Mathematical minds

David Ellwood*

David Ellwood is Research Director of the Clay Mathematics Institute. He was interviewed for the Gazette during the 53rd Annual AustMS Meeting at the University of South Australia in Adelaide.

Gazette: Can you tell us about the Clay Mathematics Institute?

Ellwood: The Clay Mathematics Institute (CMI) is different from other mathematics institutes in several respects. First of all, CMI is not part of any graduate school, university system or national research initiative. Rather, CMI is a private philanthropic foundation based in Cambridge Massachusetts, and was founded in 1998 through the vision and generosity of Boston businessman Landon T. Clay. Landon's vision was to create an institute that would further the beauty, power and universality of mathematical thought.

CMI has been extremely active and diverse in its approach to Landon's vision. We offer various types of research appointments, ranging from fellowships to support senior researchers at a thematic program, to our one-month 'Lift-Off' fellowships that are awarded to new PhDs in the summer of their graduation. The Clay Research Fellowship (formally called Clay Long Term Prize Fellowship) is one of our flagship programs, a 'dream' postdoc position lasting from three to five years and tenable at any institution of the Fellow's choice. For example, when Terry Tao was a Long Term Prize Fellow, he used this flexibility to return to Australia and visit UNSW.

We also organise a great variety of conferences, workshops and summer schools, sometimes independently, but often in partnership with other institutions. A personal passion of mine has been to develop CMI's potential as a global research vehicle. I like to think of CMI as an institute 'without walls' since we organise the majority of our programs off-site. This means that we have the potential to operate 'without borders' like no other more localised entity. We seek out opportunities at the highest level, and work to implement them wherever it makes most sense mathematically, with an emphasis on both quality and impact. Although CMI has a physical base in Cambridge, Massachusetts, all our researchers are hosted elsewhere, and typically more than 50% of our programs are conducted abroad. For example, another of our flagship programs is the CMI Summer School. This is a high-level four-week school for 100^+ graduate students and young mathematicians. In its 10 years of operation, we have held schools on different subjects every year, ranging from Mirror Symmetry to Galois Representations, and conducted these schools at a great variety of international venues: Boston, Berkeley, Cambridge (UK), Toronto, Budapest, Göttingen, Pisa, Zürich and Manoa (Hawaii). We are

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currently gearing up for our 2010 school in Brazil, which will be on 'Probability and Statistical Physics in two or more dimensions'.

Gazette: When will there be a school in Australia?

Ellwood: That depends on the enthusiasm and suggestions that come out of the Australian mathematical community, but it's interesting to note how prominently Australian mathematicians have featured in CMI's activities to date. For example, Terry Tao and Akshay Venkatesh have been Clay Research Fellows, and Terry won the Clay Research Award in 2003. Danny Calegari was a Clay Lift Off Fellow in 2000, won our Clay Research Award in 2009 and is of course a Clay–Mahler Lecturer at this meeting! Proportionally, Australia has been very strongly represented in CMI programs. This shows the excellence that has been cultivated in Australian mathematics. The Clay–Mahler Lectures is the first major event in Australia and I hope our visit will open doors to future collaborations. It's been a tremendous pleasure for me to visit and talk to Australian mathematicians about what's going on here. CMI is always looking for new opportunities and I expect some exciting ones will come out of this tour.

Gazette: What are the origins of the CMI?

Ellwood: CMI was founded in 1998 by Landon T. Clay, a prominent businessman who served for many years as the chief executive officer and chairman of the mutual fund company Eaton Vance. Landon studied the Classics at Harvard and was moved by the achievements of ancient Greece in the arts and sciences. He told me that he was struck by 'the enduring power of mathematics'. Seeing the potential in starting a mathematics institute, he followed up his ideas with Arthur Jaffe, Landon T. Clay Professor of Theoretical Science at Harvard University and first president of CMI. Talking to Landon you quickly appreciate his deep understanding of the relevance and cultural significance of our discipline.

