. The team has successfully synthesised Salvarsan and determined its true structure. They have also been able to back up their results by analysing a rare original Salvarsan sample prepared by Ehrlich, thus solving a nearly 100-year-old mystery.



Launching a temperature probe into open water from the edge of the sea ice.

Using Birds to Examine Fundamental Evolutionary Questions

Over the last ten years, Professor David Lambert and his research team in the Allan Wilson Centre for Molecular Ecology and Evolution has used New Zealand and Antarctic animals to answer fundamental questions of evolutionary biology. His group has extracted DNA and examined genetic diversity and evolution in a number of bird species, including saddlebacks, robins, kiwi and penguins, as well as extinct moa. Recently, the team has focused on the Adélie penguins of Antarctica, where they have compared DNA from ancient penguin bones (up to 6,000 years old) with DNA from their modern descendants. They found that penguin evolution may be driven by giant icebergs breaking off and creating a barrier for penguins returning home to breed, forcing them to mix with new colonies. This work has generated international interest, including cover stories in *Science* and *Proceedings of the National Academy of Sciences*, and prompted them to test whether the rate of change of DNA is constant over time in different species. This molecular clock hypothesis is currently being further tested tested in kiwi, tuatara and Antarctic silverfish. Do all these species' molecular clocks tick at the same rate?

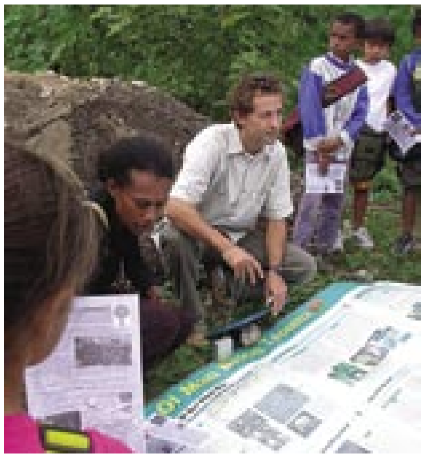
Antarctic Physics

Drs Pat Langhorne and Tim Haskell have been able to provide reasons for the appearance of platelet ice during the growth of Antarctic sea ice, a phenomenon that has puzzled people ever since the explorers of the British Antarctic Expedition noticed it in 1910. Their explanation is based on comprehensive measurements of the ice and underlying ocean right through the Antarctic winter, a hugely challenging task. Their results are assuming more significance now that icebergs are affecting the oceanography of McMurdo Sound, and a new ice shelf appears to be developing that will affect the operations of the New Zealand and United States programmes on Ross Island.

Children's Voices

Professor Anne Smith led a major study to examine children's participation and physical well-being in schools. Specifically, the study looked at young people's rights to participate in decisions about daily school life, their opportunities for recreation, their safety, and their health care. A key aspect was a comprehensive survey to ascertain the feelings of the children themselves. The results of the research are informing policy and form a base from which New Zealand's progress under the terms of the United Nations Convention on the Rights of the Child can be evaluated.

Professor Anne Smith.



Dissemination of research findings, Vanuatu style. The poster, written in Bislama (the local pidgin), was prepared for presentation to the Vanuatu National Museum as a means of reporting to the Ni Vanuatu people. Here local school children discuss the poster with teachers and museum staff.

The Lapita People

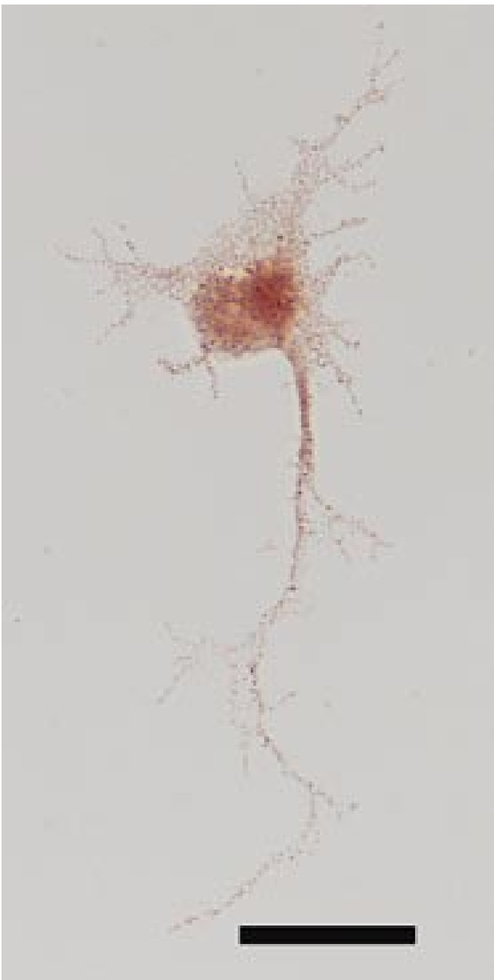
Associate Professor Peter Sheppard together with Dr Richard Walter, Dr Stuart Bedford, and Dr Hallie Buckley have all received Marsden grants for research on the Lapita people, the mysterious voyagers who were the common ancestors of the Polynesians, Micronesians and Austronesian-speaking Melanesians. Peter Sheppard and Richard Walter have demonstrated that the central Solomon Islands were one of the stepping stones on the eastward spread of the Lapita culture during colonisation about 3,000 years ago. Drs Bedford and Buckley have concentrated on Vanuatu, to the east of the Solomons. A significant, ancient burial site has just been discovered and promises to provide invaluable information on the initial settlement of Vanuatu and the quality of life at that time.

