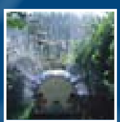
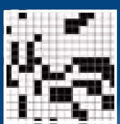
NZ IMAges

ISSUE FOUR

INSIDE





New Zealand Institute of Mathematics & its Applications

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The patterns of tiny feet

Professor Ian Stewart, in New Zealand on a Seelye Fellowship late last year, tells the story of the bet that launched a new branch of science.

The Governor of California bet $25,000 in 1870 that a trotting horse is completely off the ground at some point.

"You can't tell with the naked eye," says Stewart, "but the governor's friend Edward Muybridge invented a camera that could freeze very fast motion and trotted a horse past a line of these cameras. And it was off the ground at one point." Muybridge went on to photograph the gaits of every large animal he could, down to dogs and cats, founding the branch of science called Gait Analysis.

From fossilised dinosaur footprints and skeleton structure, Gait Analysis has been able to analyse how these animals must have moved, and how quickly. And by analysing how people move, it is possible to spot problems before they become serious and deal with them. Stewart describes this as a fascinating application of the mathematics of rhythmic patterns.

One result of Stewart's work in the area was a prediction that the number of sinusoidal waves moving along a centipede would be either an integer or half an integer. Photographs bear out the prediction.

Stewart is a Professor of Mathematics at Warwick University in the UK. He started out as an abstract algebraist, and working on the dynamics of symmetry as a way to get closer to applied mathematics. "There is a lot of potential for dynamic systems modelling in biology. Biologists have realised that it's not enough to list the interactions of chemicals and genes, we need to look at how the whole system works - and they're maths questions."

Welcome

We hope you enjoy this fourth issue of IMAges, which contains a range of items about the work and interests of the New Zealand mathematical sciences community. There are profiles of two of the world's leading mathematical communicators, who were both in New Zealand last year, plus one of our most recent Maclaurin fellows.

Find out more from www.nzima.org

Marston Conder and Vaughan Jones
Co-Directors of the NZIMA

Stewart illustrates, with typical enthusiasm, the Fibonacci number sequence in nature; after two starting values, each number is the sum of the two preceding numbers.

"Networks of neurones create the rhythms underlying patterns of gait," says Stewart. "The vestibular system in our ears, three semi-circular canals, senses head movement and signals our neck and shoulder muscles to keep us balanced. We know the wiring diagram that sends those signals; it has an elegant mathematical structure. You can draw it on the surface of a cube, with canals at the centre of each of the six faces and eight muscle groups at the eight corners of the cube."

"Each canal sends inhibitory signals to the four nearest corners, and excitatory signals to the four furthest corners, so this symmetry group has 48 elements. When a neural system has a lot of symmetries, we can predict some of the dynamics because they are organised by the symmetries."

Stewart is more widely known outside the mathematical world for his science fiction writing, and his best-selling books about the science of science fiction novelist Terry Pratchett's creation, Discworld. Stewart's position at Warwick involves responding to media queries on mathematics-related issues, and producing popular lectures and maths items for media, including internet podcasts. He has won several awards for his active popularising of mathematics and related science areas.

"A challenge is that a lot of people think the maths they did at school represents the whole subject; that very few new discoveries are made. It doesn't mean maths is frozen if you don't hear about them."

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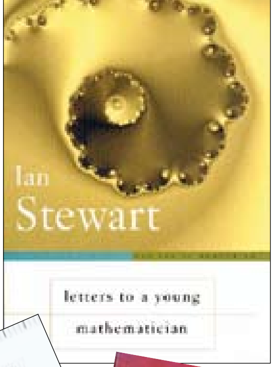

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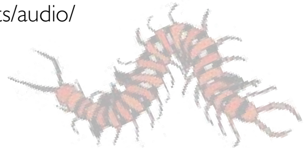
Stewart is enthusiastic about the public understanding of science, because "we need to get across why we're doing maths research, why it's interesting, and what they are getting out of it." One of the reasons for his visit was to share some ideas about building public understanding of maths.

"As soon as you start thinking of that, behind the scenes are massive amounts of maths, most of it quite new. Your MP3, CD and DVD players and GPS navigation, wouldn't work without error correcting code, for example."

"The Reed-Solomon code developed in the 1970s, based on very abstract algebra, is now the main error correcting system used in CD and DVD players. If you're driving and you go over a bump, this code makes sure the music comes out the way it should. The code can spot mistakes in the signal and transform it to what it should be. These devices work smoothly and seamlessly because of this underlying maths." *Jenny Rankine*

