Australian Government

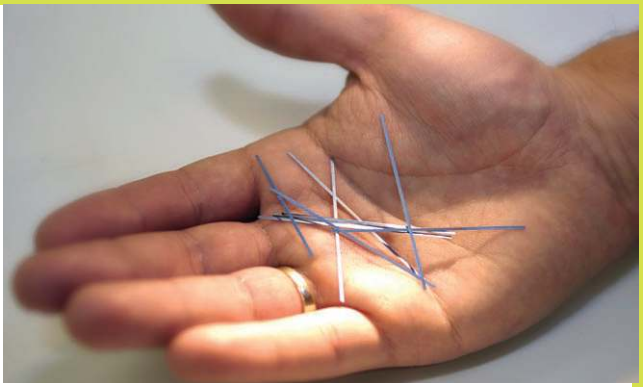
TRANSFORMING LIVES AND ECONOMIES TOGETHER

The United States is the world's undisputed innovation leader, but Australian ingenuity is helping to meet America's biggest challenges and improve the lives of its citizens every day. This is an introduction to a series of factsheets showcasing some of the successes of past and present US-Australian collaboration in science, and signaling future collaboration. **It's not a comprehensive account—just some of the people and transformational projects spanning a breadth of research areas.**

Australian Government

INNOVATION TODAY MEANS JOBS AND PROSPERITY TOMORROW

A factory in Boise, Idaho, is re-opening to make a new kind of solar cell invented at the Australian National University (ANU). In Pittsburgh, they're already making an 'ultra-battery' for storage of renewable energy, developed at Australia's national science agency, CSIRO. The technology will also be used in hybrid cars. **Texan cotton farmers are growing crops that use less water, less pesticide and produce better cotton, with the help of CSIRO-derived plant varieties.** In Nebraska, Cold War technology, adapted by Australian mining company BHP Billiton, is being used to find rare earth mineral deposits from the air. **In Hawaii, one of the world's largest optical telescopes uses an instrument built at ANU to analyze infrared light.** Across America, deaf children are hearing for the first time thanks to a cochlear implant or bionic ear invented and manufactured in Australia. **Young women have access to vaccines that prevent cervical cancer, because of the work of an Australian medical researcher at the University of Queensland.** And millions of people are connecting to the internet wirelessly, thanks to discoveries by CSIRO astronomer-engineers. **These are just a few examples of the way Australian and US science and innovation are working together to build a healthier, sustainable and more connected future for the people of both nations.**



Shared perspective, shared gains

With a population of 22.5 million, Australia has only about one-fourteenth the population of the US—but in the science and innovation sphere, Australia punches above its weight. With only 0.3 per cent of the world's population, Australia publishes about 3 per cent of the world's scientific papers. It spends 2.21 per cent of its GDP on research and development.

Australia and the 48 contiguous states of the US are about the same size, face similar environmental challenges, and have similar societies and perspectives on the world. Their respective national science programs are focused on many of the same areas—energy, resources, defense, health, climate change, materials, the environment. Given this, and the sheer scale of science and technology investment in the US, it's not surprising that the US is Australia's number one collaborator in science. In 2009, nearly one in six Australian papers listed a US co-author, and that level of cooperation is increasing.

The benefits to Australian science are obvious: being able to tap into and collaborate with the broad, top-level expertise and gain access to facilities in America; raising the profile outside Australia of its research capabilities and sophistication; and gaining access to a huge potential market for its research-based products.

But the US gains too, which is why Australia ranks eighth as a source of international co-authors for American journal articles in science and engineering. Collaboration provides a different perspective on areas of mutual interest, and access to a unique environment and facilities in the southern hemisphere and to world-class expertise in certain strategic areas such as Antarctic, climate and marine research, clinical medicine, astronomy and space science.

Solving practical problems

Australia's research scene features two large government science and technology bodies. CSIRO (Commonwealth Scientific and Industrial Research Organisation), established in 1926 as a scientific response to Australia's unique environment and place in the world, has an annual budget approaching AU$1.4 billion.