Let me put it this way, as a philanthropist you might build a building, and if you build it well it can last a long time, but in funding mathematics you create something that is eternal. After all, Euclid's Elements served as a text book until the early 20th century, that is, for more than two millennia! I think the impact of ones activities in time, rather than space, is often poorly anticipated.

In 2000 we launched the Millennium Prize Competition in Paris. That really helped put us on the map. The idea was not only to promote excellence, but also to draw attention to the fact that mathematics is, in a certain sense, inspired and driven by these extremely hard problems, even if they're not the problems that we are working on most of the time. If you like, these problems let us know how to orientate ourselves and where the future wealth of the subject can be found.

Gazette: Were you surprised that the Poincaré Conjecture was the first of the Millennium Problems to be solved?

Ellwood: There was a lot of discussion in 2000 as to what might happen. At the time some people thought that it was possible none of these problems would be

solved in our lifetime, and so it was really surprising that so much progress was made on the Poincaré Conjecture so quickly. I don't think anyone expected that. It was a remarkable turn of events for mathematics and great for CMI because it was one of the problems we had selected for the competition.

When we launched the Millennium Problems, one of the goals was to draw attention to the fact that mathematical problems are intrinsically valuable, independently of their applications. The reward itself honours both the importance and difficulty of these problems. But the competition spoke to the general public in a compelling way, communicating first of all that there are unsolved problems in mathematics (which is something that needs to be better appreciated!) and that mathematicians are not technicians, but more akin to explorers, primarily focused on the frontiers of their field. This is something that's hard to communicate, so highlighting these problems and then actually solving one of them in 'real time' exhibits the functioning of our establishment at its highest level. It a phenomenal event that benefits every mathematician, not only because of the specific advances that enrich our discipline, but also because of the opportunity it provides to put our vocation in the spotlight and for people to pay attention.

Gazette: What is the process now to award the prize?

Ellwood: CMI must follow through the rules that were set out when the Millennium Prizes were announced. After the solution to one of the problems is published, there is two-year waiting period, as there has to be a consensus within the mathematical community that it is valid. Then a special board is set up to evaluate the solution. They report to our scientific advisory board, who then make recommendations to the board of directors. Once all the steps are completed, there will be official recognition and an award ceremony. This process will culminate for the Poincaré Conjecture sometime in 2010. It will be exciting when the award is finally announced.

Gazette: So do you have a sense of which problem might be solved next and when that might be?

Ellwood: I think Terry answered that question well in one of his talks here at the AustMS meeting. All of these problems are certainly extremely difficult and appear to be beyond the reach of current technology. It seems that something unknown, some critical advance, is required for the solution of each problem. People get excited about various new results, but I believe the general consensus is that something really big is necessary in each case. For me, the knowledge that a critical new development will have to happen before any of these problems can be solved makes them all the more exciting.

When Hilbert launched his list of problems in 1900, he set them out as signposts for 20th century mathematics — milestones both to measure our progress as well as chart out a road map for his vision of future progress. I think the scientific advisory board of CMI was much more humble in its perspective. It just wanted to highlight some very important unsolved problems and draw attention to the fact that mathematics is concerned with such very deep questions.

Gazette: Can you tell us a bit more about how the lecture tour in Australia has gone?

Ellwood: Attendance at the talks and public lectures has been excellent. Terry Tao's public lectures often filled the auditoriums to capacity! I think the tour has been a great success, and we are extremely grateful to all the people who worked so hard to coordinate events between six cities and 14 institutions across Australia (special mention should be given to Alan Carey and Andrew Hassell at ANU, as well as all the local organisers and the efforts of AMSI and AustMS). Previous Clay Lectures have been organised in the UK, India and Japan, but this is the first time we've attempted a multi-city tour. It has added enormous value in terms of the amount of exposure and dissemination, and it's a format we should consider adopting for future events.

