Portals into other worlds by Elizabeth Connor

Sometimes truth is stranger than fiction. Hidden in six locations around New Zealand are over twenty portals into other worlds. Unlike Narnia or Middle Earth, these worlds are real, although you would have to shrink around a hundred million times to enter them.

At this scale, an orange would loom the size of a planet and you could slip through its skin into a world of pulsing molecules, strange creatures and unpredictable forces. MacDiarmid Institute researchers use these portals to enter the tiny worlds inside things, exploring, cataloguing and tweaking the strange dance of atoms and molecules to create extraordinary new materials.

Three years ago, I had the privilege of visiting these portals, which are in fact scientific instruments. I was escorted, wearing white booties, lab coat and shower cap, by their proud guardians down winding stairs into underground vaults, behind thick black curtains and into golden glowing rooms.

The instruments themselves looked deceptively unassuming, but it is well known that portals are concealed in everyday places such as telephone boxes and wardrobes. One instrument looked like a hair-dryer, rigged up to a vacuum cleaner pipe, attached to a carburettor with a tangle of pipes and electrical wires all joined onto a jet engine. Other instruments were neatly contained in boxes like microwaves. Some looked like old-fashioned submarines with shiny metal vaults and bolted round glass windows. Others involved blue and red lasers darting to and fro across tables in dark rooms. Many of them purred and pulsed.

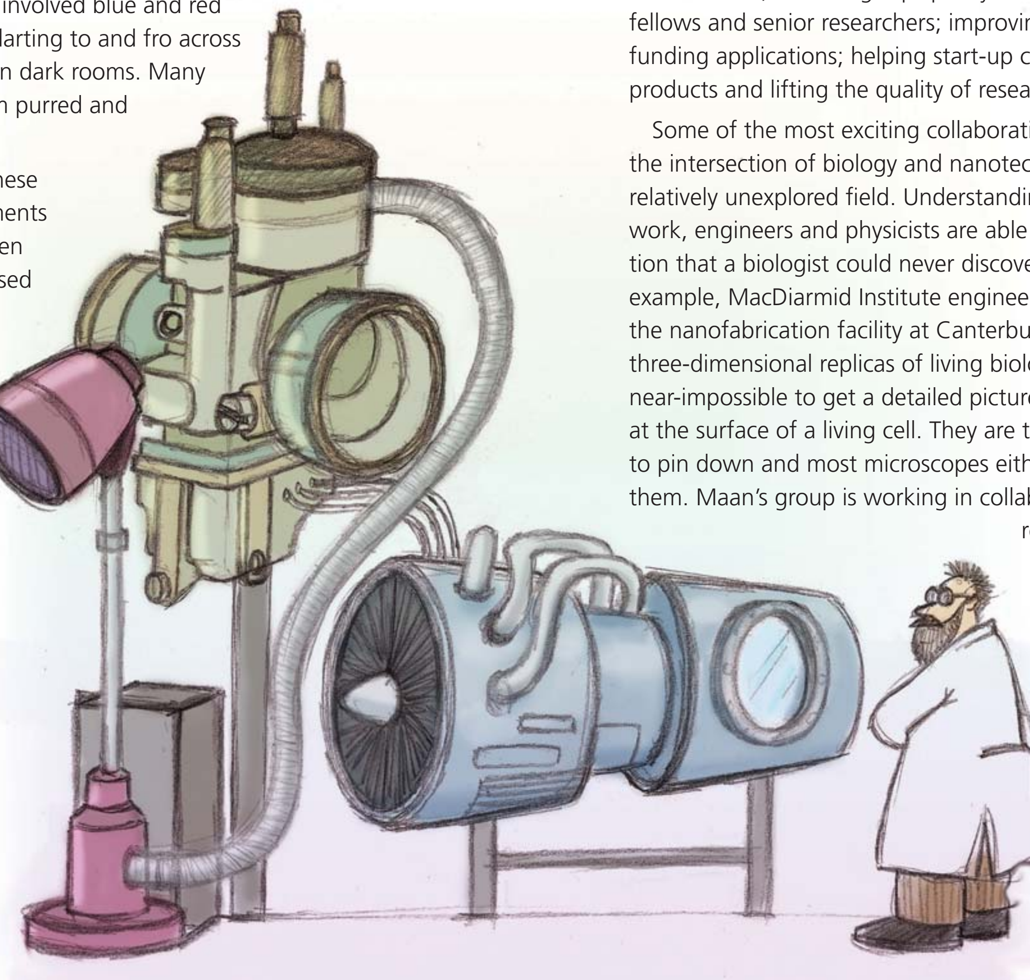
All these instruments had been purchased or built with two injections of funding from the government's education budget. It was like rain after drought. The government had not funded capital equipment for many years and, without it, New Zealand scientists struggled to perform world-class research. Finally, the portals were opened and they could now enter the world stage with confidence.

Ten million dollars may seem a lot but, compared to the budgets of top overseas labs, it was a drop in the ocean. The key to the MacDiarmid Institute strategy was an ethos of openness and collaboration. They decided to locate equipment where the expertise was and give all MacDiarmid Institute researchers free access. Facilities ended up at Industrial Research, Canterbury, Otago, Victoria, Massey and later at Geological and Nuclear Sciences.

What began as a practical measure for making the most of limited resources had a remarkable side effect, as founding director Paul Callaghan explained: "The instruments became nodal points for collaboration. In each case there were one or two people looking after the equipment who became experts. They had a brief of supporting the work of teams from elsewhere and, as we moved around and used each other's equipment, new research relationships developed."