The Defence Science and Technology Organisation (DSTO), created in 1974 from a series of pre-existing defense laboratories, receives a budget appropriation of about AU$440 million. Other Government agencies include the Australian Nuclear Science and Technology Organisation, ANSTO (AU$369 million in 2010-11), the Australian Institute of Marine Science (AU$66.2 million in 2010-11), Geoscience Australia (AU$156 million in 2010-11) and the Bureau of Meteorology (AU$345.3 million in 2010-11).

The Government's annual budget for research and research training at the country's 41 universities is currently around AU$2.5 billion. Business sector expenditure on research and development in Australia has grown rapidly in the past 25 years, rising from 30 per cent of the country's total research expenditure to just over 60 per cent today.

One of the ways in which private enterprise has become more fully integrated in research is through the Cooperative Research Centres (CRCs) Program. The program supports end user driven research collaborations to address clearly articulated, major challenges facing Australia, many of which are global. CRC activities include research, utilization and commercialization, education and engagement with small and medium enterprises.

AUSTRALIA AND AMERICA'S SHARED VISION OF GROWTH THROUGH INNOVATION HAS IN THE PAST LED TO DEVELOPMENTS FROM THE NULKA HOVERING DECOY ROCKET WHICH PROTECTS SHIPS AGAINST INCOMING MISSILES, TO IMPROVEMENTS IN IVF TECHNOLOGY. IT CAN GENERATE NOT ONLY JOBS, BUT A BETTER FUTURE FOR BOTH COUNTRIES.

There are 42 active CRCs that operate across four broad industry categories: agriculture, forestry and fishing (11 CRCs), manufacturing (5), mining (4) and services (22). Since 1991, the Australian Government has committed more than AU$3.4 billion in CRC Program funding. Participants in CRCs have committed a further AU$11 billion in cash and in-kind contributions.

Creating jobs in technology

In Boise, Idaho, a high-tech manufacturing facility, shut down by Micron Corporation, is reopening. A joint venture between Micron and Australia's Origin Energy will make a new type of solar cell there, known as sliver cells. Developed at the Australian National University in Canberra, sliver cells provide significantly more power for the same price as conventional silicon cells.

In Pittsburgh, East Penn Manufacturing has secured a license and funding to make a new kind of battery for electric cars—the UltraBattery—which charges rapidly, lasts four to five times longer and slashes production costs by about two-thirds. It was developed by CSIRO.

Astronomy protects and connects America

Australian-developed technologies for astronomy are equipping US telescopes, and finding other applications such as earthquake monitoring.

The Canberra-based company Electro Optic Systems has developed instruments and sensors to detect, track, classify and characterize objects in space; makes remotely controlled weapon systems; and is involved in a strategic alliance with US-based global defense company Northrop Grumman.

And Australian technologies first developed for radio astronomy are now used to deliver fast, reliable Wi-Fi access to the internet.

Improving quality of life

While some of the areas of mutual interest where Australia is particularly strong are obvious, others may surprise some Americans.

Deaf people across America now hear using Australian-developed bionic ears, and hundreds of thousands of people with sleep apnea can rest more easily with devices invented in Sydney. New technologies are in the pipeline—from the bionic eye to home-fitted hearing aids for a fraction of the cost of traditional hearing aids.

Young women across America have the choice of two vaccines that work to prevent infection with a virus responsible for many cervical cancers, both based on work at the University of Queensland.

And Trident chewing gum can now actively repair tooth decay thanks to Recaldent, a product derived from casein harvested from milk in Australia, and also found in a range of dental products.

Other Australian achievements include: the world's first medicine for mental health—lithium to treat bipolar disorder; a major contribution to the development of the first widely available antibiotic, penicillin; and the Nobel Prize-winning discovery that stomach ulcers are caused by bacteria, not by stress.

Sustainable cotton and environmental protection

As in the US, there is also huge interest in Australia in agriculture and food security.

More than 35 per cent of the cotton grown in America is now provided by plants derived from varieties developed by CSIRO. The plants are high yielding, water efficient, disease resistant and produce high-quality fiber. In Australia these plant varieties have resulted in an 85 per cent reduction in pesticide use.

Other similar developments may well be in the pipeline if agreements signed by a Melbourne biotech company, Hexima, with the three largest agrichemical businesses in the US—Dow, Monsanto and DuPont—come to fruition. Hexima scientists have uncovered two families of genes which can protect plants against fungal and insect attack, and a mechanism for delivering their products to where the plant needs them.

