



Nuclear science and technology benefiting all Australians



Discover the amazing world of nuclear science

The world is made up of atoms. It therefore follows that the science that helps us understand the atomic world, nuclear science, can be applied to just about everything.

Nuclear science and technology already play an important role in our daily lives, with widespread applications throughout medicine, industry and the environment.

While there has already been much progress, the potential of nuclear science and technology remains vast. By enabling scientists to discover how things work from the inside out, we learn how things work at the most fundamental level.

Researchers are using nuclear facilities and techniques to help find cures for cancer and other diseases, make breakthroughs in clean energy production, create new materials, gain new understandings about the environment, and invent products to create brand new industries.

ANSTO

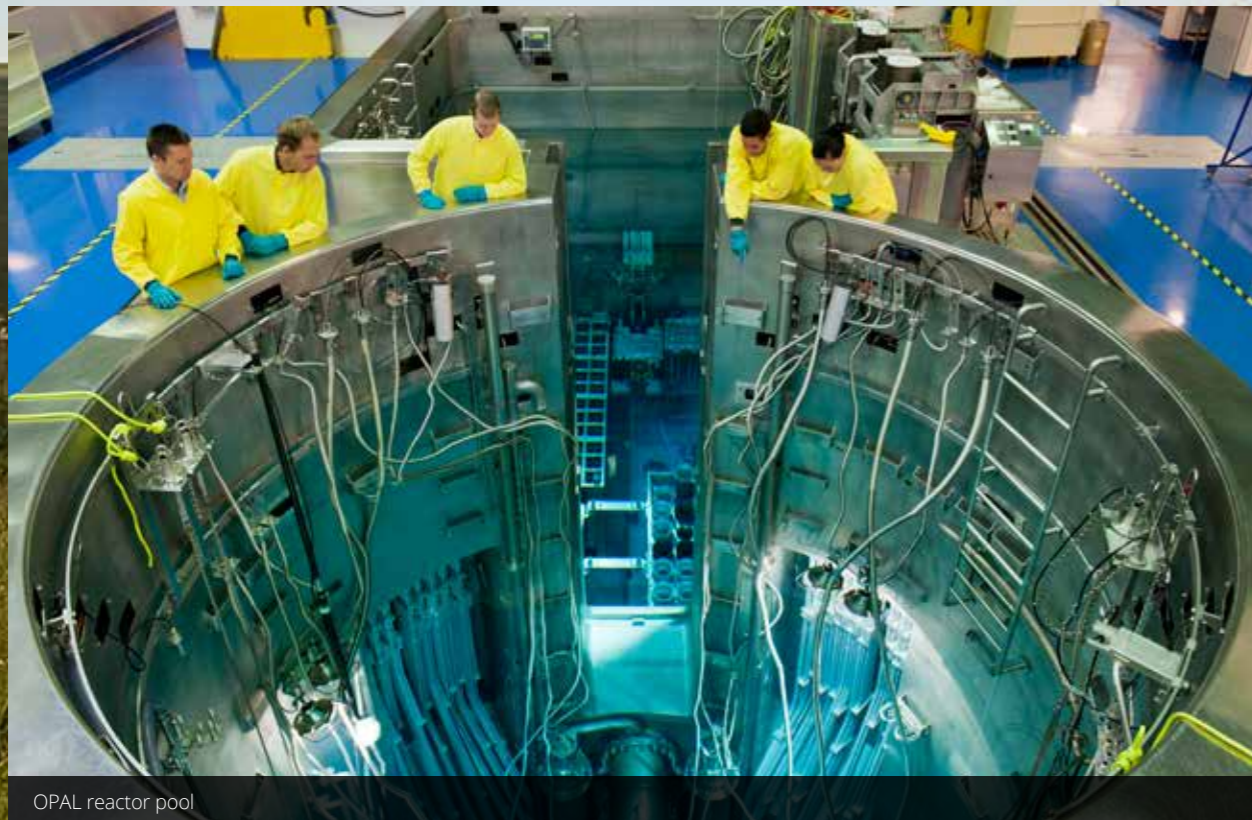
The Australian Nuclear Science and Technology Organisation (ANSTO) is home to Australia's nuclear science and technical expertise. Like the CSIRO, ANSTO is a Federal Government funded organisation.

ANSTO is one of Australia's largest public research organisations and a widely recognised international player in high-end nuclear science and technology.

We operate much of our country's landmark science facilities including one of the world's most modern nuclear research reactors, OPAL, a comprehensive suite of neutron beam instruments, the Australian

Synchrotron, the National Imaging Facility Research Cyclotron and the new Centre for Accelerator Science. These facilities are used by our own scientists and visiting scientists from other local and international research organisations.

