A personal tour of the Australian Synchrotron, and a few of its impacts on Australia

March 31 2014, by Helen Maynard-Casely

A whole heap of science awesomeness. Credit: John O'Neill

To my dismay I read this article while trying to enjoy my Saturday coffee. Once again the jewel in the crown of Australian science infrastructure is fighting for survival. This is a fabulous facility which has put out some awesome science of late and I would like to extend a massive "pat on the back" to my colleagues there.

Ok yes, I am biased. Those of you who've read my column before will recall that I was a post-doc at the Australian Synchrotron and I currently work for the Australian Nuclear Science and Technology Organisation (ANSTO) which now operates it. But this does mean that I know how hard my colleagues there work, despite the funding challenges, to provide this vital piece of infrastructure for all Australians.

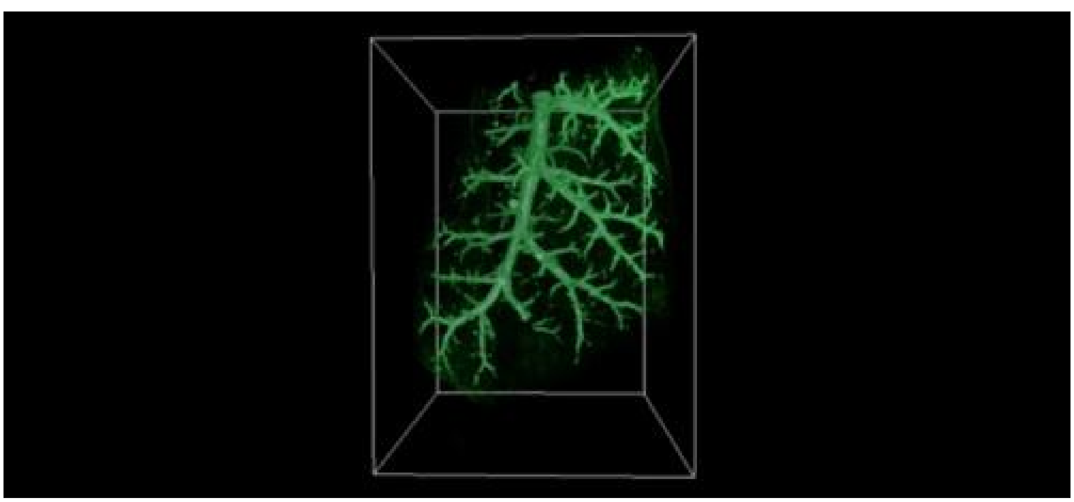
I think one of the issues that the synchrotron has in communicating its worth, is that it is just too good. Outcomes from the synchrotron cross over all areas of science, with everything from blue skies to applied impacts. There have been a few explainers already pointing out what the synchrotron is, but perhaps it's not clear that it's actually ten instruments in one. Let me take you on a tour of them all, and show you how they are each solving Australia's problems and supporting her industries.

If you were to walk into the synchrotron, probably the first thing you would notice is a smaller building to the left that sits outside. This is IMBL, the Image and Medical Beam Line. This instrument is a real world-first. This beamline will hopefully be used to treat cancer one day. Using the biggest X-ray beam in the world (so the instrument boss Danny claims. He's worked in most of the world's big synchrotrons – so should know!), the scientists there are working tirelessly to understand exactly what photon goes where, so that it will be safe to treat people before too long. While they are working this out though, the beamline is available for to the rest of Australia's scientists for imaging. The advantage of using this instrument, over a normal X-ray instrument, is the incredible 3D detail that you can pick out especially from soft tissue.

So you now enter the synchrotron and say "hi" to Carlos the security guard, and start on your anti-clockwise journey about the ring. You'll see the prototype magnets sitting there: red, green and yellow. These are a big feature for the educational program – every year 12 student studying physics in Victoria will get to visit these, when they visit the synchrotron as part of their course (just another impact the synchrotron has had).

Next to the magnets is the enclave of the accelerator physicists that keep the machine ticking over nicely at 99.9999% the speed of light. Study using the synchrotron itself has lead to results that helped out its bigger brother the Large Hadron Collider in its own (Nobel prize-winning) efforts.

