



# Losing control of our gums

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Australia is losing control of its genetic inheritance as other nations step in and decipher the genetic code of its native plants and animals.

Tim Thwaites reports on the beginnings of a campaign to put genetics and genomics back on Australia's scientific and political agenda.

THERE IS nothing more Australian than a gum tree. Almost all species of eucalypt evolved in Australia. It's the plant that shapes our environment. And it's good for the economy too.

Not only do gum trees help us manage salinity in the soil and carbon dioxide in the atmosphere, but they are now bred and farmed intensively as the most important source of short fibre for the world's paper industry, and for their solid hardwood. But, of the 15 million hectares of eucalypts under cultivation worldwide, Australia accounts for less than 1 million hectares. And we are contributing next to nothing to learning about eucalypt genes, the CEO of the Forestry CRC, Rod Griffin, told a recent forum of scientists and parliamentarians in Canberra on the future of genetics in Australia.

Only three of hundreds of species of this hugely diverse group are widely grown, Griffin said. "It represents a largely unexploited genetic resource. Biologically and industrially *Eucalyptus* is a good candidate for applied genomics." Yet, of several significant initiatives investigating the genetic resources of *Eucalyptus*—in Japan, Brazil and the US in particular—none at present involves Australia.

Local forestry scientists are presently looking for significant resources to join the international push to persuade the US Joint Genome Initiative to sequence *Eucalyptus*. They also want to be able to influence the initiative to study the particular species of most interest to Australia.

"We are rather high cost producers in relation to our international competitors," Griffin said. "If we are going to stay in the market successfully, we need every bit of advantage that science can bring to bear. Also, we can't expect access to the genome intellectual property generated overseas, unless we contribute something to it. Australia is the custodian of the eucalypt genetic resource for the world. To conserve and protect it, we need to know a lot more about the genome."

The gist of Griffin's message was repeated again and again at the forum. For lack of basic infrastructure in genome science, Australia looks like missing out on important economic opportunities in agriculture, medicine, biotechnology, and the environment in general.

"Life in all its forms has a common denominator, the genetic material of DNA," said Phil

*Capturing the value of the genetics revolution for Australia*

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Batterham, an insect geneticist from Melbourne University, and one of the organisers of the forum. “Genomes form the dictionary of life. No species can be studied in detail these days without information on its genome.”

“Genome data can help unlock puzzles of disease, pest and weed resistance, environmental conservation, agricultural production, the design of new and improved drugs and vaccines, waste management and basic science,” he said.

“With a Federal Government investment of about \$30 million a year over the next five years, on top of what is being spent on scientific research at present, we could be doing all this. Not to provide these resources would cost a vast amount more,” he said.

For instance, the removal of phosphorous is a key step in waste management and recycling of water, particularly since the introduction of phosphorous-based fertilisers. Authorities around the world spend hundreds of millions of dollars a year on a process which uses micro-organisms to achieve this. But the process itself is not reliable, says Linda Blackall, director of research at the Environmental Biotechnology CRC. “We don’t know how it works, and therefore what to do if things go wrong.”

The best clues are coming from work at the CRC on the genomes of the microbes comprising the community involved. “We want to determine the functionally relevant genes, so that we can understand the process, make it more reliable,” Blackall said. “We would then be able to save money, and recycle water and nutrients.” The work is being hampered by lack of access to genome technology and information.

It was only the willingness of the Victorian Government to put \$4.5 million into a joint program with the US National Institutes of Health (NIH), which allowed geneticists from the Australian Genome Research Facility (AGRF) to add the Tammar wallaby to a marsupial gene sequencing program originally to be based solely on North America’s only indigenous marsupial, the American opossum. Not only has the Tammar wallaby for years been used as a model for basic research into reproductive biology, but marsupials in general are an important evolutionary stage between reptile and birds, on the one hand, and humans, on the other.



From the marsupial genome, researchers hope to find important information on molecular biology of fertility control, seasonal breeding, lung development, control of milk production and spinal cord regeneration, said Sue Forrest, the director of the AGRF and co-convenor of the Canberra forum. Already, there have been exciting new leads in understanding the genetics of prions, the complex proteins involved in BSE and Jacob-Creutzfeldt syndrome. But, despite the efforts of the Victorian Government, there is not enough money to complete the sequencing of the wallaby genome.

More directly in the area of health, Western Australia boasts the most complete and oldest database of population-based health information in the world, and is now seeking to overlay it with genome information from DNA samples. “We are building upon 30 years of health data, and one of the best-linked medical research databases in the world,” said Lyle Palmer, professor of genetic epidemiology at the University of Western Australia. “The next best datasets you could find are in Scandinavia and they have nowhere near the breadth and depth.”

The WA database can be used for looking at the social, environmental and genetic determinants of what makes people sick and what keeps them healthy. The US and the UK are already planning to spend billions of dollars in establishing equivalent databases, Palmer told the forum, but they won’t be

ready to use for another 25 years. The WA database can be used to provide such information now. “For \$100 million invested in the WA Genome Health Project, Australia could save many billions of dollars in healthcare costs.”

A limited number of genes are responsible for the evolution of resistance to insecticide in the world’s number one insect pest, the cotton bollworm. Despite its name, it attacks more than 100 economic plant species and currently costs about \$5 billion a year to control. Phil Batterham leads a team at the Bio21 Institute in Melbourne which is working at revealing which genes confer resistance, and at countering their impact.

