



Australian Academy of Science - Science education

Interview with Professor Sir Gustav Nossal

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Professor Sir Gustav Nossal, Australian of the Year, was interviewed for the Australian Academy of Science's *Video Histories of Australian Scientists* program in April 1998. The interview was conducted by Dr Max Blythe of the Medical Sciences Video-archive of the Royal College of Physicians and Oxford Brookes University in the United Kingdom. Here is an edited transcript.

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[List of edited transcripts.](#)



An enduring directorship

Sir Gustav, 11 years and 24 days ago we met in Melbourne for our first interview.

And of course we're both 11 years younger, aren't we? And particularly, I'm at least five kilograms lighter, aren't I!

At that time, you were Director of the Walter and Eliza Hall Institute – and still had nine years of your directorship to run. How was it that the Institute gave you that massive job when you were still so young?

About Christmas 1961 I came back from the United States, where I had been a post-doctoral fellow and a young assistant professor, and what greeted me was a Hall Institute obsessed with the impending retirement of Macfarlane Burnet. He actually should have gone at the end of 1964 but stayed on, for a variety of reasons, till September 1965. Everyone was saying, 'Of course when Burnet goes, the Hall Institute will shrink. Professor Lovell will take over the clinical research unit and the biochemistry department will go into our first floor, and the fourth floor will be left.' Well, I'd just brought back a big National Institutes of Health grant and Burnet had made me effectively the number three person in the Institute (with the meaningless title of Deputy Director, Immunology). So I said, 'That's nonsense. We have the best medical research institute in Australia. Far from shrinking, we're going to grow.' I suppose I was projecting a positive vision – no *Götterdämmerung* after Burnet, but a new beginning.

That perception gained currency but to what extent it influenced the board of the Institute after my application went in, I don't know to this day. I do know that I was vain enough to have three Nobel Laureates as referees: Burnet, Peter Medawar and Joshua Lederberg, who'd been my boss in the United States. As to whether they spoke up for me, that is probably buried in the Burnet papers somewhere.

I suspect that this capacity to produce catalytic friendships has had a lot to do with the development of the ambassadorial, leadership/administrative side of your career.

You're right, and I was immensely lucky to be jetted into the big league, a very able peer group, quite early. I can remember, for example, coming to Stanford just after Josh Lederberg had won his Nobel Prize and before Arthur Kornberg won his, and one of the first things that Lederberg, my young boss, did was introduce me to Kornberg. Now, how do you have opportunities like that? I think in general terms people respected the work that I did, and that's been tremendously influential in my life. There is this capacity that Aussies can do it – they can go off overseas and 'fly'. That's been very fertilising for me, and I think I've been able to convey that sense to a lot of my younger colleagues, who indeed have 'flown' in the international arena.

Very early on you were creating an international network for them all, from the time you got the Hall and even a bit before – a critical basis for what was to happen.

Absolutely right.

So what has happened at the Hall Institute since our first interview, 11 years ago?

They say that a chief executive should stay in a job for 10 years, or 15 at the very most. I had 31 years in that institution, and the only way I can justify it is by saying that every five years or so I did try to redefine the role. And in that last period we made some fairly significant developments that I look to as justification. One of them was to become much more savvy about commercialisation. That was born out of travail and some bad mistakes that had been made. The second is conceptually more trivial: we built a beautiful new building and had to work our way into all the growth opportunities that it gave. Thirdly, we became considerably more deeply involved in molecular biology and everything that comes from the cloning revolution.

A steep commercial learning curve

Let's just take in the bad before the good: that period in the mid-1980s of commercial interests that you say weren't exactly the best deal.

The whole country has been on what you might call a learning curve about commercialisation. Turn the clock back to the late 1970s, early 1980s: the word 'patent' did not exist in our lexicon. 'Profit' was rather a dirty word – working for profit was what those nasty companies out there did. We were going to stun the world with our brilliance and make marvellous discoveries, publish them and move on from there.

The realisation gradually dawned that by publishing a discovery with considerable commercial potential you actually delayed its implementation, because no company will put in the immense development funds that are needed without intellectual property protection, without being able to get the financial gain, given that it now costs \$350 million to put a new drug onto the market. We had to learn fast there.

The worst aspect was to lose the brilliant invention of Don Metcalf, Nick Nicola, Tony Burgess and their colleagues in relation to the CSFs, and in particular G-CSF, which Malcolm Moore (a student of Metcalf's) actually took to Amgen and which made Amgen a multi-billion dollar company. G-CSF now sells over a billion dollars worth of material a year. That could have been a largely Australian triumph, and it wasn't. I suppose you'd have to say that was my fault and the nation's fault.

Was that really felt? Did it have emotional repercussions?

You know, it's very easy to reconstruct history. I have a distinct recollection of going to several of our companies with two little things in my kitbag: the CSFs (Metcalf's discovery) and the very first beginnings of a malaria vaccine breakthrough, when David Kemp and Robin Anders cloned the various

malarial antigens. And I distinctly remember people being much more interested in the latter than the former. People gave us little threads of help. The malaria vaccine kind of flew – it's still not commercial. But the CSFs: 'Interesting, but it's only a mouse phenomenon to date.'

Did losing that patenting really cause problems for a director of the whole Institute?

Well, I think the fact of the matter – I have to be fairly precise here – was that on one of the two agents, the one that sells less well, GM-CSF, we did maintain a good patent position, and we get a modest flow of royalties from that. With the G-CSF, we let our patent position go because we had only studied the mouse molecule and the patent attorneys in the early 1980s told us, 'Well, if you haven't cloned the human gene you're nowhere.' We let the provisional patent go. That was a bad mistake.

But I think scientifically it became so clear that the Metcalf team – which I'm sure he'd be the first to tell you involved about 100 people – so bestrode this field like a Colossus that it really didn't hurt the Hall Institute at all not to get the commercial dollars. Scientifically we learnt to live by our wits, we did the old peer-group-review grant things, and we got more grants every year than the previous year for the whole period of my directorship. So I think the short answer is: Gus's bad mistake, but it didn't hurt him as much as it should have.

Perhaps you were living on a good economy that you had already founded.

Yes, and I think in a funny sort of way the peer group that is in a place like the Hall Institute does quite enjoy living on its wits, with the pain of having to raise those grants, of competing in the basic science marketplace without having perhaps to be too worried about commercialisation – although it is changing quite rapidly.

