

The New Zealand Institute
of Mathematics & its Applications
(NZIMA)

ANNUAL REPORT

for the year 1 July 2003 to 30 June 2004

Approved by the NZIMA Governing Board
on 24th August 2004

1. Introduction: History, Aims and Activities of the NZIMA

The New Zealand Institute of Mathematics and its Applications (NZIMA) was established in 2002 as one of the five Centres of Research Excellence selected by the New Zealand government in March 2002. It is hosted at the University of Auckland and headed by Fields Medallist and Distinguished Alumni Professor Vaughan Jones *DCNZM DSc FRS FRSNZ* (Berkeley) and Professor Marston Conder *DSc FRSNZ* (Auckland), with involvement of many of the best pure and applied mathematicians and statisticians from across the country.

The principal aims of the NZIMA are to

- create and sustain a critical mass of researchers in concentrations of excellence in mathematics and statistics and their applications
- provide NZ with a source of high-level quantitative expertise across a range of areas
- facilitate access to new developments internationally in the mathematical sciences, and
- raise the level of knowledge and skills in the mathematical sciences in N.Z.

It is modelled on similar mathematical research institutes in other countries, notably the Fields Institute (Canada), MSRI (Berkeley), and the Newton Institute (UK). In particular, it places considerable emphasis on world-class research in fundamental areas of the mathematical sciences and the use of high-level mathematical techniques in modern application areas such as bioengineering, bioinformatics, medical statistics, operations research, and risk assessment.

Its key activities include

- the organisation of 6-monthly programmes on themes drawn from a range of fields of significant interest
- associated workshops held at various locations around NZ
- establishment of postdoctoral fellowships in the theme areas
- establishment of PhD and/or Masters degree postgraduate scholarships in the theme areas
- establishment of a small number of merit-based open scholarships for research students (from New Zealand or worldwide) in unrestricted areas of the mathematical sciences
- establishment of annual Maclaurin Fellowships (*), to enable mathematical scientists from NZ or worldwide to take time out from their usual occupations and undertake full-time research in New Zealand (or partly overseas if based in New Zealand).

(* Richard Cockburn Maclaurin was a graduate of Auckland University College who went on to study at Cambridge, where he won the Smith Prize in Mathematics and Yorke Prize in Law, and was appointed as Foundation Professor of Mathematics at Victoria University College in 1899, and later Dean of Law and Professor of Astronomy. In 1908 he was invited to become President of the Massachusetts Institute of Technology (MIT), and helped transform that institution into the world-class research-based technological university it is today.)

The NZIMA was formally established in June 2002 as a partnership between the University of Auckland (its host) and the N.Z. Mathematics Research Institute (NZMRI). The NZMRI is an incorporated society, which for the last ten years has organised summer meetings in New Zealand on particular topics of contemporary significance in mathematics, with support from the Marsden Fund and contributions by individuals (from N.Z. and overseas) and by mathematics and statistics departments at N.Z. universities. The NZIMA is building on this activity.

2. NZIMA Governance and Management

2.1 Governing Board

The NZIMA is overseen by a *Governing Board*, with seven members appointed by each of the University of Auckland and its partner organisation the NZMRI (Inc.), and has an independent chairperson. The Governing Board's responsibilities are to oversee the Institute's activities and finances and ensure that it is meeting its responsibilities under the terms of the joint venture agreement and those of the Centres of Research Excellence Fund.

In particular, the Governing Board will help formulate the research strategy of the NZIMA, the method by which its research programmes and projects are developed, and the strategy and responsibility for the recruitment, education and ongoing development of students and other new researchers. The Governing Board also has responsibility for appointing an International Scientific Advisory Board (see 2.2 below) and an Executive Committee (see 2.3 below), approving annual budgets and financial accounts prepared by the Co-Directors and the Executive Committee, and ratifying contracts and fellowships that are let by the NZIMA. The Governing Board is to meet at least twice yearly, in person or by audio-conference.

The current membership of the NZIMA Governing Board is as follows:

Chair of Board

- Sir Ian Axford *DSc FRS FRSNZ*

Members appointed by the University of Auckland:

- □ Professor Philippa Black (University of Auckland)
- Emeritus Prof. John Butcher (University of Auckland)
- Prof. Peter Hunter (University of Auckland)
- Dr John Kernohan (Auckland UniServices Ltd)
- Prof. David Ryan (University of Auckland)
- Prof. Alastair Scott (University of Auckland)
- Prof. James Sneyd (University of Auckland)

Members appointed by the NZMRI (Inc.):

- Prof. Rod Downey (Victoria University of Wellington)
- Prof. Mike Hendy (Massey University)
- Prof. Gaven Martin (University of Auckland)
- Prof. Mike O'Sullivan (University of Auckland)
- Prof. Andy Philpott (University of Auckland)
- Emeritus Prof. David Vere-Jones (Statistical Research Associates)
- Dr Graham Weir (Industrial Research Ltd).

Co-Directors (ex officio):

- Prof. Marston Conder (University of Auckland)
- Prof. Vaughan Jones (University of Auckland and University of California Berkeley).

2.2 International Scientific Advisory Board

The NZIMA seeks advice and guidance on its research programmes from an *International Scientific Advisory Board*, which is made up of prominent New Zealand mathematical scientists resident overseas, representatives from similar organisations (such as the CMA, MSRI and Fields Institute), and other notable individuals with a positive record of contact with the New Zealand mathematical sciences community. The composition of this advisory board is arranged to ensure balanced representation across the various disciplines of the mathematical sciences.

Members of the International Scientific Advisory Board are invited to review proposals for NZIMA programmes and applications or nominations for Maclaurin Fellowships, and to recommend new themes, suitable visitors and workshop speakers. This advisory board will meet virtually, by electronic mail, however the NZIMA plans to invite one of two members each year to visit New Zealand and take part in some of the NZIMA's activities.

Two new members joined the NZIMA's International Scientific Advisory Board this year, and the current members are as follows:

- Prof. Sir Michael Berry (University of Bristol)
- Prof. Andreas Dress (Universität Bielefeld)
- Prof. Peter Hall (CMA, Mathematical Sciences Institute, Australian National University)
- Prof. Gus Lehrer (University of Sydney)
- Prof. Jerrold Marsden (California Institute of Technology)
- Prof. Robert Megginson (Mathematical Sciences Research Institute, Berkeley, California)
- Prof. Cheryl Praeger (University of Western Australia)
- Prof. Dale Rolfsen (University of British Columbia)
- Prof. Mike Saunders (Stanford University)
- Prof. Bruce Weir (North Carolina State University)
- Prof. Keith Worsley (McGill University, Montreal)
- Prof. Margaret Wright (Courant Institute, New York University).

2.3 Co-Directors and Executive Committee

Management of the NZIMA's activities is the responsibility of the two *Co-Directors* and an *Executive Committee* appointed by the Governing Board. The Co-Directors and Executive Committee have delegated authority to manage the affairs of the NZIMA in accordance with the policy of the Governing Board.

The main responsibilities of the two *Co-Directors* are to:

- recommend policy to the Governing Board
- carry out the directions of the Governing Board
- convene meetings and discussions of the Executive Committee and other sub-committees
- maintain financial oversight of activities, staffing, and resources
- coordinate administrative matters with the host and partner organisations (the University of Auckland and the NZMRI), the CoRE Fund administrators, and other funding agencies

- coordinate collaboration with other organisations involved in research in the mathematical sciences in New Zealand (such as the NZ Mathematical Society (NZMS), the NZ Statistics Association (NZSA), the Operations Research Society of NZ (ORSNZ), and the NZ branch of Australia & New Zealand Applied Mathematics (ANZIAM)
- maintain and further promote linkages with other mathematical research institutes overseas.

The Executive Committee consists of the two Co-Directors (ex officio) plus three other members (each appointed for a 2-year term), with assistance from an Executive Administrator. Appointments to the Executive Committee will be on a rotating basis, with the aim of ensuring balanced representation both in terms of pure/applied focus and affiliation.

The main responsibilities of the Executive Committee are to assist the Co-Directors in:

- developing policy for and carrying out the directions of the Governing Board
- selecting (preliminary) proposals for NZIMA programmes to be developed into full proposals for consideration by the Governing Board
- selecting candidates for Maclaurin Fellowships, postdoctoral fellowships, student scholarships, and other activities for NZIMA support
- appointing programme directors and committees
- setting programme budgets and reviewing reports if required.

The *Executive Committee* considers such matters in consultation with the two Co-Directors on a regular basis, either in person, or by electronic mail, or by audio-conference.

The current members of the NZIMA Executive Committee are as follows:

- Professor Marston Conder (Co-Director, ex officio)
- Professor Vaughan Jones (Co-Director, ex officio)
- Prof. Rod Downey (Victoria University of Wellington)
- Prof. David Ryan (University of Auckland)
- Dr Graham Weir (Industrial Research Ltd).

2.4 Programme Committees and Programme Directors

All special thematic programmes run by the NZIMA are organised by *Programme Committees*, each convened by a Programme Director.

Each Programme Committee is charged with the responsibility of organising the programme (or theme) as approved by the Governing Board, and includes the Programme Director plus at least one member appointed by the NZIMA Executive Committee. The main responsibility of the programme committee is the organisation of the programme, including conferences/workshops, and selection and appointment of visiting experts, postdoctoral fellow and postgraduate scholars.

Each Programme Director is expected to provide written interim and final reports through the Executive Committee to the Governing Board, on both scientific activity and financial arrangements. These reports include a final financial statement for the entire programme, a list of all persons involved, and a list of scientific publications and other research outputs resulting from the programme.

