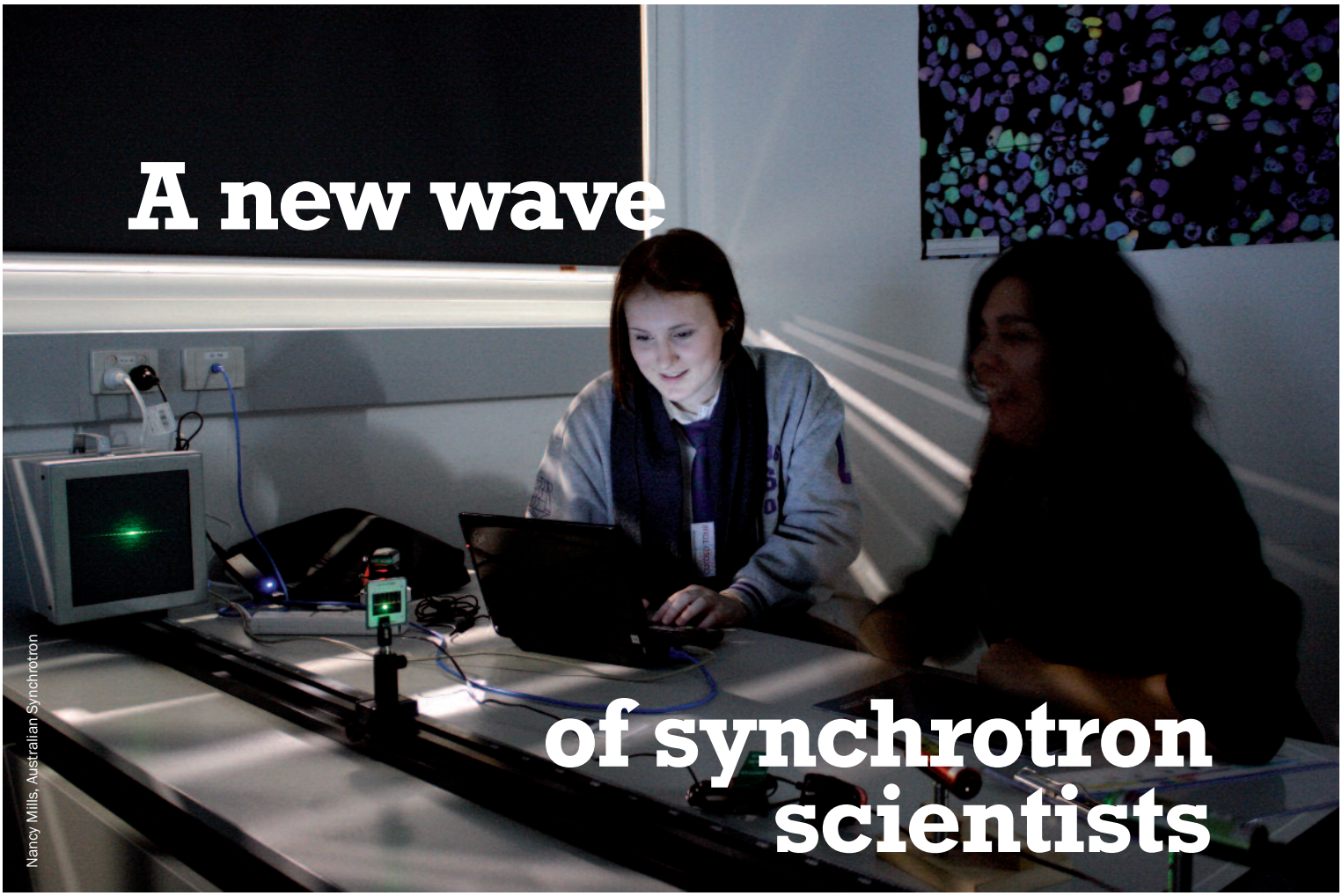
A new wave of synchrotron scientists



Nancy Mills, Australian Synchrotron

High-energy science: a year 12 student from Brighton Secondary College measures diffraction images at the Australian Synchrotron.

