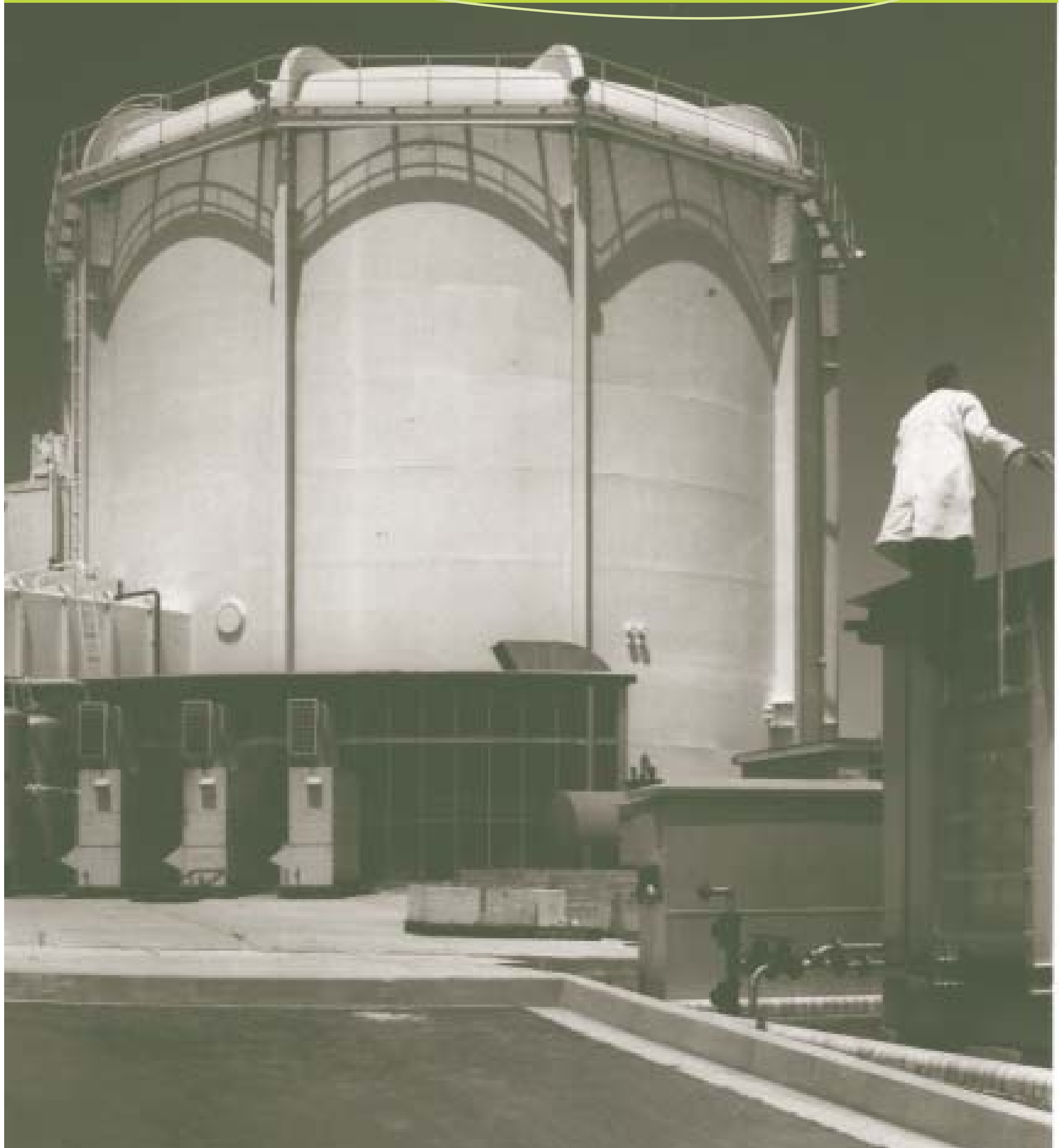
Celebrating 50 years of applying Nuclear Science to Daily Life



2003 ROYAL EASTER SHOW HANDBOOK

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INTRODUCTION by Prof Helen Garnett

WELCOME TO THE AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION (ANSTO) 2003 Royal Easter Show display. This year we have chosen a 1950s theme in order to celebrate the anniversary of fifty years of successful nuclear research and development in Australia. On 15 April 1953, the Atomic Energy Act was passed by Parliament. This allowed a program of scientific research and development of atomic energy for peaceful purposes to occur in Australia. Fifty years on, many people remain unaware of the widespread uses and benefits of nuclear based products in our daily lives. This is what we hope the "Daily family home" display demonstrates, in a manner that is fun as well as informative.