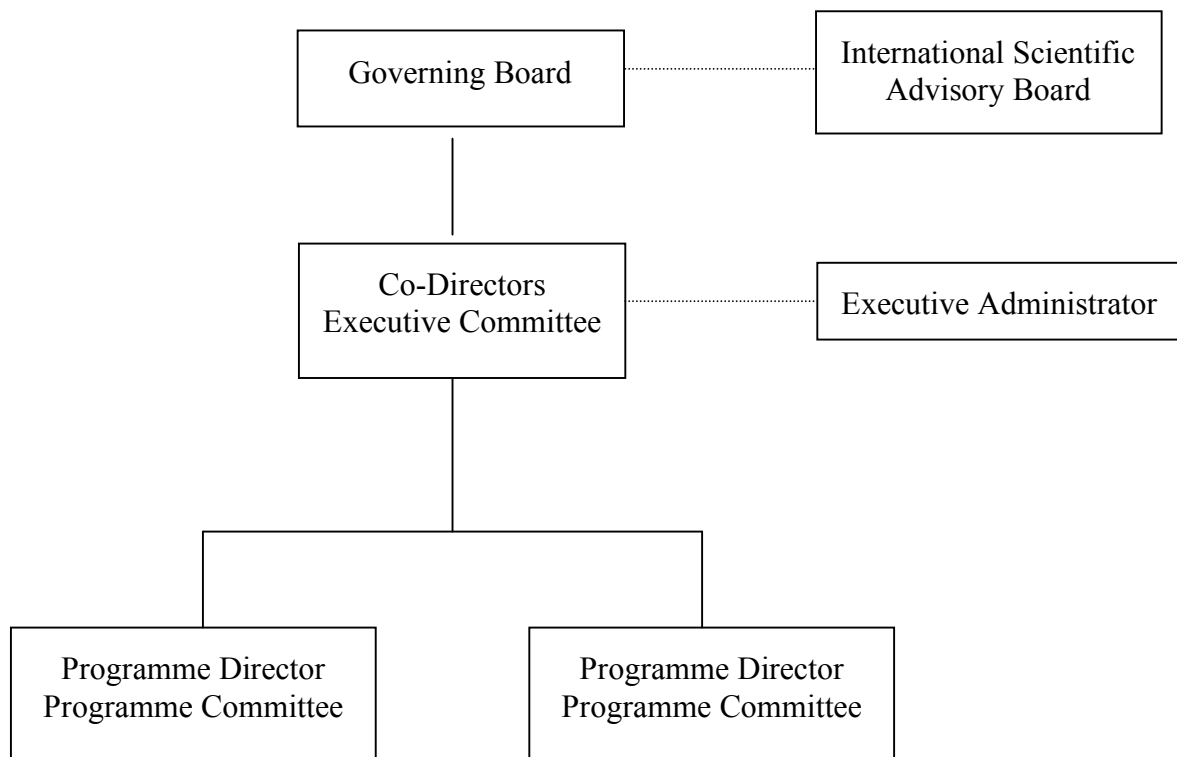
2.5 Executive Administrator

The main responsibilities of the *Executive Administrator* are to:

- provide HR, financial and other administrative assistance to the Executive Committee and Co-Directors
- help coordinate workshop and conference organisation for each programme committee
- liaise with Programme Directors, Maclaurin Fellows and scholarship holders
- maintain correspondence for the NZIMA
- prepare and disburse publicity material on the activities and outputs of the NZIMA.

The Executive Administrator is Margaret Woolgrove (University of Auckland).

2.6 Organisational Chart



2.7 Host and partner arrangements

Office accommodation is provided by the host organisation (the University of Auckland) for the NZIMA Co-Directors and Executive Administrator, along with support services for administrative functions, including human resource and management accounting services. The costs of these are covered from overhead funding in the NZIMA's CoRE Fund budget. A partnership agreement between the host organisation and the partner organisation (the NZMRI) has been negotiated to ensure appropriate division of responsibilities, revenue and expenses (including allocation of overheads).

Arrangements are made for subcontracting services (including programmes and Maclaurin Fellowships as necessary) through the University of Auckland's Research Office. Arrangements will be made as necessary for commercialisation of NZIMA-funded research and protection of intellectual property through Auckland UniServices Ltd, which has a wealth of experience and a track record of success in this area.

3. Board member and Director profiles

3.1 Chair of the NZIMA Governing Board

Sir Ian Axford *DSc FRS FRSNZ* is a distinguished scientist who recently retired from his position as Director of the Max-Planck Institute für Aeronomie in Germany. He was named New Zealander of the Year in 1995, in recognition of his distinguished international career in the field of space science. His work placed him at the forefront of near-Earth and Solar System research. He was closely involved with the Voyager 1 and Voyager 2 planetary explorers, the Giotto space-probe, and the Ulysses galaxy explorer. He has made a lifelong commitment to excellence in research and also to the growth and popularisation of science. He previously held positions as a professor at Cornell University (New York) and at the University of California at San Diego, Vice-Chancellor of Victoria University of Wellington, and Chair of the Marsden Fund. He is a Fellow of the Royal Society of London and an Honorary Fellow of the Royal Society of New Zealand, and has an Honorary Doctorate from Victoria University of Wellington.

3.2 Governing Board Members

Philippa Black FMSAm FRSNZ is a Professor of Geology at the University of Auckland, and is also acting as Dean of Graduate Studies and Associate Deputy Vice-Chancellor (Research). She was formerly President of the Royal Society of New Zealand, and also formerly chair of the University of Auckland's Postgraduate & Scholarships Committee. She has considerable experience and wisdom in dealing with academic and research matters.

John Butcher DSc FRSNZ is an Honorary Research Professor of Mathematics at the University of Auckland, having previously been Head of the Applied and Computational Mathematics Unit, Head of the Computer Science Department, and Head of the Mathematics Department during his distinguished career. He is a world authority on the numerical solution of ordinary differential equations, won the NZ Mathematical Society's annual Research Award in 1991, and won the Hector Medal (of the Royal Society of NZ) in 1996.

Rod Downey FRSNZ has a personal chair in Mathematics at Victoria University of Wellington, is one of the five (unpaid) directors of the NZMRI, and was President of the NZ Mathematical Society for the last two years. He won the Hamilton Award of the Royal Society of NZ in 1990, the NZ Mathematical Society's annual Research Award for 1992, the NZ Association of Scientists' Research Medal in 1994, and has won numerous other awards for his work in logic and computational complexity.

Michael Hendy FICA FRSNZ holds a personal chair in Mathematical Biology at Massey University, and is Co-Director (with David Penny) of the Allan Wilson Centre (one of the other Centres of Research Excellence in NZ). He has been Head of the Mathematics discipline group in the Institute of Fundamental Sciences at Massey University and Assistant Editor of the journal *Molecular Biology and Evolution*.

Peter Hunter FRSNZ is a Distinguished Professor at the University of Auckland, and is Director of its Bioengineering Institute. He was awarded a James Cook Fellowship in 1991, and was elected a Fellow of the American Institute for Medical and Biological Engineering in 2001. He has also been Chair of the Physiome Commission of the International Union of Physiological Sciences and a member of the Scientific Advisory Board of Physiome Sciences Ltd.

John Kernohan is Chief Executive Officer of Auckland UniServices Ltd, which is responsible for commercial research and consultancy partnerships, forming new business ventures based on University research, and developing intellectual property. With a PhD in Chemistry, he spent some years in R&D management for General Electric and as CEO of several businesses for ICI New Zealand Ltd. He was appointed UniServices' founding CEO in 1988, and has helped it grow from small beginnings to a significant entity with annual revenue exceeding \$60m pa.

Gaven Martin FRSNZ has a personal chair in Mathematics at the University of Auckland, is one of the five (unpaid) directors of the NZMRI. He won the NZ Mathematical Society's annual Research Award for 1994, held a James Cook Fellowship from 2001 to 2004, and has also won several other prestigious awards, prizes, fellowships and visiting positions overseas. He is joint author of a recent book *Geometric function theory and non-linear analysis* published by Oxford University Press.

Mike O'Sullivan FIPENZ has a personal chair in Engineering Science at the University of Auckland, and is a former Head of the Department of Engineering Science. His speciality is mathematical and computational modelling of geothermal fields, and has been involved as a consultant for over 20 geothermal projects in Indonesia, Japan, Kenya, New Zealand, USA and Mexico. He is Associate Editor of the journal *Geothermics*, and has supervised over 40 postgraduate research students at Masters and PhD level.

Andy Philpott has a personal chair in Engineering Science at the University of Auckland, where he is currently Head of the Department of Engineering Science, and he is also chair of the Royal Society of New Zealand's Standing Committee for Mathematical and Information Sciences. His research interests are in stochastic optimisation and operations research.

David Ryan FIMA FIPENZ FRSNZ is a Professor of Operations Research at the University of Auckland, a former Head of the Department of Engineering Science, and is currently Deputy Dean of the Engineering Faculty. He is well known internationally for his work on developing methods for solution of large-scale linear programming problems, especially in the context of scheduling. He won the Engineering Excellence Award in Information Technology from the Institution of Professional Engineers New Zealand (IPENZ) in 1999, and won the Hans Daellenbach Prize of the Operations Research Society of NZ in 2001.

Alastair Scott FASA FIMS FRSNZ FRSS has a personal chair in Statistics at the University of Auckland, and was previously Head of the Departments of Mathematics and Statistics. He has a worldwide reputation for his research on sample survey statistics, and has been appointed to many editorships, fellowships of professional societies, and visiting positions at universities and laboratories overseas. His expertise has also been recognised by appointments to government and professional bodies (such as the NZ Environmental Risk Management Authority).

James Sneyd is Professor of Applied Mathematics and Head of the Applied Maths Unit at the University of Auckland. He is best known for his work in physiological modelling, and was joint winner of the American Association of Publishers' Award in 1998 for Best New Title in Mathematics, for his book *Mathematical Physiology* (co-authored with J. Keener). He is also closely involved with programmes at the Mathematical Biosciences Institute (in Ohio).

David Vere-Jones FRSS FRSNZ is an Emeritus Professor at Victoria University of Wellington, and a director of Statistical Research Associates (a private consultancy firm). He specialises in mathematical and statistical modelling, with particular interests in geophysics and in statistics education. He won the International Statistical Institute's Henri Willem Methorst Medal in

1995, and the Royal Society of New Zealand's Rutherford Medal in 1999, and has won a significant number of other grants and awards and distinctions.

Graham Weir DSc FRSNZ is leader of the Applied Mathematics group at Industrial Research Ltd, and is currently chair of the NZ Branch of the professional organisation ANZIAM (Australia and New Zealand Applied Mathematics). He specialises in the mathematical modelling of physical systems. He won a Ministerial Award for Excellence in Science in 1987, a Royal Society of NZ Science and Technology Medal in 1996 and the NZ Mathematical Society's annual Research Award for 2000. He has also served on several key committees.

3.3 Co-Directors

Marston Conder DSc FRSNZ is a Professor of Mathematics at the University of Auckland, best known for his work on the application of combinatorial and computational group theory to the analysis and construction of discrete objects with maximum symmetry. He obtained his doctorate from the University of Oxford, where he won the Senior Mathematical Prize and Johnson Prize in 1980. He held a postdoctoral fellowship at the University of Otago in 1981, followed by a Royal Society (UK) Research Fellowship at the University of Tübingen (Germany) in 1982, and a Fellowship from the Alexander von Humboldt Foundation in 1987. He won the NZ Mathematical Society's annual Research Award for 1993, was elected a Fellow of the Royal Society of NZ in 1998, and awarded a DSc by the University of Oxford in 1999.

He was President of the NZ Mathematical Society from 1993 to 1995, co-founder and initial convenor of the NZ Mathematical and Information Sciences Council (now a standing committee of the RSNZ) in 1994, and is a co-founding Director of the NZMRI (Inc.). He participated as a lead expert in the MoRST Review of New Zealand's Scientific Knowledge Base in 1996, was a member of the TEAC Research Working Group (2000–2001), and in 2002 chaired the NZ Ministry of Education's Working Group that developed recommendations for a Performance Based Research Fund (PBRF) for tertiary education institutions in NZ. At the University of Auckland he was Head of the Department of Mathematics from 1996 to 1998, and served a term as Deputy Vice-Chancellor (Research) from 1999 to 2001. He is a member of the Editorial Board of the *NZ Journal of Mathematics*, and a member of the Marsden Fund Council (and convenor of its Mathematical & Information Sciences panel).

