



Australian
Synchrotron



Facility Activity Update

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REVISION HISTORY

Revision	Date	Prepared by	Description
1.0	26 June 2014	Nancy Mills, Andrew Peele, Michael James	Update to stakeholders on various facility activities
1.1	30 June 2014	Sarah Bartlett	The addition of photographs to the High impact publications (2.2) and Media Relations (7). The addition of four case studies to the Industry Engagement section (3).
1.2	7 July 2014	Sarah Bartlett	Addition of photo captions and other minor text revisions

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COVER IMAGE

(L – R): The Hon Ian Macfarlane MP, Minister for Industry; Dr Adi Paterson, CEO, ANSTO; and Prof Andrew Peele, Director, Australian Synchrotron, outside the Australian Synchrotron in Clayton, Melbourne.

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THIS PUBLICATION CAN BE DOWNLOADED FROM:

<http://www.synchrotron.org.au/news/publications/annual-report>

1. OVERVIEW

The Australian Synchrotron, operated by the Australian Nuclear Science and Technology Organisation (ANSTO) enables science for the benefit of the community, by providing world-class synchrotron expertise and facilities. The research undertaken at the facility is notable for its excellence and its impact – a testament not only to the staff and facilities at the Australian Synchrotron but to the quality of the research community, particularly in Australia and New Zealand.

ANSTO's experience in neutron science and 60 years serving Australia, means that the strengths of the Australian Synchrotron are complemented, and the facility has consolidated its position as national landmark infrastructure essential for the region.

1.1 Productivity and impact

In the seven years since the Australian Synchrotron opened, users and staff have continually improved the number and quality of the facility's outputs and impacts. The facility quickly reached excellent levels of productivity that not only benefit the research organisations using the Australian Synchrotron but also provide high-impact outputs that benefit society. Examples include widely reported results in disease and immunity, including advances in the understanding of insulin, research improving prospecting methods for gold, and research cited by the Cancer Council showing how zinc nanoparticles are dealt with by the body's natural defences.

1.2 High throughput, high output

More than 100 institutions have used the Australian Synchrotron, including all research-active universities in Australia and New Zealand. Our science program is therefore extremely productive, with more than 1400 peer-reviewed papers published to date; and over 700 protein structures added to the worldwide Protein Data Bank as a result of data collected at the Australian Synchrotron.

1.3 Industry outcomes

Many of the research and development teams that use the Synchrotron have partnerships or close connections with industry. Consequently, beneficial industry outcomes through research providers have been a feature from day one. More recently a \$1.4M NSW government funded program for industry access has increased direct industry access. We have also formed a dedicated team to boost our direct interactions with Australian-based businesses, which complements users' industry engagement efforts and strengthens our ability to provide direct benefits to companies ranging from multinational corporations to small and medium-sized enterprises and start-ups. Our success in this area is demonstrating the utility of the Australian Synchrotron as an excellent place for translational research.

1.4 Unique medical research

The flagship Imaging and Medical Beamline (IMBL) supported by the NHMRC was commissioned in late 2012 and is routinely catering for general users, while continuing a development pathway towards clinical research. It provides a new discovery space for accelerated research into treating tumours, chronic lung disease, haemorrhage and inflammation in the brain, bone growth and replacement, and various heart-related conditions.

1.5 Delivered infrastructure

Several major building projects funded by the Education Investment Fund were completed in early 2012 and are fully operational. These include the National Centre for Synchrotron Science, a 50-room User Guesthouse, technical support building, office extension pod and switchroom extension with uninterruptable power supply (UPS).

1.6 Fostering the next generation of synchrotron scientists

Education and outreach programs continue to yield positive results, with onsite VCE physics laboratory sessions for 929 teachers and students in the 12 months to June 2014, and education tours for 1425 students and teachers.

2. SCIENTIFIC HIGHLIGHTS

2.1 Publication productivity

Our world-class facility has contributed to over 1400 synchrotron-based papers from nine beamlines in its first seven years of operations (to June 2014). Figure 1 shows how publication rates have climbed steadily since the facility first started user operations in mid-2007.