Many people are already aware of the important medical diagnostic and treatment procedures that would be impossible without radioactive materials. On average, every Australian will have a radioactive test at least once in their lifetime. Radioactive diagnostic tests have no physiological effect on the body at all. Indeed, the radiation dose is lower than that delivered by most x-ray procedures. Because of the extreme sensitivity of radiotracers, they are able to detect disease up to three years earlier than other methods like x-ray and ultrasound.

Medicines with safe low-doses of radiation are being used more and more, giving Australia first-class services for diagnosing and treating diseases such as cancer, hyperthyroidism and leukaemia. Well over 480,000 doses are administered in Australia every year.

As well as the important field of health and medicine, nuclear products and services are also used extensively in agriculture, industry and manufacturing, science, the environment, business and government and in our everyday life. Radioactive materials perform many tasks more quickly and easily, more precisely and more simply than non-radioactive materials. In many cases, there is no substitute for radioactive materials and radionuclides.

ANSTO's work has evolved and changed as Australia, and the world, has evolved and changed. Scientists at ANSTO are continually seeking new and better nuclear-based technologies across a very broad range of applications.

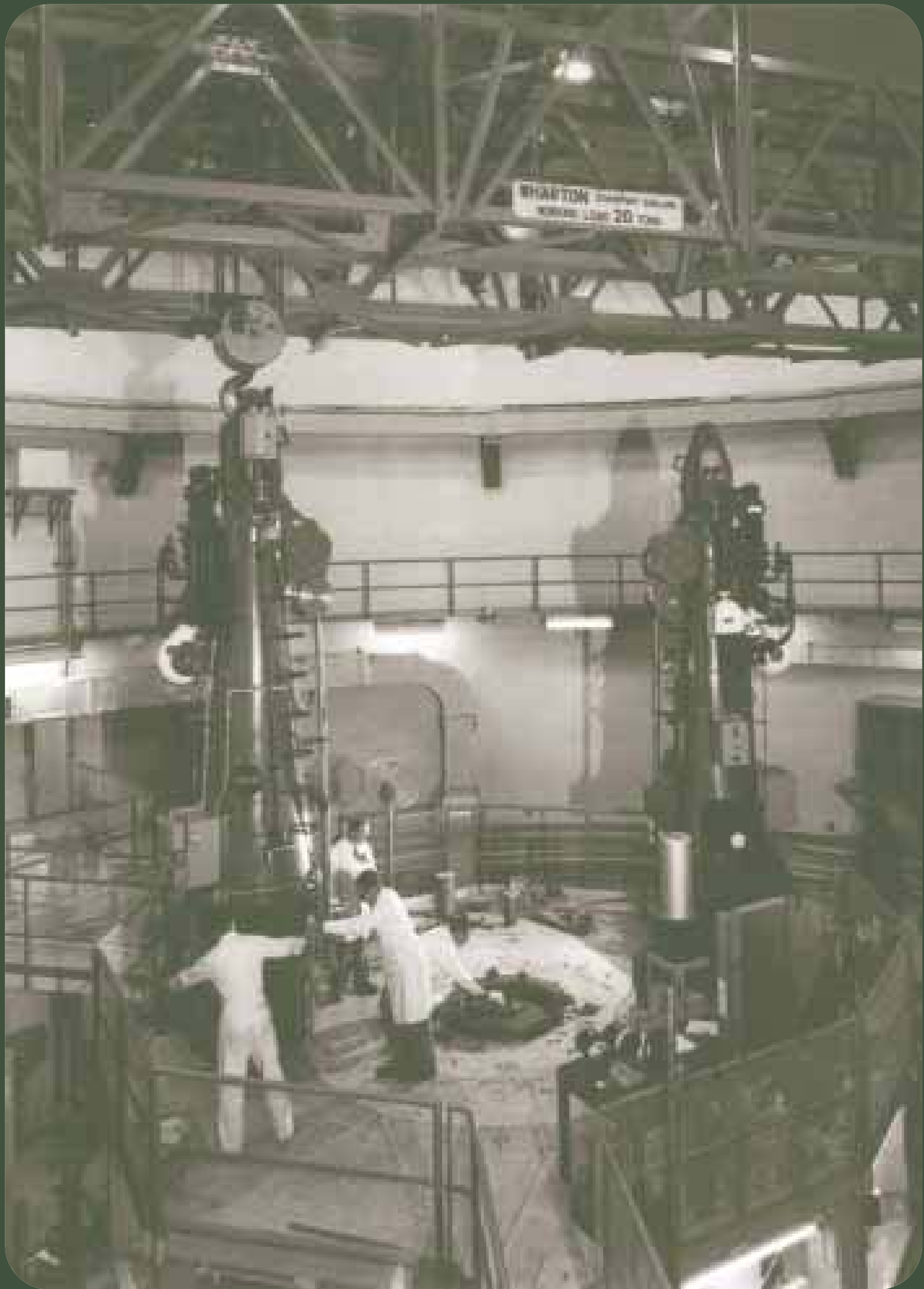
ANSTO's nuclear infrastructure includes the research reactor HIFAR (High Flux Australian Reactor), as well as particle accelerators, radiopharmaceutical production facilities, and a range of other unique research facilities. HIFAR is Australia's only research reactor. It is used to produce radioactive products for use in medicine, industry and environmental studies, as a source of neutron beams for scientific research and to irradiate silicon for computer chips and other electronic equipment.

