AUSTRALIA'S CHIEF SCIENTIST

INSPIRING AUSTRALIA'S SCIENTIFIC CULTURE

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Good evening and thank you for inviting me to speak tonight. It's a pleasure to be offered opportunities like this, to share ideas about how we might go about engaging our students, our parents, our *country* with science.

Science has always been a part of my life. In fact, I have been immersed in science for as long as I can remember. At every stage of my career, I have, in some way, been a scientist, worked with scientists or with scientific institutions.

When I say always been part of my life, I guess I mean that almost literally. As I have said on other occasions, my early years were spent on a farm – my parents, me and my dog, and a few other adults. I went to a single teacher school – six rows, six grades about 25 kids. And when I am asked why I am like I am, I go back to that time. I can remember thinking about why things around me were like they were as I saw them; I can remember wondering why there were so many stars up there and whether there was anybody up there looking back at me; I can remember being dissatisfied if I hadn't done what I had to do while the teacher was with another row. I can remember being very internally competitive and I don't know that I ever felt wholly satisfied with what I had done.

Of course I was competitive – still am – but the bit you don't see is the bit where I know deep inside that I can do better. I was impatient then to find things out and I am still impatient. I didn't know any trendy expressions like 'benchmarks' in those days; but I do know that I didn't think much of those who didn't try. I still don't like backsliders, or coat tailers or the languid finger flicker who believes in entitlement as a due, not as something to be earned. I can also remember that South Melbourne (being me) won every match I played – but then I had only to be able to kick the rolled-up newspaper further than my

dog to win those, but I do know my dog tried really hard and he knew how to show it.

I was lucky in that later in life some of those characteristics (and doubtless others) stood me in good stead. But above all, I had great mentors. I could list them all and tell you what each did for me, but I won't. But I will say that if I am an example of anything at all to anybody at all, it would be that it has been important for me to be reflective, to try to see myself as others do – even in the tough times - and learn all the time. And pick your mentors if you can. (and your family if you can).

I don't have a lot of regrets. I am often asked if I regret giving up the bench. Well, no. I don't. I would be a sad old man if I still regretted it after all these years. It was one of the best and most enjoyable times of my life – but I guess I always wondered what I could do. Did I have the capability to do several different things; harder things. Things that stretched and challenged in a different way.

I remember saying to my wife on my 41st birthday: life has to be tougher than this. I had it pretty good. Large lab; well funded. Teaching medical students – who by and large wanted to learn. Couple of PhD students. Lot of friends.

Anyway, she went inside and looked up removalists; I applied a little later for a Deputy Vice Chancellor job at Wollongong. And so it went.

My one professional regret is that I am not sure that I was too good at being a mentor. I took very seriously my responsibilities but I don't think I was patient enough to be a good mentor. I think I knew it; but didn't take the time – like many people, I assumed that example and osmosis was sufficient. I knew it wasn't.

My present job is a new and different challenge. I do not present myself as an expert in the details of any science. I don't know too many who could be an expert across the board. We scientists have spent decades becoming more and more specialized; but there are clearly some who think all you need is time, a cherry picker, a pulpit and a megaphone to be an expert on anything and everything. As I will comment later, if you have a heart problem would you go to a dentist – they are doctors after all.

Part of my job is to know where the experts are and how to get to them. Another part is to present 'science' to the government, to the Australian community and Australian science and its capability to the world.

So I start with a simple premise. It is, I think, through scientific knowledge and its application, through the wise use of technologies, that we will secure a prosperous future for ourselves – prosperous in all senses.

I am proud of Australian science. We perform remarkably well at the international scientific table. We punch well above our weight, as we like to say. With 0.3% of the population, we produce around 3% of the world's scientific publications. We have significant expertise in many areas.

And yet despite this, by and large, most Australians are disengaged with science. You can see this in our university science and mathematics enrolments. You can see it in the projected shortages in engineering, statistics and the research workforce. And you can see it in the ways the public conducts scientific debate about climate change, stem cells or nanotechnology.