Vaughan Jones DCNZM DSc FRS FRSNZ is a Professor of Mathematics at the University of California at Berkeley and Distinguished Alumni Professor of the University of Auckland. After obtaining a Masters degree with first class honours at Auckland in 1973, he won a Swiss Government Scholarship and an FWW Rhodes Memorial Scholarship to study for a doctorate at the University of Geneva. In 1979 he was awarded the degree of *Docteurs Sciences (Mathématique)*, and the following year the Vacheron Constantin Prize for his doctoral thesis. He held postdoctoral positions at the University of California at Los Angeles (UCLA) and the University of Pennsylvania. During the 1980s his research focussed on von Neumann algebras, and in the course of this work he discovered a new polynomial invariant for knots which led to surprising connections between apparently quite different areas of mathematics.

He was awarded a Fields Medal at the 1990 International Congress in Kyoto (Japan) for his remarkable and beautiful mathematical achievements, and he is believed to be the only person from Australia or New Zealand ever to have won this prestigious award. Since then he has gone on to receive numerous awards and honours, including a Guggenheim Fellowship in 1986,

Fellowship of the Royal Society (of London) in 1990, the Rutherford Medal in 1991, honorary doctorates from the University of Auckland in 1992 and the University of Wales in 1993, membership of the US National Academy of Sciences in 1999, the Onsager medal of Trondheim University (Norway) in 2000, foreign membership of the Norwegian Royal Society of Letters and Sciences 2001, and a Distinguished Companionship of the Order of New Zealand in 2002.

He has been invited to lecture at numerous international congresses, and has served as editor or associate editor of many top international journals, including the *Transactions of the American Mathematical Society*, *Reviews in Mathematical Physics*, and the *Journal of Mathematical Chemistry*. Also he has been a member of the Scientific Advisory Boards of the Fields Institute for Mathematics (Canada), the Erwin Schrödinger Institute for Mathematical Physics (Vienna, Austria), the Mathematical Sciences Research Institute (USA), the Center for Communications Research (USA), and the Institut Henri Poincaré (Paris, France). He is also currently a Vice-President of the American Mathematical Society.

He is founder and principal director of the NZMRI, a role in which he has been instrumental in attracting some of the world's best mathematicians to NZ. His own style of working is informal, encouraging the free and open interchange of ideas, and this has rubbed off on many others. His efforts have made it possible for graduate students to gain first-hand knowledge of developments at the leading edge of their discipline, here in NZ.

3.4 Executive Administrator

Margaret Woolgrove has a background in research project management, both in New Zealand, where she worked for the Health Research Council from 1997 to 1999, and in the United States and Britain. She spent three years with the Michigan Public Health Institute in the USA, and has worked for both the University of Auckland and Massey University since she returned to New Zealand in 2002.

4. Chairman's Report

Sir Ian Axford reports:

I am delighted to offer some words for this annual report on the second year of operation of the NZIMA, as chair of its Governing Board. As I wrote last year, I think it is wonderful to see New Zealand recognising and supporting centres of research excellence, especially in areas of fundamental importance to society and the economy.

The NZIMA has built on its early success by pursuing a suite of programmes in a variety of themes led by excellent people, by appointment of some very fine Maclaurin Fellows and postgraduate scholars, and by supporting high quality international visitors and local conferences. The benefits are apparent from the highlights mentioned in this report.

The Governing Board will play its role in the ongoing development of the NZIMA, and continue to shape its strategy in the years ahead. We face some positive challenges in helping the NZIMA to build up its resource base, to use its centres of research excellence funding and status as leverage to obtain enhanced support for its activities and further its mission, and to create its own identity.

I congratulate the NZIMA and all those involved in it, especially the two Co-Directors and the Executive for their efforts in facilitating its development, and look forward to its continued success.

5. Co-Directors' Report

We are very pleased to report on another great year, building on the important foundations laid in 2002/03 and earlier.

Some very complimentary comments about the NZIMA (and its logo) and the mathematical sciences in New Zealand more generally, were made by the 2003 Forder Lecturer, Professor Caroline Series, in her report as Forder Lecturer to the London Mathematical Society published in its March 2004 Newsletter; see <http://www.lms.ac.uk/newsletter/325/325mail.html> on the web.

During the second year of the NZIMA's existence we have selected three further **thematic programmes** for special support over the period 2004 to early 2005, as follows:

- *Combinatorics and its Applications*, led by Professor Geoff Whittle (Victoria University of Wellington) and Dr Paul Bonnington (University of Auckland)
- *Dynamical Systems and Numerical Analysis*, led by Professor Robert McLachlan (Massey University)
- *Geometry: Interactions with Algebra and Analysis*, led by Professor Gaven Martin (University of Auckland) and Associate Professor Eamonn O'Brien (University of Auckland).

These were chosen following consultation with our International Scientific Advisory Board and other members of the NZ mathematical sciences research community.

Each programme is of approximately 6 months duration, and involves a concentrated period of activity centred around a meeting or workshop (held at an appropriate location in New Zealand), participation by visiting lead experts in the theme area, and the appointment of a postdoctoral fellow and a number of postgraduate research students.

Typically a programme is supported by a funding package that allows for a 3-month stipend for the Programme Director (plus overheads for his/her host institution), a 2-year Postdoctoral Fellowship (plus overheads for the host institution), scholarship support for two postgraduate research students (one at PhD level and one at Masters level), travel costs for invited experts from other countries to take part in the programme, and funding and administrative support through the NZMRI for costs and activities associated with the programme's key meeting/workshop (for accommodation, meals, facilities hire, other local expenses, for up to about 45 participants). Our Executive Administrator also helps with some of the arrangements.

We have also selected a number of people for the award of **Maclaurin Fellowships**, to enable them to spend a period of full-time research in New Zealand. These fellowships are of two types: one for researchers normally resident in New Zealand, tenable for one year, and the other for visiting researchers, tenable for one to three months. Each comes with a funding package that allows for a mix of stipend and travel expenses for the fellow, plus overheads for the host institution (in the case of the 1-year fellowships). Maclaurin Fellowships have been awarded to:

- Professor Rod Downey (Victoria University of Wellington), for all of 2003
- Professor Richard Laugesen (University of Illinois at Urbana-Champaign), visiting in 2003
- Dr Rod Gover (University of Auckland), for all of 2004

- Prof. Mike Steel (University of Canterbury), for all of 2004
- Prof. Hal Caswell (Woods Hole Oceanographic Institution), visiting in 2004.

We have decided to offer more visiting Maclaurin fellowships of shorter duration in future, to attract more high quality visitors and to optimise the research benefits of these.

At an early stage we allocated a small number of **scholarships in support of postgraduate research students** enrolled for PhD or Masters degrees in the mathematical sciences in New Zealand, on a merit basis (not necessarily tied to NZIMA thematic programmes). In addition, we decided to lend some support to a proposed programme in Industrial Mathematics by way of postgraduate scholarships for students engaged in research projects in industry. More details about these are given in the next Section.

In addition, we have allocated a small amount of our CoRE funding to the support of **local conferences and short visits to New Zealand by international figures** in a range of disciplines (as listed in the next Section).

The NZMRI's summer meeting (co-sponsored by the NZIMA) in January 2004 was a great success, with invited speakers giving excellent courses of lectures on topics ranging from ptychography types and their geometry through to Escher and the Droste effect, and over 40 mathematical scientists and around 30 students taking part. The support by the NZIMA was notably valuable, especially in terms of the benefit to younger researchers, who were able to use this as leverage with their host institutions to provide the remaining funding. The NZIMA also gave support to VIC2004, a meeting that was attended by 100 mathematicians from 13 different countries, including 14 graduate students. The quality of the presentations was uniformly high and represented research in a number of areas of fundamental importance in contemporary mathematics creating many opportunities for interaction and collaboration.

Similarly the NZIMA's sponsorship of a small number of international visitors has been highly successful. Relatively small amounts of money (spent mainly on travel costs) have led to new interactions and an increased level of excitement, especially among early and mid-career researchers. The pay off will be long-term and significant. We also offered funding in support of visits in early 2004 by two leading figures in mathematical economics, Professors Herve Moulin (Rice University, Texas) and Walter Bossert (Montreal, Canada).

The NZIMA offices are housed at the University of Auckland, on Floor 3 of the same building in which the Departments of Mathematics and Statistics are housed (Building 303), on the corner of Princes and Wellesley Streets.

We would like to thank all those who have been involved positively in NZIMA's second year of operation, including (but not limited to) the following:

- Sir Ian Axford and other members of the Governing Board for their guidance and oversight
- Members of the Scientific Advisory Board for their advice and insight
- Members of the Executive Committee and others who have been involved in the selection of programmes and candidates for Maclaurin Fellowships and other support
- Programme Directors and Maclaurin Fellows for their research and research leadership
- Margaret Woolgrove for her administrative support and perspicacity
- Professor Tom Barnes (DVC (Research)) and the Science Faculty Office at the University of Auckland for their ongoing support
- Directors and managers of the other CoREs for sharing their experiences.

6. Research Highlights

6.1 Thematic programmes begun in 2002/03

□ **Modelling cellular function** – Dr Nicolas Smith (University of Auckland) et al

This programme has now been running for 18 months. The research activities and outcomes associated with the programme, the programme director (Dr Nic Smith), the postdoctoral fellow (Dr Edmund Crampin) and graduate students funded under the programme (Anita Lin, Richard Faville, Jack Lee and Steven Niederer) are summarised below.

• **International meeting**

During the week 14-18 July 2003, an international meeting on “Modelling Cellular Function” was held at Waiheke Island Resort, on Waiheke Island, New Zealand. The dates of the meeting were chosen to follow directly on from ICAM (International Congress on Applied Mathematics) held in Sydney so that a number of invited speakers could follow on directly to Auckland, thereby minimising conference costs.

The main theme of this meeting was the mathematical modelling of cellular function. The overwhelming complexity of entire biological systems creates a challenge for mathematical modelling. This complexity can be overcome by breaking down whole systems into a hierarchy of models at different spatial and temporal scales — that is, the molecular, cellular, tissue and organ levels. These are then combined in an integrative modelling framework such as the Physiome and the Cardiome Projects.

• **Research supported by the programme and activities of the postdoctoral fellow**

A hierarchical modelling approach has been developed by Edmund Crampin (postdoctoral fellow) and others that is consistent with the thermodynamic principles underlying energy supply and demand in the cell. This approach incorporates detailed biophysical information, while allowing simplification of the model to enable computer simulation of the heart. The strategy rationalises the differences in timescales between different cellular processes to produce simplified model components and has been demonstrated for the cardiac sodium pump and has been published in the special issue organised as part of the meeting.

High performance computing now provides the capacity to embed this cellular model into whole organ simulations, using the Auckland framework for whole-heart modelling. In particular this will allow the incorporation of a model of the coronary artery network, previously developed by Dr Smith. By simulating the blockage of specific coronary vessels, different regions of the heart will be affected to determine whole heart function in coronary disease. This gives the ability, for the first time, to bring the powerful quantitative modelling approach to bear on coronary heart disease.