A great welding job

We have taken in the less palatable aspects of the last 12 years or so at the Institute. What were the most impressive things?

The growth and thriving of molecular haematology, the field that Metcalf, in a way, created, was and was seen to be highly successful. The second thing that I should note from that period was the growth and growth of Adams and Cory, two of my colleagues whom I'd been extremely fortunate to tempt back to Australia as very young and untried people from Fred Sanger's lab – impeccable pedigree. Jerry Adams was Jim Watson's student; Suzanne Cory was Francis Crick's student. How could you have a better marriage than that, the two strands of DNA? They actually did get married and went off to Tissiere's lab in Geneva, and I was fortunate enough to pick them up from there.

So actually we were in molecular biology as an institute before the gene cloning revolution. They brought the gene cloning revolution to every aspect of the Hall Institute's work. Over that last decade they became very prominent in what is still an enormously fertile area – we'll call it broadly the oncogene era of cancer research – really coming to a deep understanding of cancer as a biochemical phenomenon, cancer as heritable, not from person to person but in the sense of from cell to cell. Now that Suzanne Cory is my successor, that thread has become quite dominant.

A third success story, though not a commercial success, was our deepening involvement in the field of parasitology and thus of Third World health generally. Whereas we do not yet have a commercial malaria vaccine, the definition of the blood stage antigens of the malaria parasite and the pathways which will eventually make a really good malaria vaccine possible has to count as major work. And that stems from the unit headed by Graham Mitchell and the work of a lot of scientists, including David Kemp, Robin Anders, Graham Brown and a good number of others.

Did keeping all that together over the years give you great pleasure? It can't have been easy; there were many different personalities. Did it suit your temperament?

Absolutely. It would be remiss of me not to make reference to the motherlode, which continued to be immunology. Through the whole of this period, Jacques Miller, Ken Shortman and I carried on in a linear kind of way what you might call the Medawar/Gowans style work – or, if you want, the Burnet or the Gus Nossal/Jacques Miller style work. That was a continuous thread. I was publishing primary research papers until the day of my retirement in 1996, and a couple of them even afterwards. So there always was this base of science, but then adding to that what you might call the 'Big three' areas: molecular haematology, oncogene research and parasites. Yes, that was a great welding job – and it was a lot of fun.

Advising at the World Health Organization

Within a few years of being Director of the Hall Institute, you took a year off and then got involved in a big way with advising at the World Health Organization.

That's right. I had a sabbatical leave in 1976. The WHO association in a way has deepened down the years.

And in these 10 years you've become chairman of a major scientific advisory committee at WHO, haven't you?

Yes. Again I was very lucky. Niels Jerne, a great Nobel Laureate and a peer of

Burnet's as a theoretician in immunology, for a brief period had the very practical job of building up immunology at WHO. But then in 1964 he was followed as head of immunology by my good friend Howard Goodman, an American scientist. So I've been on various committees down the years and got tremendously involved in the Tropical Diseases Research Program – TDR, since everything in WHO has three initials. It is thought by many to be WHO's most successful program, and I am still very proud of it. I had a good period after 1976 working on that; I had a good period on their Advisory Committee for Medical Research, which is the top committee; and then the recycled energies of the last 10 years have gone into global immunisation.

I have had the great good fortune of being able to parlay my knowledge of immunology to this very practical business of (a) getting the vaccines that we have to the 125 million children born into the world each year who need them, and (b) leading the fight for more research into new vaccines, particularly for unpopular diseases where the industry is not too interested in making vaccines, such as some of the diarrhoeal or acute respiratory diseases. President Clinton has boosted AIDS research needs and now everybody wants an AIDS vaccine, but even a malaria vaccine effort is not easy because it's not top of the pops with industry.

At our last interview, you were quite optimistic about where malaria research would go – and that seemed quite justified at the time. You've got to correct that now.

Another *big* Gus mistake – tremendously naive about the timeframes for major practical discoveries. When Robin Anders and Dave Kemp had their breakthrough in 1983, Graham Mitchell and I genuinely thought that within about 5 years we would, from those cloned antigens, have a malaria vaccine. We gravely underestimated all of the practical things: scale-up – 18 months wasted on realising that what 5 milligrams of protein can do is not the same as what 5 grams of protein can do – and the very arduous process of step-wise clinical testing. We are now in clinical trials of a malaria vaccine in Papua New Guinea, but it is an agonisingly slow process. A third field is a bit technical and shouldn't delay us: we gravely underestimated the importance of adjuvants, which are substances that make the human immune response strong (it turned out that these molecular vaccines were not very strong vaccines). So, a big mistake about the timeframes; still, I believe, on the right track intellectually. But this is another learning process.

What kind of approach does your advisory committee take? What kind of interface do you have with the strategic forces of WHO? What filters down from you, and how?

It's a little bit complex, Max, but I will go into it because it's interesting. I chair one central committee, the Scientific Advisory Group of Experts (SAGE) of the Global Program for Vaccines. That meets as a full committee only once,

in June, every year. The meetings go on for about a week and then there is a meeting with the donors for an extra couple of days. So my first 10 days of June are always WHO.

There is a second entity, which glories in the name of the Children's Vaccine Initiative (CVI). That's a kind of umbrella body, which doesn't have a huge amount of money but attempts to coordinate and plan the components of the different elements in the vaccine spectrum: WHO, UNICEF, the World Bank, industry, the non-governmental organisations. That also has meetings which I chair, because the same SAGE is also the SAGE for the CVI. So that's a second commitment each year.

Then I come to a third. There is a new kid on the block, the International Vaccine Institute (IVI), based in Seoul, Korea. It is only a little embryo. It's in temporary quarters but it will be inhabiting a \$40 million building, and it's going to be responsible for doing phased clinical trials, disease burden studies, epidemiology – putting flesh on the bones of a lot of this research, to do very practical things. I go to Korea once a year for that, and then once a year elsewhere for an executive committee meeting.

Has that Institute been set up in your time?

The IVI is all quite new, and I'm the deputy chairman of that board. When you add all of those things up, it's a heavy involvement, particularly now that it's embracing the World Bank to a greater extent than before.

Realistic funding for health

There's a great seriousness about the difficulties of managing immunisation in arenas where the budget is falling. How are you going to overcome the economic problems?