The HIFAR research reactor has operated safely at Lucas Heights for 45 years. Following several major reviews into Australia's nuclear science and technology needs, the Federal Government decided in 1997 to fund an ANSTO proposal to replace the original HIFAR research reactor with a new, world-class facility to also be located at the Lucas Heights Science and Technology Centre.

The replacement research reactor, currently under construction, will have enormous potential for unlocking knowledge associated with biotechnology, engineering, materials, and environmental science. It will also allow Australia to keep up with medical research and provide new reactor-produced nuclear medicine treatments.

I hope you enjoy your visit through the "Daily" family's 50s-inspired home and that you find your interest in nuclear products and research is stimulated by the experience. The display and this accompanying booklet provide only an introduction to the work of ANSTO. We hope that you will also visit our website www.ansto.gov.au to learn more. You may also like to join the thousands of people who visit ANSTO's Lucas Heights Technology Park every year for a guided tour. Tours are free and can be booked by phoning 9717 3626.

Professor Helen Garnett
ANSTO Chief Executive



Interior of HIFAR *December 1963*

MAX DUPAIN 1911-1992

ONE OF AUSTRALIA'S MOST IMPORTANT, influential and prolific photographers, Max Dupain worked from studios in Sydney from the early 1930s until his death in 1992.

Dupain is often studied in Australian schools and is increasingly revered in the artistic and photographic community. His exhibition images have become well known and his famous shot "Sunbaker", taken of a friend relaxing on a New South Wales South Coast beach in 1937, is now an instantly recognised icon and a symbol of Australian culture.

What is not so well known is that Max Dupain ran a successful commercial photography studio all his working life, with many clients from such diverse fields as advertising, magazines, fashion, corporate, industry and architecture.

From the beginning of his career Dupain was intrigued by industry, machines and man-made construction. The twentieth century saw an acceleration and proliferation of all these things, and Dupain was on-hand to capture many of Sydney's twentieth century achievements in his own beautiful and inimitable style.

Dupain's strong style of composition and analysis of form proved to be perfect for architectural representation. Rising architects such as Harry Seidler and Arthur Baldwinson began using Dupain from the early 1950s.

When construction of the Sydney Opera House commenced in 1958, Max Dupain was immediately commissioned to photograph it. He continued to document progress on the Opera House for the next 13 years.

Max Dupain's first commission at Lucas Heights was in May 1960 when he was hired by the Australian architectural firm, Bunning and Madden, to photograph some of the distinctive buildings it had designed for the site.

