Australian Government

Chief Scientist

Dr Cathy Foley AO

Thomas Baker Oration

To

Melbourne Rotary Club

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Harnessing the power of science and technology in a rapidly changing world

Thank you Dr Johnston for the kind introduction.

I would like to also acknowledge the traditional custodians of the land we are meeting on, the peoples of the Kulin Nation, and I acknowledge the elders who are caring for these lands. I pay my respects to the old ones who have come before and the young ones who will follow.

I also acknowledge the value Indigenous Australians bring to science and innovation - the need for us to do more to engage with Indigenous communities - to embrace their knowledge and to build a sustainable future together.

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Rotary Melbourne President Reg Smith, distinguished guests.

I am deeply honoured to be here today, in the company of this esteemed audience, to deliver the 2022 Thomas Baker Oration, and thank Rotary Melbourne for this opportunity.

The Rotary Club of Melbourne was only seven years young when Thomas Baker became its president.

Ninety-four years later, it is great that you are still going strong – a testament to the valuable humanitarian service provided both at home and abroad to help create a better world.

The last time you welcomed Australia's Chief Scientist here was in 2016, when Dr Alan Finkel delivered the inaugural Thomas Baker Oration. It is indeed a privilege to be following in Dr Finkel's footsteps six years later.

With nearly a century separating the world that Thomas Baker left behind and where we are today I have been reflecting on the passing of time. Thinking on the life and wide-ranging interests of this celebrated son of Australia, I couldn't help but ask one question:

If Thomas Baker was living in the 21st century what fields of human endeavour would he be interested in – with so many exciting technology frontiers being explored and advanced, what would capture the attention of a man described as having such 'a curious scientific mind and a talent for technology'?

3D printing? Magnetic resonance imaging? Systems engineering? Artificial Intelligence? Or perhaps quantum computing?

One thing is for certain - so much has changed since Baker's time.

Even the photography business of Kodak, the 20th century's global market leader of which Baker was a part, collapsed under the weight of digital disruption.

Yet the parallels between our two worlds cannot be overlooked. War in Europe, geopolitical tensions, global pandemics, disruptive technologies – these are all features of both periods. In fact, as early as the 1920s, there were a few people actually talking about 'climate change', 'global warming' and the 'greenhouse effect'.

What is different today is that we now have, and continue to develop, better and more powerful tools to understand the world around us. These tools are helping us to tackle the big challenges we face in an increasingly dynamic world.

There has never been a better time than right now to harness the power of science and technology to solve complex challenges and make the world a better place.

This, in essence, is what I want to speak to you about today. But first, let me share a bit of my personal story.

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When I was in high school, I wanted to save the world. After Year 12 in 1975, I worked with the young Wangkumara people from the Tibooburra region near Bourke in western New South Wales.

I helped run a preschool for the local kids from the reserve where most of the Bourke indigenous people lived. My aim was to help address injustices and improve societal perceptions. But this was frustrating as I have to say that I made very little, if any impact. However, I did learn that I like to change or fix the system rather than work at the one-to-one level.

So I decided I would be a high school teacher – a very eminent and important profession. Remembering at that time women the choices of being a secretary, hair dresser, nurse or, in my case, nun as I come from a Catholic background.

But secretly I yearned to be a scientist as I thought this could be my way to change the world.

I wanted to make a bigger impact beyond the classroom. And if you want to change the world, what better way to do that than to study physics!

Towards the end of my undergraduate degree, one of my science lecturers, Dr Heather Adamson, challenged me to do an honours degree, followed by a PhD, and then become a scientist. No-one had ever openly challenged me like this before.

So, I changed my plans, I did my Honours then my PhD, and got a job at the CSIRO - where I stayed for over 35 years and I had 20 different roles.

This education and experience laid a strong foundation for becoming Australia's Chief Scientist. It also underscored the power of mentoring in helping people believe in themselves and to unlock their potential.

Growing up at a time when science was not considered a natural first choice for women, Dr Adamson's encouragement gave me the self-belief that it was possible to achieve my dreams.