Well, through the great generosity of UNICEF and of Rotary International, we have the Expanded Program of Immunisation (EPI), a solid program which has got rid of poliomyelitis from the Americas and should have got rid of poliomyelitis from the world by 2000 or within a couple more years – a wonderful triumph. This same program has materially upgraded the use of the six vaccines that are common in childhood and it has also made big progress in measles.

Now comes the big 'but'. We got stuck at a coverage rate at or just below 80 per cent. Going the extra mile to put it into the 90s or even the high 90s has proven very difficult. And, of course, countries are heterogeneous. In the 28 poorest countries of the world, mostly in sub-Saharan Africa, the progress has been less than remarkable.

So, constraints. In financing, the hundred million bucks or so that UNICEF

brings to the party are not enough. That is why recently I've been working very hard with the World Bank. It's my real belief that it should be lending more in health for development, and what better area to begin to lend in than in this field of vaccines. You see, if you use soft-money loans with very low or in some cases even negligible interest rates, repayment 20 years down the track by a country that has upgraded its development because it has upgraded education and health is not so very difficult. And the cash flows of a World Bank exceed by at least one order of magnitude, if not two, the cash flows of organisations such as UNICEF.

Is it realistic to assume that the World Bank and the economic community are going to bail out the Third World? Surely it's been going the other way in the last 10 years.

Let me tell you what I think is realistic. I think it's realistic to see the World Bank as a big agent in the poorest countries of the world. Its President for the last 2½ years is Jim Wolfensohn. He happens to be an Australian and our friendship goes back 40 years plus, to university. Under Wolfensohn the Bank has a very special focus now on Africa, and we had an excellent meeting with him just a few weeks ago. I think for the countries that are a bit further along the pathway of development we can get the Bank to do a lot of advocacy. At the level of international movements the World Health Organization comes in and talks to ministers of health, who unfortunately are usually rather lowly individuals in the decision-making processes of the Third World, but the Bank comes in and talks to heads of state or at least finance ministers, who are much more influential.

If we get that advocacy, with a trickle down of, 'Yes, vaccines are good. Vaccines buy you a lot of health for a small amount of money,' I think we can have industry coming in and we can let the free market work. Industry actually wants to be in India, in Indonesia, and above all in China. We need a push that says, 'Now look, amongst the things that you do we want you to go in there and we want you to sell your vaccines – but of course at a price that the market can bear.' Industry is good at that. It's actually quite good at setting differential prices for different markets, and in some countries we may not require the Bank to do much more than advocacy. That is realistic.

To galvanise the world

I think you're looking forward to the new millennium, when you're going to be able to announce the absence of polio from the world. It'll be a classical moment.

Yes. I actually think that if we can do this task – it's now only a matter of time – it will have a galvanic effect on the world. We had the smallpox triumph, but in our lifetimes smallpox really affected only people in very poor countries, whereas polio crippled a President of the United States. Practically everybody

has a friend who's got a gammy leg or arm from polio. The chief executive of my wonderful Victorian Health Promotion Foundation is very seriously handicapped in the legs from polio, and she's only in her 40s. So people can identify with that. If that's gone from the world, if you do not have to vaccinate any more, just think of the savings. Not having to vaccinate would probably pay for all of the previous research on vaccines since the dawn of history in a single year. It'll have a galvanic effect, and I want to be able to do that again and again. I want to do it with measles, which is a very serious disease in a Third World setting. Looking further ahead, neither hepatitis A nor hepatitis B has an animal reservoir and they should, in principle, be eradicable – but over a very long time.

Are river blindness and schistosomiasis and all these other things on the agenda too?

It's good to get back to parasitism. The river blindness (onchocerciasis) story has been a great triumph. It started off in an inefficient way by dumping a lot of insecticides into rapidly running waters where the vector of the disease breeds, so getting the larvae of the flies that carry it. But the real breakthrough has been drugs. Ivermectin, which is given to dogs for heartworm, was actually given free to these African countries. It was backed up by a second drug, and the remarkable fact of the matter is that that disease has now virtually gone, even from some of the poorest countries in the world. I certainly don't think immunology is the only important science. Chemotherapy is hugely important, as is vector control, vector biology, and – though I'll only confess it to friends – even environmental sanitation, seen as the big rival of the technological fix with vaccines and antibiotics, is enormously important.

I mentioned these things because I knew they were also important in your horizons at WHO. Perhaps now we could take the measles story.

The cessation of measles transmission in certain Latin American countries, including Cuba, is totally fascinating because the immunisation rates of infants are not that flash: 80 per cent or anyway the high 70s. But if you combine that with catch-up immunisation, on so-called national immunisation days, where there is a great involvement of the media, where there's a great involvement of political personalities and where you line up all kids under five, in the case of Latin America, you will catch the hard to catch. It may have to be all kids under 14 in a country like the United Kingdom, where you've had a brilliant measles eradication campaign coordinated by David Salisbury, a great man. But you don't have to achieve 100 per cent. If you can achieve, say, 90 per cent, the virus doesn't have enough soil in which to grow and it dies out – the herd immunity effect. So I think that measles eradication is possible. Some of the Latin American countries have shown it, as have some of the Scandinavian countries and the United Kingdom (all cases of measles in the United Kingdom now are imported). In Australia we've had tremendous help from Michael Wooldridge, our relatively new Minister for Health, who is very keen on

public health, and we're going to give it a shot here.

A Pilgrim's Progress away from the bench

We have been talking about your change of focus to the World Health Organization. Something has kept pulling you away from personal science. But we had papers coming out right till the end of the Hall Institute days. How was that managed?

To be incredibly frank, that was crafted by very devoted technicians and students and post-doctoral Fellows. It would be remiss of me to suggest that I would trot off into the lab and pipette 5 milligrams of this into 5 milligrams of that. I did not do that for the last 10 to 15 years in the Institute, but I did do a lot of microscope work, of supervision of the primary data, of walking into the lab after I'd opened the mail, saying hello and, 'Now, what are we plotting with this little group here this week?' Then it would be the others doing the experiments – which is why my CV has a lot of last-author Gus Nossal papers but not too many first-author Gus Nossal papers, except the reviews.

Were you still into supervising PhDs at that stage?

Yes. One of the most touching things that happened to me shortly after my retirement was the arrival of a big photo, just ready for framing, of my first PhD student and my last, with a timespan of 30 years in between. They met by chance in Cambridge, of all places, recognised what they were, and sent me this photograph with a very sweet dedication on the bottom. It is now in my retirement office in the medical school.