The step currently underway is the development of a model of myocardial pH regulation. This model includes the major pH-regulating mechanisms in the heart cell, allowing the role of pH changes on intracellular Ca homeostasis to be unravelled. This work will be presented by Dr Crampin as a poster contribution at a forthcoming meeting in Oxford (Physiological

Society, UK, October 2004) with a full manuscript being submitted to the *Journal of Biophysics* by November 2004.

Dr Crampin has also developed research directed at inferring biochemical reaction mechanisms from time series data of reactant concentrations, and has shown that it is possible to predict the reaction mechanism for simple pathways of elementary chemical reactions from time series measurements of their concentrations. This result will be presented at the forthcoming international conference on Knowledge-Based Intelligent Information & Engineering Systems (KES) in Wellington, September 2004, and will be published in the conference proceedings, in the series Lecture Notes in AI (Springer-Verlag).

This technique is currently being applied to gene expression data, and it is anticipated that a manuscript on this application of the approach will be submitted by the end of 2004. Dr Crampin has also supervised three final year undergraduate projects: 'Reverse engineering of genetic regulatory networks', R. Faville, 2003; 'Modelling of genetic regulatory networks: bacteriophage-lambda as a case study', E. Powell, 2003; and 'Modelling electrical activity and fatigue in skeletal muscle', L. Hurmez, 2004; and one Honours thesis in Bioinformatics (School of Biological Sciences): 'Linear models for regulatory network inference', J. Wildenhain, 2004. Dr Crampin also teaches a final year paper in Engineering Science on Mathematical Modelling in Physiology, and a third year paper on the Biomedical Engineering degree programme on Continuum Modelling in Bioengineering.

- **Research volume published**

Drs Smith and Crampin have organised and co-edited volume 85, issue 2–3, of the prestigious international journal, *Progress in Biophysics and Molecular Biology* which contains twenty-three full length peer reviewed research articles submitted by invited speakers at the Waiheke conference, and includes an editorial and paper written by Drs Smith and Crampin.

- **Graduate student projects**

There are four graduate students funded by NZIMA, three are currently enrolled in Masters and one in a PhD. All students have achieved excellent results in the postgraduate papers and thesis proposals. Details of their individual projects and expected outcomes are given below.

- **Steven Niederer (ME student)**

The aim of Steven's Masters' project is to calculate work in the normal and ischemic (low coronary blood flow) heart. The research on modelling the heart continues to make progress; an initial two-dimensional heart slice model that exhibits qualitatively accurate contraction and activation patterns has been developed. The next step is to improve on the cell model and then fully analyse the results of the two dimensional study before moving into three dimensions.

- **Jack Lee (ME student)**

The aim of Jack's Masters' project is to quantitatively investigate the mechanisms of coronary autoregulation using combined mathematical and computational approaches. The heart requires a constant supply of oxygen and its intrinsic tendency to control the coronary

perfusion ensures that its metabolic demands are met despite fluctuations in perfusion pressure. Several mechanisms — including myogenic, flow-dependent and metabolic means — by which the heart adjusts the calibres of its blood vessels and thus the coronary vascular resistance have been identified from in vivo and isolated vessel studies, however the role of each mechanism in autoregulation has yet to be characterised. While the difficulty in studying their interaction in vivo is concerned with unmasking the responses of individual mechanisms from the whole, a computational model must adequately represent a sufficient number of biological processes within a biophysically-based model of coronary blood flow and be able to reproduce the high level of spatial and temporal heterogeneity that is observed. The current state of modelling lags the knowledge base built up by the experimental work and therefore the goal of this project is to address this issue. By integrating the experimental findings available in literature with an existing modelling framework of coronary blood flow, a new understanding of how the heart regulates its function and responds to diseases will be acquired.

- **Richard Faville (PhD student)**

The specific objective of Richard's PhD research is to develop detailed mathematical and computational models of the electrophysiology of the Interstitial Cells of Cajal (ICC) and smooth muscle cells of the stomach and small intestine. The model for the ICC will be based upon the hypothesis posed by Prof. Kenton Sanders (see Sanders KM, O. T., Koh SD, Ward SM (2000), 'A Novel Pacemaker Mechanism Drives Gastrointestinal Rhythmicity', *News Physiol. Sci.* 15: 291-298). The aims of these models will be to: (1) accurately capture the fundamental mechanisms associated with electrical activity of GI cells, (2) provide a rational basis to aid in the design of future cell based experiments and (3) construct a cellular model which can be used to predict electrical signals measured on the body surface. A poster presentation outlining the preliminary cell model has already been accepted for the EMBS conference held in San Francisco, USA September 2004. It is expected that this project will produce at least three peer reviewed publications resulting from the development and use of a model to interpret of Prof. Sanders experimental results and the embedding of the cellular model into anatomical models of the G.I. system.

- **Anita Lin (ME student)**

The gastrointestinal (GI) system has similar electrical propagation and mechanical contraction to the heart. For the GI system, however, there are relatively few electrical, magnetic and anatomical recordings for either normal or diseased functions. Often such conditions are associated with a disruption of the normal electrical activity occurring within the musculature of the GI system. However, many of these clinical conditions are difficult to assess without resorting to invasive surgical techniques. Computational models are useful in simulating the electrical and magnetic activity and helping to develop new non-invasive diagnostic procedures. The main focus of this project is to apply modelling schemes similar to these used on the heart and stomach to modelling the electrical activity of the small intestine. Results of the model simulation will be compared with the experimental data obtained at the Vanderbilt University.

An initial simple electrophysiological model of the intestine has just finished. The current model investigates the electrical propagating along the small intestine. In addition, this model shows the solution of electrical potential fields on the torso resulted from electric

activity of the small intestine. This work will be presented at the IEEE BMES in San Francisco in September 2004.

The next extension is the inclusion of the magnetic fields just outside the surface of the torso generated from the electric fields. More detailed anatomy model coupling the longitudinal muscles and pacemakers cells (ICC) of the intestine wall will be implemented by the end of October 2004. The experimental validation will use CT scans of normal human intestine geometry. From this geometry, the electrical propagation and torso magnetic fields will be simulated and compared with results from Vanderbilt University recordings.

- **Other outcomes of the programme**

Another important aim of this programme was to introduce and promote CellML, a markup language, developed by a group at the Bioengineering Institute, which is used to describe mathematical models of cellular function. It is intended that CellML will provide the potential for increased involvement from the mathematical community in cellular modelling, by facilitating and accelerating the means of model exchange and reuse.

The July 2003 meeting of international scientists (at Waiheke) was regarded as presenting an excellent opportunity to expose and promote the cellular modelling efforts of the New Zealand mathematical community. It also provided the chance to obtain new knowledge, ideas and methods from some acclaimed scientists in the cellular modelling field.

As a focal event for the programme this conference has continued to generate further research activities and has provided a number of other opportunities to develop new research relationships and contribute to the research community in New Zealand. Outlined below are the details of each of these developments.

A new collaboration has developed between the groups led by Associate Professor Nigel Lovell (Graduate School of Bioengineering, University of New South Wales) and Professor Kevin Burrage (Department of Mathematics, The University of Queensland) around the development of a tool for the CellML standard to represent mathematical models of cell function. The collaboration has resulted in the organisation of a special session of the EMBS meeting in San Francisco (in September 2004) which will be attended by the Auckland and Australian groups. Each of the NZIMA graduate students will be attending this session and the EMBS meeting as a whole and presenting either an oral presentation or a poster. These graduate student presentations resulted from the submission of a four-page extended abstract which was peer-reviewed.

Also as a result of the Waiheke meeting Nicolas Smith has given three invited talks at meetings arranged by meeting attendees. The most recent of these was a two hour lecture at the University of Queensland Computational Biology winter school, where funding was also provided in the form of a scholarship for Jack Lee and Richard Faville to attend the week and fully participate in the school.

Finally, a number of the meeting participants extended their stay in New Zealand beyond the conference dates to make valued contributions to wider academic environment:

- Professor Jim Keener has been in discussion about setting up an exchange programme between Utah and Auckland for postgraduate students
- IBM global life sciences manager Kirk Jordan visited the Bioengineering Institute at the end of the meeting to discuss participation in NIH and US government funding

- Professor Andrew McCulloch (San Diego) joined the review board for the Bioengineering Institute (at the University of Auckland) the week following the meeting
- Dr Satoshi Matsuoka, Professor Hidetoshi Kotera (Kyoto) spent two months working in the Bioengineering Institute during which he collaborated with Professor Andrew Pullan on ventricular cell models
- Dr Jose Puglisi (Chicago) spent two weeks in Auckland after the meeting to collaborate with Professor James Sneyd on calcium handling in myocytes. Dr Puglisi supplied the Institute with software he has developed to simulate electrophysiology in heart cells which has been used very successfully in two undergraduate biomedical engineering papers
- Dr Richard H. Clayton (Sheffield) stayed for the week after the meeting to collaborate with Nicolas Smith and gave a talk at Auckland University entitled “Modelling ventricular fibrillation in the heart”
- Dr Santiago Schnell (Oxford) stayed for the two weeks after the meeting to work with Dr Edmund Crampin, and gave a talk at Auckland University entitled “Biochemical reaction kinetics in non-homogeneous media: simulations and rate laws”.

□ **Numerical methods for evolutionary problems** – Prof. John Butcher (University of Auckland) et al

The aims of the Numerical Methods programme were to run a workshop and to foster ongoing research through the appointment of a Postdoctoral Fellow.

- The two international research meetings (ANODE 03, 14-18 July 2003, and the Computational PDE-ODE Conference, 21-23 April 2004) brought many notable visitors to New Zealand, and this was of enormous benefit to research already being conducted here. It was also of great benefit to Auckland students who were able to participate alongside world leaders and have their work tested through discussions with overseas colleagues as well as through their own contributed lectures. Proceedings for the last of the meetings will be published in *Applied Numerical Mathematics*. These proceedings are now under construction by guest editors John Butcher, Allison Heard and Helmut Podhaisky.
- The postdoctoral fellow, Dr Helmut Podhaisky, participated in the research being conducted by Professor Butcher on the development of the theory of general linear methods and on the practical implementation of these methods. A crucial step has been in the construction of algorithms to derive specific methods and collaboration between Dr Podhaisky and Prof. Butcher has led to the identification of a special class within the family of IRKS (Inherent Runge-Kutta stability) methods. This special class is named FSAL, borrowing a terminology from Dormand and Prince, who applied a similar idea to Runge-Kutta methods. FSAL methods have many important advantages over IRKS methods that do not have this property. It is possible in the FSAL class to estimate local truncation errors in a reliable and asymptotically correct manner and it is also possible to estimate the local truncation error for a contending higher order method. This is quite remarkable, and is being regarded as an important breakthrough because the project team had been looking for a way of doing this for some time and expected that a much more complicated, and therefore computationally expensive, technique would have to be used. This is important also since it makes possible

variable order algorithms. Preliminary numerical tests confirm the accuracy of the error estimating formulae.