My education and career have given me deep insights into the power of science and technology to change the world - backed by firsthand experience and observation.

My research work – from semiconductor materials to quantum technologies and their real life applications – has given new meaning to my childhood dream to 'save the world'.

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As Australia's Chief Scientist, I have a responsibility to provide advice to government on matters relating to science, technology and innovation.

I have the opportunity:

- To make a difference on a national scale by working with a diverse range of individuals to change the system to be more inclusive.

- To create a more diverse workforce.

- To ensure we use our full human potential. Embracing diversity is how we gain the novel insights to solve the problems we face, which in turn will result in the accelerated application of existing technological solutions and the development of new ones.

We can make the world a better place, by not just accepting the status quo, but by considering new ways of applying our knowledge to the world's complex problems and achieving this by embracing our diversity.

These were some of the hallmarks of Thomas Baker's success.

Baker challenged the status quo. He looked at the system and considered what needed to change or improve. He recognised the value of a diverse workforce.

His wife and sister-in-law were partners in his business and research. They worked closely together at the lab, testing materials and producing photos at a time when most women were expected to stay at home as mothers and housewives.

Baker also liked to experiment, exploring and embracing technology disruption along the way.

He produced and mastered photographic dry plates, a major advancement over the wet plate process that was the norm at the time[1], and later turned his focus to the roll-to-roll film.

In short, Baker had an innovation mindset. He made the most of the resources and opportunities available to him to achieve success. Australia has much to learn from him.

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As I have mentioned, I have the great privilege of being Australia's Chief Scientist, and with this role comes various responsibilities and opportunities. However, first and foremost, I am a scientist.

When I view the world through my research lens, I see a bright outlook.

The power of science and technology can solve some of the greatest and most complex challenges humankind faces in the 21st century. I have hope for a better future for Australia and the world.

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The world I wanted to save in high school in 1975 is very different to the one we now live in.

The scale and pace of innovation has been phenomenal, yet it is easy to forget how much transformation has occurred already.

Let's think back 30 to 40 years.

When I graduated with my PhD over 35 years ago, the first mobile phone calls had just been made, the first Super Mario Brothers video games were released by Nintendo, Windows version 1.0 has just been released, we listened to music on CD's for the first time, the first test for AIDs had just been developed and the hole in the Ozone layer had just been discovered.

They were all a novelty. But the world has rapidly changed since they were first introduced.

We have seen a massive expansion in technology: smart phones, electric cars, driverless vehicles and aircraft. Internet of Things – with up to 40 billion connected devices worldwide in 2021.

Emerging technologies such as artificial intelligence are revolutionising many things from speech recognition to healthcare, education and manufacturing. Tech advances over the next 30 to 40 years will surpass anything we've seen, or can even imagine!

However, in the midst of this transformation, there are national and global challenges that need to be urgently tackled.

In a space of about three years, Australia has lived through severe drought, deadly floods and bushfires, a recession, a once-in-a-century pandemic, not to speak of associated challenges such as supply chain disruptions, made worse by ongoing geopolitical tensions.

An example of one of these challenges is of course the COVID-19 pandemic. It took the world a record 300 days to produce a safe and effective vaccine after the World Health Organization declared a public health emergency of international concern.

Even so, many lives could have been saved if we had achieved this feat in a shorter period. Are we up to the challenge to make vaccines available within 100 days of a future pandemic?

I think the answer is yes.

There was a rule of thumb that it takes more than 10 years to develop an effective vaccine for most diseases. The COVID-19 pandemic has shown that effective vaccines can be developed in months.

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Food security is another major global challenge. Each night, more than 800 million people around the world go to bed hungry, according to the United Nations World Food Programme.

How do we ensure access to sufficient, safe and nutritious food for everyone? In raising food security as an issue, I would like to acknowledge Rotary Melbourne's project to improve nutrition for Aboriginal children in remote communities – one of your many causes and a great example of how your work helps improve lives and create a better world.

We also want a world of low carbon emissions. Our nation wants to boost renewable energy production and build new low-emissions industries.