US fisheries environments from California on the west coast to the Georges Bank and Chesapeake Bay on the east coast are now being managed using ecosystem models put together by researchers from the National Oceanic and Atmospheric Administration, US universities and CSIRO.

Australian, New Zealand and US researchers and fire fighters are collaborating to develop and employ the latest remote sensing technology to fight forest fires. The collaborations have been strengthened following the major wild fires in Victoria, Australia, and in California in recent years.

Finding tomorrow's mines

Australian mining giant BHP Billiton has redeployed US Navy technology that detects minute changes in gravity. Now known as Falcon, it is an airborne detector which can be used to scan the landscape for deep ore bodies. In Nebraska, it is being used to search for rare earth mineral deposits.

Meanwhile, CSIRO has just sold its LANDTEM system to Crone Geophysics in North America. The system detects ore bodies by sensing tiny differences in magnetism. It has already found new nickel sulfide and silver deposits worth billions of dollars.

THIS IS AN INTRODUCTION TO A SERIES OF EIGHT FACTSHEETS EXPLORING US-AUSTRALIAN COLLABORATION AND OUTLINING SOME OF THE WAYS THAT AUSTRALIAN SCIENCE IS CONTRIBUTING TO AMERICA'S SOCIETY AND ECONOMY.

IMAGE CREDITS: COCHLEAR IMPLANT PIONEER PROFESSOR GRAEME CLARK WITH RECIPIENT, COCHLEAR LIMITED; ASTRONOMER NAOMI MCCLURE GRIFFITHS AT PARKES, CSIRO; TROPICAL CYCLONE YASI, NASA GSFC/JEFF SCHMALTZ; SLIVER SOLAR CELLS, AUSTRALIAN NATIONAL UNIVERSITY; COTTON HARVESTER AT WORK, CSIRO; US NAVY OHIO-CLASS SUBMARINE, US NAVY/LT REBECCA REBARICH; MONTANA COPPER MINE, ISTOCKPHOTO; GARDASIL PROMOTION, CSL; SILVER JACK SHOAL, ISTOCKPHOTO.

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Department of Innovation
Industry, Science and Research

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SLIVERS OF SUN: CLEAN ENERGY AND SMARTER MINING

Australia's investments in energy and resource research are helping the world go green, and creating jobs in America's heartlands. The world's largest manufacturer of photovoltaic cells depends on Australian technology, and US companies are working on turning Australian ideas into practical electric cars and sustainable plant-based fuels. **Over the last 20 years Australia has been able to meet the rapidly growing demand for minerals and energy in China, India and other Asian countries through a culture of innovation that has over the past 150 years changed the very shape of mining.** Two recent innovations—one sourced from US military technology—are assisting in the search for new mineral and energy reserves in America and across the world.


Slivers of the Sun

Australia and the US have a long history as world leaders in solar research. In fact, researchers from the University of New South Wales (UNSW) in Sydney, the National Renewable Energy Laboratory in Colorado and Emcore Corporation in New Mexico have created the world's most efficient solar cell combination. And the world's largest photovoltaic cell manufacturer, Suntech Power of China, as well as companies in Europe, use Australian technology to develop their businesses.

Now, the new technologies are creating jobs in America. In June 2010, Transform Solar—a joint venture between US company Micron Technology and Australia's Origin Energy—announced it will reopen a plant in Boise, Idaho to make efficient, new, sliver solar cells. As a consequence, the city looks like regaining many of the 3,000 jobs it lost when the factory closed.

Sliver cells were invented at the Australian National University (ANU) by Dr Klaus Weber and Professor Andrew Blakers. A single flat wafer of silicon is cut vertically into thousands of slivers. These are rotated 90 degrees and laid side by side to create a solar cell. The much larger and thinner active surface generates current on both sides, and the result is more power for about the same cost.

UltraBattery drives cars further

The UltraBattery, invented by CSIRO and launched in 2008, has brought the conventional car battery into the era of low-emission transport and renewable energy storage. By combining lead-acid technology with a supercapacitor, the UltraBattery not only charges and discharges rapidly, but lasts four to five times longer than an ordinary battery. It also costs about 70 per cent less to produce than the nickel-metal hydride batteries normally used in electric vehicles. These properties, while especially useful for electric vehicles with regenerative braking, also are excellent for capturing and storing electricity produced from intermittent renewable sources, such as solar and wind power. In 2009, as part of a package to accelerate the production of advanced battery technology for electric and hybrid vehicles, the East Penn Manufacturing Company was awarded US$32.5 million under the *American Recovery and Reinvestment Act* to produce the UltraBattery.