Just as Paul described, I discovered thriving ecosystems of researchers and students developing around the facilities. I found that the equipment was improving the international reputation of researchers, spurring collaborations both here and overseas; attracting top-quality PhDs, postdoctoral fellows and senior researchers; improving the success rate for funding applications; helping start-up companies improve their products and lifting the quality of research across the board.

Some of the most exciting collaborations have emerged at the intersection of biology and nanotechnology, a rich and relatively unexplored field. Understanding how the instruments work, engineers and physicists are able to reveal information that a biologist could never discover on their own. For example, MacDiarmid Institute engineer Maan Alkaisi is using the nanofabrication facility at Canterbury University to produce three-dimensional replicas of living biological cells. It is usually near-impossible to get a detailed picture of what's going on at the surface of a living cell. They are tiny, slippery and hard to pin down and most microscopes either damage or kill them. Maan's group is working in collaboration with medical researcher John Evans using a nano-imprint machine, which takes miniature "plaster-casts" of cells giving snapshots of processes such as hormones travelling in and out.



Dafnis Vargas

At Massey University, physicist Bill Williams is using optical tweezers to reveal the mechanics of biological systems. This fascinating device, purchased in 2008, uses tightly-focused lasers to pick up tiny objects and move them around. It gives you such a direct appreciation of the forces at work in the microscopic world that you feel like you've eaten a "shrink me" pill and popped yourself in there. You can, for example, grab the ends of a DNA molecule and pull them apart; measuring the force it takes to unravel. Bill is collaborating with Canterbury University biologist Juliet Gerrard to unravel the molecular machinery inside living cells. The tweezers can also be used to pick up emulsions, the tiny drops of oil and water found in foods like chocolate and mayonnaise. This forms the basis of the collaboration between MacDiarmid Institute Director Kate McGrath and the Riddet Institute for food science and nutrition.

Once you understand how biological systems work you can start to imitate them. Several exciting biomimicry projects have sprung up within the MacDiarmid Institute, in particular around the Electron Microscope Facility at Victoria University. These microscopes take extremely high-resolution images of materials almost to the level of single atoms. Auckland-based Principal Investigator David Williams is using them in collaboration with the Maurice Wilkins Centre for Biodiscovery to understand and imitate the way nature builds materials like seashells, bone and teeth. These incredibly light and strong materials assemble themselves from common minerals using virtually no energy and producing no waste. If we could imitate their construction, it could solve a host of problems.

New Zealand has long been famed for its innovative use of tools. What more is the number 8 fencing wire legend than an example of using the tools at hand to solve new problems? Paul Callaghan's own field of research came about this way. After returning home from completing his PhD in Physics at Cambridge University he found himself in a chemistry department. In order to do experimental physics he had to innovate with the equipment at hand. This turned out to be a nuclear magnetic resonance (NMR) spectrometer that one of his colleagues let him share. By applying his physics knowledge to the spectrometer, he developed a new tool for measuring the movement of molecules inside a material. This was his first major breakthrough and opened up a completely new field of Rheo-NMR, for which he soon became famous. Paul's company Magritek is centred on a portable NMR tool, which his team developed by simplifying and improving existing technology. This story illustrates a formula for success in New Zealand: take an old tool, apply it to a new field, invent a cheaper more effective version and sell it to the world. A similar formula has been followed by IZON, the Christchurch-based company that sells instruments for measuring nanoparticle size. Both IZON and Magritek use the MacDiarmid Institute-funded equipment to test and improve their products.

When Paul first used an NMR spectrometer it wasn't the applications that interested him. "I did it because I had a tool," he said, "a window that allowed me to see a whole lot of complexity and dynamics at a molecular level that was otherwise not accessible." It is the thrill of discovery that propels many researchers through the portals into the unknown. And yet, from these strange compelling worlds at the frontiers of human knowledge, the seeds of our future are found.

Cultivating NZ's Talent Since 2005 by Elf Eldridge

As a CoRE, one of the MacDiarmid Institute's goals has always been the development and promotion of its talented students. Recently, this has gained much wider attention through the creation of MESA, the MacDiarmid Emerging Scientists Association at the end of 2010. However, the MacDiarmid Institute's commitment to its students stretches right back to its inception in 2005.

One of the MacDiarmid Institute's earliest PhD students was Dr. Timothy Drysdale, currently leader of the Electromagnetics design group at the University of Glasgow, who studied under Professor Richard Blaikie at the University of Canterbury in 2005. Timothy fondly remembers participating in the MacDiarmid outreach programmes with local schools and assisting with the early AMN conferences as part of the development of the MacDiarmid Institute 'family', though he freely admits he couldn't have dreamt where his MacDiarmid Institute journey would ultimately lead him.

He's not alone. MacDiarmid Institute students are exposed to some of the rarest scientific opportunities available to PhD students worldwide just by virtue of being associated with the institute, opportunities which many students cite as being crucial steps on their respective pathways to success.

Dr. Reuben Mendelsberg and Dr. Shelley Scott are two further MacDiarmid Institute success stories. Both currently pursuing science research careers with prestigious American institutions (the Molecular Foundry at Lawrence Berkeley National Laboratory and Professor Max Lagally's materials science group at the University of Wisconsin respectively), Mendelsberg and Scott each regard the opportunities offered to them through the MacDiarmid Institute community as life-changing points in their careers. Dr. Mendelsberg was selected as one of the first two students to participate in the IBM visiting scholar's programme in 2008 and Dr. Scott was one of the 2005 MacDiarmid Young Scientists Awards recipients as well as being selected by the Royal Society to attend the 5th Nobel Prize Winners Meeting in Lindau, Germany in 2005. Whilst both are undeniably

Electrochemistry bootcamp