“Not only does this pest cost us up to \$500 million a year in Australia, but it is also devastating Indian and Chinese farms where farmers are spraying insecticide up to 30 times a season and causing all sorts of human health problems. Yet it would cost only \$10 million to \$15 million to sequence the bollworm genome. That would allow us to rapidly identify the resistance genes, monitor the level of resistance in each population and reduce chemical usage. It would also help us identify potential targets for the rational chemical design of more effective insecticides. What’s more, the work would be transferable to other species which cause perhaps another \$15 billion damage a year.”

One counter to the bollworm has already made a significant difference to the Australian cotton industry, Australia’s new Chief Scientist Jim Peacock of CSIRO Plant Industries told the forum. The introduction of just three genes into CSIRO-developed Australian varieties of cotton has provided the crop with resistance to the bollworm and allowed sustainable weed management, leading to higher yields and better quality with less damage to the environment. The new varieties, now responsible for 93 per cent of local cotton, have taken the Australian industry from the edge of disaster to profits of about \$1.8 billion a year. And it all stems from a knowledge of the genome.



In same fashion, German Spangenberg from the Department of Primary Industries in Victoria told the forum of important work being carried out in understanding plant genomes to allow drought- and heat-proofing of agricultural plants in the face of climate change. Spangenberg and his colleagues are also partners in a multinational project to sequence the Brassica genome. Canola is Australia’s most important Brassica crop – with exports earning Australia \$500 million a year. But this project is also struggling to find the \$3 million to complete sequencing the genome.

But it wasn’t all bad news. Shaun Coffey, Chief of CSIRO Livestock Industries, for instance, reported on the achievements of the \$75 million bovine genome initiative. CSIRO’s investment of \$1 million early in the project has given Australia a seat at the table where the project’s priorities are determined. And Australian beef producers are the winners as researchers start to apply information from the genome to improve disease resistance, meat quality and other factors.

Sometimes genome research leads to quite unexpected results. Studies of the genome of one of the simplest of multicellular animals, the coral *Acropora millepore*, are building knowledge to help conserve and protect the Great Barrier Reef and its counterparts around Australia’s coastline. But they have also provided important new information on the processes of the evolution and development of life itself, Rob Saint, the director of the ARC Special Research Centre for the Molecular Genetics of Development, explained to the forum.

“Coral belongs to a family which is a common ancestor to all the more complex animals, including humans. What we’ve found so far is an enormous surprise. The coral genome is more closely related to the human genome than the two genetic workhorses, the roundworm *Caenorhabditis elegans* and the fruit fly *Drosophila melanogaster*. In fact it seems that a high proportion of the genes that differ between these two species and humans, are there in the common ancestor.” What this means, said

Saint, is that loss of genes and streamlining of the genome may be just as important a process in differentiating species as the evolution of new genes.

From these stories and many others presented at the briefing in Canberra, the economic importance of genomics and gene sequencing to the future of Australia was made clear. Yet, speaker after speaker said, Australia still lacks the funding for the major genomics projects so critical to its economic future.

And the money to complete these projects—about \$150 million over five years—cannot be provided through the usual granting agencies of the ARC and NH&MRC, without severely distorting their structure and processes. “The scale of money required for these projects would make it very hard for them to prioritise research on genomics in competition with the other demands that are put before them,” Phil Batterham said.

“Our leaders need to see the big picture—the profound impact they could have on Australia, both in terms of fundamental discoveries and applied outcomes,” said Phil Batterham. “This money would allow us to get some of these very significant projects on the road. I have been inspired by examples from overseas, where countries such as Canada and the Netherlands have set up major government-funded genomics programs, and would like to suggest a model whereby Australia has an organisation called Genome Australia.”

A lot of genome science is no longer research, Batterham argued. Sequencing, for instance, is now a production line process, he said. “There is no iffy nature about it any more. It is not an experiment. It’s just a matter of generating the data.”

And, unlike buildings and equipment, he said, the genomic information we accumulate does not degrade or depreciate or cost money to run. It forms a platform upon which all sorts of research can be done. “It is a soft infrastructure that does not depreciate in value. In fact, it increases in value over time. The more you use it, the greater the impact it has.”

A nominal target of a \$1000 human genome has been set by the NIH, said Richard Harrison of the Applied Biosystems, the world’s largest supplier of gene sequencing equipment. The NIH is now offering large inducements towards the research to make it a reality. “When \$1000 genomes become available in a decade’s time or so, we can anticipate a massive increase in medical and consumer applications. Australia better be ready at that time, as well as being expert enough to deal with genome data.”

In addition, he said, it is only through its involvement in genome science, that Australia can have a voice in steering this accumulation of data into areas of significance to its own needs. And in the process it could also develop a genome products industry for export, in software and scientific instruments.

The forum agreed that in order to influence the views of parliamentarians, researchers needed to convince the basic stakeholders in industries dependent on biology—such as agriculture, medicine, biotechnology and tourism—that genome science is no longer an optional extra, but a basic tool of their work.

Tim Thwaites is a Melbourne-based science writer.

The Australian Genome Alliance supported his visit to Canberra to attend the Alliance forum.