Australian Government

Chief Scientist

DR CATHY FOLEY AO PSM

MACQUARIE [EX]PLORE CONFERENCE

Young scientists to meet the challenges of our time

Monday 11 September 2023

Sydney, NSW

I would like to acknowledge the Dharug nation as the Traditional Custodians of the land on which we are gathered, and their ongoing cultural and spiritual connections to the lands, waters, seas, skies, and communities. I pay my respects to their Elders past and present, and I extend my respect to all First Nations peoples that may be present in the audience.

You are here today because you are curious. You like learning new things about the world around you, and you enjoy applying that knowledge in developing new ideas, tools and solutions. In doing so, you are drawing on a long history of scientific practice – you have already learned its core elements:

1. Develop a research question,
2. Formulate a hypothesis, and
3. Develop responses based on evidence in the form of a scientific research report.

Some of you may have seen the ABC 'First Weapons' documentary, which shows how First Nations peoples used science over tens of thousands of years to perfect the tools they needed to survive. In one episode, Phil Breslin goes bush with Larry Blight – a Minang man from southern WA – to source the materials for a traditional axe known as a kodj.

There are three parts to a kodj:

- A wooden handle, and
- Two pieces of quarried dolerite – a sharp one for cutting and a blunt one for hammering.

These are bound together using finely ground Xanthorrhoea resin, charcoal, and kangaroo poo that has been mixed and heated. The secrets behind the science of the kodj are uncovered with the help of:

- A mechanical engineer and physicist, and an archaeologist and applied analytical biochemist, to understand its physical properties; and
- A biomedical engineer and a biomechanics specialist to understand how the weapon works in combination with the human body.

They demonstrated that with the right stone you can chip down the edge of the dolerite to a couple of atoms thick, fine enough that you can cut yourself and not feel it – it's sharper than your usual surgical scalpel. They also demonstrated that the impact from the kodj struck on a force plate is about 170 kilograms of force – much greater than the force generated by a modern hammer. They explained that by combining the phenolic compounds in the Xanthorrhoea resin, with the cellulose fibres from the kangaroo poo and the porous charcoal, and then subjecting this mixture to heat, a binding agent is created that has both compressive and flexible qualities.

If you think about it – to make a kodj – First Nations peoples needed to master the craft of stone knapping as well as botany, geology, chemistry and physics. The knowledge of Australia's First Nations peoples includes some of the first scientific feats in astronomy, engineering, ecology, sustainability, medicine, land management and food security in Australia – and in many cases, the world. Because this knowledge has been developed with different cultural frameworks with different priorities over tens of thousands of years, it can provide fresh perspective and a depth of history that can't be duplicated.

Last week the government released the draft National Science and Research Priorities to give direction to Australia's science system. And for the first time, First Nations knowledge has been embedded in this statement – an approach that will give Australia a national competitive advantage. We are only just starting to get our heads around the depth of First Nations knowledge and the value it can add to our understanding of our world.

Many years ago, I was in your place, in my final years at school. I thought I wanted to be a high school teacher. What I really wanted to be was a scientist who could change the world – but a high school teacher sounded better than the other career options that were available to me at the time: a secretary or hairdresser, nurse or nun. I didn't know that I could be a physicist, much less Chief Scientist at CSIRO – where I worked for much of my career – or my current role as Australia's Chief Scientist.

And it really came down to a senior lecturer here at Macquarie University, Heather Adamson, who noticed what I had to offer and who let me know the paths available to a budding scientist. She believed in me and my capability, and steered me onto a path where I could excel. I took my first steps on that path here at Macquarie University, doing a Bachelor of Science with Honours, majoring in physics, and a Diploma of Education, followed by a PhD in physics.

You are here today at what may be your first research conference – I hope it is the first of many. What you will find – should you choose to continue along a STEM pathway is that science is both a personal and collective endeavour. Science is built on the work of many. It's a process where discovery builds upon discovery – and can lead to unexpected outcomes, outcomes that are bigger than the sum of their parts.

Science enables us to look beneath the surface, understand how things are put together, and understand how you can put them together in new ways to solve problems. And conferences are a great place to meet with other scientists, to make connections, to learn new things that may have real relevance to your own work. So I encourage you to introduce yourself to people who are here today, people that you have never met before. Ask them about their research, what they discovered, what worked, and what didn't. And share a little of your own work, because it's by sharing your experience, as much as your findings, that you help to build a community.

I commend you for choosing to do science and for your commitment in coming here today to give talks and present posters to other students from across the state. Australia needs new scientists, because science and research are fundamental to Australia's future. Science and research are the drivers of our future prosperity, our health and wellbeing. They are also the tools with which we can meet one of the great challenges of our time – climate change. It is so important that we hold the increase in the global average temperature to well below 2ºC above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5ºC above pre-industrial levels.