- Research by Prof. Butcher and Prof. Zdzislaw Jackiewicz on aspects of variable stepsize behaviour was crucial in this work and Prof. Butcher and Dr Podhaisky have built on this in the choice of method parameters, so that stability at zero and infinity is maintained for as great a range of stepsize ratios as possible.

These developments have led to the construction of an experimental code for stiff problems; this works very well and competitively, in relation to existing low order methods. Although stepsize and order selection can be based in a simple way on a fixed tolerance for truncation error and a choice between orders based on maximising stepsize per cost, it is possible to use a more sophisticated criterion for stepsize and order based on optimisation principles. Although the use of this calculus of variations approach, due to Prof. Butcher, is not recent, it has never been adopted in software design and it is a very satisfactory by-product of these experiments that its use leads to marked improvements in performance.

There are now programs in Maple, Mathematica and Matlab to construct methods for stiff and non-stiff problems with and without the FSAL property. These are being used to construct what is being called an atlas of methods based on good design criteria.

- Other staff and students who have taken part in and benefited from the activities of the programme include Dr Robert Chan, Senior Lecturer, Dr Allison Heard, Senior Tutor, as well as PhD students Shirley Huang, Nicolette Rattenbury (née Moir) and Angela Tsai. Dr Heard has begun a study of control theory in as much as it applies to step-size selection strategies. This has fitted in well with visits by the world authority on this subject, Professor Gustaf Söderlind, and it is expected that this work will be directly beneficial as more elaborate aspects of general linear method code are worked on.
- Ms Huang has now completed her PhD thesis and the overlap between the final stages of her research with the visit of Dr Podhaisky, as postdoctoral fellow, has led to useful insights for the research team. Her work was on a variable order stiff solver and many of the ideas she used have led and will lead to related, but possibly more sophisticated, techniques in the current project.
- Ms Rattenbury has also benefited in her research through the presence in Auckland of Dr Podhaisky and other visitors associated with the programme. She is expected to submit her thesis in the second part of 2004, but she is also working on the final form of a paper for the proceedings of a conference attended in 2003. Her work on stiff ARK methods as well as her existing publications on non-stiff ARK methods have all come out of an environment greatly enriched through visitors of the calibre of Dr Podhaisky and of the other outstanding people who have visited in relation to the programme.

□ **Logic and computation** – Prof. Rob Goldblatt (Victoria University of Wellington) et al

- **Logic & Computation Workshop**

The programme's main workshop took place at the Tahuna Beach Conference Centre, Nelson, the week 11–16 January 2004. There were 36 registered participants, including 12 graduate students. Slides and related material from the lectures given are available for downloading from <http://www.clc.vuw.ac.nz/LandCworkshop.shtml> on the web.

- **Director**

Professor Rob Goldblatt carried out a collaboration with Prof. Ian Hodkinson of Imperial College London (who was one of the invited speakers at the Nelson workshop) and Dr Yde Venema of the University of Amsterdam. Together they solved a problem in the field of algebraic logic that was first posed in 1973 and which had been the subject of attention by a number of leading researcher over the years, without resolution till now. It had been conjectured that any class of algebras having a certain natural closure property must be specifiable in the language of so-called first-order quantificational logic, and settling this question either way would provide insight into the relationship between quantificational logic and the logic of equations of algebras. The outcome of this project was to show that the conjecture is false: infinitely many counter-examples were constructed having various properties, including examples of every degree of unsolvability. These constructions used certain finite graphs of high chromatic number that had been discovered by Paul Erdős using probabilistic methods.

The results have been presented in two papers, one concerned with algebraic aspects and the other more model-theoretic. The first has just appeared in the prestigious *Bulletin of Symbolic Logic* in its section devoted to communications of important new results. The other is due to be published in the journal *Logique et Analyse* later this year.

- **Special issue of journal**

A special issue of the major mathematical logic journal *Annals of Pure and Applied Logic* (Elsevier) is being prepared. This will contain research articles by participants in the Logic and Computation programme from NZ and overseas. Submissions have closed and a rigorous refereeing process is well advanced and should be completed by the end of 2004. It is expected that 8-10 papers will be included.

- **Postdoctoral Fellow**

Dr Liang Yu took up a postdoctoral fellowship in July 2003 under the supervision of Prof. Rod Downey, working in computability theory and the algorithmic study of the notion of randomness. Some of his work has focused on the “degrees of unsolvability” a complex mathematical system that is used to calibrate the difficulty inherent in solving various mathematical problems and in computing various operations. He has solved a number of problems about the structure of the degrees. These theorems typically have the form of showing that there is no largest, or no smallest, degree having a prescribed property. A paper containing some of these results has been published in the *Proceedings of the American Mathematical Society*, and two others have been accepted, by the *Journal of Symbolic Logic* and by the *Notre Dame Journal of Formal Logic*.

A sequence of objects may be called “random” if the simplest algorithm for generating the sequence is at least as complex, in some suitable sense, as the sequence itself. This approach to defining randomness is due to the great Russian mathematician Kolmogorov and has recently become the focus of intense study by Professor Downey and his co-workers. A real number can be represented as a sequence whose randomness can be studied, and Yu and Downey have been comparing the degree of randomness of different random reals and studying their complexity. A joint paper recently appeared in the *Annals of Pure and Applied Logic*. Dr Yu has also collaborated with Dr Joe Miller who has been visiting Victoria University Of Wellington as a Marsden Fund postdoctoral fellow; they have proved

some new theorems together in randomness theory, and are now writing up this material for publication.

Dr Yu gave lectures on this research at an international conference VIC2004 held at Victoria University Of Wellington in January 2004, and at the annual meeting of the Association for Symbolic Logic at Carnegie-Mellon University in May 2004. Over the next year Dr Yu plans to study some applications of randomness theory to reverse mathematics and higher recursion theory.

- **Postgraduate Student – David Friggens**

David Friggens's thesis "A Modal Proof Theory for Polynomial Coalgebras", supervised by Rob Goldblatt, was submitted in May 2004 and graded A+ by an external examiner. He has been awarded MSc with Distinction in Logic and Computation.

The thesis studied a certain class of "coalgebras", which are mathematical systems that have become of interest in theoretical computer science because they can be used to model various notions of state-transition system and data-type. Of particular importance is the notion of a special "terminal" coalgebra whose elements represent all possible "behaviours" of a computational process. The thesis gave a new model-theoretic construction of terminal coalgebras, using techniques from modal logic, and developed an infinitary proof-theory for the associated logical system.

David gave a talk on this work at the annual conference of the Australasian Association for Logic held at Dunedin in January 2004. It is planned to derive a publishable paper from the thesis.

- **Postgraduate Student - Ranald Clouston**

Ranald Clouston's thesis "Comonads, Coequations and Behavioural Covarieties", supervised by Rob Goldblatt, has been submitted and is being externally examined. It is also about coalgebras, but from a category-theoretic standpoint. It considers "behavioural covarieties", which are certain classes of coalgebras defined by computationally significant properties, and closed under bisimilarity, which is a fundamental relation expressing "observational indistinguishability" of state-transition systems. Earlier work of the supervisor had given a categorical characterisation of these behavioural covarieties over the category of sets, and the aim of the thesis research was to identify relevant conditions on an abstract category that would support this theory, and enable its application to broader classes of systems, such as non-deterministic automata with nominated sets of accepting states. The analysis was also extended to more general kinds of covariety.

- **Phylogenetic genomics** – Prof. Mike Steel (University of Canterbury) et al

The goal of this programme has been to bring together leading experts to investigate the following topical problem: How can new types of genomic data best be used to infer evolutionary information? This question involves many challenging combinatorial problems.

- Year two of the programme began with an international phylogenetics conference (Doom04), held at Tongariro in February 2004. The annual phylogenetics meeting is part of a series of conferences that bring together mathematicians and biologists to develop new methods for addressing problems in molecular evolution and ecology.

- Dr Stefan Grunewald is a German mathematician from Vincent Moulton's group in Uppsala, Sweden, who joined the programme for six months as a postdoctoral researcher. He has developed new techniques for analysing reticulate evolution, and related combinatorial problems.
- Dr Magnus Bordewich is an English mathematician, who completed his doctorate at the University of Oxford in 2003. While there he began working with Charles Semple on some difficult combinatorial problems arising in phylogenetics (involving computational complexity of enumeration). Together they have since developed and published new results on supertree theory, as well a far-reaching extension (with Steel) of an earlier result that prescribes precisely how many 'characters' are required to reconstruct a phylogenetic tree. Magnus was with the Phylogenetics programme for six months in a postdoctoral role.
- Philip Daniel was supported on a Masters scholarship from the NZIMA for the period March 2003 to February 2004. His thesis title was "Supertree methods: Some new approaches". He was awarded an MSc with Distinction in May 2004.
- Tobias Thierer is being supported on a Masters scholarship from the NZIMA for the period September 2003 to August 2004. His MSc thesis title is "Generalized and directed characters in phylogenetics". He is expected to submit this in August 2004.
- David Phillips is being supported on a Masters scholarship from the NZIMA for the period March 2004 to February 2005. His preliminary thesis title is "Reconstructing hybrid phylogenies".
- The programme has had several visitors throughout the year, including Professors Andreas Dress and Daniel Huson from Germany; Vincent Moulton, Katherina Huber, Johan Karström and Carl Masek from Sweden; Rod Smallwood from the UK; Peter Jarvis from Tasmania. The programme also involved many biological and mathematical scientists from within New Zealand.

6.2 Thematic programmes begun in 2004

- **Combinatorics and its Applications** – Geoff Whittle (Victoria University of Wellington) and Paul Bonnington (University of Auckland)
 - This new programme's major focus will be on major recent advances in combinatorics, and it will aim to enhance and develop linkages with the world's best combinatorial researchers and their institutions. Additional points of focus will be applications to computational biology, complexity theory, theoretical computer science and abstract algebra.
 - The programme will begin with an instructional workshop at Auckland in July 2004, where a series of lectures will be given on each of six key focus areas by internationally recognised experts (from Australia, Canada, New Zealand and the USA).
 - The programme's main event will be an international conference at Taupo in December 2004. This conference will be held jointly with the Combinatorial Mathematics Society of Australasia's 29th Australasian Conference in Combinatorial Mathematics and Combinatorial Computing. It will be the most significant international event in combinatorics for 2004, and the range and calibre of the invited speakers is unlikely to be repeated anywhere in the foreseeable future. Over 100 participants from all around the world are expected to take part.