See also

Stewart's podcasts at www2.warwick.ac.uk/newsandevents/audio/more/symmetry/



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First NZMASP conference

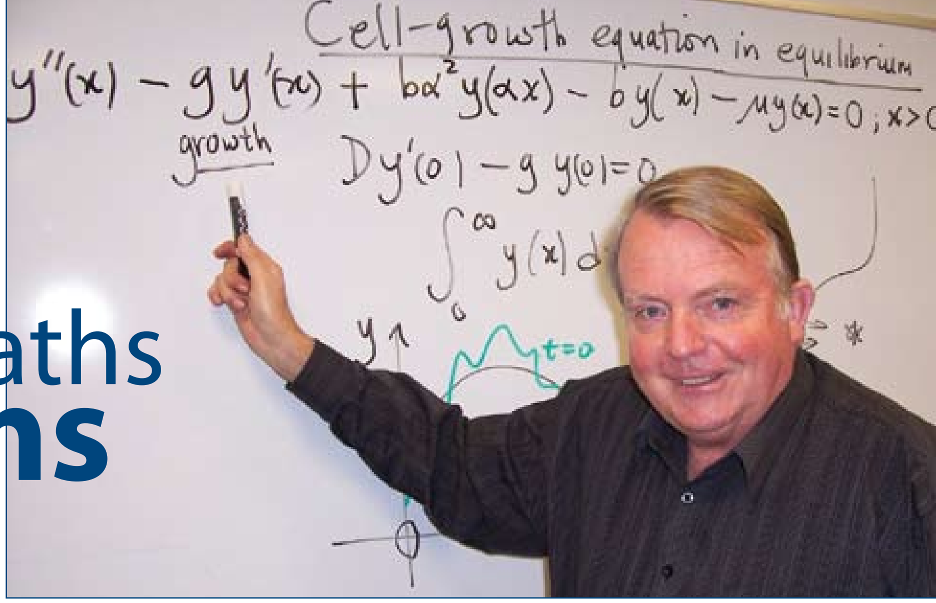
Nearly 40 postgraduate students from six New Zealand universities presented their research at the first New Zealand Mathematics and Statistics Postgraduate (NZMASP) Conference in Queenstown in November 2007. Topics varied from abstract algebra to physiological modelling, from Bayesian statistics to mathematics education, and all were well received.

Hannes Diener's talk, *The Dark Side of Constructive Reverse Mathematics*, won the NZIMA Best Presentation Award, while Michael Langton's presentation on *Surface Reconstruction with Piecewise Radial Basis Functions* earned him the Peoples' Choice Award sponsored by Hoare Research Software

Michael later revealed that searching for the algorithm to most clearly animate his talk led to the discovery that this algorithm gave the best selection of points for surface reconstruction.

Registration for the two-day event was free, due to sponsorship from the NZIMA and the University of Canterbury Mathematics and Statistics Department.

Dion O'Neale and Peter Humphries



Finding maths solutions

Professor Graeme Wake is surrounded by a ferment of mathematical problem-solving. Jenny Rankine explains.

He is Director of the Centre for Mathematics in Industry at Massey University in Albany. Every summer for the last four years, organisations have brought their maths-related problems to the Mathematics-in-Industry Study Groups of the Australian and New Zealand Industrial and Applied Mathematics (ANZIAM), the first time they had been held in New Zealand.

Some of the best applied maths minds in the country concentrated on solutions for TransPower, Fisher and Paykel, New Zealand Steel and other organisations in power supply, manufacturing, soil erosion, aeronautics, horticulture, tree growth, mining and financial markets. "Over three years we made substantial progress on 19 out of 20 problems," says Wake. "Many were completely solved in a week and some led to ongoing contracts."

"Financial maths is one of the fastest growing areas of applied maths - the futures and foreign exchange markets are heavily mathematical. Good maths models are crucial for survival in big markets. The New Zealand stock market is just starting to get involved, but the finance industry can't get the right graduates - we're not producing enough of them here."

Maths consultancy

Professor Wake also relishes the problems he works on as a private maths consultant. They range from large projects about controlling agricultural spray drift to smaller contracts. "The unique mix of academic and consulting mathematics is very enriching."

"I finished a problem this morning for a company producing materials to clean air conditioning systems in large buildings, to stop Legionnaires Disease and other bugs. They wanted an optimisation routine to reduce waste. The engineers knew what they needed but couldn't work out the relationship between the processes and the constraints. I managed to do the algorithm for Excel and the engineers wrote up the programme."

An even more local problem came from a family friend who manages a carpet warehouse. "She asked me about carpet offcuts; she didn't know how much was left in off-cut rolls and didn't want to waste staff time unrolling them. She knows how wide they are, so I gave her a solution and told her how to use it. All she had to input was the number of rings in the roll, the thickness of the carpet, the diameter of the hole in the middle and the outside of the roll, and that gave her the length. Industrial mathematicians need to be able to take problems that are not stated in mathematical terms, solve them and provide a user-friendly output."

"There is a lot of consulting work out there, although it's a challenge. There wouldn't be more than a couple of dozen people in the country earning their living by maths consultancy, although a lot of people do it on the side. Some of the most successful have interdisciplinary backgrounds in medical, agricultural or engineering fields and are able to talk the client's language. You learn it by doing; it's not so easy to train students in it - it's not like textbook maths."

Wake is Professor of Industrial Mathematics at Massey and the NZIMA's full-time Maclaurin Fellow for 2007/08. The fellowship is named after Richard Maclaurin, the foundation Professor of Mathematics at Victoria University of Wellington more than 100 years ago, who later became a noted President of the Massachusetts Institute of Technology (MIT) in Boston.

During Wake's research year he is mounting a "full attack on non-local calculus", which is used in mathematical models of situations where cause and effect are separated by time, space or age. This interest grew from his earlier work on modelling cell growth, which is now used to quantify the growth of tumour cells and the effects of chemotherapy treatment.

"Calculus at year 13 is about rates of growth proportional to size now, but the rate of growth in cells is related to the size of the organism one division before. It's non-standard calculus - in fact, it's not in the text books. There are few procedures for the generic analysis of these types of problems."

Wake is investigating properties such as wavelengths and frequencies, and developing solution techniques for the functional differential equations involved. If he is successful, his work will relate to a wide range of applications.

Top: Graeme Wake. Below: A model of the effectiveness of shelter belts in stopping insecticide spray drift has resulted from a Maths-In-Industry Study Group, bottom.