BY NANCY MILLS

A new generation of scientists is finding lots to like about the Australian Synchrotron's education program, thanks to Education and Outreach Officer Jonathan de Booy.

The room is dark. As you cautiously push open the door, you notice shadowy figures peering intently at computer screens. Piercing beams of red and green laser light dart along the benches towards detector screens that light up with complex diffraction patterns.

You're in the education laboratory at the Australian Synchrotron with a class of year 12 physics students.

'The experimental set-up we have here is as close as we can get to having a synchrotron on every bench, but using visible laser light instead of X-rays or infrared,' says Jonathan de Booy, the synchrotron's 20-something education officer. 'The students shine laser light through different apertures onto a detector screen and examine how factors such as wavelength, distance from detector, and aperture size and shape affect the diffraction pattern they see.'

A new generation

Every year, thousands of scientists from a wide range of disciplines undergo a highly competitive selection process that enables successful applicants to use the Australian Synchrotron's specialised X-ray techniques to help achieve their academic and industrial research goals. The value of the synchrotron's unique research tools is clearly demonstrated by the increasing number of researchers willing to run the gauntlet of yet another competitive selection process.

But the facility's true value to Australia over the course of its anticipated 30-year lifetime rests as

much on its ability to foster the development of a new generation of synchrotron-savvy scientists.

'We work in a brand-new building where state-of-the-art X-ray tools and techniques are used by researchers from just about every area of science,' Jonathan de Booy says. 'Every week researchers use the synchrotron to discover new knowledge about the human body, planet Earth or our ability to manage the world around us for the benefit of future generations.

'My personal challenge is to use the synchrotron's capabilities to encourage students to learn more about how science affects them as members of the community – and to inspire them to take up careers in science, particularly synchrotron science.'

Jonathan's activities mainly cater for senior high school students, but he also hosts or organises tours for tertiary students. A tour for second-year physics students from Monash University in August 2011 prompted the following feedback from Monash Research Fellow Dr Lincoln Turner: 'This experience makes physics (and physics career options!) much more immediate and accessible to our students, and we suspect it is a significant driver of retention to third-year physics.'

Jonathan is education and outreach officer at the Australian Synchrotron, with the strategically important long-term goal of creating the synchrotron users of the future. His work responsibilities include running laboratory sessions and tours for teachers and students and developing web-based resource materials. There is no charge for the laboratory sessions or school tours, but schools are advised to book well in advance.

For the last two years, Jonathan has conducted hands-on activities at the synchrotron for year 12 physics students to support the (optional) synchrotron detailed study unit 'Synchrotron and its applications' in the Victorian Certificate of Education (VCE) physics course and the 'Interactions of light and matter' section of the central physics course. He is currently devising ways to offer synchrotron-related activities to chemistry students and hopes to eventually provide activities for biology students as well.

Around 1800 students and teachers take part in synchrotron tours and laboratory sessions each year. The peak period is August–October, when Jonathan conducts full-day education laboratory sessions to coincide with schools teaching the VCE physics units.

The experiments look at absorption, fluorescence and diffraction with visible light, which is broadly analogous to what the synchrotron does with X-rays. The equipment mimics the synchrotron's X-ray equipment and can therefore demonstrate the same principles that apply to the synchrotron X-ray equipment used by researchers.

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Students conduct experiments to investigate various factors that influence the diffraction patterns created when laser light is passed through apertures of various shapes and sizes. They capture and 'crunch' their experimental data at the synchrotron, generating an approximate image for comparison with student calculations. Back at school, they can use the same software to further analyse the data and images.

'The experiments we offer are things that schools couldn't do for themselves, and they require equipment that is often too costly for schools to justify purchasing. Here we have enough kit so that every student can do the same experiment at the same time, in groups of two or three, and students can then discuss their results. Many different experiments are completed in one day,' says Jonathan.