Australia and a number of countries around the world have committed to net zero emissions by 2050.

Emissions reduction is a huge challenge for most economies.

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Net zero emissions. Food security for all. A hundred days mission to respond to future pandemic threats.

How do we turn these aspirations to reality?

The answer is science.

Science is the solution.

Science and the application of scientific knowledge offer practical pathways to achieving these goals.

Science is uniquely placed given its strengths in problem solving and experimentation.

But science must transcend merely troubleshooting and reacting to problems.

As the Australian Academy of Science immediate-past President Professor John Shine recently pointed out, and I quote here:

> *Science is about far more than crisis management. It's about how we understand our present and future, and realise our potential as people*.

That is why as a nation, it is important that we discuss the world we want.

This way, we will be able to have a common vision, identify the changes we need to realise that vision, and design a system to implement them.

Now is an opportunity to have more discussion about this in Australia. And it is great to see this beginning to happen.

We need to have this conversation.

We need to look at the whole picture, take a whole-of-system approach and see how best we can support the whole research ecosystem – discovery, problem solving and experimentation – to build the world we want.

When we do this, it will create the ambition in us to seize the opportunities that 21st century science and technology has to offer to make the world a better place to live in.

And the opportunities are endless.

Science and technology can lead to extraordinary things for Australia.

And Australia has what it takes to make this happen.

We have world-class scientific research capability to support the development of globally competitive deep-tech industries.

But, Australia needs to be ambitious. We need to become not only globally competitive but a world leader in critical technologies – those technologies that can significantly enhance or pose a risk to our national interest. Technologies that have the capacity to future proof our economy and create a safer and more resilient nation.

Critical technologies create enormous opportunities, underpin exponential improvements in productivity, facilitate economic growth and are the basis for creating high quality jobs.

I am pleased to say Australia is making strong progress in creating the foundations for a thriving ecosystem in this area.

We have a Blueprint for Critical Technologies to maximise the opportunities and manage the risks that come from them, including emerging digital ones such as artificial intelligence and quantum computing.

We have been investing in quantum research and development for decades and, in recent years, AI has also become a major focus for us.

These technologies are transforming the way we live, the way we work, the way we conduct science. They have opened up a whole new world of unprecedented opportunities that Australia must do well to tap into.

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Take artificial intelligence, the Internet of Things, big data and robotics.

They are driving capabilities for developing virtual replicas of physical systems – known as digital twins – to improve decision-making and develop potential solutions through better modelling.

Imagine if we could develop digital twins for not only physical systems like infrastructure, but more complex systems like the economy, health and the environment!

A digital twin for Australia's economy could help us run simulations of the economy, study performance issues within it and generate possible improvements.

We could then use the insights gained to better manage the economy – maybe to boost growth, improve productivity, reduce inflation and unemployment, or even forestall a recession.

Of course, digital twins of our economy or health systems will require having enormous computing power to simulate what happens in those areas in the real world, possibly using quantum simulation.

Which brings me to quantum information technology – the next big thing in the digital revolution.

Researchers still have a way to go, but this technology is far from being futuristic. It is already being applied and its enormous potential means Australia cannot afford to take its eye off the quantum ball.

Quantum IT offers exciting opportunities to solve complex problems across every sphere of human endeavour. For example, it will enable better modelling to assist with the removal of carbon dioxide to mitigate climate change, help design better drugs, more accurately predict changing weather patterns and develop more effective ways to combat cybersecurity threats.

We should take pride in the fact that Australia is a quantum trailblazer with an international reputation for generating global quantum talent, but we have to make sure this talent remains here to support the industry.

You may have heard about ANU's Quantum Random Number Generator, the world's most sought-after quantum number generator. Last year alone, ANU is said to have received 2.4 billion requests from around the world for random numbers. That says something about how important this technology is.