Studying signals in the brain

The brain is a complex network of specialised nerve cells, known as neurons. In order for it to function properly, stability is very important. Parts of it are only slowly replaced, and some of it may even be permanent. This is in contrast with other parts of the body, where cells are constantly replaced. Thus, a seventy-year old may be digesting food with intestinal cells that are a few days old, but thinking about the enjoyment of the food with brain cells that are decades old – perhaps even as old as the person themself.

For this stability to be achieved, signals between brain cells are very important. Interestingly, most cells are programmed to automatically self-destruct, unless they receive messages from other cells telling them to survive. Getting the signals right, therefore, is vitally important. As well as regulating the lifespan of neurons, signals control other aspects of how they function. If something goes wrong with the signalling, degenerative conditions such as Alzheimer's and motor neuron disease can occur – conditions which are becoming more common as communities age.

Associate Professor Ian McLennan and Dr Kyoko Koishi from the Department of Anatomy and Structural Biology at the Otago School of Medical Sciences are conducting research, funded by a Marsden grant, to study signalling between brain cells. This research has led to the interesting discovery that a hormone known as Müllerian Inhibiting Substance (MIS) may have a vital role to play in not only maintaining the brain's stability and function, but also in shaping the differences between the brains of the two sexes.



Embryonic motor neuron that has been treated with MIS and stained to reveal the location of the MIS receptors. The bigger red blob in the middle is the nucleus. The brown spots are regions with a higher density of MIS receptors. The black bar corresponds to a length of 20 μm.

MIS had previously been known to exist only in the reproductive system, but Professor McLennan and Dr Koishi have discovered that MIS is also found in the adult brains of both males and females. Motor neurons, which activate muscles, produce MIS as well as the proteins that enable the neurons to respond to MIS. This indicates that MIS may be a regulator of these cells. This exciting possibility is currently being tested, and could lead to MIS-based therapies for conditions such as motor neuron disease. The results of this research were published in the November issue of the prestigious *Proceedings of the National Academy of Sciences* with one of the group's students, Pei-Yu Wang, as the first author.

As well as the effect of MIS on the adult brain, the researchers discovered that MIS also prevents embryonic motor neurons in tissue culture from dying. This indicates that as well as regulating the adult brain, MIS may also affect how the brain develops. Since MIS would only be found in the brain cells of *male* embryos, as a result of its production by the testes, MIS might have a role in creating the differences between the brains of the two sexes. Studies of the human brain are revealing that men and women use their brains differently, and that most disorders of the brain have gender-specific aspects. Men are more prone to develop drug dependency, for example, whereas anorexia is largely a female disorder. Dementia occurs in both sexes, but the types of dementia and the genetic drivers of them have gender-specific aspects. It is known that the male brain is shaped by the presence of testosterone, the absence of female hormones, as well as the social environment. So it is possible that MIS is another hormone that shapes the differences between the brains of the two sexes.

Associate Professor McLennan and Dr Koishi are now working to further examine MIS, to explore its use as a possible treatment for motor neuron disease.

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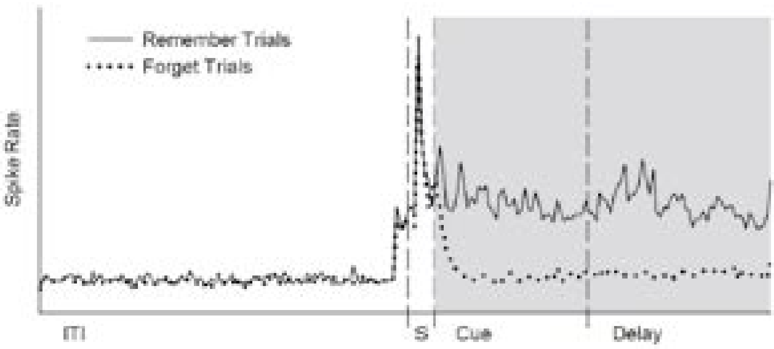
Marsden on-line
For further information,
visit our website: www.rsnz.org

Mind control – how do we know what to remember?