ANSTO plays a crucial role in Australia's healthcare, with one in two Australians benefiting from the nuclear medicines produced using the OPAL research reactor when being treated for serious illnesses such as heart disease and cancer.



OPAL reactor pool



Understanding our environment

ANSTO uses nuclear research techniques to solve the puzzle of how environmental systems function and interact, and the impact humans have on the environment.

Revealing the sources of Sydney's air pollution

There can be few more important issues for humans than the quality of the air that we breathe. Air pollution is made up of countless fine particles that can travel hundreds of kilometres and create serious problems for both the environment and human health.

In recent years, nuclear techniques have been developed to 'fingerprint' pollution, so it can be traced back to its source across cities and across nations. In short, researchers can identify the origin of the particles in the pollution and its impact on our environment.

By using a combination of techniques including analysing the particles' chemical composition and taking account of meteorological data, ANSTO researchers are able to quantify the effects of air pollution. This information is invaluable for planners when it comes to making decisions that impact the quality of the air we breathe.



ANSTO's David Cohen and his team have collected fine particles in Western Sydney for more than 25 years.

Studying Western Australian caves to better understand our changing climate

The availability of fresh water is a crucial issue for people in Perth, one of the world's most isolated cities. Rainfall has declined by 17 per cent on average in Australia's south-west since 1970, so gaining an understanding of rainfall patterns is of great importance to the city's planners.

Since conventional rainfall records are limited to around 110 years, researchers need to apply different climate research methods to gain longer-term understanding of rainfall patterns. ANSTO researchers have turned to cave stalagmites to help provide the answers.

Cave stalagmites are a rock formation that rises from the floor of a cave due to the accumulation of material deposited on the floor from minerals dissolved in dripping water. Using nuclear techniques, scientists are unlocking thousands of years of rainfall-sensitive data, preserved in the crystallised calcium carbonate from Golgotha Cave in south-west Western Australia. This information is providing an invaluable archive of previously unavailable climate data.



ANSTO helps protect sensitive wetlands

Wetlands of international significance are protected by an international convention known as Ramsar – and ANSTO scientists are doing their bit to monitor and provide invaluable information about these sensitive sites.

One of the most potentially vulnerable sites is the Towra Point Nature Reserve, located on the southern end of Botany Bay. Towra Point is Sydney's largest and most diverse wetlands environment, containing 60 per cent of the saltmarsh communities in the region and 40 per cent of the region's mangroves. More than 100 species of birds have been identified at the Nature Reserve including 34 species of migratory birds, some of which fly up to 12,000 km from places like Siberia, China and Japan.

Using world class facilities, researchers from ANSTO analyse core samples of sand taken from Towra Point Nature Reserve. By analysing the heavy metals in the sand, the researchers are able to compile a history of pollution and gain an understanding of how to best manage this important site.



ANSTO graduate Stephanie Kermode and environmental scientist Henk Heijnis undertaking sediment core testing at Towra Point near Kurnell, NSW.

Rottnest Island's bore water: a sustainable resource?

ANSTO researchers are studying groundwater on Rottnest Island, Western Australia to assess the isotopic composition of the water underlying the island. The groundwater is used during the summer months to supplement the island's other water supplies. This study is looking into whether it can be sustainably used as a resource long term by determining how much groundwater there is and how quickly it is being replenished.

ANSTO's chemical analysis of the water includes measuring the naturally-occurring isotope tritium as an indicator of the water's age. This isotope is used as it gives added information on the history of the water.

As tritium (or hydrogen-3) has a half-life (time required for it to reduce to half its quantity) of 12 years, groundwater with none of the isotope present would be deemed to be a subterranean resource more than 50 years of age.

Graduate Eliza Wells (left) and environmental scientist Karina Meredith undertaking groundwater quality sampling at Rottnest Island, Western Australia.

If the water contains any measurable tritium, it follows that it has been in contact with the atmosphere within the past 50 years. When the water molecule goes into the ground it undergoes radioactive decay and every 12 years its tritium activity will decrease by half.

Regular sampling and analysis will assist in planning the island's future water needs.