- The programme has appointed two postdoctoral fellows, each for a term of one year. Dr Jana Siagovia will work with Dr Paul Bonnington and Assoc. Prof. Jozef Siran (University of Auckland) on the degree-diameter problem in graph theory, and on Cayley maps and their quotients, while Dr Primož Potocnik will work on a range of topics including regular maps, Cayley graphs, and infinite transitive planar graphs..
- **Dynamical Systems and Numerical Analysis** – Prof. Robert McLachlan (Massey University) et al
 - This new programme will focus on the theory and applications of dynamical systems and the numerical analysis of differential equations; particular attention will be paid to the interaction between the two areas.
 - The main international conference will take place at Raglan in August 2004, with a smaller workshop planned for December 2004 at Leigh.
 - A postdoctoral fellow (Dr Bart Oldeman) was appointed to a two-year position with the programme in June 2004, and will be working with Prof. MacLachlan and Dr Vivien Kirk (at the University of Auckland).
 - Two postgraduate students (Elan Gin and Xingyou Zhang) will be undertaking projects with scholarship support from the programme from July 2004.
- **Geometry: Interactions with Algebra and Analysis** – Prof. Gaven Martin (University of Auckland) et al
 - A significant focus of this new programme will be on algorithmic and probabilistic group theory. The research conducted will contribute to the “matrix recognition project”, a major international research project that seeks to develop well-understood high-performance practical algorithms for the study of linear groups and their representations.
 - Several distinguished world experts have been invited to participate, including Professors Craig Evans (Berkeley), Martin Liebeck (London), Alex Lubotsky (Jerusalem), Peter Sarnak (Princeton) and Aner Shalev (Jerusalem).
 - A workshop focusing on the interaction between analysis and geometry will take place in Napier in January 2005, and an international conference in Auckland during February 2005 will focus on the interaction between algebra and geometry.
 - A postdoctoral fellow (Dr Richard Evans) took up a 2-year position with the programme in April 2004, and is working with Prof. Gaven Martin on aspects of the tameness conjecture for hyperbolic 3-manifolds, and deformations of Kleinian groups.
 - Two postgraduate students (Tara Bonda and Tian Zhang) will be undertaking projects with scholarship support from the programme from July 2004.

6.3 Maclaurin Fellowships

- **Professor Rod Downey** (Victoria University of Wellington) completed a year’s concentrated research activity on algorithmic complexity, randomness and structure in December 2003 while supported by a Maclaurin Fellowship. This work was concerned with clarification of the notion of algorithmic randomness, its calibration and its relationship with

classical computability notions. This work was done jointly with a number of co-authors, such as postdoctoral fellows Joe Miller, Evan Griffiths, Wu Gouhua, and Yu Liang. Also involved was graduate student Stephanie Reid. The Maclaurin fellowship allowed Professor Downey to devote almost all of his time to this enterprise.

During the course of the Fellowship Professor Downey and colleagues have essentially invented new methods of trying to measure the level of randomness of a real. For instance, comparing the relative initial segment Kolmogorov complexities of the reals. This material has had such remarkable spin-offs as new solutions to longstanding questions in computability, and real insight into randomness as a lowness notion. Professor Downey devoted much of the time to writing a book “Algorithmic Randomness and Complexity” with Denis Hirschfeldt of the University of Chicago. This is to be published in the prestigious Springer-Verlag Monographs in Computer Science series. At the time of this report a first draft is essentially finished and can be found on the web site http://www.mcs.vuw.ac.nz/_downey. Publication is planned for 2005.

Prof, Downey has given several invited addresses concerning the remarkable progress in this area at major international meetings, such as Mathematical Foundations of Computer Science 2004, VIC 2004, Computability and Complexity in Analysis 2003, and the 8th Asian Logic Conference, as well as a number of lectures throughout New Zealand.

- **Professor Richard Laugesen** (University of Illinois at Urbana-Champaign) took up a 3-month visiting Maclaurin Fellowship at the Universities of Auckland and Canterbury in July 2003, focussing on his primary area of research in Besov spaces and other areas of mathematical physics. During his time in New Zealand he worked with colleagues at the Universities of Auckland, Canterbury and Otago, and gave research lectures at the Universities of Otago, Wellington (Victoria), Massey at Albany, Auckland, and Canterbury. He also attended VIC2004 in Wellington in February 2004.
- **Professor Hal Caswell** (Woods Hole Oceanographic Institute) took up a 3-month visiting Maclaurin fellowship at the University of Auckland in December 2003. During his time in New Zealand he worked with a number of different colleagues in Auckland and Wellington on the development and analysis of matrix models for spatially structured populations. As a result of his attendance at the 3rd International Wildlife Management Congress at the University of Canterbury, he participated in a workshop organized by the New Zealand Ministry of Fisheries to develop plans for using population models to guide policy on reducing the by-catch of albatross and other seabirds in New Zealand waters.
- **Professor Mike Steel** (University of Canterbury) was appointed as a Maclaurin Fellow for a 14-month period (at 0.85 FTE) from February 2004. His research goal is to apply techniques from the study of random discrete structures to the following problems:
 - Analysis of maximum likelihood generally, and information-theoretic results for evolutionary reconstruction under general Markov processes.
 - Resolution of some outstanding questions related to random auto-catalytic networks (which have been studied in origin of life models).
 - Investigation of stochastic models for tree shape.

Considerable progress has been made on the first of these objectives, resulting in three research papers. Further work is being undertaken on this objective with Dr Laszlo Szekely who will be visiting from the US for three weeks during July/August 2004.

The second objective above has been the most successful so far, largely due to a very productive visit to UC Berkeley where Mike Steel worked with Elchanan Mossel on these questions. They were able to resolve the outstanding questions and conjectures that had been posed in earlier papers; moreover, their analysis appears to apply to more general models than had been considered in those papers. This led to a further paper which was recently submitted and which both authors believe will have a high impact.

Background work for the third objective has begun, and the emphasis will likely stay on this objective for the remainder of the Maclaurin Fellowship. After discussing the Aldous conjecture with David Aldous (UC Berkeley) and other probability experts, a decision has been made to consider a related question which seems both more tractable and also more relevant for biology – namely, there is increasing interest in a biodiversity measure called ‘phylogenetic diversity’ (PD). Investigation of this measure found that it satisfies a mathematical property that is related to exchange properties that are more familiar in the study of valuated matroids – this allowed for the development of a simple greedy algorithm for maximizing phylogenetic PD (and extensions of it), which was apparently new. As such this is a purely combinatorial result, with no ‘random’ component, however, at the annual Evolution meeting in the USA in June, biologists were heard using this index to study the decay of phylogenetic diversity as species go extinct according to various random processes, and they were describing characteristic concave relationships on real and simulated data sets. Progress is now being made on establishing a variety of theorems to help model and understand this process (so far little had been done in this area) and plans are underway to develop this into a paper later in the project, perhaps with the biologist Arne Mooers from Simon Fraser University, who is applying PD to conservation genetics.

- **Dr Rod Gover** (University of Auckland) was appointed as a Maclaurin Fellow for a 1-year period beginning February 2004. In joint work with overseas colleagues, he is developing tools and techniques that will enable the use of Lie representation theory and certain geometric constructions to solve hard problems concerning conformal geometries, CR geometries and related structures.

6.4 Directors’ Research

- **Professor Marston Conder** has been continuing his research (supported by the Marsden Fund) in combinatorial and computational group theory, with applications to the study of discrete objects with maximum symmetry. A highlight has been his construction of infinite families of finite Cayley graphs with 5- and 7-arc-transitive automorphism groups, answering questions of Cai Heng Li, and generalisation of the techniques used in this discovery to classify trivalent regular maps with 4- or 5-arc-transitive underlying graphs, answering questions of Cheryl Praeger and Sanming Zhou. Another has been joint work with Arkadii Slinko (Auckland) on comparative probability orderings (as used in preference theory and other aspects of mathematical economics and psychology), including their refutation of a 1995 conjecture by Fishburn on the number of mutually consistent inequalities that sum to an equality in non-trivial orderings that obey de Finetti’s axioms, and generalisation of this

work (jointly with Mathematical Olympiad gold medallist Simon Marshall) to comparative orderings on multisets. In addition, Marston Conder has been working together with Vaughan Jones on some questions in the theory of imprimitive permutation groups related to intermediate subfactors of von Neumann algebras (see below).

- **Professor Vaughan Jones** has been investigating a foundational question in quantum mechanics and the study of pairs of intermediate subfactors of type II factors. The quantum mechanics question is the Hilbert space description of two highly entangled quantum systems. He has proposed that if the degree of entanglement is extremely high, then certain observables on one system could become identical to observables on the other. This suggests a “relative” tensor product, and he is examining the use of the Connes tensor product of Hilbert spaces over a von Neumann algebra. It seems to give a correct picture for Chern-Simons gauge field theory and certain lattice models. Intermediate subfactors exhibit an extraordinarily rich structure. They include as special cases subgroups of groups, intermediate subgroups of groups, certain subalgebras occurring in representations of compact groups and many “sporadic” examples from conformal field theory. With Feng Xu he recently showed that the intersection of a family of finite index subfactors has finite index if and only if the algebra generated by the projections onto them is finite dimensional; this extends a result in Galois theory. Vaughan Jones’s main effort however is in the systematic classification of pairs of intermediate subfactors and the angles between them (building on old work with Bisch on the case of a single intermediate subfactor). The situation appears to be quite rigid and he has shown with his student Grossmann that there are (probably) only two examples where the intermediate subfactors themselves have no extra structure. One is from group theory and thus has integer index, and the other involves the “GHJ” subfactor construction and has index $2(2+\sqrt{2})$. This has led to some conjectures about the group case on which he is working jointly with Marston Conder.

6.5 Postgraduate Scholarships

- The following postgraduate research students are being supported by NZIMA scholarship funding awarded in open competition (on a merit basis):

Zhaojing (Jean) Gong is enrolled for a PhD in medical statistics at the University of Canterbury. Zhaojing contributed a mini-seminar on January 30th 2004 on “Causal inference in time to event analysis: the mathematics of assessing non-compliance” to members of the Christchurch School of Medicine and Health Sciences, members of University of Canterbury mathematics and statistics departments and also in attendance was Associate Professor O’Malley from Harvard University. Subsequent to that seminar Drs Hudson, Graham along with Zhaojing have set up a formal collaboration with Professor O’Malley to further integrate causal inference work between the University of Canterbury and Harvard. Gong, Hudson, Graham and O’Malley are in process of formulating a paper of recent results and theory for the *Biostatistics* journal. Jean Gong also has linked in with an international breast cancer study in the USA.

- **Garry Nathan** recently completed a Postgraduate Diploma in Science with Distinction, and is now completing a Masters degree in mathematics education, at the University of Auckland. An initial research study in 2002 examined the nature of mathematical cognition in a mathematics classroom, investigating the effects of teacher-student interactions on the level of thinking used by students in a Year 13 Mathematics with Calculus class in low decile schools. This has been extended in Garry’s Masters thesis research which addresses the question; ‘What is the conception of calculus for Yr 13 Secondary School ‘Mathematics with Calculus’ students compared with first year undergraduate university students who are studying calculus?’ An aim of this research is to identify and make sense of key influences that contribute to students’ conceptions of calculus within a developing theoretical framework. Anticipated outcomes are that it will inform university first year mathematics programmes and consider implications for the transition from senior school study of mathematics to tertiary studies in mathematics.
- **Tissa Senanayake** is enrolled for a PhD in magnetohydrodynamics at the University of Waikato. The reconnection rate and Eigen function description of a disturbed X-type neutral point configuration with the effect of Hall current has been investigated. The results were obtained numerically, but their general validity was checked by comparing them to previous work of Craig and Watson (1992). The role of the viscous dissipation in the damping of the X-point has also been investigated. Although viscous effects can never remove topological magnetic energy from the plasma, they can provide effective damping for non-reconnective disturbances. This point is emphasized by giving numerical examples, the theory underlying the resistive dissipation of X-point disturbances. The effectiveness of viscous dissipation for damping the excess global energy of the plasmas has been considered. Results suggest that, since a natural equality between the magnetic and kinetic energy of the fluid exists, viscosity can act as a highly effective damping mechanism even for disturbances that alter the initial X- point topology.
- **Josef Silhan** is enrolled for a PhD in differential geometry at the University of Auckland. Josef has been working on the construction of invariant differential operators, focusing in this past year on the setting of conformal geometry using a tool known as tractor calculus. In

addition, he has continued his previous research concerning algebraic structure of the cohomology of real Lie algebras.