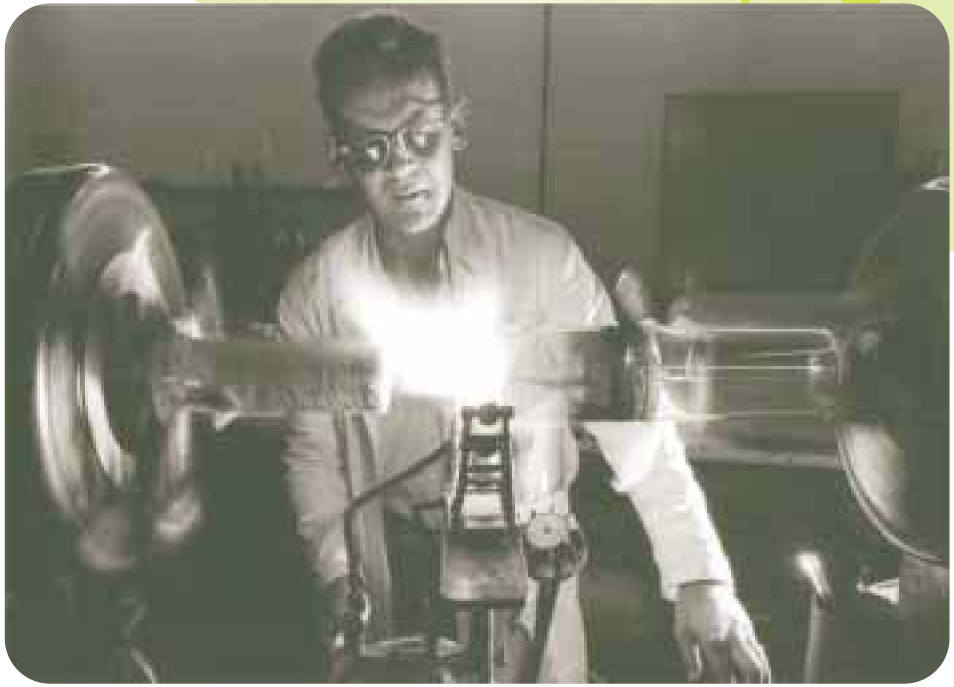
Between May 1960 and August 1972, Dupain returned to Lucas Heights ten times to work, three times again for the architects and on seven occasions for the Atomic Energy Commission (now ANSTO). On a separate visit to Coogee in November 1964, Dupain documented both the contemporary and historic Atomic Energy Commission head office buildings in Beach Road, drawing striking juxtapositions between the old and new styles of architecture.

ANSTO was pleased to rediscover these Max Dupain prints of various aspects of our nuclear facility at Lucas Heights on a recent search of our archives. We are proud to be able to place them on public display here at the 2003 Royal Easter Show for the very first time.

ANSTO gratefully acknowledges the assistance of Eric Sierins at Max Dupain and Associates in compiling this information.

INTRODUCTION

Radiation is energy. It occurs naturally in many forms. It comes from both natural and man-made sources. Light that allows us to see, and the warmth we get from the sun or from a fire, are natural forms of radiation. Examples of man-made radiation include the microwave radiation that is used for cooking and radio waves used for communication over long distances. Higher energy "ionising" radiation also comes from both natural and man-made sources. It comes from outer space, the sun, the earth, the air and our food and drink, and from building materials such as concrete, bricks and mortar. This is the natural background radiation to which everyone is exposed.



A glass blower at work making special-purpose vessels

Radioisotopes are atoms with a nucleus containing an unstable combination of neutrons and protons. Such combinations can occur naturally, or can be produced artificially by altering the atoms, using a cyclotron or neutrons from a nuclear reactor. Such atoms give off radioactive energy and are called radioisotopes.

Scientists have developed safe ways of using radioactive material for a number of purposes. Nuclear medicine uses man-made radioactive material which emits gamma rays and other radiation. In industry, radioisotopes are commonly used for analysis, quality control and safety checking of both equipment and/or processes. Radioisotopes are playing an increasingly important part in Australian life.

Neutrons are an ideal tool for probing the structure of solids and liquids. Neutrons generated by research reactors such as HIFAR are scattered by atoms in the material being probed to reveal the sample's atomic and magnetic structure. Neutron scattering also enables researchers to learn how new materials can be fabricated, because materials can be studied under conditions of extreme heat, cold or pressure.

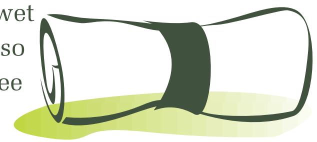
Neutrons are especially useful in studying the structure of materials made from light elements such as ceramics and polymers (plastics). Neutron science continues to support the development of new materials for use in the home and industry.