Improving our health

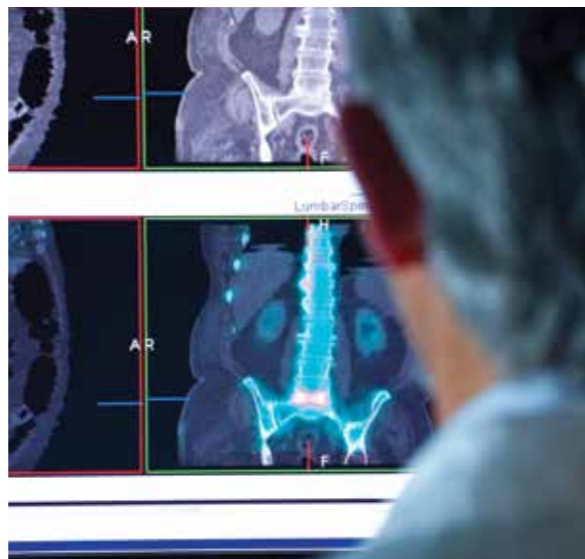
Nuclear medicines are a vital tool for diagnosing and treating a range of diseases. The unique properties of some nuclear medicines are also of great interest to researchers, offering pathways to exciting new treatments for a range of illnesses.

Nuclear medicine helps doctors diagnose diseases

Each week ANSTO Health delivers 10,000 patient doses of potentially lifesaving nuclear medicines to more than 250 hospitals and medical practices across Australia.

ANSTO's nuclear medicines, produced in the OPAL research reactor, deliver significant advantages for doctors needing to diagnose patients quickly and accurately. Imaging techniques involving nuclear medicine can target tumours and show the function of organs and other body parts in ways that X-rays cannot.

Nuclear medicines are also used to provide doctors with a clearer picture of the brain, salivary glands, thyroid, lungs, liver, spleen, kidney and gall bladder.



Research to aid the detection and treatment of dementia

Dementia is the most common cause of disability in Australians over the age of 65. The term 'dementia' actually encompasses more than 100 degenerative disorders, including Alzheimer's, Parkinson's and Huntington's diseases, that affect the central nervous system, and in particular, the brain. In order to develop better treatments, we first need to better understand the basic underlying disease processes.

We know that calcium plays an important role in neurons, which are cells that are essential for a healthy functioning human nervous system. An alteration in calcium homeostasis is one of the events known to initiate irreversible deterioration of the nervous system, which ultimately leads to degeneration of brain tissue.

By measuring particle induced X-ray emissions in sections of inflamed rat brain tissue, ANSTO scientists have been able to capture images of changes in calcium distribution. These images give potential insight into the early stages of dementia and help scientists better understand how these diseases start and progress.

It is hoped that the results of this research will enable scientists to not only detect these diseases before symptoms are visible, but also contribute to the development of better treatments.

ANSTO biologist, Paul Callaghan's research is contributing to better treatments for serious diseases such as Alzheimer's and Parkinson's.



Miniature radiation dose detectors to aid hadron therapy cancer treatment

Hadron therapy is an alternative radiotherapy cancer treatment which is being increasingly used when other treatment options, such as conventional radiotherapy, cannot be employed because of risk to vital organs close to the tumour.

In order to improve hadron therapy treatment, it is vital to have an accurate measurement of the dose the patient is receiving, not only in the treatment area, but also in any surrounding critical organs such as the brain and nervous tissue, eyes, and reproductive organs.

A collaborative effort by scientists from ANSTO and the University of Wollongong has resulted in the development of a new, miniature radiation dose detector that uses silicon, similar to that used in the manufacture of computer processors and USB flash memory devices. Scientists have fabricated these detectors, called microdosimeters, to be equivalent in size to human cells, and they have been successfully tested at hadron therapy facilities in Japan and Germany.

Testing demonstrated that these microdosimeters have the potential to provide a more accurate measurement of the radiation dose received by the area being treated and the surrounding sensitive organs. Further testing is now planned to continue developing and improving this cutting-edge technology.



New imaging agents to diagnose stroke

Stroke is Australia's second largest killer after coronary heart disease, with 50,000 Australians suffering strokes each year. According to the National Stroke Foundation, stroke costs the Australian health system more than \$5 billion annually and is expected to increase with Australia's ageing population, unless incidence rates can be lowered.

The processes of cell division and programmed cell death - called apoptosis - keeps living organisms in a stable state. This happens by cells communicating with one another and activating a series of enzymes that initiate apoptosis. In some instances, programmed cell death can stop occurring normally, leading to disease. During a stroke, cells are starved of oxygen. This activates particular enzymes, called caspases, which then begin the process of cell death causing irreparable damage.

ANSTO and French Atomic Energy Agency (CEA) researchers worked together on a joint project to develop small molecules which can be radiolabelled with fluorine-18 and bound to the enzymes involved in apoptosis. The intention is that the compound can then,

potentially, be injected into a patient so that a PET scan reveals pictures of the affected brain area, allowing the stroke to be diagnosed more quickly.