- **Krasimira Tsaneva-Atanasova** is enrolled for a PhD in cell modelling at the University of Auckland. During this past year she completed her bifurcation analysis of the point coupled model system of three oscillators and submitted her PhD thesis in June 2004. Krasimira visited the Mathematical Biosciences Institute (MBI) at Ohio State University, USA from mid-January to mid-March 2004. During her visit she participated in MBI workshops and attended seminars and discussions. During her stay in the USA she visited David Yule's lab in the School of Medicine and Dentistry at the University of Rochester, NY. All the work for her PhD has been done in close collaboration with this group and it was a great experience for her to visit them. In June 2004 Krasimira was awarded a postdoctoral fellowship with the NIH Visiting Program at the Laboratory of Biological Modelling, National Institute of Diabetes and Kidney Diseases, USA. This award is effective from September 2004.
- The NZIMA has lent its support to **research projects in Industrial Mathematics**, with selection of students being arranged by Professor Robert McKibbin (Massey University at Albany). The students who have been supported are:
 - **Jae-Hoon Chung** (University of Auckland), project in modelling of breast deformation during X-ray (mammographic) and MRI imaging
 - **Jack Lee** (University of Auckland), project in modelling vasoregulatory mechanisms
 - **Joanne Mann** (Massey University at Albany), project on modelling the generic characteristics of diseases in different population structures
 - **Steven Niederer** (University of Auckland), project in modelling whole heart ischemia
 - **Kirk Spragg** (University of Waikato), project in metallurgic applications of magnetohydrodynamics.
 - **Asher Treby** (University of Auckland), project on simulation modelling of TranzRail's freight network and terminal operations.

6.6 NZIMA-sponsored Conferences and Visitors

- The NZIMA used its CoRE funding and status to lend support to the following **conferences held in New Zealand** in 2003/04:
 - The NZMRI's summer meeting on "Computational Algebra and Number Theory", held at Nelson the week 4-10 January 2004. This meeting featured five outstanding international researchers: John Conway (Princeton University, Hendrik Lenstra (Berkeley/Leiden)), Peter Neumann (Oxford), Karl Rubin (Stanford), and Charles Sims (Rutgers), each of whom gave a series of three lectures. A highlight of the meeting was the topicality of the content of the lectures, including the latest developments in many fields (such as elliptic curves, primality testing, and other computational algorithms for solving problems). Another was the diversity of backgrounds of participants, who included pure and applied mathematicians, statisticians, computer scientists and physicists. Many participants described the workshop as the best they had been to.

- A week-long international conference, VIC2004, took place in Wellington the week 9–13 February 2004, and presented research in a number of areas of fundamental importance in contemporary mathematics. This meeting was attended by 100 mathematicians from 13 different countries, including 14 graduate students. The quality of the presentations was uniformly high and represented research in a number of areas of fundamental importance in contemporary mathematics. The organisers felt that the conference was highly successful in creating an opportunity for interaction and collaboration.
 - A workshop in statistics was held in April 2004 at the AgResearch campus in Hamilton. This was organised by Nye John (Waikato), and the principal speaker was Prof. Peter Green (Bristol).
- The NZIMA also sponsored the following **visitors to New Zealand** in 2002/03:
- Dr D.J. Daley (ANU, Canberra), to work with Prof. David Vere-Jones (Victoria University of Wellington) on a monograph and also participate in a workshop on “Point Process Models in Reliability” in Wellington in September 2004.
 - Prof. V.S. Sunder (IMS, Madras), who visited Auckland and Christchurch for four weeks in April. Professor Sunder is the author of several articles and books on von Neumann algebras and their subfactors. During his time in New Zealand he gave lectures in Auckland and Christchurch, and established contact with many local mathematicians.
 - Prof. Herve Moulin (Rice University, Texas), to work with Dr Arkadii Slinko (University of Auckland) in March 2004 on scheduling probabilistic mechanisms that satisfy the minimal liability test. The standard mechanism “Shortest Job First” minimises the total waiting time but the liability even of a very small job may be unlimited. This is an area that is of interest to economics, applied mathematics and operations research, and has a wide range of applications.
 - Prof. Walter Bossert (University of Montreal) to work with Dr Arkadii Slinko (University of Auckland) in April 2004 on the topic of decision making under uncertainty and the attitude of decision makers towards uncertainty. As above, this is an area that is of interest to economics, applied mathematics and operations research.

6.7 High Performance Computing

The NZIMA is pleased to have been able to help facilitate access by researchers in the mathematical sciences in NZ to high-performance computing platforms, as follows:

- A Silicon Graphics Origin 3400 (with 16 R14000 processors) and an IBM Regatta P690 (with 32 processors) housed at the University of Auckland’s Bioengineering Institute
- The HELIX Beowulf-class cluster supercomputer (comprising 66 dual-processor AMD Athlon computing nodes connected to each other using dual gigabit Ethernet networking), created by the Allan Wilson Centre for Molecular Ecology and Evolution, and housed at Massey University’s Albany campus.

6.8 Other Research Highlights and Linkages

- In 2003 the NZIMA offered a sum of money to support the involvement of young researchers at the conference “PP2003” on Permutation Patterns. This support from a national body representing mathematical research was a key factor in the success of the conference and several of the resulting papers gratefully acknowledged the support of the NZIMA. The conference initiated an annual event: PP2004 was held on Vancouver Island in July 2004 and preparations are well under way for PP2005 in Gainesville (Florida) and PP2006 in Sweden. These conferences are following the model established at Otago for PP2003 in that national funding agencies (NSERC and NSF) followed the NZIMA’s example by supporting PP2004 and PP2005.

More locally, the Theory of Computing Research Group at Otago received wide recognition as the result of PP2003 and is now recognised as the leading research group in the world in this area. As a measure of their activity, they published four papers on permutation patterns in 2003, two further papers have so far been accepted and will appear in 2004, a further three are currently under submission, and two are currently being written. In addition they have presented their work at numerous different international venues. Further details of activities appear at <http://www.cs.otago.ac.nz/staffpriv/mike/TheoryPages/Welcome.html> on the web.

- Mike Steel (Maclaurin Fellow and Programme Director) has observed that many things have happened (in phylogenomics) because of NZIMA support that would never have happened otherwise. For example, Charles Semple and postdoctoral fellows Magnus Bordewich and Stefan Grunewald have made some exciting discoveries concerning hybrid phylogenies (and in particular, the question of what is the smallest amount of hybridization biologists need to postulate in order to explain contradictory gene trees). Also Charles Semple and Philip Daniel (MSc student) were the first in the world to solve the problem of how to combine ‘nested taxa’ into supertree studies; it is likely that Rod Page (UK) will soon implement this computationally, and it may become one of the main tools in some of the big international collaborations to construct a ‘tree of life’.

6.9 Publications

The following is a selection of publications by researchers either supported or stimulated by (or otherwise involved with) the NZIMA’s activities during 2003/04:

Books and Books Edited

Butcher, J.C.: *Numerical methods for ordinary differential equations*. John Wiley & Sons, Ltd., Chichester, 2003. xiv+425 pp.

Daley, D.J.; Vere-Jones, D.: *An introduction to the theory of point processes. Vol. I. Elementary theory and methods*. Second edition. Probability and its Applications (New York). Springer-Verlag, New York, 2003. xxii+469 pp.

Downey, Rod, Chief Editor, with Ding, Decheng; Tung, Shi Ping; Qiu, Yu Hui; Mariko, Yasugi, and Wu, Guohua, editors: *Proceedings of the 7th and 8th Asian Logic Conferences. World Scientific*, 2003, viii+471 pp.

Semple, Charles; Steel, Mike: *Phylogenetics*. Oxford Lecture Series in Mathematics and its Applications, vol. 24. Oxford University Press, Oxford, 2003. xiv+239 pp.

Articles in Refereed Journals and Refereed Conference Proceedings

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6.10 Conferences and other presentations

John Butcher gave a lecture on “Some new methods for stiff problems” at the SciCADE 2003 Conference in Trondheim (Norway) in June/July 2003, and organised a minisymposium on Stiff Problems at this conference. He was a co-organiser of ANODE 2003 in Auckland in July 2003 and contributed a lecture on “Life after Trees”. He also gave two lectures on “Runge-Kutta methods for stiff problems” and “The construction of methods with inherent Runge-Kutta stability” at a Computational PDE-ODE Conference in Auckland (of which he was co-organiser) in April 2004. He gave an invited plenary lecture on “High order A-stable methods for stiff problems” at the 2003 AFOSR Workshop on Advances and Challenges in Time-Integration of PDE’s, at Brown University, Rhode Island (USA) in August 2003, and an invited plenary lecture on “General linear methods for stiff problems” at the 12th NUMDIFF Conference held at Halle (Germany) in September 2003, and another invited plenary lecture on “Some numerical methods for stiff problems” at the ICCMSE 2003 conference in Kastoria (Greece) in September 2003. He gave a lecture on “Practical general-linear methods for ordinary differential equations” at ANZIAM 2004 in Hobart (Australia) in February 2004, and gave another invited plenary lecture on “Multistage methods for stiff and non-stiff problems” at the Volterra 2004 conference, held at Tempe, Arizona (USA) in May 2004.

Hal Caswell (Visiting MacLaurin Fellow) gave three contributed talks at the Third International Wildlife Managment Congress, held at the University of Canterbury in December 2003:

- Caswell, H. and M. Fujiwara. “Stochastic models for the North Atlantic right whale.”
- M. Neubert and H. Caswell. “Dispersal and demography: quantifying invasions, reintroductions and range expansions of wildlife populations.”
- Hunter, C., H. Caswell, and M.G. Neubert. “Sensitivity analysis for spatially distributed wildlife populations.”

He also gave an invited plenary lecture on “Population growth, linear algebra, and ecology” at the 11th Conference of the International Linear Algebra Society, University of Coimbra (Portugal), in July 2004.

Marston Conder gave an invited plenary lecture on “Symmetries of Cayley graphs and graphs underlying regular maps” at an International Workshop on Group Theory and Algebraic Combinatorics held at Beijing (China) in June 2004.

Vaughan Jones gave an invited plenary lecture titled “Two subfactors” at the VIC2004 international conference in Wellington in February 2004.