I've got a flavour now of the Hall Institute: four main channels of work flowing through, producing results; finance coming on stream; you still getting a bit involved at the bench, keeping that Fred Sanger part of you alive and burning; but out of it coming a person who really wants to be more ambassadorial in science.

I would agree a bit with your idea of a Pilgrim's Progress. I suppose there exists in every scientist's breast some kind of a deep admiration for the Fred Sangers of this world – to stay close to the bench, with that unique ingenuity that Fred has got, and make that the 80 hours a week of your working life. And there are such scientists. You have recently interviewed Don Metcalf, who is very much that ilk of scientist – the person who stays absolutely close to the primary data and is very channelled.

I would say that at the senior levels of science it is more common for interests to broaden out and for people to take on wider roles. And because there are only 24 hours in every day and everything competes with everything else – as it really does – the hours that you are spending on a committee or the hours that you are spending working with the media, or for that matter with the

business community, are hours when you are not thinking about antibody production by B lymphocytes. Also, having the good fortune of an early promotion as Macfarlane Burnet's successor, at the ludicrously young age of 34 (although you couldn't have explained to me at the time how ludicrous it was), forced me to think on a wider framework.

Successive, overlapping preoccupations

I find it exciting that even though you are still a governor and patron at the Hall Institute, the WHO activity has increased and is really at the top of your agenda now.

Let me pick that up, Max, because there's a fair bit embedded in it. First of all, how can a person work for an institution for 40 years and not have it deeply embedded in their heart and in their brain? But I felt quite strongly when I finished at the Hall Institute that I had really finished. I have a wonderful successor. Professor Suzanne Cory is a great molecular biologist, a mature scientist and extremely able leader. She knows different things from the things that I know: she knows much more molecular biology, she's also quite a good cellular biologist. She'll be taking the Institute in a direction that will be hers, and she will be a fine leader. It's important for her to be able to do what she wants to do without me breathing down her neck, so I moved right out. Of course I remain enormously supportive. She's kind enough to consult me not infrequently, but she's doing her thing and that's how it should be.

As to what has come to occupy the space in my life, you're quite right in saying that the World Health Organization and global immunisation is number one, but I'll give you a number two and a number three. I'd want my colleagues from the Academy to be very careful now as to how I phrase these words. I have the great honour of being President of the Australian Academy of Science, to me a very important job. When I say number two, I will say it's equal number one for the years that I am President, but that's a fixed 4-year term, whereas the other involvement is ongoing. In terms of space in my total persona it's for that reason number two – for no other. Number three is a very recent preoccupation, Aboriginal affairs. We might talk about that later.

Would you say that at the World Health Organization, after a long time of enormous commitment to getting things in order, the results are in gestation?

The results are coming through, Max, although I think you and I are men of the world enough to recognise that this is a really hard one. The world's not always a very pleasant place, and this demands a great deal of unselfishness on the part of the world. Sustainability in all of these programs will be very difficult. But yes, I tackle the job with optimism because that's in my nature and I will carry on this advocacy for global immunisation till I die. How successful we are will depend to a considerable extent on how successful the world is in ridding itself of its prejudices, ridding itself of warfare, ridding

itself of this incredible gap between rich and poor. And one can't be overwhelmingly optimistic that all of those things will happen.

An ambassador for science

I detect in you a deep commitment to try to give a fundamental protection against infectious disease for kids right across the globe. Also we have glanced at an ambassadorial role for you in science. For many years you've been involved internationally in a range of organisations, trying to promote science.

I've always been interested in the interface between science and society, the question of not just the products of scientific research – motorcars, television sets, vaccines – but also the process of how it can be interesting for people. That's been a concern for me since I first came down to Melbourne and started thinking about these issues with some of the people teaching microbiology to university undergraduates.

Even while you were at the Institute did you think that Australia was a bit out on a limb and needed wider international networking?

Well, that's true also. But that concern with science and the public, science and society (what the French call *vulgarisation*, which I always think is such a lovely word, whereas we use a nicer word, the 'popularisation' of science) has always been a thread. And, as one's power base increases, that leads pretty naturally into science and politics. If you have a network, as I've been fortunate enough to be able to do, which has you meeting a lot of influential people – from the business community, the bureaucratic community, the political community – it would become natural to extend that desire to preach about science into these new networks.

You've published quite a lot. A few books are due now, and early on there were a lot of publications that popularised your area of science.

I must say I feel very guilty. I thought that literally as soon as I retired I'd be able to get back to something I really enjoy: writing books for wide consumption. I have an unfulfilled contract with Harvard University Press which is at least a year overdue, to do a book on the general field of global immunisation – which I think is a good read. It's a good story, which needs to be told. And I am shockingly overdue for the third edition of a very successful book, *Reshaping Life*, which was essentially key issues in genetic engineering. I now have a co-author for that, Ross Coppel, and he's feeling equally guilty.

When the presidency of the Academy falls away there will be an extra slab of time. But I feel guilty: there is a quiet, reflective part of Gus Nossal that, by happenstance, because of things that people ask me to do, has really not shown its face in the two years since my retirement. It's about time the more thoughtful strand came back.

Whither the Australian Academy of Science?

You've mentioned the Academy of Science. It is a wonderful body of senior academics, elevated scientific personages. How do you take that kind of an organisation forward? Is there too much dignity in its scientific background and too academic a base for it to be a really exciting popularisation-of-science body?

The answer to that question is yes and no. The Australian Academy of Science is quite unashamedly a local copy of the Royal Society of London (which prefers now to call itself just the Royal Society). Election to the Academy of Science, in a world that has demeaned and diminished status symbols, I believe, is genuinely still seen as a major recognition for an Australian scientist and is, to be quite frank, something that most scientists of note still aspire to. We elect only 12 people each year – there are about 300 Fellows of the Academy. It is unashamedly an elite body, which considers the conferring of status on other scientists as a not totally trivial and not totally unimportant function. Now comes the 'but': as the peak body of Australian science I believe it can, should and does do much more than just pat old boys on the back.

What does the Academy do? Firstly, we're very heavily into both primary and secondary school education, and during my time there have been two initiatives of which I'm very proud, although both of them had precedents.