At moments of information overload, most of us have been heard to utter the sentiment "Help, my brain is full!" Strangely enough, this could have the potential to become the case, as we are constantly bombarded with an enormous amount of data, from the colour of our neighbour's towels on the washing line, to the numberplate of the car that overtakes us dangerously on our way home from work.

The majority of information we encounter can be immediately forgotten, as it is not essential or even useful to us, while more important information must be remembered longer. Impressive though the brain is, it does have a limited capacity for information storage and retrieval, and it is therefore essential that we can filter the information we receive, to allow us to access memory which is important, and restrict access to memory which is not. This ability to selectively filter information is called 'executive control'.

Although it has long been recognised that the prefrontal cortex of the human brain is responsible for executive control, finding the exact cells involved has been difficult. Now, Associate Professor Mike Colombo from the Department of Psychology at the University of Otago has made significant progress in this area by conducting research, funded by a Marsden grant, to discover just which brain cells are involved in executive control in birds.



Activity of pigeon brain cells during memory tests. The "ITI" period is prior to the test, "S" is when the pigeon is shown the object, "Cue" is when the tone is sounded to tell the pigeon to either remember or forget the object, and "Delay" is the period in which the pigeon is waiting for the memory test.

Associate Professor Colombo and his team trained pigeons to participate in a standard memory task in which they were first shown a sample stimulus (sometimes a circle and sometimes a dot). The birds were then presented with either a high-frequency tone or a low-frequency tone. The high tone told the bird that it must remember the stimulus it had just seen because a memory test was forthcoming. In the memory test that followed, the bird was shown both the circle and dot stimuli. If it responded to stimulus that it had seen previously as a sample stimulus (in this example, the dot), it was given a food reward. The low tone instructed the pigeon that it could forget the stimulus it had just seen because no memory test was forthcoming.

From these tests, the researchers were able to discover that particular cells in a region of the of the birds' brain known as the 'nidopallium caudolaterale' (NCL), a region analogous to the frontal lobes in mammals, increased their firing rate when the birds were told to remember, and decreased their firing rate when the birds were told to forget. This, the researchers believe, is the most straightforward evidence for the specific cells engaging in the process of executive control.

That these cells exist in the avian brain, in a species that has evolved separately from mammals for over 300 million years, is evidence that the processes of selectively filtering information is not an ability exclusive to humans. Birds, too, have an ability to think things through.

In a wider sense, understanding the method by which cells code for executive control opens up many more possibilities to cure disorders of executive control, such as those that follow either damage or disease of the frontal lobes in humans.

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Overcoming barriers – quantum tunnelling and conducting plastics

As electronic components become increasingly smaller, some strange things start to happen. One of these is a curious process known as 'quantum tunnelling', where electrons can 'tunnel' through insulating barriers that would normally contain them. This phenomenon is one of the key frustrating problems in continuing to miniaturise electronics because, when devices get small enough, the electrons will not stay where they are supposed to be, but will leak away by tunnelling to other parts of the device.

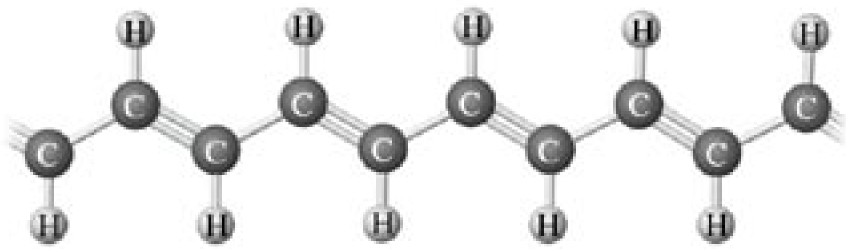
The good news is, however, that tunnelling electrons produce currents that could actually be useful. Supported by the Marsden Fund, Professor Alan Kaiser from the School of Chemical and Physical Sciences at Victoria University is conducting research to understand different types of quantum tunnelling in novel materials.

Professor Kaiser talking at the MacDiarmid Institute's Second International Conference on Advanced Materials and Nanotechnology (AMN-2), in February.