Companies like IBM, Google, Xanadu and Righetti are rapidly building quantum computers with ever increasing capacity – somewhere between 72 and 216 qubits depending on the technology used - and all of them are accessible via the cloud

The race is on to achieve higher numbers of qubits – both IBM and Google working towards 1,000,000 qubits by the end of the decade, the holy grail for a fully error correct quantum computer. This is expected to be able to process more pieces of information than the number of particles in the universe.

That may sound like sci-fi, but given the pace of advances in digital technology, I don't think it is farfetched.

After all, not too long ago, the idea of using solar panels to power homes was a novelty; the technology was an emerging one.

However, thanks to the silicon solar cell research of Australian engineer Professor Martin Green in the 1970s, solar panels went from an idea far in the future to being installed on around 30% of roofs here in Australia.

It made solar photovoltaic technology viable by taking solar cell efficiency initially from 5 per cent to 17 per cent – the absolute best performance at the time – most commercial panels are now between 15-20 per cent, with some researchers having developed panels that have around 50 per cent efficiency.

But like the Black Box, Australia did not take this research seriously enough or have the confidence and capability to commercialise it. Progress was slow – as it was actually a really hard technology to get right, plus we needed to develop the manufacturing sophistication and develop the right materials. Instead we let China commercialise this technology.

This breakthrough took about 30 years to progress from lab to market.

Today, 90 per cent of the world's solar panels are made using Professor Green's technology developed at the University of New South Wales.

And as we strive to push the boundaries of our knowledge, there are now teams working on how to harvest solar energy at night – the next challenge. This is totally inspirational work harnessing different wave-lengths of light.

Like solar technology, Australia can become a leader in quantum computing. This technology, and its potential applications, are far beyond what I ever could have imagined when I started working in quantum over 30 years ago.

Technologies such as quantum give me optimism about the future of our nation and the world more broadly.

Even though we didn't have what it took to capitalise on solar cells in the 1980's – we have now.

Our ambition must be to nail this opportunity for the next generation of the semiconductor and quantum industries.

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I have heard too many people expressing concern about the future of their children and grandchildren and the kind of world they will be living in. I can understand why they feel anxious.

But the foresight that technologies like digital twins and quantum can deliver gives me hope about the future.

It will enable us to envision and develop solutions to complex problems like climate change, pandemics, and food security – within much shorter timeframes.

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Science, and the application of scientific knowledge, does not take place in a sterile bubble of isolation. It is linked to the social environment in which it operates.

Society has a stake in what scientists do. Society is directly impacted by its outcome, particularly when used to inform evidence-based decision making.

As scientists, our key stakeholders include policymakers, businesses and the Australian community.

If we are to maximise science and technology's impact, we must continue to build and maintain the trust of our community. That is how we get the social licence to solve the problems that affect our community.

Isn't it a paradox that despite the immense contribution of science and Australian scientists to our nation, people continue to question the science - like the science of climate change and the science of vaccination?

Some people in our community may feel anxious about science and technology; for example, what automation means for the future of jobs.

That is understandable.

But a few others have shown a lack of respect for the scientific method by refuting widely settled evidence from research and, in some cases, by peddling misinformation.

That is frustrating for scientists.

That said – and beyond scepticism and denialism born of ideology – Australians and people the world over continue to look to science to solve problems and to support a better future.

Is there a better alternative? Snake oil? I don't think so.

As we face the challenges of a rapidly changing landscape, the world is hungry for science and technology to show us the solutions.

If I may borrow the words of French philosopher Albert Camus from his novel *The plague* when the COVID-19 pandemic arrived on our shores, Australians did not

dismiss it - but viewed it as '*only an unpleasant visitor which would leave one day as it had entered*'. This was because they trusted that science would provide a way out of the pandemic.

We looked to science and technology for a solution.

And Australia has seen tremendous cooperation from our community with the public health response – physical distancing, mask wearing, quarantine, contact tracing and terrific vaccine uptake.

It was refreshing to see state premiers and health officials frequently referencing, in their daily briefings, 'what the science says' and 'what the health experts say' to back their response measures.

Australians understood that accepting sacrifices for the common good outweighs individual rights and that is why we have done very well in this pandemic compared with many other countries.