To do our share of this global challenge we need to reach – as our parliament has legislated – net zero greenhouse gas emissions by 2050. And to meet this target, we need to decarbonise at an average annual rate of 17 Mt CO_2-e per year, more than 40% faster than we have since 2009. This means we need to ramp up our efforts, and act with speed and smarts. Responding to climate change is a huge and complex task that is beyond any one country to 'go it alone'.

One area where science and technology are moving very quickly in response to climate change relates to the energy transition. Let me give you an example. In today's power grids, approximately 5 percent of electricity is lost on its way from the power plant to the end users. Well, actually, the losses are converted to heat, due to the resistance of the cables.

Five percent may not sound like much, but keep in mind there are currently more than 3,000 large power plants in the world with over 500 million watts outputs. That means we need around 150 of those power plants producing power just to compensate for the loss. What if we could stop these losses? Can we have better cables? The answer is yes.

Superconducting cables can take far more current than existing aluminium or copper cables before they become resistive, and they are much lighter and smaller. As they can carry current with no loss, more power can be carried and there is less infrastructure required. These new transmission lines are based on a whole new technology. It is an example of a high temperature superconducting tape. It's a quantum technology.

Quantum technologies are incredibly exciting, and for those of you interested in a science career, so many options are opening up in quantum. Scientists are trying to build a fully error-corrected quantum computer, it's not far away, and when we get there, it will be game-changing. It will change the game for climate technologies: everything from battery chemistry, to the efficiency of solar cells, to reducing methane emissions, to the manufacture of magnets for offshore wind turbines and electric vehicles, to finding new catalysts for hydrogen.

These technologies depend on a wide range of critical and rare-earth minerals. Let's take electric vehicles as an example. If you pull a conventional car apart, you'll find about 30 kgs of critical minerals – copper and manganese – that help make it run. In contrast, when you build an electric vehicle, you need a much wider range of critical minerals – yes, you still need copper and manganese, but you also need lithium, nickel, cobalt and graphite. And you need them in much greater quantities, about 200 kgs in total.

So mining is going to play a big role in the energy transition and it's an area where Australia is well positioned – we have deposits of many of these critical and rare-earth minerals. But think about it for a moment. We know that mining has environmental impacts. And we also know the demand for rare-earth minerals will grow by seven times by 2040. So if we just focus on mining these minerals, that's going to have increased environmental impacts: in fixing one problem we're creating another.

One way to reduce the impacts of mining, is to reuse and recycle these valuable minerals, once they've been dug up, processed and used. I mentioned lithium a moment ago because it's used in the manufacture of electric vehicles. In 2021, Australia produced more than half of the world's lithium – 55,000 metric tonnes. But only 10% of Australia's lithium-ion battery waste was recycled. The waste from lithium-ion batteries is growing by 20% per year, and could exceed 136,000 tonnes by 2036. So you can see the scale of the challenge, and some of its complexity.

The other point to bear in mind is that when we do recycle critical minerals, we're using technologies that are heavy on energy and the environment. This means that as well as mining these critical minerals in the quantities required, we also need to develop a circular economy so that the waste from their production doesn't continue to build up, and the impact of mining on the environment can be reduced. We'll need your contributions to work through and solve these tricky problems that relate to the transition to net zero emissions.

But there are many other challenges – in medicine, in our food production systems, in the biosecurity threats we face from weeds, pest animals, insects and pathogens. There are challenges that relate to our built environments, to our responses to severe weather events – whether they be flash-flooding in our cities and towns, flooding of our major rivers and the consequences of black-water events that starve rivers of oxygen and lead to mass fish kills, to bushfires and hailstorms.

We will need passionate and inventive scientists, engineers and mathematicians putting their minds to these challenges and creating solutions. Two such scientists are with you today. Professor Sakkie Pretorius is internationally recognised as a pioneer in molecular biology and biotechnology. And Professor David Spence is a physicist specialising in lasers and photonics. Both are making important contributions to Australia's future, and you can too. If your passion is biology. There is a role for you. If your passion is physics, chemistry or mathematics, there is also a role for you. And if your passion is earth and environmental science, there is a role for you.

And like the First Nations peoples who drew on their knowledge of geology, botany, chemistry and physics to create a tool as simple and as powerful as a kodj, we are at a time when there is a convergence of knowledge from across the scientific disciplines as we've known them, along with quantum, AI, machine learning and cybernetics. As a scientist, I am excited for our future – a future that you, the next generation of scientists, will create. When you've finished your HSC – if you do further study – places like this university can give you the skills and knowledge that will set you up for a long-term career in science.