In one avenue of research, Professor Kaiser has been working with Professor Yung Woo Park, Chief Scientist of the Nano Systems Institute at Seoul National University, to investigate quantum tunnelling in extremely thin fibres of polyacetylene, a type of plastic that conducts electricity. This interesting substance played a major role in New Zealander Alan MacDiarmid receiving a Nobel Prize in 2000. History records that it was a misunderstanding by a student that led to the plain, black material developing a metallic sheen; it was this form of polyacetylene that was subsequently investigated and made into a good conductor by MacDiarmid and his fellow prize winners, Hideki Shirakawa and Alan Heeger.

Alan Kaiser and Yung Woo Park have been looking at how the electrical conductivity of fibres of the plastic changes as temperature is lowered and voltage is increased. At very low temperatures (about 240°C or so below freezing), any further temperature drop makes no difference at all to its conductivity, but applying high voltages dramatically increases conductivity. Professors Kaiser and Park have proposed that this is because a novel quantum tunnelling process involving many electrons is occurring along the fibres. Most interestingly, the tunnelling appears to occur independently on each of the individual polymer chains that make up the fibre. This means that an individual chain could form one of the smallest imaginable conducting 'wires'.

But how could such a wire actually be made? Professor Kaiser's former PhD student, Dr Gregory McIntosh, working in Seoul with Professor Park's group, calculated that a single polyacetylene chain would be stable if inserted into a tiny tubular carbon structure, known as a 'nanotube'. Conveniently, it also appears that the chain would actually be sucked

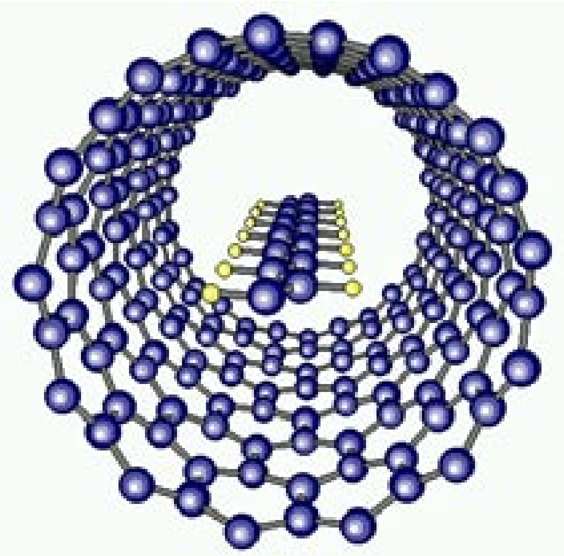


Polyacetylene chain.

into the nanotube automatically. Actually obtaining a single polyacetylene chain is the hard part, but work on this is under way.

Tunnelling is important in other conducting plastics, and also in carbon nanotubes themselves. Small defects in quasi-one-dimensional materials cause barriers to electron flow and, because electrons cannot easily circumvent these small barriers, they have to tunnel through them. Professor Kaiser's models for this conduction process have been applied to a surprising range of different materials, including conducting plastics, carbon nanotube networks, and even granular magnetic materials of interest for 'spintronics' (a new paradigm for electronics in which, for example, tunnelling currents can be controlled using the spin of the electrons).

Overall, Professor Kaiser's aim is to add to our understanding of the strange processes that occur at very tiny scales.



Polyacetylene chain inside a carbon nanotube.

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Marsden at a glance

The Marsden Fund supports excellent research in a wide range of topics covering the sciences, social sciences, humanities and engineering.

Each year, Government provides funding for projects that will foster research of the highest calibre. This work is not subject to government priorities but will nonetheless enhance New Zealand's ability to participate in, and benefit from, research of an international standard. Set up in 1994, the Marsden Fund is a contestable fund that has been administered by the Royal Society of New Zealand since 1995.

A Marsden Fund Council of ten eminent researchers, chaired by Dr Garth Carnaby, is appointed by the Minister of Research, Science and Technology to make recommendations for funding. Selection criteria focus on the merit of the proposal, the potential of the researchers to contribute to the advancement of knowledge, and the enhancement of research skills in New Zealand, especially those of emerging researchers.

Nine panels have been established to help the Marsden Fund Council assess proposals. These are:

- Biomedical Sciences
- Cellular, Molecular and Physiological Biology
- Earth Sciences and Astronomy
- Ecology, Evolution and Behaviour
- Economics and Human & Behavioural Sciences
- Humanities
- Mathematical and Information Sciences
- Physical Sciences and Engineering
- Social Sciences

Applying to the Marsden Fund

Applications are now invited for the 2006 funding round. Proposals are due on Thursday, 9 February 2006.

