Australian Government

Chief Scientist

Dr Cathy Foley AO

Chaikin Oration

To

ATSE NSW Division

Thursday 17 March, 2022

Thank you inviting me to speak and for the kind introduction.

Firstly, I'd like to acknowledge the many lands we're all coming from today.

Here in Sydney, I am speaking on the traditional lands of the The Gadigal people of the Eora Nation. I pay my respects to them and to the traditional custodians of other lands where our online audience members are based.

I acknowledge the elders who are caring for those lands. I pay my respects to the old ones who have come before and the young ones who will follow.

It's an honour to be acknowledged alongside some of the esteemed past recipients, including;

- 2020 recipient, The Hon John Anderson, former Deputy Prime Minister who addressed the challenges of the looming global food crisis.
- 2017 recipient, Professor Chris Roberts AO, PluS Alliance Professor who spoke about Australia's World class Hearing Health Ecosystem,
- And 2014 recipient, Professor Mary O'Kane, former NSW Chief Scientist & Engineer whose oration focussed on examining the often overlooked innovation system factors to address the productivity growth problem.

I'd also like to acknowledge:

- The Honourable Gabrielle Upton – Parliamentary Secretary to the Premier,
- Professor Andrew Parfitt - Vice Chancellor of University Technology Sydney,
- Dr Susan Pond AM – President of the Royal Society NSW
- And members of the Chaikin family who are here today:
    - Mrs Lyn Chaikin
    - Son David and
    - Daughters Catriona, Gwen and Elizabeth and her husband Phillip Porter.

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I have been asked to speak about what I've learned so far in my role of Australia's Chief Scientist.

Well, like all of us during the pandemic, I've learned a lot about the intricacies of navigating online meeting platforms, so it's great to be here in person!

I've certainly learned how to optimise my driving route to Sydney Airport to catch that early flight to Canberra.

And I have also learned about what I'll describe as the three "Rs" in government. These are - and I'll need a little poetic licence here -

The reality that government – whether big or small:

> - Is reactive to situations completely outside of their control. This has been most starkly demonstrated by the challenges we have collectively faced both domestically and globally over the last few years
>
> - That government Is required to manage risk. Risk is part of everything we do. It is complex and the pace of change is increasing.

- And government must be responsive. Delivering with flexibility, quality and assuredness to sharp deadlines.

The research world, as you'll know, can be quite different on many levels.

Research works more slowly, in many cases decades more slowly. Research, discovery and innovation have their own rhythms that don't always align with those of policy or government.

I'd also venture to say that the science and research system has a different relationship with **risk**. In many ways risk is **inherent** to the process of science. It is deeply embedded in discovery, which is all about untested ideas, trying something out, hitting dead-ends and trying again. There are many areas of government where that level of ambiguity and uncertainty would not match community expectations.

But I've also learned there are aspects these worlds of research, innovation and government have in common:

- There is enormous goodwill throughout the ecosystem.
- We're in a world hungry for science and technology and looking for ways to realise the potential.
- And there are a lot of people like yourselves looking for solutions to the global challenges.

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As I was preparing to speak with you today, I reflected on the legacy of Malcolm Chaikin, a scientist with a drive to solve real-world problems.

I understand he was at the CSIRO only briefly in the early 1950s before his long academic career. I started at the CSIRO 30 years later, so we were a long way from overlapping.

But we do have one aspect of our careers in common.

Professor Chaikin was a textiles expert. I read one of the many patents that he filed; this one was in 1966 for a machine that would improve the efficiency and speed of the combing for wool fibres. I won't attempt to explain it in more detail than that – Suffice to say, as with all patents, the description runs to 220 words in a single sentence!

At the CSIRO I, too, found myself responsible for work in textiles. In 2010, I was appointed to head the Materials Science and Engineering Division.

When I started that job, I remember wondering why some of the staff appeared to be zipping off to Italy.

I mean, apart from the obvious!

It turns out there was good reason.

And this story will bring me to the point I want to make today.

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If you remember the 1970s, you will remember the woollen jumpers. They were bulky in awkward ways. Scratchy. Downright difficult things to wear.

Synthetic fibres had hit the mass market. They were proving popular and they presented a real threat for Australia's wool producers.

Wool had to stage a fightback - but how?

In the 1970s, the wool industry faced a problem. Synthetic fibres were sold on the basis of an objective measurement of fineness and length. But wool had no objective measurement of fineness. There was really no way of saying for sure - or guaranteeing to a standard that would meet commercial needs - how fine the fibres were in a given bundle.

It wasn't a complete mystery - the bales were assessed by professionals, but it was done by human eye. It was a subjective assessment made by buyers who looked at the fibres at the top of each bale. This system served its purpose.