Rod Downey gave a plenary lecture at the Annual Conference on Computational Complexity held at Aarhus (Denmark) in July 2003, and a plenary lecture at the annual Conference on Computable Analysis held at Cincinnati (USA) in August 2003.

David Friggens (postgraduate scholar) gave a talk on “A modal proof theory for polynomial coalgebras” at the annual conference of the Australasian Association for Logic held at Dunedin in January 2004.

Rob Goldblatt gave an invited address on “Questions of Canonicity” at the conference “Trends in Logic: 50 Years of Studia Logica”, at Copenhagen (Denmark) in November 2003.

Rod Gover was a principal organiser and speaker at the workshop “Conformal Structure in Geometry, Analysis, and Physics”, held at the American Institute of Mathematics at Palo Alto (California) in August 2003. He also gave a series of three plenary lectures at the “24th Winter School on Geometry and Physics” held at Srní, Czech Republic, in January 2004, was also an invited participant at the workshop “Geometric and analytic problems related to Cartan connections” held at the Erwin Schrodinger International Institute for Mathematical Physics (Vienna), Spring 2004, gave an invited talk on “Strings and Branes” at the American Mathematical Society sectional meeting at Rider University in April 2004, and was an invited speaker and participant at the workshop “Geometric Partial differential equations” held at the Institute for Mathematical Sciences, Singapore, in May/June 2004.

Gaven Martin gave a plenary address on “The minimal volume hyperbolic orbifold” at the conference “Future Trends in Geometric Function Theory” held at Jyväskylä (Finland) in June 2003, and also gave an invited talk, “Holomorphic Motions” at the XIX Nevanlinna Colloquium held at Jyväskylä (Finland) the same month.

Helmut Podhaisky gave a lecture “On implementing general linear methods” at the ANZIAM meeting in Hobart (Australia) in February 2004, and another “On implementing general linear methods for stiff ODEs” at the conference “Volterra 2004” held at Phoenix (Arizona) in May 2004.

Andrew Pullan (together with Vanessen, N.L., Anderson, I.A., Hunter, P.J., Clarke, R.D.) gave a presentation on “Anatomically Based Modeling of the Human Jaw and Face” at the Third Scientific Meeting of the TMJ Association, “Advancing Diagnostic Approaches for TMJ Diseases/Disorders”, held at Bethesda (Maryland) in May 2004.

Nicolette Moir Rattenbury gave a talk “Improving upon the ARK” at the 10th NUMDIFF Seminar, held at Halle (Germany) in September 2003, and another on “A new class of methods for solving Ordinary Differential Equations” at the ICCMSE 2003 Conference, held at Kastoria (Greece) in September 2003.

Charles Semple gave an invited conference presentation on “Generalised delta-wye exchange for matroids” at the SIAM Conference on Discrete Mathematics, held at Nashville (USA) in June 2004.

Arkadii Slinko (with Geoff Pritchard) gave an invited plenary talk, “Comparing the rules Chamberlin’s way” at the Mathematical Modelling of Social and Economical Dynamics conference (MMSED-2004), held at Moscow in June 2004. Also he gave papers (with Geoff Pritchard) “On the Average Minimum Size of Manipulating Coalition” and (with J. McCabe-Dansted) on “Exploratory Analysis of Similarities between Common Social Choice Rules” at the Seventh International Meeting of the Society for Social Choice and Welfare, held at Osaka in July 2004, and another (with Walter Bossert) on “Relative uncertainty aversion and additively representable set rankings” at the 2004 Workshop on Economic Decisions, held at Pamplona (Spain) in June 2004.

Mike Steel gave a contributed talk and was a session chair at the annual joint meeting of the Society for Systematic Biology, the Society for the Study of Evolution, and the American Society of Naturalists, held at Colorado in June 2004.

In addition to these, keynote presentations given at the Phylogenetic Combinatorics and Applications meeting in Uppsala (Sweden) in July 2004 by participants in the NZIMA’s Phylogenetics programme included:

- Peter Lockhart, “Some phylogenetic approaches to studying the radiation of alpine *Ranunculus* in New Zealand”
- Charles Semple, “Extending the Limits of Supertree Methods”
- Mike Steel, “Some open problems in phylogenetic combinatorics”
- Daniel Huson, “Consensus Super-Networks from Partial Trees”
- Stefan Grunewald, “Hybrid Phylogenies and Rooted SPR Operations”.

7. **International Linkages**

The NZIMA is a member of the International Mathematical Sciences Institutes (IMSI), an international consortium of research institutes in the mathematical sciences that run thematic programmes and have large visitor programmes, and is listed on the IMSI website. IMSI meetings are normally held in conjunction with major international conferences, notably the International Congress of Mathematicians (ICM) held every four years.

Communication linkages with such institutes overseas have been set up through visits by one or both of the two Co-Directors (often while attending other conferences). These include the Fields Institute in Ontario, the Mathematical Sciences Research Institute (MSRI) in California, and the Pacific Institute of Mathematical Sciences (PIMS) in British Columbia.

Very strong international linkages have been developed by the NZMRI through its earlier programme of annual summer workshops, and these are being taken further by the involvement of invited overseas experts in NZIMA programmes and as visiting Maclaurin Fellows. The NZIMA's website and a quarterly series of NZIMA newsletters (begun in November 2003) are proving useful devices for maintaining and enhancing international contacts.

These linkages are also being maintained through the NZIMA's International Scientific Advisory Board (Section 2.2), which includes a number of prominent New Zealand-born mathematical scientists resident overseas and representatives from other members of the IMSI (such as the CMA, MSRI and PIMS). Members of this advisory board are invited to participate in the NZIMA's activities.

8. Staff Awards and Honours

- Prof. John Butcher was awarded the International Conference of Computational Methods in Sciences and Engineering (ICCMSE) 2003 Prize for Computational Mathematics
- Prof. Marston Conder (NZIMA Co-Director) has been elected to the Council of the Academy of the Royal Society of New Zealand
- Prof. Rod Downey (Maclaurin Fellow for 2003) has been elected a Fellow of the New Zealand Mathematical Society
- Prof. Rod Downey (Maclaurin Fellow for 2003) has been elected a life member of the Combinatorial Mathematical Society of Australasia
- Prof. Rob Goldblatt has been appointed Coordinating Editor of the *Journal of Symbolic Logic*
- Dr Rod Gover (Maclaurin Fellow for 2004) won the NZ Mathematical Society's Research Award for 2003, for his work in conformal differential geometry
- Prof. Vaughan Jones (NZIMA Co-Director) has been elected as a Vice-President of the American Mathematical Society
- Assoc. Prof. Peter Lockhart (a key participant in the NZIMA's Phylogenetics programme) has been appointed Associate Editor of the journal *Molecular Biology and Evolution*
- Prof. Gaven Martin was an invited participant at the Miller Colloquium at the Marconi Center in California, in July 2003
- Prof. Gaven Martin was awarded a Research in Peace Fellowship at the Institut Mittag-Leffler, Swedish Academy of Sciences in November 2003
- Prof. Robert McLachlan (Programme Director for the programme in Dynamical Systems and Numerical Analysis) won the NZ Association of Scientists' Research Medal for 2003, for his work in geometric integration
- Garry Nathan (an NZIMA-sponsored postgraduate student) won the Mathematics Education Technology Prize for 2003 at the University of Auckland
- Dr Charles Semple (member of the programme committee for the NZIMA-sponsored programme in Phylogenetics) won the Royal Society of New Zealand's Hamilton Memorial Prize (for beginners in scientific or technological research) 2003, for his work in matroid theory and evolutionary trees
- Dr Charles Semple (member of the programme committee for the NZIMA-sponsored programme in Phylogenetics) held a Visiting Research Fellowship at Merton College, University of Oxford, for its Trinity Term 2003
- Dr Guohua Wu (a participant in the NZIMA's Logic and Computation programme) won the Royal Society of New Zealand's Hatherston Award (for the best paper by a PhD student at a New Zealand university in the physical sciences, earth sciences, or mathematical and information sciences, for 2003) for his work on isolation and lattice embeddings.

9. Financial Reports

This is a limited report on the financial performance and financial position of the NZIMA at the end of its second year of operation. It covers only the activity supported by the award to it from the NZ government's Centres of Research Excellence (CoRE) Fund.

9.1 Statement of Financial Performance for 2003/04

Income	Actual	Budget	Variance
CoRE Funding	\$ 1,767,778	\$ 1,360,000	\$ 407,778
Host/ Partner Support	0	37,990	(37,990)
Total Income	\$ 1,767,778	\$ 1,397,990	\$ 369,788
Expenditure	Actual	Budget	Variance
<i>Salaries</i>			
Director & Principal Investigators	\$ 62,616	\$ 76,500	\$ 13,884
Associate Investigators	210,050	165,000	(45,050)
Postdoctoral Fellows	204,383	153,000	(51,383)
Research/ Technical Assistants	0	0	0
Others	29,370	22,950	(6,420)
<i>Total Salaries (a)</i>	<i>\$ 506,420</i>	<i>\$ 417,450</i>	<i>\$ (88,970)</i>
<i>Other Costs</i>			
Indirect Costs: Overheads	\$ 562,942	\$ 417,450	\$ (145,492)
Direct Costs: Project Costs	169,527	107,100	(62,427)
Travel	31,963	102,000	70,037
Postgrad Student Stipends	240,495	230,600	(9,895)
Equipment depreciation	8,688	37,990	29,302
Rental - equipment	86,111	65,000	(21,111)
Subcontractors	0	0	0
Extraordinary expenditure	0	20,400	20,400
<i>Total Other Costs (b)</i>	<i>\$ 1,099,727</i>	<i>\$ 980,540</i>	<i>\$ (119,187)</i>
Total Expenditure	\$ 1,606,146	\$ 1,397,990	\$ (208,156)
Operating Surplus for Year	\$ 161,631	\$ 0	\$ 161,631
Operating Surplus Carried Forward	868,010		\$ 868,010
Nett Surplus	\$ 1,029,641		\$ 1,029,641

Notes:

- Expenditure stepped up considerably in the 2003/04 financial year as further research programmes and other activities got underway. The amount shown as "Nett surplus" here is committed and will be carried forward for expenditure in 2004/05.

- b) The amount budgeted in “Host/Partner Support” was met partially by transferring the bulk of the charges for equipment depreciation to the Mathematics Department of the University of Auckland (to reflect its shared usage of the equipment).

9.2 Statement of Financial Position as at 30 June 2003

The (limited) assets of the NZIMA are property of the University of Auckland and are treated as part of the University of Auckland’s accounts.

10. Directory of key contacts

10.1 Chair of the NZIMA Governing Board

Sir Ian Axford *PhD (Manchester) Hon DSc (Cantab, Victoria) FRS FRSNZ*
2 Gladstone Rd, Napier, New Zealand
Email: ian@axford.org

10.2 Co-Directors

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10.3 Executive Committee Members

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10.4 Executive Administrator

Margaret Woolgrove *MA (Hons) (St Andrews)*
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10.5 NZIMA Website

URL: <http://www.nzima.auckland.ac.nz>