Growing aircraft fuels

Aircraft manufacturer Boeing and California biotech company Amyris have joined the Queensland Government, the University of Queensland, the airline Virgin Blue, and several other companies in exploring the possibilities of producing aviation fuel sustainably using green algae. The project is based on the work of Associate Professor Ben Hankamer from the University of Queensland's Institute of Molecular Bioscience and his team, who have had great success in improving the efficiency of the process.

At the Queensland University of Technology, Syngenta Biotechnology Inc of North Carolina and Australian company Farmacule are using molecular technologies to develop efficient ways of producing the transport fuel and chemical feedstock bioethanol from the sugarcane residue known as 'bagasse'. The process is complicated and involves employing a string of enzymes to break down cellulose. But if the researchers get it right, the applications will extend to plant resources far beyond the waste generated by the sugar industry.

Finding tomorrow's mines from the air

In the 1990s, Australian resources company BHP recognized that a sensor that measured minute changes in gravity, and hence density of the Earth below, might be useful as a means of discovering potential ore bodies in remote areas.

In 1999, BHP obtained a license to adapt to mineral exploration technology that originally had been developed by Lockheed Martin for the US Navy to help submarines avoid seamounts. The airborne sensor, which BHP named Falcon, has been responsible for discovering new diamond pipes in northwest Canada, and has assisted in detecting iron, copper, gold and coal deposits elsewhere.

Magnetic squid

Another Australian technology already out in the marketplace makes use of superconducting quantum interference device or SQUID technology that can detect extremely small magnetic fields. Known as LANDTEM and developed by CSIRO, the sensor, a high-temperature superconductor that must be stored in liquid nitrogen, is sensitive enough to detect the difference between an ore body and overburden. In less than 10 years the technology, which cost just AU$4 million to develop, has been directly responsible for helping to unearth about AU$6 billion worth of previously undiscovered ore bodies.

Mining with bubbles

In the 19th century, miners at Broken Hill in far western New South Wales pioneered the use of bubbles to separate minerals from their ores. This ubiquitous technology was modernized in the 1980s with the creation of the Jameson Cell by Dr Graeme Jameson at the University of Newcastle and Mount Isa Mines. The Vigo and A.T. Massey coal companies in Indiana and West Virginia respectively are among hundreds of mines worldwide now using this system marketed by Xstrata Technologies.

Making virtual minerals

Researchers at the University of Sydney led by Professor Dietmar Müller are collaborating with colleagues at Caltech, the Scripps Institution of Oceanography and the University of Hawaii to develop a Virtual Geological Observatory. The facility will store data on rocks, processes and movements over geological time and use this information to simulate mineral formation. In future, this technology will help in the detection of mineral deposits underground.

New extraction technologies

Once a new mineral deposit has been found, the next challenge is to determine which minerals you can extract and at what cost. The Australian Nuclear Science and Technology Organisation (ANSTO) has for the past 30 years been helping mining companies assess and develop processes for uranium ores, extract rare earth metals, and remove radioactivity from ores. This work has contributed to mining projects around the world, including the US.

Mopping up gases

A bright young researcher in the area of carbon capture is Australian chemist Dr Deanna D'Alessandro. Dr D'Alessandro, who has returned to the University of Sydney as a postdoctoral research fellow after a postdoctoral fellowship at the University of California, Berkeley, has constructed crystals full of minute pores. One teaspoon of the most effective of her chemicals has the surface area of a football field. What's more, the size and shape of the pores can be customized using light. So, she believes she can create molecular sponges that will mop up carbon dioxide, hydrogen, or almost any gas, and then release it on cue.

IMAGE CREDITS: KLAUS WEBER (LEFT) AND ANDREW BLAKERS (RIGHT), INVENTORS OF SLIVER SOLAR CELLS, ANU; ULTRABATTERY AT WORK, CSIRO; DR DEANNA D'ALESSANDRO, L'ORÉAL/SDP MEDIA; TUCSON COPPER MINE, ISTOCKPHOTO.