But how can you exploit the true value of the merino grown here without being able to give evidence-based assurances to the buyers about quality, fineness and consistency?

Thus was born the Australian Objective Measurement Project!

This was a major collaborative effort across not only the CSIRO, but our universities and the wool industry. They created an evidence base that directly correlated the grading of the raw fibre with the end product. This made wool less commercially risky and allowed it to realise a premium price.

The second part of the equation was making the processing side of textiles more efficient, automating the cleaning, dyeing and manufacturing process to keep wool competitive against synthetics.

This technology was adopted by the Italian textiles industry - And so explained the trips to Italy!

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What's my point?

Well, I can now stand here today, wearing my favourite merino suit and find it beautifully comfortable.

This story illustrates the principle that in science you can never really understand something unless you can **measure it**. And the corollary: You have to know that you're measuring the right thing.

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Starting a new role is challenging for anyone. The first thing I noticed in my role as Australia's Chief Scientist, was working in an office block which didn't have any laboratories!

One of the biggest transitions was recognising the lack of access to academic literature - when it was previously at my fingertips. How can you be a Chief Scientist if you don't have access to the latest research?

My role as Australia's Chief Scientist is to ensure Australia has access to high-calibre, independent and authoritative scientific advice. There is immense opportunity in working across the science and technology landscape. Choosing key areas of focus is the challenge!

- How to better link up research innovation, industry and government so we can improve the pull-through of our world-leading research to impact.
- How to increase the number of people with STEM qualifications.
- How to build the high-tech workforce so that Australia can realise its ambitious agenda in new low-emissions industries, and in digital, quantum, space and other emerging industries.

- And exploring the potential for a national open access strategy to improve industry, government and public accessibility to research literature. This will assist with increasing innovation outcomes and combatting misinformation to create a more informed and engaged society. Of course, there's no self-interest here.

I suspect you'll know what I'm going to say next:

You can't solve those problems unless you can measure them and get the measurements right.

Except I'm not talking about the length and fineness of the wool on a sheep's back.

The measurements I am talking about are:

- The data we use to measure innovation and compare innovation internationally
- The data we use to measure commercialisation
- The data we use to measure university rankings[1]
- The data we use to measure the success of individual researchers

The current approach is no longer working for us.

- Innovation systems are dynamic and interconnected. Many metrics have focussed on measuring R&D. But the R&D data doesn't capture all innovation – since not every innovation is the result of a research breakthrough.

  For example, it is increasingly important to measure digital activities in the economy. But digital innovation and take-up is not adequately captured in measures of innovation.

- There is significant focus on commercialisation of public research and counting start-ups. But this, too, fails to recognise that most commercialisation happens **within** businesses – what's called "intrapreneurship".

- Internationally, the inputs to various commercialisation indices differ between countries, which makes comparisons less than enlightening.

- When you consider how to measure the work of universities, you run into the same kinds of complexities. Universities are extraordinary institutions that have many different roles and there are different ways of measuring what happens within them. Measurements of industry engagement are fairly blunt.

- International rankings drive behaviour and priorities in the university sector, but the parameters used can be narrow.

- Even **within** research institutions, the incentives operate to encourage a kind of scientific version of the Hunger Games! Citations, publication numbers, grants, bonuses for publishing in Nature and Science.

  These are good journals, but they're not the only ones, and they're not for every discipline.

[1] https://www.sydney.edu.au/news-opinion/news/2016/09/13/university-rankings-how-do-they-work-and-are-they-important.html#:~:text=Rankings%20can%20take%20into%20account,tend%20to%20pay%20attention%20to.

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In the case of citations, I have my own experience of how strange things can get.

My most widely cited paper relates to what I always think of as a really unnecessary debate about the band gap of indium nitride. There was so much debate and there are so many papers about this one number. And I often think all that of it could have been headed off if I had just added that extra chapter to my PhD which I now realise showed the answer.

But as with all PhDs, I ran out of time!

The result is lots of citations; that's good for my research rating! But no advancement in the science.

You'll all have heard of cases where papers are shown to be wrong but continue to be cited over and over, despite being discredited.

Here's another example. Professor Genevieve Bell, Director of the School of Cybernetics and 3A Institute at the ANU, and Vice President in the advance research and development labs at Intel Corporation.

Such an inspiration in the world of technology. So much important work in the academic field and in her term as Vice President of Intel.

However, in industry, publishing is not the major way you share insights and because of that gap, she laments that she's not competitive in the ARC funding rounds.