Teachers have provided valuable feedback for further improvements to the programs, and some compliments for Jonathan's hard work. A student trip to the synchrotron in September 2010 was rated as 'the most valuable excursion for senior students for the year!' by physics teacher Rob Storr, who was then teaching at Casey Grammar School in the Melbourne suburb of Cranbourne.

From physics to chemistry

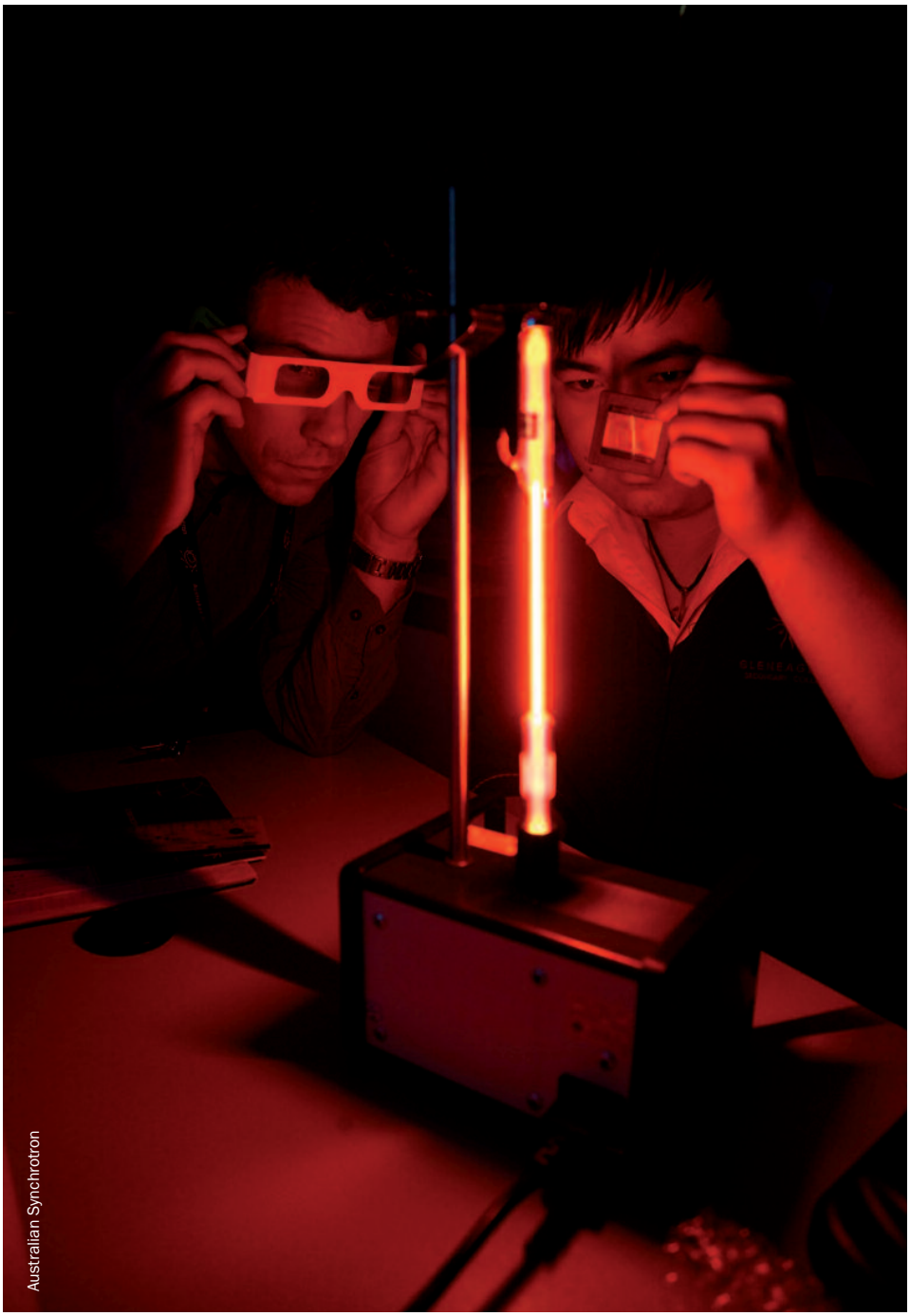
Jonathan says the equipment already purchased for physics students can also be used for chemistry curriculum areas such as absorption curves, kinetics and reaction rates.