This is an important time in our country's history. The problems we face – indeed, the problems that the world faces – won't be solved, or even managed without science and technology. Yet it is not clear to me that most people,

or even many people, really understand the importance of science and technology to our future.

In fact a recent survey of year 11-12 students in Australia indicated surprisingly little understanding of the science all around us, all the time, and its value[1].

Of those studying science, just 33% thought science was 'almost always' relevant to their future (although 47% thought it 'almost always' relevant to Australia's future!) and only 19% thought it 'almost always' useful in everyday life.

Of the students **not** studying science (roughly one-third the cohort), 1% thought it relevant to their future 'almost always' (42% thought never) and 4% thought it 'almost always' useful in everyday life, 42% thought sometimes and 18% thought never. Considering the science and mathematics in everything from their school shoes, clothes, plastic bank notes, television, mobile telephone and food, this is profoundly discomforting.

We all find this shocking, and that is because most of us in this room naturally assume that people think science is 'a good.' We are probably all quite sympathetic towards science and maths, so it may surprise us; but most people seem to take it for granted.

Nowhere can this be seen more prominently than in our attitudes to food and agriculture. A survey released last week found that 75% of school children thought that cotton socks were made from animals, and 27% were convinced that yoghurt was a plant based product[2].

As a society, we are almost entirely disconnected from the food production and distribution process. Very few of us

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[1] Australian Academy of Science, 2011. *The Status and Quality of Year 11 and 12 Science in Australian Schools*

[2] Department of Primary Industries
http://www.primaryindustrieseducation.com.au/resources/reports/foodfibrefuture.pdf

have visited an abattoir, even fewer a cotton farm. And yet with no knowledge of the process, we continue to expect quality foods on our supermarket shelves day after day.

There was a book released in 2010 called “The Rational Optimist”. The gist of it was that there is no need to be concerned about the future because humans will always have technology and innovation to get out of trouble[3]. And in some ways, I think this view is true of a lot of Australians, they assume that science will always be there when we need it.

And while I agree that science, maths and engineering hold the solutions to many of our future challenges, assuming that science will always be there when we need it is incredibly risky, especially if we can’t engage and inspire the younger generations to pursue science. .

A study in Norway asked 15 year olds from more than 40 countries for their views on science and technology[4].

The results revealed that the more developed a country, the less young people are inclined towards education and careers in MST. It is pretty stark and the message holds for whether or not they would like to become a scientist – or to get a job in technology.

The researchers suggest that *it might be that we have now passed the era in which the work of physicists, technicians and engineers is seen as crucial to people’s lives and well-being*. Today’s youth will not make their choices because it is good for European competitiveness

[3] Matt Riley, 2010. The Rational Optimist: How Prosperity Evolves. UK: Harper Press.

[4] Schreiner, C and Sjoberg, S. (2004). The Relevance of Science Education – A Comparative Study of Students’ View of Science and Science Education. Norway: University of Oslo Press.

or because they may earn a good salary. They are more interested in *who they will be* rather than *what they will do*.

Australia was not one of the 40 countries. But, like most other developed countries, high school students in Australia are not very interested in doing science or advanced mathematics in high school.

Between 1992 (after which school retention rates were fairly stable) and 2009, the proportion of Year 12 students taking physics, chemistry and biology fell by 31%, 23% and 32% respectively. The proportion taking one of advanced mathematics or intermediate mathematics has dropped from 41% to 29% over the same period.

And they have lost interest except for what may be an irreducible core. A little over 50% of year 12 students (about 105,000) took at least one science subject in 2010. While the proportion is drifting down, it has at least slowed – maybe that is the close to the irreducible core[5].

The same is true of universities. It shouldn't be a surprise that university enrolments for certain science disciplines, mathematics and engineering are low and have been essentially flat over at least a decade. IT enrolments have dropped like a stone.

I mentioned earlier, the disconnect between society and food production. It will probably not surprise you then that only *half of one per cent* of university students take agriculture. In 2010 we had only 743 graduates in agricultural science. That same year, approximately 4500 agricultural science jobs were advertised[6].