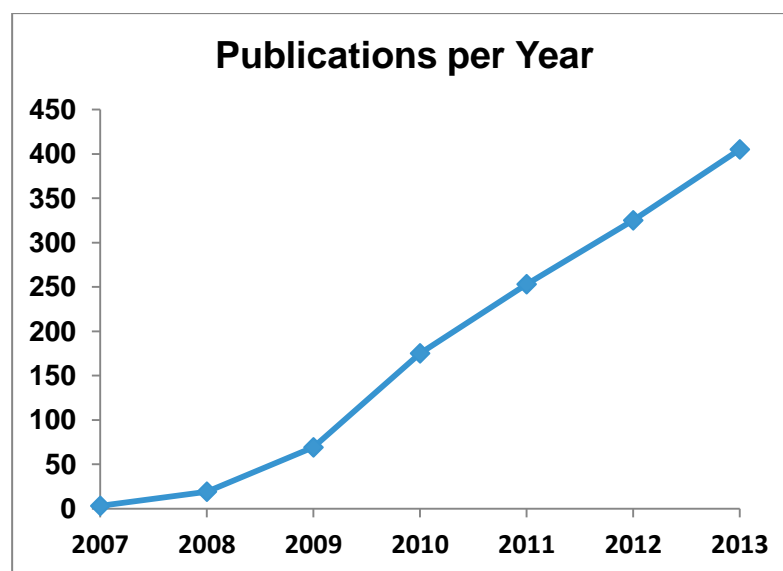


Figure 1. Publications by year to December 2013.
(containing data collected at the Australian Synchrotron)

Around 700 publications (not included in Figure 1) have come from other activities supported by the Australian Synchrotron, including the *Australian National Beamline Facility (ANBF)* at the Photon Factory in Japan and the *International Synchrotron Access Program (ISAP)*. The ANBF closed in March 2013 after 20 years of hosting visiting researchers; much of its role is now fulfilled by the x-ray absorption spectroscopy (XAS) and powder diffraction (PD) beamlines at the Australian Synchrotron. ISAP is administered by the Australian Synchrotron and facilitates access to overseas synchrotrons when the research lies outside current AS capacity; in turn this generates expertise within the Australian scientific community to drive future development of the AS beamlines.

This rate of productivity is in a class with the most productive synchrotron facilities world-wide and is of direct benefit to our research partners. In addition to the facility's world-class experimental capability and exceptional reliability, Australian Synchrotron staff have an excellent track record in collaboration and value-add to experiments. Now with operations by ANSTO, and coupled with extensive high-performance computing facilities, remote access and on-the-spot data analysis tools this means that experiments at the Australian Synchrotron are converted into research outcomes very efficiently.

The quality of publications produced from Australian Synchrotron instrumentation is of a very high standard; having an average Impact Factor of 4.84. More than 15% of these articles were published in the in the world's leading journals (Impact Factor > 7): such as *Nature*, *Science*, *Cell*, *Immunity*, *Advanced Functional Materials*, *Energy & Environmental Science*, *Angewandte Chemie*, *ACS Nano*, *Physical Review Letters* and *Proceedings of the National Academy of Science USA*. Another indicator of the quality of publications from the Australian Synchrotron is that they are regularly featured on the cover of leading scientific journals. A selection is shown in Figure 2.



Figure 2. Journal covers based upon studies containing Australian Synchrotron data

The Australian Synchrotron produces a steady stream of research outputs, many of which can be found on the facility [website](#) and in regular publications such as the [annual report](#) and [research highlights](#) report. Individuals and organisations can also see their publication outcomes on the publication [search page](#) on the website.

2.2 High impact publications

Just a few recent high-impact publications include:

Waking-up the body's immune system

An international research team led by Australia has identified the biochemical signal that wakes up a group of front-line immune cells. The findings will help improve treatment of tuberculosis, peptic ulcers, periodontal disease and inflammatory bowel disease.

[*Nature*, 509, 361 \(2014\).](#)



How plants fight back

New insights into the way plants such as potatoes and tomatoes defend themselves against potentially lethal bacterial invaders will assist development of crop plants that are less susceptible to pre-harvest diseases, which can account for up to 15 per cent of crop losses in a single season.

[*Science*, 344, 299 \(2014\).](#)

Hydrogen storage with high efficiency

Hydrogen is an excellent potential source of renewable energy due to its abundance, high chemical energy and pollution-free combustion. Australian researchers recently developed a way to incorporate complex metal borohydrides with high hydrogen storage into a type of mesoporous silica and showed that the resulting material had much better hydrogen release characteristics in terms of release rate, hydrogen purity and lack of problematic by-products.