We have a series of educational tools for primary school science education, all the way from kindergarten to grade 6, called Primary Investigations. That had a long germination period – Neville Fletcher worked extremely hard with the committee to get it off the ground. Professional teacher-educators are writing the materials and it's been strongly promoted by the Academy. It is making an impact, I believe, on the teaching of primary school science in Australia. It has been very well sponsored by Federal and State governments; there is some of the Academy's own money in it, including money that people have donated – the Fellowship's Australian Foundation for Science has been behind it.

The most interesting thing in secondary school science is our first flutter in multi-media, in the Internet. Nova: Science in the News is a product predominantly for secondary school teachers, but it is also accessible to the brighter students. It seeks to take 50 or 60 of the most pressing scientific issues of the day, present them in an accessible form and guide the Web user to authoritative and, again, fairly simple secondary points. For example, if you want to read about malaria it will tell a story, but it will also lead you to other places on the Web. We have found it very easy to get sponsors for that, because we've made it very cheap, at \$5000 a throw. Most institutes or CSIRO divisions can scrape that up somehow. I'm hoping for big things from that initiative because students don't like just to learn from textbooks any more, but

also to learn how to learn. The teachers, too, love their much greater role.

Secondly I must stress the international work. The Academy is the corresponding body for all of the 30-odd international unions and societies in science. Our 'national committees' (really, international committees) network with those unions, which tend to be more important in some fields than others. For example, the National Committee for Immunology is not very important because the Australian Society for Immunology is so good and you hardly need the Academy to buy into it. But the national committee associated with the International Union of Pure and Applied Physics is very important. It is the same in some of the geosciences.

The Academy is a coordinating body internationally and nationally?

It is important in coordinating the international effort, right. A third, very important area is advice to government. For better or for worse, the Academy's voice is still very seriously listened to in respect of advice to government, including through the Prime Minister's Science, Engineering and Innovation Council.

A fourth area – these are not exclusive – that I would delineate as of great importance to me is the public awareness of science. Fairly recently the science academies and other bodies have been able to team up with journalists to create a kind of a peak body to take over the annual ANZAAS Congress. The congresses that we used to have ran out of puff a little bit, and for the time being, anyway, ANZAAS is not going to have an annual congress any more. The new forum will be called *Science Now!* and will be chiefly about communication, not between scientist and scientist as ANZAAS mainly was, but between scientist and the public, prominently including schoolchildren and younger university students – an important role for the Academy.

The funding of science

The Academy is the premier science advisory body and you have alluded to influencing government. Private sector funding of the needs of science in Australia, however, is not particularly impressive. Would you like to talk about science funding?

We have to break the funding of science in Australia into two major portions. Government funding, which tends to be concentrated on the 'purer' end – but bear in mind that science and technology are a spectrum and there aren't any sharp boundaries – is not too bad. It's not crash hot, but among the OECD countries we'd be fourth or fifth in the percentage of GDP spent by government on science: about 0.8 or 0.9 per cent of GDP.

Where Australia has fallen quite seriously behind but is playing a clever catch-up game is in industrial research and development (R&D). When I first

got into the big league, as it were, we were down at about 0.3 per cent of GDP going into industrial R&D: it was pathetically small. That is now approaching about 0.7 or 0.8 per cent of GDP and heading up closer to a 1:1 ratio with government science and industrial science.

And this has been happening in the last 10 years?

Yes. In point of fact, the fruits of that are very apparent. Already we have a far bigger proportion of the exports of this country than before in elaborately transformed manufactures (ETMs), at the higher-tech end of the spectrum. If you go to the most highly developed countries, such as the United States, you will generally find that the industrial R&D is about twice the government R&D. An ideal picture would be 1 per cent of GDP going into government science, 2 per cent of GDP into industrial science, 3 per cent into R&D altogether. The United States comes close to that.

Do you think that your publicising of science is going to really fuel that change?

Absolutely. This is really a question of education, of wrestling for the hearts and minds of three groups of people. Firstly, politicians are important. They are just beginning to grasp the importance of science and technology. Secondly, bureaucrats are very important in shaping the government's views. They readily understand the industrial R&D but need a bit more convincing about the worth of university research and they need to be convinced that we're not just a lot of self-indulgent dreamers. That's an interestingly hard battle, and maybe the academics haven't helped themselves by being very much ivory tower people until 15 years or so ago, spending most of their life saying, 'Gimme, because I'm so clever.' That won't work anymore.

What are the persuasive arguments of today to win bureaucrats over?

I think the argument must continually be mounted of science as a part of our culture, but that won't 'play in Peoria'. We must never forget that argument, never forget the crucible, the forging of the absolutely basic science, but package it in a context that says, '*Inter alia* this basic science is absolutely essential for you to have the applied science which you need to make the industrial base of this country higher tech.' We're not going to be a nation of miners and brewers forever. Yes, we will feed and clothe the world with our food and fibre – but in that, there's got to be a lot of high tech. I would love to see a totally integrated fashion industry in this country. Why do we just grow the wool, scour only about a third of it, make tops out of only some proportion of that? Why don't we make the cloth and build a fashion industry and be like Milan? I see no reason why we couldn't have a completely vertically integrated clothing industry, aiming at the higher end of that market. And in the minerals area we have to begin to move downstream and transform the minerals more, do more of the smelting here, the refining – and maybe even go

further than that, to begin to make things out the metals. So the science and technology are important for that.

I've mentioned the politicians and the bureaucrats but there's a third battle to be won, the battle for the hearts and minds of the people in the big boardrooms up and down Pitt Street and Collins Street, because in fact they have no first-hand knowledge of true wealth generation through high tech. There's no Bill Gates in this country. There is no Sony, no IBM, not yet a Merck manufacturing drugs. The people who have generated wealth in this country have done it out of much, much lower-tech endeavours, and I think until first-hand experience comes they're going to be sceptical. But in the longer term I am absolutely certain that science and technology, knowledge, innovation and entrepreneurship are going to drive the country to a more prosperous future, and not just the food and the fibre and the minerals.

An adviser to the Prime Minister

You mentioned the Prime Minister's advisory body, hoping to move science forward. Is that a significant role you're playing there?

I hope so. Let me take you over the hurdles of the Prime Minister's Science, Engineering and Innovation Council, PMSEIC [pronounced P-M-sake] – no longer PMSEC [pronounced P-M-seck] as it was for a few years. For decades the Australian Academy of Science has been urging on government the importance of independent advice on science and technology. It is not that we don't trust the bureaucracy, which in the Westminster system always has to be a government's primary source of advice, but we believe the bureaucracy can get a little insulated in its cocoon in Canberra from the real world issues, and also has no way of being at the cutting edge of science and technology. So we believe its advice, which we respect and value, has to have parallel to it external advice from a mixture of scientists and industrialists. That view finally prevailed and we had various versions of the key think tank for science which came to be called the Australian Science and Technology Council (ASTEC). That involved scientists, bureaucrats and industrial people.

