The best mistake ever

Chemist: Alan MacDiarmid

Alan MacDiarmid is a big part of the reason your cell phone screen works. He is also the second New Zealander to win a Nobel Prize in Chemistry – the first, of course, was Ernest Rutherford who is on the $100 note.

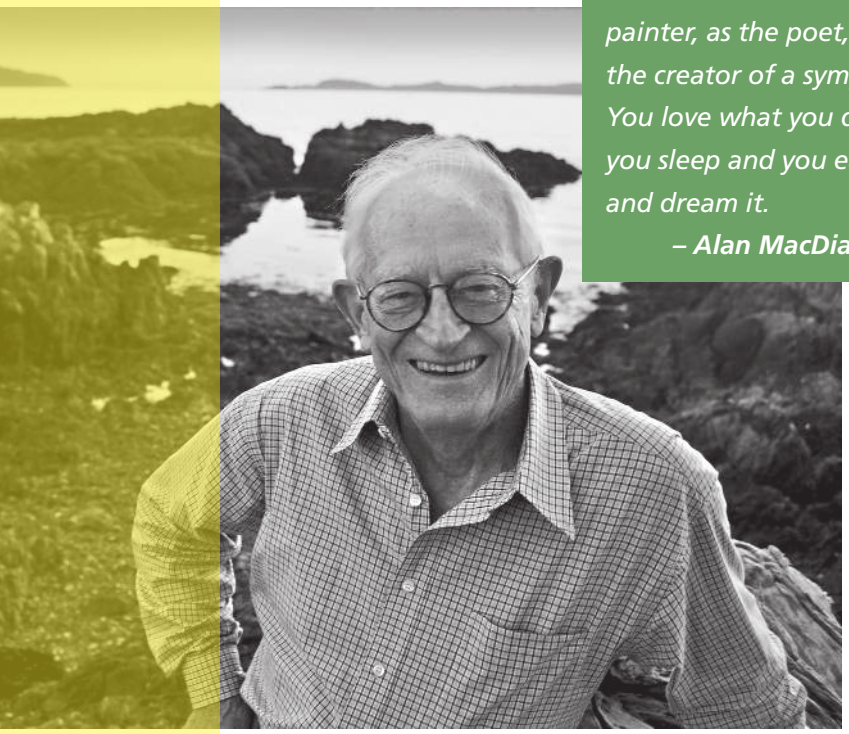
Alan grew up in Masterton and Lower Hutt and had to work hard to get himself through school and university. His family didn't have much during The Great Depression but he reckons that growing up in a supportive family was the very best training to face life anywhere in the world. He worked in the lab at Victoria University in Wellington while he was studying and in that lab he prepared some fascinating golden-yellow crystals made up of sulfur and nitrogen. He liked them so much that he researched them for his Masters degree. A lucky choice as it turned out.

Colour and Curiosity

Alan believed that it was his love of colour and his solid work ethic which contributed to his success as a scientist, but in his youth they combined in a different way. During World War II when necessities were hard to come by and frivolous entertainments such as fireworks were non-existent, Alan used his hard-earned paper-round money to buy the chemicals to make his own fireworks. His sister remembers that they set them off in the backyard because a blackout was in force and it was the only fireworks display in the neighbourhood. While Alan's enthusiasm for chemistry turned out extremely well, please don't follow his example in this!

The real creative scientist is as much an artist as the painter, as the poet, as the creator of a symphony. You love what you do, you sleep and you eat it and dream it.

– Alan MacDiarmid



They say that beauty is in the eye of the beholder, but it would be truer to say that it is in the mind of the beholder. Different people can appreciate the same beautiful thing in totally different ways. A painter might see a colour as reflecting a certain feeling or mood. For Alan the beautiful colours he found in certain compounds represented to him the amazing phenomenon of electrons releasing energy in the form of light. After studying at Victoria University in Wellington and doing a Masters degree investigating the golden-yellow crystals he'd liked so much, Alan continued his studies overseas. First he did a PhD at the University of Wisconsin in the USA, and then won a scholarship to do another PhD at Cambridge University, England. Soon after finishing his second PhD Alan started working at the University of Pennsylvania where he stayed for 45 years and where he met one of his most important collaborators.

Lost in translation

Becoming a scientist may at times seem like becoming a citizen of a foreign country. After years of studying the history (how past scientists discovered what they discovered), the culture (why we know what we know), and the language and symbols, scientists are finally ready to contribute their own research and understandings to scientific knowledge. When Alan began his research into conducting polymers, he found that even among

SN vs. Sn... What's the big deal?

Alan Heeger came to MacDiarmid and told him that a paper had just been published about a highly conducting material. When MacDiarmid asked the formula, Heeger replied "sss-nnn-ex". Being an inorganic chemist, MacDiarmid wrote down on a piece of paper, "(Sn)x" and said, "Of course you expect it to be conducting, it's a metal!" To which Heeger replied on paper, "No, not (Sn)x, but (SN)x." As you may know, there is a big difference. Sn is the chemical symbol for tin (because it is called Stannum in Latin) whereas S and N are Sulfur and Nitrogen, two very different elements which wouldn't be expected to conduct electricity – and those same elements that MacDiarmid had worked on for his Masters.

scientists – between chemists and physicists – there were differences in language and culture. In his work with Alan Heeger at the University of Pennsylvania he found "... you have to learn a different language – a different lingo – for a physicist to be able to talk to a chemist and a chemist to talk to a physicist." Fortunately for us, the two Alans overcame the language barrier, published extensively on their work together, and ultimately shared the Nobel Prize. Winning a Nobel Prize is a huge deal in science – like an Olympic Gold.

