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(speaking on behalf of the Australian Academy of Science)

Thanks very much. I'm called a senior member because I have been elected incoming secretary biological sciences and that's just the biological bit. But there is a connection to Hyam, because in 1965 I did my matric in Melbourne and I did pretty well. But we were just all blown away by this nerdy guy from Melbourne Boys' High and he then went to Monash where I was too. And it was really unfair being in the same year; you just looked so poorly and he did extremely well, as you could imagine, in maths and physics. And it leads me as a biologist to make this complaint that whenever we get scholarships within the university, we always have our poor biologists compared with people like Hyam Rubinstein: not always Hyam Rubenstein, but you know the point I'm making. The people that have the great grades are the mathematicians and to some extent the physicists, and it's led us to start asking how would they have gone if they had actually done biology, because this is not a symmetrical situation. The biologist had to have done physics and maths, but not the reverse. Now this might sound like I'm actually saying something divisive, but we actually want biologists with mathematics and I can't get them. I can't get them here.

So the biologists that I have been working with mostly over the last few years actually come from France. This is the students that I work with, because they have been through something like the Ecole Normale Supérieure[1] and so they've got what I would consider by my scale, not by your scale, but by my scale, fantastic mathematical skills, because it's a part of what every biologist at ENS would be expected to have. Why can't we have them here? My biology in fact does have a mathematical component and in my little area of science I'm famous for making mathematical models that explain how photosynthesis in leaves work or how to improve water-use efficiency. And that's actually led to release of new varieties recently from CSIRO which out-yield the checked varieties by about 10%. And it is a weird thing, because I sat down with bits of paper in hotel rooms and on planes and in my bedroom, writing things, formulas, that are about really arcane things like how much of a stable isotope carbon 13 is there compared to C^{12}. And you're doing a model about something that is differing by about one part in a million and then you make a prediction and then people go away and put leaves first of all in gas exchange cuvettes and measure changes in humidity and CO_2 and the results come out. And then somebody is interested by that and actually works hard to breed plants and over 20 years later there's a variety of these and people are out there planting seeds and harvesting. And there's this amazing feeling about this correspondence between what you would have done in a

[1] The Ecole Normale Supérieure in Paris is one of the "grandes écoles" (French higher education institutions outside the standard public university sector). It has a small, highly selective annual intake of around 100 students in science and 100 students in humanities.

mathematical language and some correspondence of the physical, including biological, world.

And that is a really magical feeling and actually it's beyond magic to me. It always seems to me slightly unreal. Why is there this correspondence? It seems slightly mysterious and I think I'm not the only one who feels that way. I know enough of you people, you know far more about it than I, but what little I understood about Gödel's writing[2], is that he said that there is no single set of rules that explains why arithmetic really works. But it works for me and I guess what I wanted to say is this: that mathematics provides for us a language for predicting the future in biology. It's the one way where you can actually sit down and predict what may happen with an experiment; predict what may happen if you develop a new variety; predict what may happen if you combine genes in a new way. So that's a really exciting thing. Just going back to the point about Gödel, I don't know how many of you have read the book *Galileo's Finger* by Atkins.[3] He actually said in a really speculative chapter where he refers to this, he said well maybe the reason mathematics works is that it says something about how our brains have evolved. The fact that mathematics works in such a neat correspondence with our perception of the physical world is maybe a deeper thing. And of course that's one area in biology which is forging ahead right now.

So biology now claims all aspects of psychology, all aspects of the mind, it is part of science, it is part of biology and there is a tremendous amount of mathematics being applied in that area. And of course many of you here will know of the centres in Australia that are making advances in that area. But of course the progress, using mathematics in brain science, is not the one that's most well known in terms of mathematical applications and now in the need for mathematicians. That's really in genomics and I was delighted to see in the report, a quote from my friend Joel Cohen, who I know from Rockefeller University and it's a wonderful quote and he says "mathematics is biology's next microscope only better; biology is mathematics' next physics only better"; that's a great quote. But the reference is to the genomics revolution and that's what Joel is talking about there, although his own work is really much more associated with all kinds of things to do with population increases and he has written a wonderful book about it.[4] And I would encourage us to get him here to Australia when the next opportunity arises, on any discussion of population increase, because he is the world expert.

Anyway his reference, in that context, was to the genomic revolution with the opportunities to address obviously important issues in medicine and agriculture and they're highly dependent on mathematics. I don't know if there's any other hardcore biologist here, but Chris Somerville[5] is one of the gurus of plant molecular biology these days and I remember trying to get him a research fellowship at the ANU and of course we should have been offering a Federation Fellowship, if something had existed like that at the time. But anyway Chris' background, is that he's just won a huge international prize, $1 million, for getting the molecular revolution going using Arabidopsis, which is our model plant system,

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[2] Kurt Gödel (1906-1978) "proved fundamental results about axiomatic systems showing in any axiomatic mathematical system there are propositions that cannot be proved or disproved within the axioms of the system" (http://www-history.mcs.st-andrews.ac.uk/Mathematicians/Godel.html)

[3] Peter Atkins, *Galileo's Finger* (Oxford University Press 2003)

[4] Joel E. Cohen, *How Many People Can the Earth Support?* (Norton 1995)

[5] Professor Chris Somerville, Director of Plant Biology, Carnegie Institution of Washington, Stanford

sort of like the Drosophila that the entomologists use. Chris trained originally in mathematics and computing science before shifting to genetics and then into molecular biology. So he's got the language and that's why he's been so successful at not only understanding the concepts, but thinking through about how you are going to trawl through all the information. It's amazing that it's actually a problem for us, it's actually a problem for us to find information that we need. There'll be a relevant release very soon from CAMBIA, the Centre for the Application of Molecular Biology to International Agriculture, which is up on the hill here, which is funded by an individual guy[6] who discovered a particular reporter gene (GUS) that made him rich.

Anyway we actually don't know when we start to work on a particular gene, whether somebody else is working on it. O.K. you know that there is competition, that's one thing, but it's hard to find out whether somebody may actually have patented something and whether you should be avoiding it, because there are commercial interests that say if you touch this you're going to be in trouble. It turns out that a map of the genes of poplar has just been released, the genome of poplar the tree, the first genome of a tree, and so when you scan all the genes you find lots of those genes are in common with rice, which has been sequenced and with Arabidopsis that's been sequenced. And so it turns out that lots of those genes have already been patented and it's taken a CAMBIA mathematician working with computer scientists to try and discover ways that you can trawl through all the patent applications, as distinct from the patents that have been granted, because there are two different things here. Because you need to know about applications as well as what patents have been granted, so to actually find out what genes you can work on in what context is something that hasn't been possible until, well, yesterday.

So there are all sorts of applications of mathematics and biology and I urge you to get together with your biological colleagues, because Australia has traditionally been very strong in certain areas of biology, plant breeding, plant physiology and particularly immunology on the medical side. So there are lots of areas of Australia that are really good, but there are only a few of them where we have yet got the marriage going with mathematics and statistics. That is something that I would like to see develop more and if this report can create action that makes that happen, then I will be really happy.

END OF TRANSCRIPT

[6] Richard Anthony Jefferson is an American-born molecular biologist who founded CAMBIA as a non-profit private research institution, which he relocated to Canberra.