Then Ralph Slatyer came onto the scene as the first Chief Scientist of this country. He and [Prime Minister] Bob Hawke are both Western Australians and were school friends, and he started the Prime Minister's Science Council – which in a sense upped the ante from what the Academy wanted and was a very good thing to do. It got the Prime Minister and seven or eight of the senior ministers sitting around the Cabinet table, admittedly only twice per year but with an important follow-up through bureaucratic action, and it worked well down the years. But it left ASTEC a little bereft of a role and John Stocker, the current Chief Scientist, recommended to government, and government accepted the view, that the two bodies should be rolled together.

So we now have the PMSEIC, which will meet twice a year as a full body with

the Prime Minister in the chair and eight or so of the Cabinet ministers there, but which in between rolls the ASTEC function into itself so that the people who are not ministers constitute ASTEC, with now the Chief Scientist in the chair. In particular, that group will meet as a number of subcommittees to really bite into issues, work hard on them and develop them with bureaucratic support into something that feeds into the higher body and becomes the subject for Cabinet action. This is early days for PMSEIC – its last iteration is only a few months old – but I'm very hopeful for it.

And what about your personal contribution? Well, one can be sceptical about committees, Max. The work of the world is done by individuals, and I suspect the Chief Scientist is much more important to this whole process than Gus, who jets in and jets out. But, having said that, I think I can genuinely say that I put in a lot of energy when I form part of the committee, and I think the contribution has been, shall we say, not trivial.

An ambassador for Aboriginal health

Gus, will you now put on for me another ambassadorial hat of considerable importance. How did you come to get involved in Aboriginal reconciliation?

It does seem a strange thing indeed – how does Gus get involved in all of these different things? – but to everything that I do, I believe there is a connectivity and a kind of a seamless continuum. It began with Aboriginal health. I see my World Health Organization doings as a humanitarian effort for the poor and the disadvantaged of this world, and for quite a number of years now three individuals have been urging me to put that same kind of thinking into Aboriginal health.

First, my wife, who is on the Board of Reference of World Vision, would say to me, 'Gus, you're trotting off again to some Third World country and you're thinking about vaccines, but what about our own Aboriginal population? We should be doing more. They are a very disadvantaged population, in a Third World right here.' The second person is Fiona Stanley. She is the sister of one of Don Metcalf's close associates and she married my first student, Geoff Shellam. She is a neo-natologist, an epidemiologist, very involved in maternal and child health among Aboriginal people and especially interested in low-birthweight babies. And the third person is another former student, John Mathews, a totally magnificent guy who is the director of the Menzies Centre for Health Research, in Darwin, and arguably the most effective in the country in Aboriginal health research. Fiona and John have both been telling me we need to do something about Aboriginal health.

That led to the formation of a ginger group, a lobby group – self-appointed, no legitimacy – consisting of the Australian Medical Association and the Public Health Association of Australia, which went to the Prime Minister, to the Minister for Aboriginal Affairs, to the Minister for Health, to the media,

saying, 'Listen, Aboriginal health is a scandal. We cannot have morbidity and mortality statistics in some of our communities that are those of Sierra Leone, the world's poorest country. We must do something about this.'

Gus, how bad is that health?

The life expectancy of all Aboriginal people, including the urban ones, is 16 to 20 years lower than the life expectancy of other Australians – white and yellow and brown. The incidence of diabetes is 10 times higher. The incidence of coronary artery disease is considerably higher. The incidence of alcoholism is well known. The incidence of deaths from kidney infections is 18 times higher. Most telling of all are the mortality rates in mid-life: depending on whether you start in the 30s or in the 40s, the rates of death per 100,000 population are three to six times higher than those of white people. This is horrendous. It is just not acceptable.

About six years ago I interviewed Fred Hollows, who spoke of the eye problems.

I get very struck by deafness in Aboriginal kids. There are communities where they have had so many ear infections and so many perforated eardrums that one half of the classroom is deaf. Is it any wonder that their education is not progressing well?

Funnily enough, in immunisation we're doing reasonably well, simply because it is such a straightforward thing to do and a lot of effort has gone into it. And in maternal and child health we're doing reasonably well, a little bit better than we were, as a result of the people that Fiona has inspired. But in the broad mainstream and, in particular, in cardiovascular health, diabetes, renal disease and common eradicable infections, we're not doing well. We've still got rheumatic fever in these Aboriginal kids, caused by streps, which could so easily be conquered by antibiotics.

And that's where a lot of heart disease arises. They're desperate communities.

That's right. So I started then to get onto my hobbyhorse. I pounded the media, I gave a lot of public addresses, and as a sort of little postscript to whatever else I was talking about, I talked about how bad Aboriginal health is.

The Council for Aboriginal Reconciliation

It turns out that the Minister for Aboriginal Affairs is a doctor, John Herron, who used to be branch president of the AMA in Queensland and whom I've known for about 30 years. (One of the things about getting long in the tooth is that there are people you've known for a long, long time.) And one day, after I had been visiting a biotechnology company in California, John Herron rang me in my hotel room to say, 'Gus, I need you to do an important job, to become

Deputy Chairman of the Council for Aboriginal Reconciliation.' I have to be frank with you: never in my life did I think that I would become professionally involved in Aboriginal reconciliation. What do I know about Aboriginal affairs?

At home I talked about this to my wife, who said, 'Gus, this is one job you just won't be able to dodge. It is just too important for this country as we come close to the Centenary of Federation, as we think about becoming a republic. We have this wound, this scar in our midst, this population that has been disinherited from its land, that is disadvantaged in every conceivable way.' So I told John Herron I'd do it.

When you get involved in something it comes to be much tougher, much more difficult, with many more strands to it, than you ever thought. I believe there are two aspects about Aboriginal reconciliation, non-controversial and controversial. The social justice elements that could form part of a reconciliation package are or should be non-controversial: health, education, housing and better employment opportunities. So you begin to work on these, lobbying government and so on to overcome the log-jams in every one of the four, caused by the remoteness of many of the population groups, the alienation of the urban ones, their failure to access the health services, to which they have every right to go but where they feel awkward and uncomfortable.