The right man spots the right mistake

While Alan may have had to learn to speak the language of physics, it was a language issue of a different sort which contributed to a major breakthrough in the development of conducting polymers. In 1975 Hideki Shirakawa, who also shared the Nobel prize with MacDiarmid and Heeger, discovered a silvery form of polyacetylene after a foreign student, whose Japanese wasn't quite up to speed, added 1000 times more catalyst to a reaction than he should have. Shirakawa recognised that instead of merely catalysing the reaction at a faster rate, the student's mistake had created a brand new type of compound. When Alan came to talk about his work with polymers, Shirakawa showed him the silvery polymer. Alan was able to recognise its potential and sorted out funding so Shirakawa could come and work with him in the United States.

It may be just luck that the right person saw the right mistake being made, but it certainly wasn't luck that recognised the potential of what had been created.

Mistakes are made all the time and when a mistake is made it will usually affect the outcome of an experiment. Of course, not every mistake produces something as special as Shirakawa's silvery polymer. It takes more than being in the right place at the right time (or when someone does something wrong!) to discover something new. A scientist needs to have the skills to recognise that this is something interesting and unexpected – and that takes a lot of knowledge about what would be expected and what is already known about the sort of experiments they are doing.

It all boils down to a lot of hard work, rather than luck. As Alan was famous for saying, "I am a very lucky person and the harder I work the luckier I seem to be."

Conducting plastics - so what?

It's no coincidence that MacDiarmid, Shirakawa, and Heeger made their discovery in the 1970s but weren't awarded a Nobel prize until the end of the century. At the time they published their findings they didn't really get much attention. Plastics can be made to conduct – so what? That was the age when the silicon chip was thought to be the way of future. It wasn't until much later that the link between plastics that could conduct and the possibilities of printing electronic circuits onto plastic became apparent.

It would be difficult to find anybody today whose life hasn't been affected by Alan's discovery. The LED screen on your cell phone uses conducting plastics technology,

so do the new widescreen TVs, the touch screens you use to check into a flight at the airport, and all the flash new MP3 players with touch scrolling. Conducting plastics are also having an impact on the way we think about making electricity. New generation solar cells can be made flexible and cheap enough to cover whole houses and factories like plastic cling wrap.

Alan uses his Nobel fame to influence society

After being awarded the Nobel Prize, Alan became a popular public figure. He used this position to draw attention to what he saw as the greatest issues facing society. One of his passions was spreading the idea of scientific literacy as a necessity for modern democracy. We all see the huge impact that scientific ideas have on the world around us, not just in the development of technology, but in our relationship with the environment, our relationships with each other, how our society functions, and how our society develops. Alan believed that citizens should understand science so we can be part of discussion and debate on issues such as climate change, sustainable food production, genetic engineering, and technologies that impact our lives. He knew that science isn't just something for people in white coats, and new technologies don't just impact IT professionals. He saw understanding science as essential for anyone who wants to take part in modern society.

Inspiring other scientists to get out and talk about their work

Alan's collaborations with physicists and chemists gave us the discovery which inspired an explosion in molecular electronics. His personality and passion inspired more than new technologies. The MacDiarmid Institute for Advanced Materials and Nanotechnology was established in 2002. It brings together scientists around the country with expertise in these areas. One of the Institute's leading scientists, Sir Paul Callaghan, talks about how Alan was a personal inspiration to him through his cooperative approach to science and his positive view of the potential of science to benefit New Zealand. Says Paul:

The way in which Alan affected me and affected New Zealand was around the way in which he did science and he communicated. He wasn't just a chemist, he was a poet. And he filled venues to capacity - he filled the Wellington Town Hall. I'd never seen that before, a scientist getting people in, in those numbers. They wanted to hear about the science and his poetic imagination moved them emotionally. Alan transformed the science and technology landscape in New Zealand. You could see a complete change between pre-2001 and post-2001 - the year Alan came back to New Zealand as a Nobel Prize winner.

How do plastics conduct electricity?

Under normal conditions, plastics don't conduct well at all – that's why we use them to coat the wires that carry electricity to your appliances. They insulate the metal wires to keep the electrical charge that they carry from being conducted by you, and shocking you in the process.

So why do metals conduct electricity? Because of the way that metal atoms pack together some electrons are free to move around. These 'delocalised' electrons (ones that are not fixed to any one location) move between the atoms and carry electrical charge.

In plastics, all the electrons are usually locked into the bonds between the atoms. MacDiarmid and his colleagues discovered that they could change this by adding a small amount of iodine. With the iodine added, some of the electrons in the plastics were freed to switch between bonds and the movement of these electrons allowed electricity to move through the plastic.