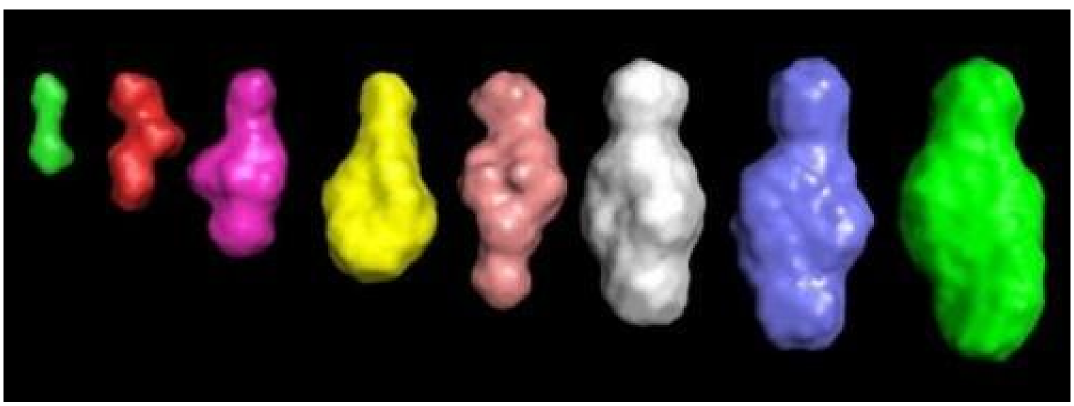
But it's no surprise to see some physicists at the synchrotron, eh? So let's keep wandering round the ring. The next instrument that you'll bump into is XFM, which stands for X-ray fluorescent microscope. You're as likely to see museum conversation scientists working on this instrument as physicists. This is the pretty picture beamline and you've probably seen images collected on this amazing instrument in many a high-profile news story. But there's some hard-hitting science behind these pretty pictures. With the occurrences of skin cancer as high as it is in Australia, you'll want to be sure that the sun creams that everyone needs to use are safe. Earlier this year, scientists working at XFM presented findings that our body can break down zinc oxide nanoparticles.



Medium-resolution CT reconstruction of the vascular structure in a rat lung. Credit: James Pearson, Daryl Schwenke, Mikiyasu Shirai and Alberto Astolfo.

The next instrument you'll arrive at is actually two. The Macromolecular crystallography (or MX beamlines) are so useful that from the outset two instruments were constructed to serve the world-leading chemical and biological crystallography communities of Australia. Using these instruments researchers from the Walter and Eliza Hall Institute (WEHI) could get images of how insulin actually interacts with proteins in our body. Published in Nature, the results of this will lead to a better understanding of diabetes (an estimated 3.3 million Australians will have diabetes by 2031) and, to quote the scientists themselves:

If we did not have this fantastic facility in Australia and their staff available to help us, we would simply not have been able to complete this project.