However, there are also very controversial angles to reconciliation. The two most pressing ones in Australian public life at the moment are native title, which is a land rights style issue, and the big saga of the Stolen Generation, the children who were forcefully removed, where some apology is required. I am chairman of the subcommittee of the Council for Aboriginal Reconciliation that is charged with preparing a document or documents of reconciliation that are so beautifully crafted and so worded that all Australians would feel good about signing it, perhaps by the time of the Olympics. I've become swept up in getting something good out of it.

It seems to me that you're deeply caring about getting a dignified resolution.

It is actually a little bit unfortunate that this overlaps with the last six months of the Academy presidency. Had I vacated the chair of the Academy it would have freed up time. This does seem totally different from anything I've ever done before but it is quite important and it's not really so far divorced from my health interests.

A lot of plates spinning in the air

This caring, Gus, this love for people, this concern for health and basic rights, has got you into a whole range of situations of importance to Australia and internationally, and a range of philanthropic support from cancer councils to health promotion institutes. How do you keep such a lot of plates spinning in

the air?

We're living in a very materialistic and rather selfish age, when people seem to want to pay less and less taxes, rather than more and more. We seem almost to have given up on the thought that governments can make society better – a 'democracy fatigue' – and we're making sure that governments have very little by way of discretionary spending. That dry, economic rationalist philosophy is the dominant ideology of most parties now. What is going to fill the gap? What is going to come in to make the society more civil, more compassionate, to make the world a better place to live in?

I think the philanthropic sector has a huge role to play here, and I don't just mean very high net worth individuals who leave \$100 million for a foundation. The people who put 20c into a can at the milkbar in favour of spastic kids are philanthropists too. All aspects of philanthropy have got to be supported, to try to create a civil society in an era when government has vacated many areas. And the corporations have a big role to play in philanthropy: they work in communities and depend on those communities having law and order and a stable base. I have had one substantial corporate involvement only – 20 years on the board of the mining company that in Australia is now called Rio Tinto Ltd, until I rotated off in 1997. I took up that opportunity because of a feeling that the director of the Hall Institute had to know a bit more about the world of business, and I've found it quite fascinating.

In my retirement I'm part of a little consultancy group in Melbourne, which is itself a business. I've already mentioned John Stocker, my former student who became head of CSIRO; I've briefly mentioned Graham Mitchell, who was the head of my immuno-parasitology unit at the Hall Institute; and David Penington is the high profile former Vice-Chancellor of the University of Melbourne. Our 'gang of four' have formed Foursight Associates Pty Ltd (not F-o-r-e-sight, but F-o-u-r-sight) and we're trying to broker ententes between people with ideas in universities and research institutes and people with money in Collins Street, in the finance arena. We're doing that quite professionally and having a lot of fun. The four of us are all very different but we're getting on extremely well together. I can only give it about 10 per cent of my time, but it's a pretty serious interest.

One rough stone, many kinds of faith

Here you are, bringing together the worlds of philanthropy and business and science. Let's go right back to 11 years ago when we first talked, in 1987, when you told me about the kid who came out from Austria in 1939, went to a Jesuit school in Sydney and had a strong Jesuit background. Does faith still figure massively in what you do?

Well, I consider myself a Catholic agnostic. I'll always be a Catholic although I don't believe in the man with the long white beard – many people don't. That

Catholic upbringing was extremely important to me in forging my personality, particularly the area of discipline and kind of driving your own bus, being in charge of yourself, having something good in the top of your brain controlling the passions, the emotions and so forth. That's been quite important in my formation. I remember being a very pious little boy at school but much of that has fallen away. Yet, in terms of the networks and the loyalties, I still feel very loyal to what has been important to making me as a person.

As to what I believe about transcendence, spirituality, metaphysical things: as a scientist you almost have to be an agnostic. But I like to leave my mind very open on issues of this sort, for the following reason. It is possible that science one day might understand things like consciousness, like beauty, like love, like the compassion that we've been talking about. It's possible that all of that will one day be explicable in terms of the Human Genome Project – DNA, the code and so forth. Until that time comes, until the mind/brain paradox and so forth is completely resolved to access those aspects of human existence, we need the humanities. And religion and theology are definitely among the humanities.

The great poets have taught us a tremendous amount about being human, and so have the great musicians and composers. It would be a very poor scientist who didn't have her or his mind open to those other forging influences on the human brain, on human existence, on personhood. I think it is stupid to close the door on other pathways to the truth. Science is actually one pathway to the truth – a partial, flawed pathway. We don't have to go to Popper or Kuhn to recognise how frequently science finds itself, in retrospect, to have been wrong in quite important ways.

Initially science was a strong religion for you, wasn't it?

I'd like to think that whatever small degree of legitimacy I may have in trying to promote patterns in the world derives from science. I often think that the only reason I can move confidently in the circles that I now move in, many of which are non-scientific, is the security in my science base. Were it not for the peer group esteem that I've been tremendously privileged to enjoy for 40 years, I don't think I could walk up to the Prime Minister and tell him he is wrong on the Stolen Generation and the apology. So I think the legitimacy comes from science.

Would you say that in the last 10 years caring has become the driving faith?

You're probably right that science now occupies less space in my daily life because these other interests have come in, but I think you're painting my caring too nobly. I think the dynamic is that I took a conscious decision in 1996, on my 65th birthday, which was different from the decision that Jacques Miller and Don Metcalf took. They took the decision to remain forcefully in primary science. Having had 40 years at the laboratory bench, wonderful years that the B cell and antibody formation gave me, I took the decision not to run a

small lab, not to have a post-doc student and a technician somewhere, because having painted on the big canvas I didn't want to paint on a small one. I suppose that primary decision to leave data generation to concentrate on the more strategic elements of science, on the literature and the broad picture, has in a sense accelerated the move away from science and into these more general affairs. But I'd like to think of myself still as primarily a scientist.

There's an enormous amount of ambition still there.