Considered from another perspective: Names on academic papers are an important part of attribution, credit and accountability, but it can get silly when author lists run to tens, hundreds, or thousands of people. This is what happens when the incentives are not driving the outcomes we are seeking. .[2]

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My predecessor, Alan Finkel, described metrics as like the tendrils of wisteria – winding their way right through the research ecosystem – from hiring and promotion, to funding and to publication. Not always with benign outcomes because of those perverse incentives that can start to shape and control the way the research sector works.

I view those tendrils of wisteria in evolutionary terms. The way we rank individuals and institutions has evolved over time and arise out of, cultural, historical practices and systems. And like Darwinian evolution itself, the result is not always optimal. There are many living things that you would design differently, if you were working backwards and starting from scratch.

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Let me give you an example here.

I'm told that hiccups serve no purpose at all.

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[2] https://www.nature.com/articles/521263f https://www.nature.com/articles/nature.2015.17567

I understand that hiccups had a purpose for our ocean-living ancestors. Now science isn't sure why we hiccup. It's possible the answer is for no reason at all! At least not for the past 400 million years.[3] [4] [5]

But nevertheless we hiccup. That's evolution in action.

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When we think about metrics we need to think about what purpose they are serving and whether they meet our needs now and for the future.

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To answer that question, we need to ask another one. What do we want to achieve?

From where I stand, the answers to those questions are:

- Support and grow our research sector

- Kick-start high-tech manufacturing here in Australia

- Solve some big technology problems, including in climate and low-emissions technologies

- Become world leaders in emerging sectors such as quantum and space

- And to make sure we are funding the best and brightest to undertake fundamental research, coming up with answers to questions we haven't even asked yet.

This is what we want to achieve.

And these things can only happen if we cultivate STEM skills in our young people; encouraging more young minds into science, technology, engineering and related fields; and substantially growing the STEM workforce.

There is such a demand for a workforce trained in science, maths and engineering for example, with digital skills in areas such as quantum and artificial intelligence.

There is an urgent need in the wider workforce - in the spheres of design, law and policymaking – to be digitally literate, recognising that STEM is pervasive in every aspect of our society.

And it starts with the education system, where we must ensure our school and tertiary graduates are equipped with the foundational skills and can see a clear career pathway ahead.

The responsibility to develop these pathways does not rest only on the shoulders of our teachers, but needs the input of the emerging industries and research and innovation leaders.

You may have heard me say this before - we need the language of quantum to be part of our kids' backpacks, just like log tables or the Pythagorean triangle were part of our vocab at school, whether or not we ended up being mathematicians.

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[3] https://www.newscientist.com/article/dn17453-timeline-the-evolution-of-life/

[4] https://blogs.unimelb.edu.au/sciencecommunication/2017/09/27/why-do-we-hiccup/

[5] https://www.sciencefocus.com/the-human-body/newborn-baby-hiccups-linked-to-brain-growth/

That really is the nub of it.

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So, how do we grow the STEM workforce?

Well, in simple terms, we widen the pool.

This means encouraging more women to study STEM and then supporting them through their STEM careers.

It also means using our full human potential – including older workers - through micro-credentialing and on-the-job training.

And it means making it easier for people to move between the different sectors – of research, government, industry and start-ups.

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The data on women's involvement in STEM is not at all good.

More women than men are enrolled in tertiary education.[6] But in STEM subjects, the ratio is reversed quite dramatically.[7]

More than a third of men in tertiary education are studying STEM qualifications - areas related to maths, the sciences or engineering – excluding health.

But for women, the figure is only 9 per cent.

The most recent STEM Equity Monitor shows that the proportion of women working across all STEM-qualified industries sat at 28% in 2020[8].

In electrical engineering just 7% of the workforce is female and the figure is even worse in mechanical and industrial engineering where just 5% of the workforce is female[9].

When I talk to young women in science about the reasons for this, it becomes clear that current research metrics can be a real roadblock.

For many women, those important early-career years coincide with having children, and time away from their research can negatively impact their publication, funding and citation records, setting them back in disproportionate ways.

A similar problem occurs for people who follow science and technology careers that are not recognised in those traditional measures.

We're using volume as a measure of energy, we don't have a metric for measuring mentoring and there are too many de-mentors in the research sector.

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[6] Women 1,690,000; Men 1,600,000

[7] Women 156,000, Men 566,000

[8] https://www.industry.gov.au/news/second-national-data-report-on-girls-and-women-in-stem

[9] http://www.professionalsaustralia.org.au/professional-women/wp-content/uploads/sites/48/2021/06/Women-in-Engineering-report.pdf

Scientists should not be disadvantaged by working in industry or government. These options should advance careers, not set them back. Where are the collaboration metrics?