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[5] Australian Academy of Science, 2011. *The Status and Quality of Year 11 and 12 Science in Australian Schools*

[6] Chief Scientist, Senate Enquiry into Agriculture. http://www.chiefscientist.gov.au/2012/02/senate-enquiry-submission-agriculture/

In engineering the story is similar.

Australia produces less than half of its annual engineering workforce needs, with only around 6000 graduates annually. In the road sector alone, we will need an additional 4000 engineers over the next 8 years[7]. The peak body Engineers Australia has reported that there is a shortage of 20,000 engineers right now[8].

As chief scientist I am charged with providing advice to government on a wide range of topics. Just recently I was asked by the Prime Minister to provide advice on ways to encourage more students to take maths and science courses.

And to answer that I spoke to teachers, students, politicians and interest groups across Australia to figure out how our country could do just that. And what I found was that if we change nothing, our future does not look bright. Our current trajectory is not good enough.

So what do we need to change?

We need to encourage more students to take science at university. Sometimes that means more money – offering students scholarships straight out of high school to study science. Sometimes it means cadetships – giving them access to businesses and careers from year one of their degree. But mostly, we need to make science inspiring again, make it interesting.

One survey found that one of the main reasons students don't take mathematical sciences or science is because

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[7] Engineers Australia, http://www.engineersaustralia.org.au/news/engineering-skills-shortage-taskforce-underway

[8] Quote from Engineers Australia – http://www.adelaidenow.com.au/news/south-australia/education-to-tackle-shortage-of-20000-engineers-in-australia/story-e6frea83-1225907964866

they think it's boring. As was written in a US journal, we do to our students what was done to us. We promote rote learning, memorizing and regurgitating. And there are those of us old enough remember how bad that was. I don't remember anybody who taught me mathematics and they probably don't remember me either.

So we do have to come to terms with the fact that we live now in a different world. We need to think about how we deliver science, mathematics and engineering to a generation of students who have many, many, many more options available to them than we ever had, and who make choices.

The issue for us is how we make it so fundamentally interesting, so grippingly interesting that people will come because they'll want to do it.

And they'll want to do it because it's fascinating, because it's explained to them and because of the simply awesome adrenaline kick you get when you discover something for the first time; whether it's understanding something complex for the first time, or doing an experiment that reveals something for the first time.

Because science *is* amazing. On Friday I read a paper in the Lancet outlining the leaps and bounds being made in research to grow entirely new organs from our own stem cells, potentially eliminating the need for organ donors. The work is still being done, but the thrill of this discovery, which could change millions of lives, is something that we need to be able to express to our students. [9] This is what science can do.

We also need to change the way we support our science teachers. I've spoken to many science and mathematics teachers and whilst not every single one would share the

[9] **Engineered whole organs and complex tissues**, Macchiarini et al., *The Lancet*, Vol 379, 2012

view, the general view would be that they've been a bit neglected. Science is moving ahead at a pace and professional development programs don't move ahead with the same pace. Yet teachers are going into a room full of smart young people who go home and watch National Geographic and they know more about the Y chromosome than the teacher does–unless they saw the same program.

So we've got to help these teachers. They've got your kids, they once had mine, and they've got the nation's children and the nation's future in their hands. We in our universities, we scientists, we mathematicians, need to work out a way to help these teachers. This is a national issue; this is a role where the federal government, I believe, has to take some direct responsibility.

In my research for my submission to the Prime Minister, we were told by *everybody* that science and maths teaching has to be inspiring, that relevance is important– and this also comes from the school students themselves.

They lament the fact that work safety rules stopped inspiring practical classes being offered these days in science; they've become demonstrations, recipes. If they do get to do them, they are pass or fail. No time for reflecting on what happened and why.

Science is not taught as it is practiced very often. They don't do what scientists do: unpick what they did to find out how they can explain what they observed; the debate, the skepticism, the very basis of the scientific process is rarely taught apparently – no time; crowded curriculum.