It is intended that the research will contribute to the development of an innovative new radiopharmaceutical that enables earlier diagnosis and greater treatment options for stroke patients.



Solutions for industry

From providing the expertise needed to create a brand new minerals industry for Australia, to ensuring our pipes deliver our gas and water safely, ANSTO scientists are providing answers to some of our most pressing industrial questions.

Dubbo zirconia project and ANSTO Minerals

What comes out of the dirt and is found in mobile phones, cameras, cordless power tools, wind turbines, hybrid vehicle batteries, and is used to polish our television screens?

The answer is an odd assortment of elements with unique properties that are collectively known as rare earths. Sometimes referred to as the vitamins of the electronics industry, they come with equally odd names such as lanthanum, neodymium, terbium or europium and are in demand for a range of gadgets that are increasingly important in the modern world.

The boom in demand for rare earths is being mirrored by the demand for experts from ANSTO's minerals division to help companies develop methods to extract and recover these valuable commodities. ANSTO possesses a range of modern analytical tools such as gamma spectrometry, radiochemistry, and delayed neutron counting that can make all the difference for miners seeking to understand how to treat their ores and create viable mines.

One such company is Alkane Resources, which is a pioneer in the field of rare earths mining in Australia. ANSTO experts in engineering, metallurgy, mineralogy, chemistry, geology and radiation safety have provided crucial services to Alkane in planning a project in Dubbo, New South Wales. This project is set to provide hundreds of jobs and inject millions of dollars into the economy.



Synroc

Synroc is a brilliant Australian-developed solution for managing nuclear waste safely and economically. Short for 'synthetic rock', it mimics the natural ability of rocks to safely lock up radioactive elements for hundreds of thousands of years.

This method is proven to significantly reduce the volume of nuclear by-products in comparison to other methods, potentially saving organisations many millions of dollars in the safe storage of their waste.

ANSTO's Synroc team have developed a range of waste form solutions involving the use of Hot Isostatic Pressing (HIP) technology where components are placed in a sealed can inside a furnace and compressed to maximum density and minimise disposal volume.

ANSTO is developing a Synroc plant at its Lucas Heights campus to manage the by-products of past, current and future manufacture of nuclear medicine. The first of its kind in the world, the plant will showcase this technology to the rest of the world.

Synroc can significantly reduce the volume of nuclear by-products



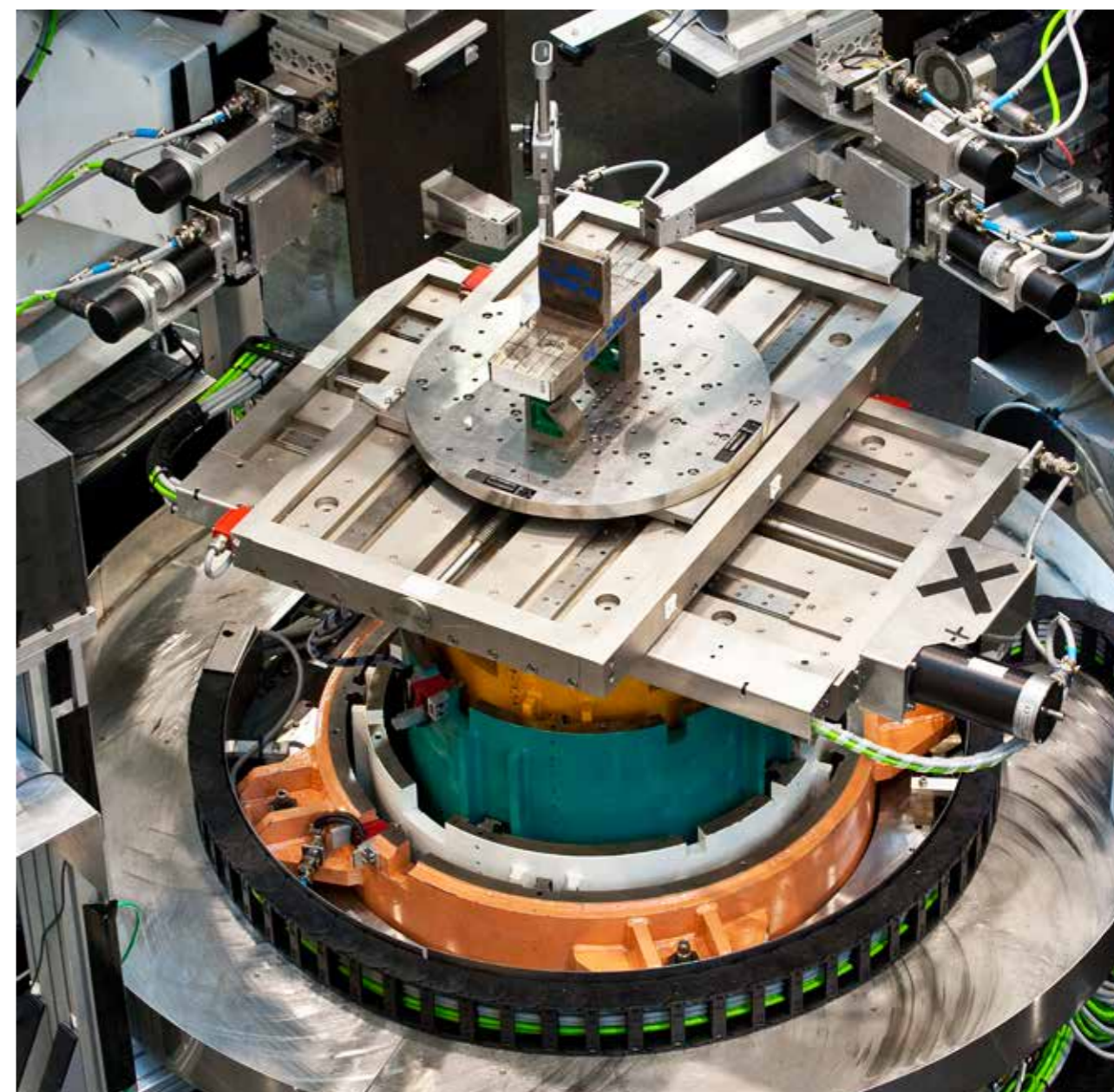
Kowari helps improve power turbine blades