Eligibility to bid to the Fund is unrestricted provided that the research proposed is either to be carried out in New Zealand or, if its nature demands that it be carried out elsewhere, by New Zealand-based researchers.

In a change from previous years, most applicants in 2006 will prepare and submit their proposals using the Marsden Fund's web-based system called Proposals On-Line. For researchers based at the CRIs, universities and other large institutions, the codes and passwords to obtain access to Proposals On-Line can be obtained from their institution's research coordinator. Private applicants and researchers at smaller organisations should contact the Marsden Fund directly.

Information for applicants is available from the web site, or from the Marsden office:
The Marsden Fund, Royal Society of New Zealand
9 Turnbull St, Thorndon, P.O. Box 598, Wellington.
Phone: (04) 470 5799 Fax: (04) 473 1409 Email: marsden@rsnz.org
Web site: www.rsnz.org/funding/marsden_fund/

Tenth anniversary

Sir Ian Axford

As Chairman of the Board of FRST, I became aware that there was a lack of support in New Zealand for basic research that was not directed or targeted. I had been accustomed to the USA and Europe, where there are systems providing funding for high quality research projects regardless of their possible applications. I had been very impressed with the Max Planck Society in Germany, which is dedicated to the advancement of knowledge (science) – when I asked its President what he wanted done in our Institute he said simply that he did not care as long as it was good – and it worked.

I wrote a brief proposal for a research fund of this type and discussed it with Dr Basil Walker, from MoRST, who gave it his full support. The Minister, Simon Upton, saw the merits of the scheme immediately and pushed it successfully through the approval process. He agreed to the use of Sir Ernest Marsden's name in its title and to the selection of a Marsden Fund Committee comprised of the best, representative group of scientists that could be assembled in the time available. The Fund was also administered by the Royal Society in order that it could operate as independently as possible. The Committee set to work with a will, agreeing to some rather arbitrary but simple procedures designed to be efficient and fair.

The results were an immediate success, even though 90% of the proposals could not be funded. Some outstanding projects were selected, including fundamental work on the value of the gravitational constant yielding a new standard value, a start in nanotechnology, Bose-Einstein condensation, quantum optics, ring lasers, mathematics and astronomy (both funded for the first time) and, in the life sciences, a start for the Malaghan Institute.

After some time I felt that the scope of the Fund should be broadened to include the humanities (but not the creative arts). Basil Walker agreed and so did the Minister. The result was again successful – the humanists responded with excellent proposals resulting in some outstanding projects. Perhaps I liked best the work on Angkor Wat, which has attracted much attention, but there is also a row of books on subjects such as Robin Hyde and Foucault, of which we can be proud.

It is obvious that the Fund should be larger. I have always believed that it should be maintained at 10% of the total Science Budget. If it were too large, there might always be a danger that it might be cut arbitrarily in favour of targeted research and never recover. The most important thing is that it should continue to be successful.

Dr Diana Hill

It is a real pleasure to comment on the tenth anniversary of the Marsden Fund. After a difficult genesis, the Fund has grown significantly and now occupies a very special place in the New Zealand innovation system, providing a mechanism to unlock the significant intellectual capital held within the New Zealand research community. It is particularly pleasing to see the outcomes of earlier investment producing world class results ranging from significant international science publications to commercial spin outs to home grown studies of New Zealand culture that are attracting world attention.

The success of the Fund has been an exceptional team effort by those with a passion and vision for New Zealand research. It has been my pleasure to work with a series of supportive Ministers (Maurice Williamson, Pete Hodgson, and Steve Maharey), committed high calibre researchers who made up the Marsden Fund Council and its predecessor the Marsden Fund Committee, and an efficient and hardworking executive managed through the Royal Society of New Zealand. Sir Ernest Marsden would be proud of the Fund's efforts and I look forward with considerable interest to the returns on an essential underpinning investment in New Zealand's future research.

Marsden Fund Council members, Marsden staff, and contact details

1. Marsden Fund Council

Dr Garth Carnaby	GA Carnaby & Associates
Professor Peter Bergquist	The University of Auckland and Macquarie University
Associate Professor Richard Blaikie	University of Canterbury
Professor Sally Casswell	Massey University
Professor Charles Daugherty	Victoria University of Wellington
Dr Rupert Sutherland	Institute of Geological and Nuclear Sciences Ltd
Associate Professor Lydia Wevers	Victoria University of Wellington
Professor Christine Winterbourn	University of Otago
Two appointments pending	

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All our news appears on the Royal Society of New Zealand's website: http://www.rsnz.org

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