Australian Government
Chief Scientist

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Collaborative problem-solving with Science PLUS

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It's my great honour to be here with you all tonight. I would like to acknowledge the Traditional Custodians of the land we are on today, the Gadigal people of the Eora nation, and pay my respects to their Elders past, present and emerging.

It's tempting to talk to you tonight about my favourite scientific field of superconductivity. This is an area of research I've dedicated nearly 40 years of my life to. Superconductivity has given me a career that allowed me to grow from a PhD student through to the heights of my career in CSIRO, and I've been fortunate to enjoy both research as well as commercial breakthroughs. I have to say, science has been my everything. That was before I was Australia's Chief Scientist – before I spent the last two and a half years looking over the vastness of the whole Australian science and research ecosystem. With this privileged and unique point of view, I've had a bit of a "road to Damascus" experience gaining a new appreciation of science and its place in society. It's a perspective that leaves me both inspired and excited, and that's what I want to talk about tonight.

Science is humanity's superpower. That's one realisation that hasn't changed. I've known it since I was young and realised the possibilities that science could unlock. Because of our ability to be curious, deduce and experiment, we humans can discover how the world works. That knowledge has given humanity the power to extend our lives with improved health and ways to fight disease. As vertebrates we are genetically designed to live for 37 years. Science has helped most of us in the room to live longer. We have worked out how to construct buildings the height of mountains with materials from the earth. We can construct electronics with features the size of an atom – Michelle Simmons' atomic scale integrated circuit is a testament to that. And there's the appreciation of the unmatched power of science and research to change our reality – I have always thought that with enough dedication, perseverance and a little serendipity, there's nothing science cannot do.

Think of the film The Martian, and Matt Damon's realisation that – and note I am quoting him exactly! – "I'm going to have to science the shit out of this" to survive. Science was really the star in that movie. Today, in the real world, there's no doubt that we're facing big challenges as a race and a planet. So as Australia's Chief Scientist, you would be expecting me to say we need to science our way out. If only it was going to be that easy. The last few weeks have made it super clear to me that this is not the case. Let me explain.

Last September, the Minster for Science asked me to lead a national conversation to inform a refresh of Australia's Science and Research priorities. These priorities will provide direction for our science system. They're not intended to be the complete list of the research Australia does. Rather what they will do is focus our attention on the most important challenges we need to address, and opportunities we must capitalise on. The most recent version of the priorities was written in 2015, and the global landscape around us has changed enormously in that time – 2015 was a time before COVID, before the global race to create a COVID vaccine; before the breakthroughs in mRNA technologies, generative AI and machine learning; before the massive take-off of renewables, hydrogen, batteries and the whole energy transition; and before the increase in the number of extreme weather events.

With so much change, I expected there would be lots of ground to cover as we developed the draft priorities. Never doing anything by halves, this consultation process was extensive, with invitations sent to representatives across the whole alphabet of science disciplines – everything from Astronomy to Zoology – as well as the community at large. I expected to hear many clashing messages at the table and a zillion different ideas. I expected to hear everyone promoting their own piece of science action as the top priority. However, I found it to be the opposite. Over the course of six weeks of consultations, around 40 roundtables, and speaking with more than 500 people across Australia, it became clear that I was hearing many variations on the same message. It's this: the problems we face are trickier than a pure science approach alone can solve.

Pure science is a loaded term. Geneticist and environmental activist David Suzuki pointed it out well – science is not absolute. He said, "You and I know that science is non-linear; science does not progress in an easy linear fashion. It is not like you have an idea, set up an experiment prove your theory and then cure cancer." And he was right! Sometimes it's iterative. Sometimes we reach a dead end and must figure out a different way to solve the problem. Let me illustrate this.

When I was in the Northern Territory there was a lot of discussion about feral animal control – cats and buffalo and the like. Now, I was told we already have the technology to deal with this. We could design a gene drive to humanely reduce the feral cat or buffalo populations. That pure science side of things – knowing how to do it, being able to implement it – that isn't the sticking point. If only it were that easy. Let's consider cats. Cats are an important companion animal for many people. Important for health and wellbeing for many people. How do we keep the feral and domestic cat populations separate, knowing that many domestic cats wander? What happens if the gene drive was somehow transferred to a more vulnerable species? Feline conservation efforts here in Australia – such as, zoo breeding programs for lions or tigers – could be destroyed, and if the cross contamination was not noticed, it would potentially have devastating effects on conservation worldwide. Also, given feral animals have already made their mark, what would happen to the broader ecological web with the feral-cat-sized gap left behind? Would prey species have a sudden population boom? What impact would that have on the plants, the soil, the waterways? How would that affect rural and urban areas? "It's a tangled web we weave." Yes, science is all about inquiry that can lead to action; but when we look to act, we also need to consider all the possible consequences and different stakeholders.