Gazette: What is your background? What exactly is your role?

Ellwood: I'm the Research Director of CMI, and as such I'm responsible for most of CMI's programs and events. I grew up in New York City, and at age 11 I went to school in England. As a teenager I became fascinated with quantum mechanics, especially Heisenberg's uncertainty principle. I started my PhD at Imperial College (London) under Chris Isham, but while studying there I was invited to IHES (Paris) by the celebrated Operator Algebraist and Fields Medalist Alain Connes. I spent three years working closely with Alain, a period that greatly influenced my taste and development as a professional mathematician. After completing my PhD, I held positions at the University of Paris VI (Pierre and Marie Curie), ETH Zürich, Strasbourg, Boston and Harvard Universities.

Arthur Jaffe was just starting CMI when I arrived at Harvard. I found his ideas completely new, exciting and fresh. In particular, the idea that an institute should have a very small administrative structure and be able to move quickly and decisively in response to new developments in mathematics. I've been working for CMI for 10 years, which is essentially since the beginning of our operations in 1999.

My field of research is operator algebras, in particular noncommutative geometry, but more recently I've become interested in homotopy theory and operads. Non-commutative geometry provides a new paradigm that is as rich conceptually as it is in its applications to mathematics and physics. Most of my time now is dedicated to CMI's activities, and I enormously enjoy being involved with so many mathematicians across so many fields of research. Besides the Clay Lectures, I'm in charge of the CMI Summer Schools, our onsite 'Bow Street' Workshop program, all external conferences, the Lift-Off Program, and I ran a special program for gifted high school students called the Clay Research Academy from 2003–2005. I continue to supervise CMI's involvement in programs for gifted students (CMI-PROMYS and CMI-Ross) and I'm editor of CMI's proceedings series.

Gazette: What are your impressions about mathematics in Australia and where it might to go in the future?

Ellwood: If we think about the last 2500 years, the evolution of mathematics and its achievements has been one of the great successes of human civilisation. Maybe that's not been appreciated by our culture at large as much as it should be, but Australia continues to do an outstanding job in both mathematics research and education. The record breaking participation of this meeting, and high international profile of its speakers, all speak of the hard work and dedication of the Australian mathematical community.

I think any scientific endeavor is best driven by the science itself, and that's what mathematicians do best. It's the most exact of all sciences and impervious to manipulation of any kind. When we find a superior way of doing things, we quickly adopt it — if something is right, we do it; when something is flawed, we drop it. It's a science that's immune to dogma because it's completely self-correcting, and sets the standards by which all others are judged.

As the frontiers of mathematical knowledge advance, we have to adapt to them and take on new challenges. I think mathematicians have to stay close to the pulse of what's happening, where the advances are, where the deep problems lie, and interact with each other as a community to exchange knowledge. These are things that we are getting ever better at. Australian mathematicians are doing all these things, and doing them well. In my opinion a meeting such as this perfectly exhibits the type of activity that keeps our research healthy, advancing and aligned with developments elsewhere. However, mathematicians must stay focused and remind politicians of their achievements at every opportunity. Mathematics is in some ways an art, but it's not a visual art, it's not an art that can be appreciated without getting involved. I think that we mustn't be content with the image that we're doing something difficult that's hard to communicate, but rather seek out ever new ways to explain and relate our achievements to others.

You can listen to a concert and derive something from it, you can go to an art gallery and find something appealing, but with mathematics it really depends on human interaction and communication. If mathematics is to receive the full recognition it deserves we must take every opportunity to communicate with all who express an interest.

Gazette: Thank you very much for talking with us.

David Ellwood has been Research Director of CMI since 2003, and was previously Resident Mathematician at CMI from 1999 to 2003. He obtained his PhD from Imperial College (London), and has held positions in France, Switzerland and the USA. In his work for CMI he has served on the organising committee of hundreds of conferences and workshops around world.