I always find it a bit ironic that when you tackle a science problem, one of the first things to resolve is the measurements, making sure you are measuring the right thing. And yet when we measure our own careers we use metrics that, in my view, are only marginally useful.

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This is a difficult question But it's an important one which we shouldn't shy away from.

The sad reality is that we've been talking about this for years.

In my view, the time for nibbling around the edges has gone.

Right now our country is building its future on high-tech STEM-related industries. **This** is our opportunity.

As many of us have recognised, the time has come to be disruptive and open to transformative changes.

Right now we are navigating a number of profound challenges – a pandemic, supply chain issues and a war. The pace of digital change and social response to these challenges has been more rapid than ever before. We cannot stand still. Never has there been a more relevant time to be responsive in the face of disruption. It is all around us. We need to be flexible and adapt.

One of the problems I see is that the people who must lead this change are those - you and me - who have benefited from the status quo. We have developed our careers in the current system and learned to operate within its rules.

A new normal requires both you - and me - to lean into discomfort.

I am pleased to see this is starting to happen.

You might have seen the recent communique from the NH and MRC calling for feedback on a range of significant changes to its grant system to improve the funding success of women, including what might seem uncomfortable ideas such as quotas or separate grants streams, and structural changes to peer review.[10]

I've heard other ideas to recognise in-kind contributions to research efforts, such as a way to tokenise those contributions.

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Just before I finish, I want to draw attention to one ambitious priority that I'm working on:

This is opening our publishing system to provide better access to our research literature.

My aim is a model that will allow all Australians to read the research literature openly, whether you work in industry or government, research institutions or schools or hospitals.

[10] https://www.nhmrc.gov.au/about-us/news-centre/gender-disparities-nhmrcs-investigator-grant-scheme#toc__12

This is a transformative change that challenges the status quo so it's not without risk. It's complex and it won't happen overnight. But we have started the conversation and we're doing the groundwork to understand the system and consider the best way forward.

Here's another thing I've learned:

I've learned that as Australia's Chief Scientist, transformative changes like this are available to me. This is where I can make a difference.

But the contribution I can make is one of **leadership and focus**. The changes in culture and practice are **for all of us to make**. If we do move to an open access system for research literature, it is up to industry, government, researchers and innovators to make the best use of it, to find and use the opportunity.

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Back in 2001, I heard Ian Chubb talk about his efforts to get industry support for a new government innovation plan. The plan would deliver more money for research, focus on STEM skills and innovation hubs, and make R&D tax changes.[11] Inspired by the partnership approach in the US between industry, research and government, Professor Chubb wanted to see a letter of support from industry.

But he couldn't find one corporate leader to sign. He described their hesitancy as "timidity beyond belief".

We cannot afford timidity if we're going to shake up the status quo.

Nor is it helpful to be defeatist. Yes, we have been having this conversation about better ways of connecting up the system for a long time. But that doesn't make it a hopeless one.

I started by talking about different approaches to risk. I suggested that scientists live and breathe risk as inherent to the process of discovery, and in government part of the job is to manage risk.

In truth, there is no dichotomy.

Risk is part of everything we do. Taking risk. But also managing and balancing risk. No-one's being asked to jump out of an aeroplane without a parachute!

Risk is not only about discovery or experimentation in research. It's about entrepreneurialism and commercialisation. Innovation and fresh thinking.

It's about challenging our comfort. Shaking up the way things have been done to ask, can they be done better?

The case for change builds over time, and when the stars align, it happens. Consider the development of mRNA vaccine technology. It was a long time in the making. It took the pandemic to create the imperative and the focus, the disruptive force, to make it happen.

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[11] Monash speech 2019, relevant section at 24:30: https://www.youtube.com/watch?v=ii29Dk2XNcY
See exec summary of Howard's "Backing Australia's Ability - an innovation action plan for the future" here: https://web.archive.org/web/20070202162519/http://backingaus.innovation.gov.au/docs/statement/strategy_doc2001.htm Included doubling money for ARC, new Centres of Excellence in biotech and ICT, extra 2000 uni places a year focused on maths and science and IT, included some complex changes to R&D tax incentives

We have an opportunity. Just as the challenge of synthetic textiles spurred research and improvement, new ways of doing things and new systems of measurement, in the wool industry, we have a moment in time to make a difference now.

It is open to all of you to challenge your comfort and join me in taking action.

Take merino as your model; rather than the accident of hiccups.

There is, as I said, a hunger for new ideas and new ways of doing things. There is a big appetite for research, science and innovation.

It is up to us, as a community, to take this opportunity and use it to invent an excellent machine, a system fit for purpose.

Thank you.