[*Journal of Materials Chemistry A*, 1, 250 \(2013\).](#)

Tobacco plant could help fight cancer

A small peptide molecule found in an ornamental tobacco plant has the potential to kill cancerous cells in humans. Researchers used the Australian Synchrotron to see detailed molecular structures, enabling them to establish how the molecule binds to and disrupts the membrane of target cells. [*eLife*, 3, e01808 \(2014\).](#)

Towards a vaccine for coeliac disease

X-rays from the Australian Synchrotron have revealed structural details of the interaction between the immune system and a component of gluten that leads to inflammation of the small intestine. This information is assisting the development of a therapeutic vaccine and a blood test.

[*Nature Structural & Molecular Biology*, **21**, 480 \(2014\).](#)

Hydrogen from water without the precious metal price tag

Electrocatalytic reduction of water to molecular hydrogen via the hydrogen evolution reaction may provide a sustainable energy supply for the future, but commercial applications are hampered by the cost of platinum catalysts. Researchers are developing a metal-free electrocatalyst that shows hydrogen evolution activity comparable to some of the well-developed metallic alternatives to platinum catalysts.

[*Nature Communications*, **5**, 3783 \(2014\).](#)

Imaging micronutrients in healthy plants

To maintain healthy cellular function, plants need to regulate the concentrations, chemical speciation and distribution of mineral nutrients and toxic trace elements. X-ray fluorescence microscopy is being used to image the cellular and subcellular distribution of elements, as well as determine their in-situ chemical speciation.

[*Trends in Plant Science*, **19**, 183 \(2014\).](#)

Did you get that car's paint type?

Researchers used synchrotron infrared micro-spectroscopy to characterise automotive paint samples from a range of international car manufacturers. They proved that the 'primer surfacer' layer of the paint provides better information than the clear topcoat, and avoids complications due to environmental degradation and component migration. A WA forensics provider is using the new analysis in forensic investigations where the vehicle is unknown.

[*Talanta*, **118**, 156 \(2014\).](#)

A ray of sunshine for molecular device fabrication

Controlling metal-organic framework (MOF) crystal growth on substrates is crucial for device fabrication. An Australian-Japanese collaboration used synchrotron small angle x-ray scattering to demonstrate a simple, room-temperature process for coating MOF crystals onto flat plates and 3D surfaces. The MOF coatings can be readily patterned using sunlight.

[*Advanced Functional Materials*, **24**, 1969 \(2014\).](#)

Looking for lead in all the obvious places

A 15-month study of interior and exterior dust, soil and paint samples from five brick houses in Sydney found that the main source of lead in interior dust was garden soils that had accumulated lead over decades of exposure to vehicle emissions from leaded petrol. The researchers used x-ray absorption spectroscopy to determine the level and speciation of lead in their samples.

[*Environmental Pollution*, **184**, 238 \(2014\).](#)

Getting a handle on high intensity x-ray beams

A study that used a graphite calorimeter to measure the high dose rates of intense x-ray beams from the Imaging and Medical beamline has provided important dose information for future microbeam radiation therapy (MRT) studies.

[Medical Physics, 41, 052101 \(2014\).](#)

The role of metals in neurodegeneration

Biometals such as zinc, iron, copper and calcium play key roles in diverse physiological processes in the brain, but excess can be toxic. Neurodegeneration often involves a failure of the mechanisms that control the concentration and distribution of these elements. Synchrotron x-ray microscopy allows researchers to map the location and distribution of zinc and calcium in cells associated with Batten disease, a childhood neurodegenerative disorder.

[Chemical Science, 5, 2503 \(2014\).](#)

3. INDUSTRY ENGAGEMENT

The Australian Synchrotron has a strong track record of valuable contributions in broad industrial areas that include mining, agriculture, health, manufacturing and SME-driven innovative technologies.

More than 200 companies have been involved in research undertaken at the Australian Synchrotron, many of them through research providers such as universities and major organisations such as ANSTO and CSIRO. In addition, CSIRO Manufacturing, Materials and Minerals estimates that 50 percent of their synchrotron research projects involve industry interaction.