Precision Measuring in Manufacturing

PAPER:

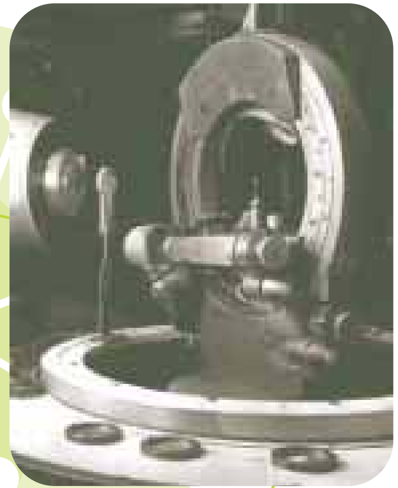
Radiation penetrates matter. Radionuclide "thickness" gauges are used by thousands of different industrial companies to measure many different types of sheet materials as they come off the production line.

The thickness of paper is continuously tested during its manufacture by the use of beta particles. The felt used to support the wet paper pulp in the first stages of paper production is also measured by radionuclide gauges. The gauges guarantee the felt remains the same thickness – very important for the high speed paper machines to work efficiently.



The variety of paper products that are measured in this way ranges from newsprint to bond paper and from tissue paper to boxboard.

Exterior of canteen designed by Bunning and Madden *May 1960*



The first computer controlled 4-circle Neutron Diffractometer at HIFAR *July/Aug 1972*

Atomic Energy Commission Head Office Buildings, new and historic, Beach St, Coogee *Nov 1964*

All photographs in this publication, except Professor Garnett's picture on the inside cover, are Max Dupain originals.

SOFT DRINKS:

Radionuclide gauges are also used to measure the level of liquid in cans of soft drink on a conveyor belt, at a rate of thousands of cans per minute.

STEEL PLATES:

Modern steel rolling mills could not manufacture steel plate without accurate, continuous measurement of thickness by radionuclide devices at every stage of production.

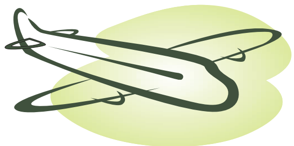
OTHER PRODUCTS:

Adhesive tape, brass plating, chemicals of many types, coke and coal, detergents, floor coverings, jet engine fuel, molten aluminium, glass and scrap irons, petroleum, plastic, rubber, stainless steel, surgical adhesive, tyre fabric, vinyl wall coverings and wood chips.

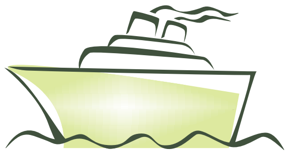
Aircraft and Ships

Another important application made possible by the ability of radiation to penetrate matter is radiography – or radiographic inspection. This well-established technique consists of taking a picture of gamma rays which pass through an object. In this way, it is possible to search for defects in a casting or weld. Just as an x-ray allows a doctor to obtain a detailed picture of a bone fracture, an industrial x-ray examination permits the foundry worker to obtain a detailed picture of an internal crack in a metal casting.

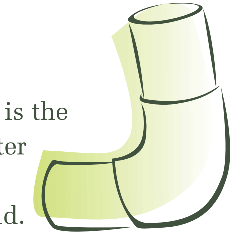
In Australia, both civil and military aircraft are inspected by radiography during their regular maintenance schedules. Jet engines are checked for correct functioning by remotely exposing a radioactive source inside the engine and creating an image on a film. The exposed film can then be examined to identify any faults in the engine. This technique requires an isotopic gamma source. Such sources are made at ANSTO.



Aircraft manufacturers require radiographic inspection of all wing structure components on commercial aircraft. Similarly, shipbuilding firms require radiographic inspection of up to 10,000 welds on a single hull.



Pipelines



The most frequent application of gamma radiography is the inspection of the welds in high-pressure, large diameter pipelines. A radioactive source is placed inside the pipe and the film is attached to the outside of the weld.

For examining pipelines that are hundreds of kilometres long, sophisticated, self-propelled crawlers which actually travel in and along the pipe are used. Virtually all new natural gas or oil pipeline systems are checked with this kind of radiographic inspection equipment.

Oil, Petrol and Gas

Radionuclides have been used in a variety of ways in oil exploration for many years. They provide the only convenient means of locating and evaluating underground flow patterns. Radioactive material measurement can help determine the best location for an oil well and is important in reducing the costs of oil exploration.