It is an example of trust in science and how it is communicated so everyone can understand it.

How science is communicated to the public is an important function of trust in science. Active engagement, open communication and consultation are critical components for enabling the trust.

It is therefore important that we strengthen the connections within the stakeholder community, linking the work of scientists, researchers and innovators with industry and policymakers, and continually striving to commercialise research to support a stronger economy and prosperity.

Trust in science also stems from scientists being able to show up when it matters.

The story of how the Doherty Institute responded quickly in early 2020 to grow the novel coronavirus from a patient sample, here, in Melbourne and share it with laboratories around the world offers great inspiration.

By providing open access to the virus, the Doherty Institute accelerated the accurate investigation and diagnosis of the virus globally and subsequently facilitated assessment of the effectiveness of trial vaccines.

Overall, the accelerated development of COVID-19 vaccines also showed how open access to the research literature can be an enormous boon for science and the world at large – and this is why I am a staunch advocate for open access.

Open access enables greater research and innovation outcomes through better access to knowledge.

Locking science behind paywalls, as is too commonly the norm in this electronic age, does little to promote science. Australia can do better.

One of my goals as Australia's Chief Scientist is to work with science stakeholders to explore the potential for a national open access strategy to improve access to research literature for everyone residing here in Australia.

This way, we can build a more informed and engaged society, boost innovation outcomes, fight fake news and misinformation and increase trust in science.

But we scientists must also keep careful watch in our own backyard.

For scientists to continue to be accorded the respect we deserve as legitimate authorities in their fields to whom government and others turn for expert advice.

We need to reinforce our basic operational principles of research integrity, quality, and excellence – developing our side of the social equation.

Scientists who demonstrate these principles and communicate the benefits of translating science – are fulfilling their side of contract by going the extra mile and taking the next step to realise the impact of their work.

That means greater emphasis on rigorous methods and processes for conducting research to ensure integrity, quality and excellence, and building ethics into the process right from the beginning.

A common understanding of, and adherence to, these standards will build trust. With trust comes respect and the social licence to use science and technology to solve problems in our community and the world.

Don't get me wrong. I am not suggesting science and technology is a panacea for all our challenges.

Science needs to make connections and work with a range of other disciplines to bring together different tools to solve complex problems – engineering tools, social science tools including marketing and communication and philosophy tools such as ethics.

It also needs to make connections with the broader community, including non-for-profit organisations such as yours. You can all play an important role in helping science obtain the social licence to operate. Bringing along the people you work with in the community. Explaining why science and technology are so important for our nation.

So what brings this all together? It is the power that comes from diversity.

It is the power from using our full human potential.

Science is the common language, enabling efficient collaboration and cooperation - linking the work of scientists, researchers and innovators with industry, policymakers and the community.

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Science is an enabler - it allows us to work together for a common purpose, across disciplines and across borders.

Gaining social licence is critical – and this is done through effective communication. We also need to make sure new technologies do not have unintended consequences, and the importance of building social licence from day one.

This is how you build public trust.

You get why science is so important, and why you need to bring others along.

As we face the challenges of a rapidly changing landscape, the world is hungry for science and technology to show us the solutions.

Australia has more to offer than ever before.

We need to be ambitious and harness the opportunities before us.

The breakthroughs of the next 30 to 40 years will lead to extraordinary things.

But success will not fall into our lap. We need to work earnestly and smartly to realise the enormous benefits of science and technology in Australia. We need to get the social licence right to solve complex problems.

We scientists must prioritise communication and engagement with our community to build trust in our work.

There needs to be greater emphasis on rigorous methods and processes when we conduct our research.

Australia must improve open access to our research literature.

Australia must use our full human potential as a nation.

Let’s get down to work to make the necessary changes, to seize the opportunities that science and technology have to offer in this century.

Let’s take a cue from Thomas Baker’s life as a man of action.

I really like how Rotary Melbourne’s Vice-President CA Hack described the motto of Thomas Baker’s life following his death in 1928. A motto that we can all live by:

‘*Deeds not Words*’

Thank you very much.