Companies benefiting from research engagement with the Australian Synchrotron include: Aduro Biopolymers, Alcoa of Australia Limited, Aqua Diagnostic Pty Ltd, Bayer Australia, BHP Billiton, Biota Pharmaceuticals (CSL), Bluechiip Ltd, Cochlear, Cytex Australia Holdings Pty Ltd, Hexima Ltd, Hospira Australia Pty Ltd, Hydrexia Pty Ltd, MiniFAB (Aust) Pty Ltd, Newmont Australia, , Rio Tinto, Pfizer Australia, Pharmaxis Ltd, Southern Innovation, Wacker Chemicals Pty Ltd, Wellcome Trust, Xstrata Copper and Zeobond Pty Ltd.

3.1 Case study examples

Recent examples include the following:

Assisting pharmaceutical development and production in Australia: Hospira

Melbourne-based Hospira Australia Pty Ltd, the world's leading provider of injectable drugs and infusion technologies – and Australia's largest exporter of generic medicines, has used the Synchrotron for quality control and product development (see case study: "Supporting affordable pharmaceutical development and production in Australia: Hospira")

Assisting SME global competitiveness: industrial and environmental water testing technology

Aqua Diagnostic, a Melbourne producer and exporter of advanced water quality monitoring equipment, used the Synchrotron to enhance the quality of its proprietary nanotechnology sensors through increased understanding of its manufacturing process (see case study: 'SME Expansion: Aqua Diagnostic').

Developing new materials

Aduro Biopolymers, New Zealand developer and manufacturer of biodegradable plastic products made from bloodmeal from the meat processing industry, used the Synchrotron to help fine-tune its processes and assist further product development (see case study: 'Developing biodegradable plastics').

Enabling innovation for SMEs: new technology

Melbourne-based, ASX-listed bluechiip Limited has developed a wireless tracking system for the healthcare and life sciences sector that also has applications in security, defence, manufacturing and aviation. The technology was developed with the assistance of the Australian Synchrotron.

Validating and supporting agribusiness technology

In collaboration with the Australian Meat Processing Association, universities and state agriculture departments in Victoria and NSW are using synchrotron technology to develop tests for meat tenderness and juiciness (as perceived by consumers) and correlating these with feed, season and region. The same technique has been used to investigate tannins in wine (See case study: 'Sector-wide benefits: Wine tannins')



Supporting affordable pharmaceutical development and production in Australia: Hospira

When a branded medicine goes 'off-patent' other companies are able to market the product more competitively. What is less well known is the amount of scientific research that must be done to produce a generic medicine. While a generic medicine is more affordable than the 'name' brand it must also be just as safe and effective – and manufactured to the highest standards.

Hospira ANZ employs more than 650 people in Mulgrave, Victoria – a highly skilled workforce manufacturing high-quality generic injectable medicines. Hospira exports more than \$280 million worth of product from this site annually.

Hospira's access to the world-class instrumentation and expertise at the Australian Synchrotron is enhancing their ongoing industrial research – research that keeps them competitive on a world stage.