Radiographic techniques are used extensively in inspecting petroleum and gas pipeline welding. The petroleum industry also uses density and liquid level radioactive gauges.

When testing motor oils and lubricants, oil companies use radioactive tracers to measure friction wear in a petrol engine without dismantling the engine or even stopping it. This method of measuring wear and tear is much quicker than other methods and more can be learned in a few hours than used to be possible by running an engine for a month!

Car Tyres

Car tyres are irradiated to increase their strength. The vulcanisation of rubber sheet using gamma radiation instead of sulphur is used by several tyre manufacturing companies.

Vulcanisation changes the physical properties of rubber, making it tougher.

Smoke Detectors

Modern smoke detectors are based on radiation emitted from a small amount of a radioactive element called americium-241. A voltage applied to two plates forms an ionisation chamber inside the detector.

The americium-241 is used to ionise the air between the plates, causing a current to flow. Smoke particles entering the cell impede the ions and reduce the current. This change triggers the smoke alarm. These devices are extremely sensitive and their reliability is unsurpassed. They are widely installed in all types of buildings.

Radiation Sterilisation

Medical products, such as surgical dressings, sutures, catheters and syringes must be sterilised. Many of these products incorporate heat-sensitive materials such as plastic bases and cannot be subjected to conventional sterilisation by steam or dry heat. Sterilisation by ethylene oxide gas or other chemicals may introduce hazardous residues. Sterilisation by gamma rays has proven to be highly effective, inexpensive and safe for these types of products.

Disposable nappies are safely irradiated in this way to ensure they are sterile before being placed on a baby's sensitive skin.

ANSTO also helps hospitals by sterilising artificial body parts such as hips.

Wine

When growing plants such as wine-producing grapevines – which need just the right amount of water at just the right time – an accurate soil-monitoring device is required. The nuclear moisture probe is the most effective method available.

These moisture detectors contain radioisotopes. Neutrons are emitted from a source as fast neutrons. When they bounce off the hydrogen atoms in water molecules they become much slower. Some of the neutrons will be scattered back into the slow neutron detector incorporated in the instrument. When the number of outgoing fast neutrons and the number of incoming slow neutrons are compared, the moisture content of the soil can be calculated.

A neutron source and detector are incorporated in a cyclindrical unit. This is lowered to various depths in aluminium tubes placed in the ground at different locations in the area to be monitored. A portable battery operated power supply and monitoring unit are located on the surface.

At critical times in the growth cycle of the vines, moisture measurements are taken in the field, the results downloaded into a computer and a log is kept of the moisture content of the soil. Irrigation is then tailored to suit the crop's needs, without wasting water.

Neutron moisture gauges help farmers improve their irrigation methods and reduce water consumption by up to 40 per cent.

Fruit Flies

The major way of controlling insects without the use of chemicals is the Sterile Insect Technique. Male insects are sexually sterilised using gamma radiation and released into the native population. When the sterile insects mate with the wild insects, no offspring are produced. This approach is environmentally friendly and has been widely and successfully applied throughout the world.

The fruit fly is the most serious insect pest of fruit and vegetable crops in Australia. The damage is caused by the female laying her eggs in the fruit. These hatch into small white grubs that feed on the fruit until they are ready to pupate.

ANSTO sterilises millions of laboratory-bred Queensland fruit flies before they become adults.

The 10 to 15 million sterilised flies that are released every week in the main southern fruit growing area ensure that few females lay fertile eggs and the larvae numbers are kept low. The irradiated fruit fly do not become radioactive and pose no threat to people who may come into contact with them.

Controlling insects with chemicals can create environmental problems and result in toxic residues in food. In addition, many insects have developed resistance to insecticides, thus requiring continually greater amounts of insecticide for control.

ANSTO has a highly accurate in-house irradiation facility that is unique in Australia. It guarantees that the laboratory-bred fruit flies get the precise, short burst of radiation needed to make them infertile while ensuring they remain virile. No harm is done to other wildlife and the possible human health risks that accompany insecticide spraying of fruit are avoided.

Coal Fuelled Power Stations

Coal fuelled power stations use radioisotopes to monitor the state of furnaces used to produce electricity. Small sources of cobalt 60 are embedded at different depths from the outer surface of a furnace. As the lining of the furnace deteriorates and collapses inwards, which is normal, the remaining thickness of lining can be monitored.