The students don't like it. I asked a group from among 145 year 11 students how they liked it–and these are really smart young people handpicked from around Australia for National Youth Science Forum–and the response was that it's good, but it would be better if it was interesting and

relevant. So I said ‘Oh well in my day we had to sit down and learn the periodic table and they said, “Well, so do we.” I thought, good grief, fifty years on and they’re still learning and remembering and repeating. And it’s worse now – there are a lot more elements than in my day.

The reason it’s so important to have students studying science in high school is partly to increase the numbers that go on to university, but also partly because we need to develop a science literate community.

We need to change the way our community thinks about science, mathematics and engineering. And give them the information they need to make informed decisions about what to do, and what is important. In the report I submitted to the Prime Minister, there was a general conclusion that the level of scientific literacy in the community is not at the level it should be.

Every day, we hear stories about climate change, cloning, genetically modified food, space exploration, DNA and new drugs to name a few. We need a community that can evaluate these claims and determine for themselves how they will respond and behave when given options.

I saw it written recently *the economists assumption that people are rational and if left to make free choice will do what is best for them has been proved mistaken time and again.*[10]

To make any choice at all especially one that is near rational, you need information and a base level of knowledge to help understand that information. Then you can make a choice and have an opinion that is not swayed simply by the repetitive use of decibels that is the chosen method of some people.

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[10] Foster, D and Young, H. 2001. On the impossibility of predicting behaviour in rational agents. *PNAS*, 98 (22).

We have seen in recent times how the scientific process has been misrepresented. How debate amongst scientists has been portrayed. How the natural unwillingness of a real scientist to talk about proof rather than the weight of evidence has been misrepresented. We can note that anybody who claims to be a scientist of any description, of any note, can claim expertise and can get a public profile somewhere, and use it.

We need the public to understand more about this. I am reminded of a piece in the Wall Street Journal recently, responding to an earlier one authored by 16 scientists two of whom had expertise[11]. The response started with words like: if you have a heart problem do you go to your dentist.

In this climate, the value of science needs to be protected – from being manipulated by politics, misinterpreted in the media and from being dulled down in our schools. To do this, we need an inspired Australia. A national culture that appreciates the role science plays in every aspect of our lives, from our health to our economy. From our food, to the way we communicate with each other. When most Australians value the incredible role scientific progress plays in our wellbeing, the other problems will almost fix themselves.

These are large steps that need to be taken, backed by both political and cultural will. The politics is obvious, to make big changes often requires big dollars. The culture is a little more elusive.

The OECD has just released a fascinating study[12] comparing how well high school students do on international math tests, with how much money their

[11] Wall Street Journal, 2011. No Need to Panic about Global Warming. http://online.wsj.com/article/SB10001424052970204301404577171531838421366.html
[12] OECD, 2012. Knowledge and Skills are Infinite – Oil is not. http://oecdeducationtoday.blogspot.com.au/2012/03/knowledge-and-skills-are-infinite-oil.html

country makes from natural resources – be it oil, uranium or diamonds.

What they found was that the richer a country was from natural resources, the poorer the students' maths results. Students in Singapore, Finland, South Korea, Switzerland and Japan had the highest scores, while resource rich countries like Qatar, Saudi Arabia, Chile, Mexico and Argentina were at the bottom.

In countries with little in the way of natural resources, education has a high status, at least in part because the public understands that the country must live by its knowledge and skills, and that these depend on the quality of education. The prosperity of their countries is dependent on the knowledge of their people – there are no oil fields or diamond mines to rescue them.

Australia is lucky to have natural resources, and our results on the international tests were not too bad[13] but as the saying goes, "when you don't have resources, you become resourceful." But I say, why wait until the resources are gone?

I have offered here today some of my opinions. These solutions are not easy, transitional changes. They are not confined to the halls of parliament, or the lab rooms in schools. We all need to be on board. As a country, we need to work together to change the very fabric of Australia's scientific culture.

Thank you.

[13] Along with Russia and Norway, we were one of the only countries to perform above average in maths and have an economy that relies on natural resources higher than average