'Some of this is already covered elsewhere, so our aim is to complement what others are doing without unnecessary overlap. We'll play to our strengths and look at structural analysis.'

Chemistry topics covered in synchrotron laboratory sessions could include diffraction, interference, structural determination of two-dimensional structures and materials, size and placement of unit cells in crystals, and information on bond lengths.

'Physics principles can help chemists to better understand their materials they're working on. You could say we're helping to break down the boundaries between physics and chemistry.

'The key concepts we want students to understand are the use of



Let there be light: Jonathan de Booy from the Australian Synchrotron and a year 12 student from Gleneagles Secondary College conduct a physics experiment at the synchrotron.

light as a measurement tool, and the special characteristics of synchrotron light, such as brilliance and bandwidth.'

Inspiration and education

Jonathan's own interest in physics was probably sparked by a combined interest in mathematics and in meaningful uses for mathematics. 'I was definitely intrigued by the basic ideas behind quantum mechanics,' he says.

'I studied applied physics and computing at Victoria University, and I really loved what I learnt. Teaching was my third preference, but I was inspired by my first-year lecturer, who was massively enthusiastic in his teaching of physics. It must have rubbed off on me because I had a real desire to go into teaching physics and hoped to inspire students the same way he inspired me.'

Rewards and challenges

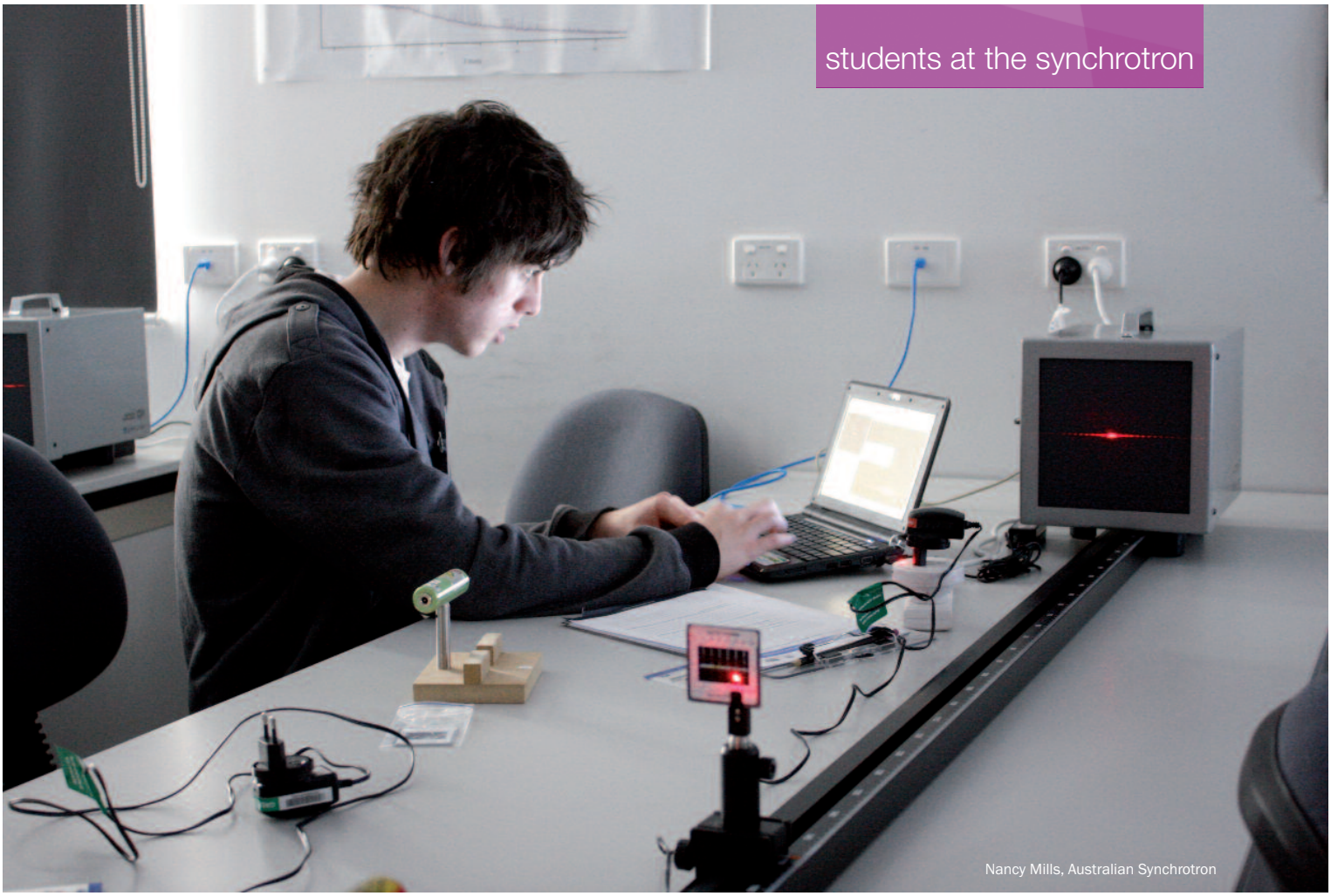
'The rewards of teaching? That's an oxymoron, isn't it? Seriously though, the rewards are when you see former students later in life and realise that you've had an influence on their lives and the choices they've made, such as further study. One of my former VCE physics students came to the synchrotron a few months ago as a third-year university student to do a beamline course, which was great to see,' says Jonathan.