Radioactive materials methods have also had significant impact on controlling atmospheric emissions. Radioactive measurements and on-stream analysers are also used for monitoring and controlling the ash and moisture content in coal and coke.

Bone Imaging (Nuclear Scintigraphy)

Bone imaging or nuclear scintigraphy is ideal for diagnosing stress fractures of bones as well as osteoarthritis and bone infections.

This procedure requires a gamma camera, commonly used in nuclear medicine facilities around Australia, along with radioisotopes produced by ANSTO's HIFAR research reactor.

A radioactive isotope is combined with a bone-seeking molecule. This is then injected into the body of the patient. The bone-seeking molecule carries the radioactive flag into the sites where natural bone rebuilding is taking place. This is detected by a gamma camera which builds up a computer enhanced image which can be viewed by the doctor or veterinarian.

Even when a very small number of radioactive atoms are concentrated in one spot, abnormalities will frequently be seen against the tissue background. For this reason it is a good test for stress fractures, which are difficult for x-rays to detect.

Stress fractures of bones are a common, expensive and dangerous problem for racehorses. Veterinarians and thoroughbred trainers are now using nuclear scintigraphy to successfully diagnose and treat their horses before costly or fatal injuries can occur.

Nuclear scintigraphy is recognised as a crucial component in the ongoing fight against cancer as it can predate x-ray discovery of the disease by as much as two years. Various other medical conditions can be difficult or impossible to identify with other methods such as x-ray or ultrasound.

Nuclear scintigraphy accounts for a significant proportion of all nuclear medicine investigations in hospitals.

Chocolate

In order to improve quality, taste and shelf-life, scientists from ANSTO have been examining chocolate to find better manufacturing techniques.

The "SANS" instrument is used to investigate the size, shape and distribution of molecules in a large range of materials including chocolate, using a technique known as neutron scattering.

A neutron is one of the fundamental particles that make up matter. They are only one-thousandth the size of the smallest atom, yet they can easily travel through centimetres of solid steel. This uncharged particle exists in the nucleus of all atoms (except hydrogen).

Beams of neutrons produced by the HIFAR research reactor can provide a different view of the microscopic world by reflecting off planes of atoms in the material being probed. The reflection pattern reveals the material's molecular structure.

Chocolate is placed in a specially designed cell where the temperature can be raised or lowered and the cocoa butter mixed at different speeds. A beam of neutrons scatter from the microscopic particles in the chocolate and provide the scientists with information on the size and shape of the particles. Detailed information about the way factors such as temperature and mixing affect the cocoa butter can be investigated.

It is known that cocoa butter can crystallise into six different arrangements of molecules. Some of these crystalline forms, or polymorphs, taste sensational. Scientists have discovered that the taste of chocolate depends on which crystalline forms predominate as the chocolate is prepared. They have now identified the one that tastes the best.

Bloodcells, plastic, paper, magnets, aircraft components – our understanding of anything with an atomic structure, can be improved by scientists using neutrons. ANSTO scientists are also investigating the impact of processes such as heating, mixing and fermenting on the molecular structure of various foods.

The neutron scattering technique was the subject of the 1994 Nobel Prize for Physics.

As for the future, eight neutron beam instruments are planned for Australia's replacement research reactor. The facility will have the capacity for further expansion, including potential for a second neutron guide hall. A suite of equipment will enable studies at different temperatures, pressures and magnetic fields.

Silicon Chips

Silicon irradiation or Neutron Transmutation Doping accurately changes the semi-conducting properties of silicon, by bombarding it with

neutrons for precise periods. Large, single crystals of silicon, shaped into ingots, are flown in from overseas for irradiation at the HIFAR nuclear research reactor. ANSTO is a major world supplier of this silicon irradiation service. The replacement research reactor is designed to cater for growing world demand for high quality, precisely doped silicon for the computer and electronic industries.

Drug Development

Radionuclides are used to obtain information on a drug to enable it to be evaluated in patients. This involves a complex set of experiments to determine the drug's toxicology, pharmacology and other factors. In these tests, drugs are labelled in specific ways by selected radionuclides and administered to volunteers. The subsequent location and activity of the labelled drug are determined by measuring the radioactivity in tissue, blood or excreted products at different time intervals. Drug tests using this method are known for their speed and accuracy as well as their economy.

Front cover photograph: Exterior of High Flux Australian Reactor at Lucas Heights *November 1963*

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