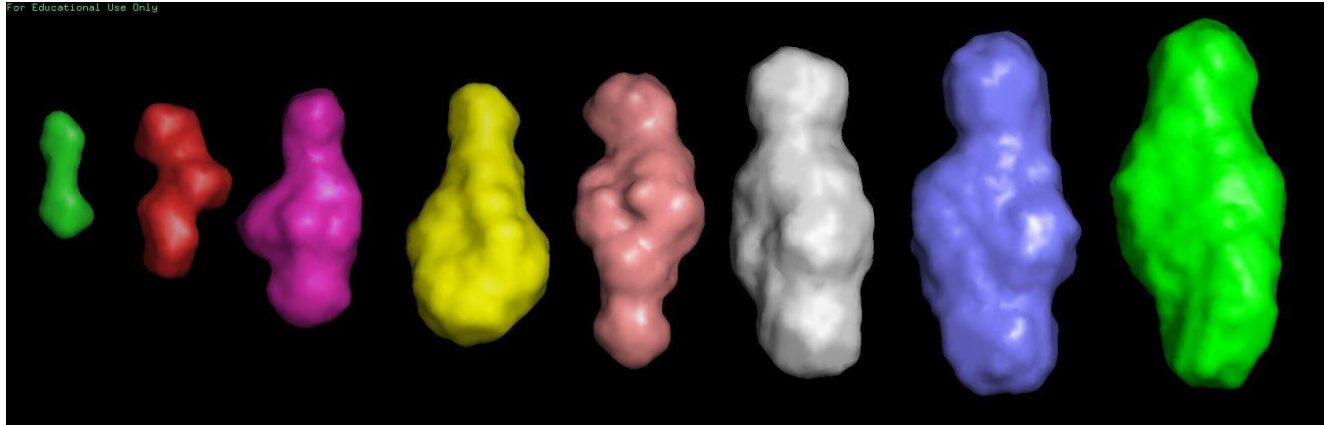


SME expansion: Aqua Diagnostic Pty Ltd

Aqua Diagnostic Pty Ltd, a Melbourne SME producing advanced water quality monitoring equipment and consumables for Chemical Oxygen Demand (COD) measurements, has used the Australian Synchrotron to enhance the quality of its proprietary nanotechnology PeCOD® sensors through increased understanding of its manufacturing process. This support is part of the company's plans to 'scale up' to create higher volumes in response to expected global demand as it expands its share of the international AU\$100+ million COD measurement market.

Ironically, conventional tests for COD involve the use of highly toxic components such as mercury and chromic acid with inherently hazardous procedures that take hours. By contrast, the Aqua Diagnostic PeCOD® COD method can test water samples in minutes avoiding the use of toxic chemicals enabling the eco-friendly by-products to be safely tipped down the sink.

The Synchrotron will continue to help in the development of the proprietary PeCOD® sensors, by shedding light on their optimal nanoscale phase structure produced in the manufacturing process. The product has recently been awarded its first independent EPA method approval in Canada, and is expecting to expand its regulatory approval into many more international jurisdictions in the coming few years, underpinning great potential for global expansion.



Sector-wide benefits: Wine tannins

The Department of Primary Industries (Mildura) is working with the Australian Synchrotron to determine the exact influence of tannins, on the taste and ageing qualities of wine. Tannins, seen above as coloured micrographs, have a large size variation and while its known that they affect ageing and taste, understanding exactly how, will provide globally competitive insights for the Australian industry.

New materials for SMEs: Developing biodegradable plastics

New Zealand researchers are turning dried bloodmeal, a waste product of red meat processing, into a compostable plastic that breaks down without harmful byproducts. The new plastic, called Novatein, is an alternative to petrochemical-based plastics, which are known to produce high levels of methane as they decompose. The material will be used in products such as pots, trays, containers and clips used in the horticultural industry. The researchers have made use of the Australian Synchrotron to understand the molecular structure of the biopolymer and will use it again to assist in improvements to the colour desired for a consumer thin-film plastic product.



4. OPERATIONS

4.1 ANSTO Operation

New funding, government and operational arrangements under the auspices of ANSTO provide a stable platform from which to optimise operations, build relationships with new stakeholders, and to secure the long term future for the Australian Synchrotron.

4.2 ISO certification

The Australian Synchrotron runs to the highest operational standards including the ISO9001 quality assurance system, the AS4801 safety management system and the ISO14001 environmental management standard. These systems help maintain user support services at outstanding levels.

4.3 Accelerator science improvements

The move to top-up operations was successfully implemented by May 2012. Using top-up injection mode has improved the intensity and overall beam stability for users and eliminated the need to close beamline shutters during injections.

The accelerator science team is improving machine set-up procedures, conducting coupling control studies to achieve extremely small vertical emittance, and developing bunch-by-bunch and fast orbit feedback systems – all of which improve beam quality and reliability and thus improve user outcomes.

4.4 Beam availability

The Australian Synchrotron has delivered more than 98 percent beam availability since we began user operations in April 2007. This is a testament to the efforts of our engineers and physicists who work constantly to make the accelerator more reliable, and the technicians and operators who maintain and repair the systems and spring into action to fix it when there is a fault. A core switch failure in late 2013 that was repaired within 24 hours was one of only two disruptions of this length since commencing service in 2007. Most light source facilities target, but do not always achieve, machine availability figures above 95 percent. The Australian Synchrotron sits amongst the most efficient in the world.

5. STAKEHOLDER RELATIONS

5.1 Funders Committee

The Funders Committee represents the five funding consortia that are currently providing operating funds for the Australian Synchrotron. Operating reports on key performance indicators (KPIs) and details of user uptake and beamtime allocations in accordance with the various funding agreements are regularly provided to this committee for dissemination within the underlying stakeholder groups.