'There are definitely challenges in teaching. Students today seem to expect technology to improve and catch up with their demands and desires without understanding (or wanting to understand) how big a role science actually plays in that. The challenge is to find a way to cover the fundamentals in a wide range of areas in a deep and interesting way so they can choose which areas of science – if any – are of interest to them.'

Jonathan's aim is to create a program for students that is engaging, exciting and unique. Budget restrictions typically mean that schools can't afford items such as spectrometers, optical benches and lasers. Even if they can afford to buy one item as a demonstration piece it's hardly exciting for students.

'I'm trying to connect synchrotron science to the curriculum and to connect students to modern science through hands-on experiments that assist them to gain a better understanding of how a synchrotron works and what it's used for.

'Teachers and students want videos and animations that explain things simply and quickly, and they want access to simulations and online experiments. We currently offer Young's double-slit experiment online using real synchrotron light, with teachers remotely controlling the experiment from their own computers. We're also developing experiments



In the education laboratory: a year 12 student from Elisabeth Murdoch College conducts experiments.

involving forces acting on electron beams in magnetic and electric fields, and these will also eventually be remotely operable.'

Jonathan also wants to demonstrate the need for various disciplines to work together; for example, protein crystallography requires biology, chemistry and physics.

'Students shouldn't feel that they have to choose one area alone, as they may become part of a multidisciplinary team.'

In late 2010, Jonathan hosted a laboratory session for a group of grade 5 and 6 primary school students. Before the event, he was a bit concerned about how it would go because he had no previous experience with students of that age, but the students quickly dispelled his concerns.

'We set the bar pretty high in terms of what we wanted them to understand, but the students took it all in. They found the experiments incredibly exciting and left feeling that they understood what a synchrotron is used for.'

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But wait, there's more ...

Teachers and students can find out more about the Australian Synchrotron by visiting the website (www.synchrotron.org.au). They can also subscribe to the synchrotron's free, bimonthly e-newsletter *Lightspeed*, which publishes general-interest stories about research done at the synchrotron. Teachers can visit the website education pages to have their names placed on the synchrotron's education mailing list for regular updates.

Nancy Mills <nancy.mills@synchrotron.org.au> is the Australian Synchrotron's science writer. She wishes she'd had Jonathan de Booy's first year university physics lecturer.