For a real-life example, I want to tell you about Kings Park over in Perth. Back in the 80s, it was noticed that the local iron-rich bore water was eating away at irrigation pipes and staining buildings red. Basic chemistry. So in the 90s, we solved the problem: additives making the water slightly more alkaline, saving the pipes. And all was well for a decade or so. Then in 2003, the trees in Kings Park started to yellow and drop their leaves. Trees centuries old had simultaneously stopped producing chlorophyll. They were diagnosed with a mysterious 'chlorotic decline syndrome' and were slated to be cut down.

Luckily, a three-year investigation sorted it out. They eventually trialled making the soil more acidic, to huge effect. The trees regained their canopy within weeks, as

they could again absorb critical nutrients. And today, the park keeps its trees happy with its own water treatment plant. There's a bigger positive outcome too – the investigation that uncovered the problem is expected to have positive effects for supporting urban greenery in cities across the world. The learning here is that consequences aren't easy to predict – especially in the long term. I have to wonder if we will get better at this with digital twins, AI and quantum?

Here is another one - the global climate challenge. We didn't know that was coming when we first moved to the industrial revolution about 260 years ago. Its consequence crept up on us. Now, it's the most urgent issue facing our planet. Science can and has given us parts of the solution, but alone, it isn't going to solve the problem with sufficient scale, in the necessary time frames. Not to mention the social licence and getting to global agreement to do something about it. We can't "science our way out" – not by ourselves. And nor should we.

After all, we scientists are not working alone. We are not the holders of all knowledge, nor are we lone drivers of action. To solve this challenge, we need to link up with other systems of knowledge. We need to be an embedded part of global discussions, decision-making and action. I call this "Science PLUS". We need science plus engineering; science plus design; science plus economics, business, governance and policy; science plus user behaviour expertise; science plus communications and user interface. Complex problems need complex solutions, which are tangled. If I hear someone claim to have a silver bullet, my first question is, "How far have you consulted?"

One complex and tangled solution that I'm very excited about is the move towards building circular economy considerations into new developments from the very start. If we're going to meet our environmental pledges, new products and technologies need to be developed with their full recycling and reuse pathways designed in from the beginning. This is a huge undertaking. It brings in questions of design, materials selection, life span, future technologies development, user behaviour, corporate behaviour, product re-collection, materials recovery and separation, recycling and reuse – and that's before we've even built the first product. The team needed is colossal, but if we do it right, imagine putting out a product that has already pre-emptively solved all of those problems – one where product end-of-life is just the start of another pathway.

I'm not going to pretend that it's easy to build this level of consultation into our work, but it's worth it. Think of the 90s cartoon show, 'Captain Planet'. He had it right: "By our powers combined". Combining all these disciplines and aspects is needed to achieve things we can't achieve by science alone. We've seen it work already.

The hole in the ozone layer is a legacy consequence often compared to modern-day climate change. In fact, many young people have never heard of it. CFCs used as non-toxic refrigerant gasses were found to break down in our atmosphere. They caused free chlorine to react with ozone, depleting the ozone layer. As a result, more UV radiation was reaching Earth's surface, with a particularly strong impact here in Australia. Just like addressing climate change, scientists couldn't solve this problem alone. We needed community buy in, and on this occasion got it!

The Montreal Protocol on Substances that Deplete the Ozone Layer was one of the rare treaties to achieve universal ratification by the United Nations. Today, the ozone layer is projected to recover to 1980s levels by the mid-2040s, and by the end of the decade, the effects of the Montreal Protocol will be saving an estimated two million people each year from skin cancer. Without the treaty, the UN estimated that ozone depletion would have increased ten times by 2050 and resulted in millions of additional cases of UV-related illness. That's astounding both in the impact on lives and the fact the world worked together. This is a real win for humanity.