5.2 VIP Visitors

Regular visits and tours are hosted for all stakeholders, including senior university representatives, with a particular focus on visits by (and to) government representatives. This has included visits in the last months by the Minister for Industry, representatives from the Department of Prime Minister and Cabinet, a presentation to the Department of Industry and a visit from The New Zealand High Commissioner.

5.3 User Meetings

The facility User Meeting provides a forum for stakeholders representing users to present and provide feedback. The meeting includes town hall discussions as well as a formal meeting of the user advisory committee.

The most recent Australian Synchrotron User Meeting was held in the award-winning National Centre for Synchrotron Science building on the Synchrotron site on 21-22 November 2013. It attracted 215 synchrotron experts, users and prospective users, providing a unique opportunity for them to showcase their research, network with some of the best scientists in Australia, and catch up with the latest developments at the Australian Synchrotron.

Meeting highlights for 2013 included: novel combinations of techniques including MX and SAXS; the growing capabilities of the Australian Synchrotron Imaging and Medical Beamline (IMBL); the industry-science relationship in synchrotron collaborations; and the inaugural Stephen Wilkins Thesis Medal award.

6. Conferences

Conference hosting provides a medium where we collaborate with our user base to enhance recognition of research and promote collaboration.

In 2014 and 2015, we will host the following workshops and conferences:

- 2014 Italian-Australian Workshop on Photon and Neutron Science – 100 delegates
- 2014 X-ray Microscopy (XRM) - 400 delegates
- 2014 Mechanical Engineering and Design for Synchrotron Instrumentation (MEDSI) - 150 delegates
- 2015 International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS) - 400 delegates.

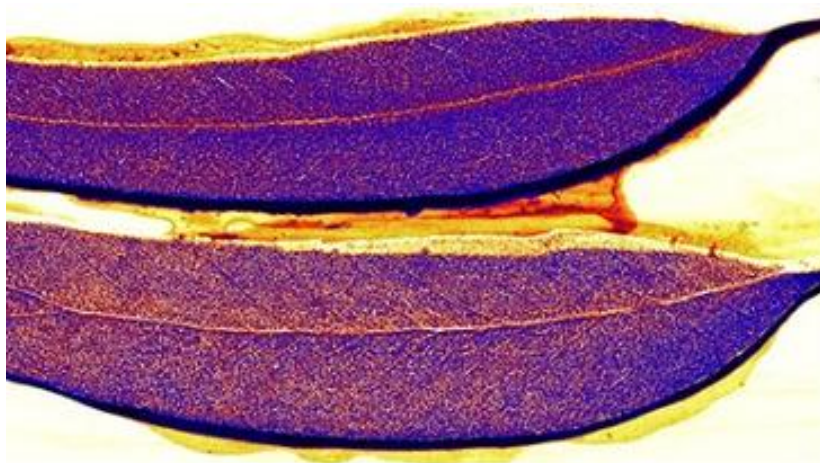
In 2013, we hosted:

- 2013: Accelerator Reliability Workshop (ARW). About 150 delegates
- 2013: Workshop on Infrared Microscopy and Spectroscopy (WIRMS), for around 150 delegates.

7. MEDIA RELATIONS

Underpinning our direct stakeholder engagement, the Australian Synchrotron is working with user organisations and the media, to raise awareness of the breadth and positive impact on Australians and Australian industries of research performed at the Synchrotron.

Just a few recent media stories are listed below, many of which were syndicated widely:



Eucalypts reveal their veins of gold: Sydney Morning Herald and The Age, 23 October 2013

“Giving gold leaf a more literal meaning, CSIRO scientists have established that eucalyptus trees draw up gold particles from deep in the soil via water absorbed by their root system.”

Full story: <http://www.theage.com.au/environment/eucalypts-reveal-their-veins-of-gold-20131022-2vzm6.html>



Beachgoers can relax about nanoparticles in sunscreen: The Age, 28 January 2014

“Fears about dangers of nanoparticles in sunscreen may be unfounded, with research showing they are unlikely to harm beachgoers.”

Full story: <http://bit.ly/SimonSaysZnOnanoSafe>



Holy smoke: tobacco plant shows cancer-fighting potential: The Age, 2 April 2014

A small peptide molecule that ornamental tobacco plants use to fight off fungal and bacterial infections has the potential to treat cancer in humans, according to a new discovery by Australian researchers.