Kowari is one of the instruments operated by ANSTO's Bragg Institute. Researchers from the Bragg Institute and their research partners use Kowari and the unique properties of neutrons produced by the OPAL reactor to look at the structural integrity of turbine blades used in power stations.

Neutrons are capable of penetrating deep into materials used in this crucial infrastructure and provide information about materials used in things such as turbines, bridges, pipes and aircraft engines. This information ensures

the safety of people using these materials, enables companies to maximise the efficiency of their assets, and provides them with knowledge about the best types of materials to use in the future.

Kowari is used for investigations into the structural integrity of large engineering components weighing up to 1000 kilograms and is just one of many instruments operated by the Bragg Institute to help solve scientific and industrial problems.



ANSTO's residual stress diffractometer or 'strain scanner', Kowari, can be used for a range of industrial applications from revealing residual stresses in welds such as rails, pipelines, airplanes, to investigating new materials.

Solutions for industry

A key player in the global microelectronic supply chain

Globally, ANSTO is the leading provider of silicon irradiation services for the microelectronics industry.

ANSTO Silicon has experienced strong growth in the last year and is now the leading global supplier of this important irradiation service.

ANSTO's silicon ingots are used in microelectronic switching devices in a range of applications such as power infrastructure, high-speed trains and to facilitate the development of energy from renewable sources such as wind.

Irradiating silicon, a process technically known as neutron transmutation doping, changes the electronic properties of silicon, making it more conductive of electricity.

During 2013 and 2014, ANSTO experienced unprecedented demand for silicon irradiation services from Asian and European companies, and this strong performance is expected to continue.



Silicon irradiated in the OPAL reactor is used by the microelectronics industry in hybrid cars and for renewable energy sources such as wind.

ANSTO Nuclear Medicine Project

Australia is set to become a very important player in health care internationally as a major supplier of the most commonly used nuclear medicine, Molybdenum-99 (Mo-99).

Mo-99 which decays to Technetium is the radioisotope used by millions of people around the world in nuclear medicine procedures for the diagnosis of heart disease and other diseases. Mo-99 gives off very small amounts of radiation that is picked up by gamma cameras, providing vital information for doctors seeking to understand how the body parts of patients are functioning.

ANSTO has long supplied the needs of Australians with Mo-99, but the global supply has come under threat in

recent years because of the closure of ageing research reactors worldwide. Since the OPAL research reactor is one of the newest and most reliable research reactors in the world, Australia is stepping up to fill the gap. With proposed major upgrades to these facilities, the ANSTO Nuclear Medicine Project is set to supply a very significant proportion of this growing world market and place Australia in a position of global leadership.





Australian Government



Discover more

Find out more about the important research being undertaken by ANSTO and its collaborators.

Take a tour

ANSTO's free Lucas Heights campus tours are suitable for novices to budding scientists, where you get to see our scientists at work.

School groups are welcome and there are several excursions available.

Bookings

 02 9717 3090  tours@ansto.gov.au



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Locations

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