But we need to remember how we got here, and the coordinated efforts behind the win. Including the work done by CSIRO on the development of Plascon to destroy ozone depleting substances, and its commercialisation. I've heard it said jokingly that the physical sciences are easy – if your experiment doesn't work the first time, you can change or control the parameters until it does. Social sciences are trickier, because the parameters aren't ours to control. Your target population isn't going to kindly stand still for a day while you change the environment around them. They're very different fields of research that don't measure things in the same way. In many ways, they are different systems of knowledge entirely, but we can and do intwine our understandings of them to great effect.

I want all of us to think more broadly in everything we do. We need to bring together not just many experts, but also many systems of knowledge in our attempt to create the future we want. Here in Australia, I particularly think of the rich knowledge systems held by First Nations peoples. Imagine being able to engage with the collected wisdom and understandings of the oldest known engineering knowledge system on the planet! That's the opportunity we have here – Australia's unique edge. We need to treat that knowledge and the peoples who hold it with the respect and engagement they deserve.

The social sciences don't use the same measurements or error bars as physics. First Nations knowledge systems use different reference points again, but that doesn't mean they're incompatible. Ultimately, all science is about describing, understanding, observing and recording. We need to work on ways to weave them together. We're all seekers of knowledge. A seeker of knowledge is where it all starts, too.

All this talk of collaboration, the tangled web we operate within, is, however, built on a starting point of fundamental science. That's how discovery begins. Not by committee, but usually by someone with an idea and a good dose of bloody-mindedness. It's crucially important to continue supporting fundamental research, because that's where breakthrough discoveries come from. This is where the winning strategy starts. I include all parts of the Science PLUS web here – including the humanities and the arts. We need to develop all these capabilities so we are ready for disruptive change.

There is much research on how to enable the best scientific discovery. Former US presidential Science Advisor, Eric Lander, calls fundamental research the "miracle machine" for this reason. "If you put funding in," he says, "Miracles come out." Unfortunately, we don't know where that's going to materialise in advance. He likes to talk about a physics lab run by Professor Sir Andre Geim, who deliberately

dedicated Fridays to odd research. Things like how geckos walk up walls, how to use magnets to levitate a live frog, and how many times you can use a piece of sticky tape to pull carbon layers off lumps of graphite.

Some of that research doesn't achieve much to start with. Some of it wins Ig Nobel prizes for levitating frogs. Some of it wins the 2010 Nobel prize for producing graphene – a single monolayer of carbon atoms with near limitless potential. Super light and super strong, graphene is proving to be a source of clean, limitless low-voltage power – using the movement of carbon atoms along a single-atom-thick graphene sheet to create a renewable alternating electrical current in a circuit. From sticky-tape experiments to potential limitless clean energy; it's a kind of magic that you can't summon up on demand.

That's why we need to be comfortable with ambiguity; to support individuals pursuing novel research even if we're not quite sure what the applications will be just yet – making our own miracles. I am doing a lot of work in this area through my review of Australia's research metrics. It's been a conversation I'm sure a lot of us have had. Are the current research metric milestones encouraging the outcomes we want to see in our science sector? I want to make sure we're measuring success in the right ways, so researcher careers, mobility and the quality of Australia's research are being uplifted – and not restricted – by research metrics. My office has commissioned The Australian Council of Learned Academies to undertake a significant survey on this, which closed earlier this week. I'm really looking forward to getting the results and diving into the insights.

The world is changing. Science is a superpower, but it's realisation to impact is a collective one. While discovery can be achieved by one person, we need to embrace multiple systems of knowledge to bring it into reality. Every action has consequences, good or otherwise. We're not going to know them all in advance. We can't let that stop us from exploring, because fundamental science is what coalesces to provide us with new capability, but it's also our duty to provide collaborative Science PLUS processes to responsibly bring those new capabilities out to the world at large.

For the more experienced members like me here in the room today, it's up to us to learn to embrace flexibility, even as our joints are getting stiffer! For those earlier in your careers, it's a lesson to collaborate widely, and respect the value of fields of knowledge far from your own. Be comfortable with ambiguity. The challenges are big, and the unknowns are intimidating. But we're scientists – and I haven't met a scientist yet who isn't intrigued by the prospect of the unknown. Especially if that unknown includes approaches to knowledge we are not used to weaving together. Just imagine the incredible, tangled, complex and beautiful things we can achieve together if we get this right.