Full story: <http://bit.ly/cancerfightingtobacco>

Melbourne researchers find trigger for coeliac disease Herald Sun: 29 April 2014

Australian and Dutch researchers used x-ray diffraction to discover the 'trigger' for coeliac disease. They are working with US biotechnology company ImmusanT to develop a therapeutic vaccine and a blood test to help 95 percent of coeliac sufferers.

Full story: <http://bit.ly/CoeliacFinding>

Australian scientists helping end malaria: ABC24 The World, May 2014

A fast, accurate and inexpensive test that uses infrared light to detect malaria at a very early stage of its development could dramatically reduce deaths from the disease, which kills around 1 million people a year.

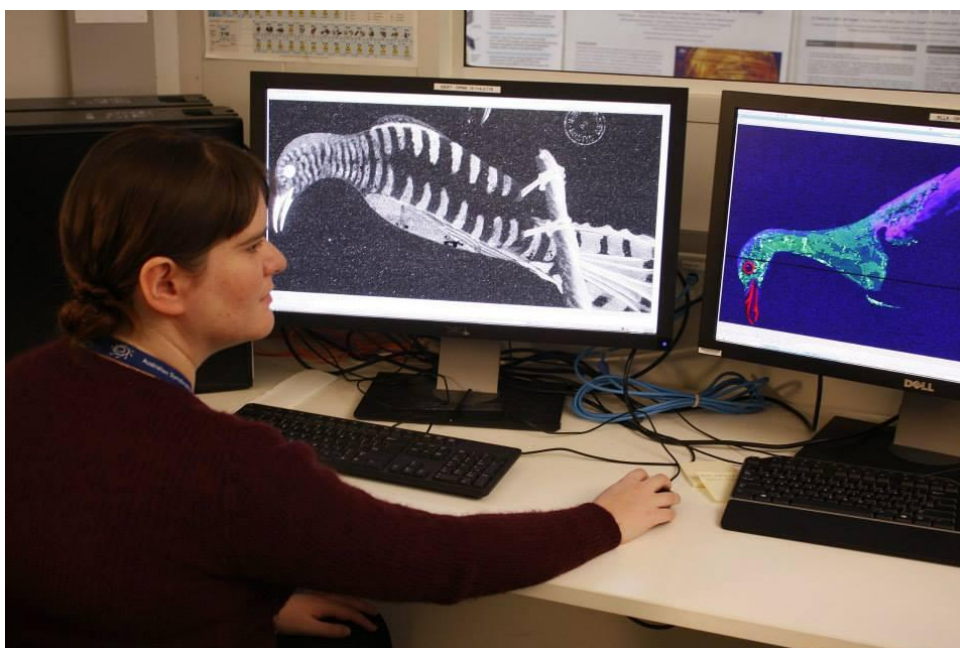
News footage: <http://bit.ly/ABCMalaria>



Scientists unlock milk formula that could save lives Herald Sun: 9 June 2014

Melbourne scientists have completed new research into the way milk is digested, which it is hoped puts us on a path to new milks suitable for premature babies and others with milk intolerances.

Full story: <http://bit.ly/MilkFatStructure>



Gold leaf may unlock secrets of early Australian paintings: The Age, 17 June 2014

Some of Australia's earliest scientific drawings are finally giving up their secrets under the watchful eyes of Australian Synchrotron scientists and conservators from the State Library of New South Wales.

Full story: <http://bit.ly/GoldenBirdDrawings>

8. EDUCATION AND OUTREACH

The Australian Synchrotron provides a valuable service in training and retaining the next generation of researchers in the country. The facility also plays an important role in promoting research as a viable and exciting career pathway with students prior to entering university. Since July 2013, we have run 61 laboratory sessions for VCE physics, catering for 929 teachers and students. We have also hosted education tours for 1425 students and teachers at levels ranging from undergraduate to primary. Education and outreach officer Jonathan de Booy is also contributing to an upgrade of the educational virtual beamline that will enable classes to participate in a wider range of experiments from locations anywhere in Australia, including measuring their own samples they have sent in.

Other outreach activities have included public tours and a well-attended Open Day. In 2014 the focus will be on targeting our key stakeholders and decision makers. Instead of an open day, we will focus on direct interactions with relevant politicians and advisors, develop a virtual tour to enable broader 'access' to the Synchrotron, arrange a speaker series, and organise other promotional activities with national coverage.