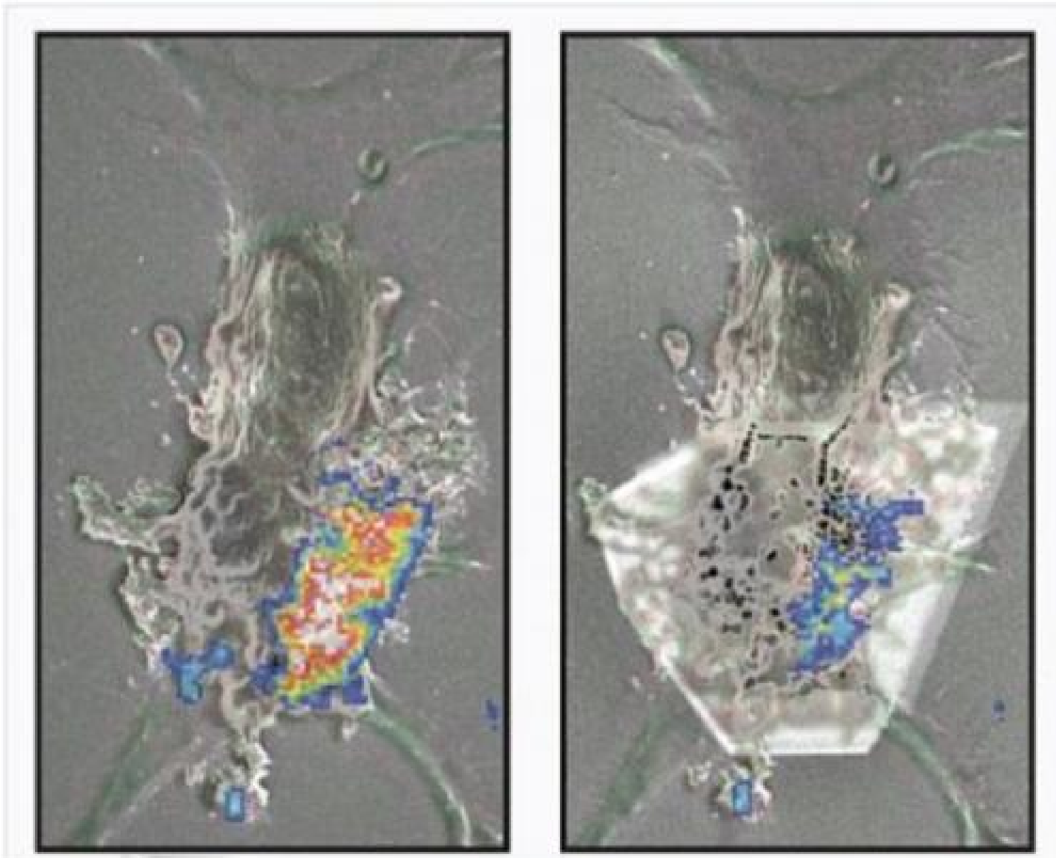
What tannin molecules actually look like when dissolved in water. The size and shape of these tiny molecules plays a part in how a wine tastes. Credit: Australian Synchrotron/Nigel Kirby

Wave to Worrell, who works in stores, as you pass and wander up to the Infrared beamlines. There are actually two branches to this instrument, so that two groups of scientists can work on it at once. These instruments can detect tiny molecular vibrations, which have a great number of applications including helping to diagnose diseases from scanning a patient's skin.

Affectionately know as the "softies" about the ring (sorry guys), the next instrument you'll arrive at is the Soft X-ray beamline. These guys are hard-hitting in the nanotechnology world and are the go-to places to undertake a number of tricky experiments. But studying samples under a super-low vacuum (it really sucks – boom, boom), they can detect the tiniest details on a surface. One upshot of this work is the potential to use these surfaces to select the right kind of drug molecule to synthesise.

Wax on, wax off … From the "softies" you'll come to the SAXS/WAXS beamline, which is the small angle and wide-angle scattering instrument. You can, pretty much, collect data here from every type of sample imaginable, whether it is built of nanoparticles, fibres, proteins – or even wine. The wine industry in Australia is valued at A$7 billion, and balancing the tannins within the wine is essential. Using this instrument, Department of Environment and Primary Industries (DEPI) scientists found the shapes of a number of tannins and can use this information to improve and tailor the flavours in the wines of Australia.

Coming nearly to the completion of the round, you'll next find the XAS beamline (or X-ray absorption spectroscopy). This is a technique that you cannot do without a synchrotron and has a number of highlights – one of which is determining where you find nutrients in grains, making sure you get the most out of a A$155 billion agriculture economy.



By carefully measuring the chemical composition of the nanoparticles through sequences of images, researchers at the Australian Synchrotron, Monash University and Melbourne Centre for Nanofabrication, were able to assess how immune cells break down these tiny particles. Credit: Australian Synchrotron/Simon James

And last, but no means least, you'll arrive at the Powder diffraction beamline, or PD. Very close to my own heart, this is my old stomping ground. Aside from my own work, we would have as many as 300 scientists a year visiting us, with many of these investigating materials that will change our energy economy (such as lithium ion batteries, the market of which is due to rise to A$44 billion in a few years). Using this [instrument](#) researchers can [watch where the lithium ions](#) are moving to as the battery is charged and discharged, with the hope to designing them to store more energy.

You only have to look at much more debt-ridden countries, such as the UK and Spain, who have continued to invest in their own synchrotron facilities. Let's not take a short-term attitude to what the synchrotron can achieve. From this tiny tip of the iceberg that I've toured you through, you can see how the synchrotron will generate billions for the Australian economy. If we took the synchrotron out of the equation we'd not feel the effect tomorrow, or even next year, but slowly and building over time the Australian economy would suffer.

So do you like it? Do you think we should put a ring (fence) around the synchrotron's funding?

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