The worst thing that ever happened to me was that I was insanely ambitious, at least from the age of seven. My Dad used to say that a person comes into the world rather like a rough stone, with all kinds of edges and crags and fissures, and that the purpose of a good life is to polish that stone, to get rid of the roughnesses and so forth. What I try to do is to harness that ambition which is somehow in the mixture of my upbringing and my genes to some purpose that sublimates it to a good direction. You might ask why I was ambitious as a seven-year-old boy. Probably the migrant experience and having been expelled from your own country had a bit to do with it – the need to succeed in an alien culture and so forth. And then who knows? It's probably reinforced by success: being dux of the junior school led to being dux of the senior school, which led to an exhibition scholarship at university so my Dad didn't have to pay fees. These things feed on themselves, don't they?

The family atmosphere

You have just spoken about your father. I think family is very important to you. Tell me about the Nossal family.

The Nossal family is a great and joyous story. I was enormously fortunate to meet my wife of now very nearly 43 years when I was a medical student and she was a speech therapy student. We met not in the corridors of the hospital but through a mutual friend – we lived not very far from each other. I waited till graduation to get married, when I was in my junior residency year and Lyn was a very active young speech therapist. We had the four children between 1957 and 1964, so my youngest child is now nearly 34 years old. All four have married, and now we're lucky enough to have 7½ grandchildren.

People say there's never enough time, time's the most precious thing that we've got, and I've been busy all my life. But I've always tried to guard at least some reasonable amount of time, and certainly a reasonable amount of energy, for my family, because they are really the most important thing – tremendously important – in my life.

All the kids have done extremely well, though none of them are in science. Some would say that's perhaps quite a good thing, particularly in a small country like Australia. Both of my boys are in the finance industry; both of my girls are teachers who've taken their teaching degrees into interesting

directions – one preparing curriculum materials and the other as a human resources management consultant. We're a very functional, very devoted family even though the elder daughter lives in Jakarta and the elder son lives in Paris. It's been my wife who has kept the whole thing going. After a good career as a speech therapist she had a second career in arts administration, and has now retired from that. Anyone who knows me knows how important a feature of my life my family is. And that's true of most people, isn't it?

Gus, it seems to me that you, Miller and Metcalf were in a way like a family, polishing the stone of the Hall Institute. Perhaps Australia's been rather unfortunate in not having a second Nobel Prize linked to the Institute.

You're right. I think it is an absolute tragedy that Jacques Miller was not included in the Nobel Prize which Zinkernagel and Doherty said was the 100 per cent Australian prize. The media didn't cotton on to that properly. Doherty is an expat Australian working in the United States. Zinkernagel is Swiss, but everything that he did towards that Nobel Prize was done in the John Curtin School of the Australian National University. So it was a 100 per cent Australian prize. I happen to think that Jacques Miller's discovery of the function of the thymus, when he was a young post-doc at the Chester Beatty Institute, really did deserve a Nobel Prize. Many people share that view. Hugh McDevitt, one of the respected immunologists in the States, once told me, 'Gus, every single year I nominate Jacques Miller for the Nobel Prize, because I think it's wrong that he never got it.' And he was a man himself who arguably could have been in the Nobel Prize for HLA.

You've modestly sidestepped, but there were several names at the Hall Institute in your time that might have been associated with big prizes.

Well, let me go on to Metcalf. Of the Aussies working today, the one whose name most frequently comes up in discussions for the Nobel Prize is Metcalf – sometimes bracketed with Leo Sachs in Israel, sometimes not. Because the CSFs are so important to our understanding of the blood-forming tissues and of haematology, and because they have had a valuable role as adjuncts to cancer chemotherapy and to bone marrow transplantation, and arguably will have a role in infections as well, you have that basic and practical science together. So I think that's still lively and it could still happen.

Now you'll tempt me, 'What about Gus?' Gus was fortunate enough to discover early in his life that one cell only made one antibody. That was really the first evidence in favour of the current paradigm of the immune system, the so-called clonal selection theory, and it was the underpinning for discovering monoclonal antibodies. I do know that I too have been multiply nominated for the Nobel Prize. But there's a big 'but'. The prize for that series of discoveries went to Köhler, Milstein and Jerne. I'd have certainly chosen those three ahead of me. I'd probably have put Dick Cotton as one of the people who got Milstein into the area ahead of me also. So, no skin off my nose. It must have

come reasonably close. A couple of people wrote to me that I really should have been in that trio. But they have to take the decision; there's only three.

Why didn't it occur to anyone to suggest maybe three Aussies working in different fields – one on T cells, Miller; one on B cells, Nossal; one on the scavenger cells, granulocytes and macrophages, Metcalf – all in the one Institute for a lifetime, and put that together? Well, the answer is, it didn't. That's not the way the cookie crumbled. And listen, we have had great lives and great careers.

I'll just say a little bit more about the trio, though. Jacques Miller and I were in school together – he's an old Aloysius boy also – and he was also a migrant to this country, having been born in France. Then each of the three of us, as medical students at Sydney University, came under the influence of Patrick DeBurgh, a very remarkable teacher and researcher who has gone on to be the supervisor, in their younger years, of many other excellent scientists – a great mentor. He took us across the hurdles of what science was about. It is an interesting coincidence that Metcalf was two years ahead of me and Miller, though exactly my age, happened to be one year behind me. The three of us went into that lab, and the three of us ended up in the Hall Institute. Metcalf probably didn't do a second year as a resident, so he would have gone down three years ahead of me. I came down there in 1957, and I invited Miller to join the two of us, he having had much of his career in the United Kingdom. So we were together for 30 years, from 1966 till 1996, doing our own thing – chiefly, anyway – and each forging ahead with our own team, sometimes collaborating and always talking, discussing, largely marching forward together.

A terrific collaboration of very different people.

Yes. It is interesting that there is not a huge number of co-authored Metcalf and Nossal papers, Nossal and Miller papers – a few more Nossal and Miller papers but not a huge number – but that collegiality in a very family-like atmosphere at the Hall Institute has, I think, been very important to the three of us. When we had the 'Big Bang', with the triple retirement in May 1996, with the international symposia and that sort of thing, there was a lot of comment about how these three people, over a 30-year period, had been, let's say, not unimportant to Australian science.

Gus, we're coming to the end of this interview. A videotape of the interview is also available. I hope we'll meet in 10 years' time and take this story another volume further.

Well, I'm fully intending to be around in 10 years' time, Max. We might even make it 11 years and 24 days again, so you'd better look in your diary! This general field of popularising science through making it very human is really important. We're coming up to the centenary of Florey and, in the following

year, of Burnet, and colleagues led by Jack Best are going to make this very educative for the Australian public.

It has been great to talk to you. Thanks again.

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