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DELIVERING SUSTAINABLE AGRICULTURE AND BIOSECURITY

Across America's Deep South, farmers are growing Australian-derived cotton and, as a result, slashing their use of pesticides. It's part of a global drive to increase production and sustainability involving Australian and American researchers, and agritech giants such as Monsanto, Dow Chemical and DuPont. **All these companies have agreements with Australian researchers helping to develop the next generation of smart crops.** The underlying technologies are being applied to dozens of crops and even to medical research. **Meanwhile, US and Australian scientists are working side by side to enhance biosecurity—fighting deadly new killers such as Nipah virus, ancient plagues such as malaria, and emerging threats to agriculture and the environment.** American scientists working in Brisbane are testing biological controls to fight against invasive plants that threaten the Florida Everglades, while NASA technology is helping Australia cope with its locust plagues and teams across both countries are trying to understand what is killing frogs worldwide.

Smart, sustainable crops

The southern US states are famed for their cotton fields, but what many of the farmers there might not realize is that their plants are likely to be derived from Australian varieties developed by CSIRO. These varieties are high yielding, water efficient, disease resistant and produce high-quality fiber, and with the incorporation of GM technologies, are pest resistant. CSIRO-derived varieties account for more than 35 per cent of the US cotton crop, and over 60 per cent in Texas. In Australia these varieties have resulted in an 85 per cent reduction in pesticide use.

US companies are already investing in one of the more promising next steps towards improved crops with Hexima, a biotechnology company in Melbourne.

Hexima is based on the discovery of two families of genes that help protect plants from fungus and insect attack. Hexima scientists, led by plant molecular biologists Professor Adrienne Clarke and Professor Marilyn Anderson, have found a third gene complex that plants use to make, package and release a set of protective proteins that help them to fight off invaders. The team has found a way to hijack this system, inserting genes so that the plants will produce any set of proteins the researchers want. Their work is considered so important for future agriculture that Hexima has concluded agreements with the three largest US agrichemical businesses, DuPont, Dow and Monsanto.

Meanwhile, underlying tools developed by CSIRO, such as gene shears and gene silencing in plants, have become part of the molecular biology tool kit for researchers worldwide.

Fighting back against emerging diseases

When the Hendra and Nipah viruses emerged, killing people and animals in Australia and Southeast Asia, the virologists at CSIRO's Australian Animal Health Laboratory (AAHL) were thrown into the front line. With support from their colleagues at Centers for Disease Control in Atlanta and the US Department of Agriculture's (USDA's) Plum Island facility, they quickly identified the new viruses, and showed that bats were the carriers.

AAHL is one of the world's most sophisticated biological containment facilities, capable of working with large animals at the highest biosecurity levels. It's been kept busy in recent years responding to emerging threats such as SARS (severe acute respiratory syndrome), chikungunya virus, and the chytrid fungus currently devastating frog populations across the world. At the same time, it continues to develop better tools to fight ancient threats such as foot-and-mouth disease.

Protecting grapes and fighting locusts

Through the Cooperative Research Centre for National Plant Biosecurity (CRCNPB), Australian researchers are working with Cornell University to trial a new pruning regimen for grape vines to control the destructive black rot caused by the fungus *Guignardia bidwellii*. CRCNPB also is testing NASA's Terrestrial Observation Predictive System as a way to assess the growth stage of crops and predict where plague locusts are most likely to spread.

Saving the Everglades

Many invasive weeds in the US, particularly in Florida, originated in sub-tropical and tropical Australia or Southeast Asia. So, since 1985, the US has maintained an Australian Biological Control Laboratory as a base for searching the region for useful biological control agents and testing them. The laboratory currently is based at CSIRO's Brisbane facility and operated by the USDA.

People

A vision for smarter crops

A Foreign Associate of the US National Academy of Sciences and former head of CSIRO Plant Industry, Dr Jim Peacock is a passionate advocate for the power and potential of genetic manipulation of plants as a means of improving agricultural production while reducing its environmental impact. Under his direction, CSIRO has developed many new plant varieties and a range of tools for improved plant breeding.

Dr Peacock is also a former Australian Chief Scientist, former President of the Australian Academy of Science and an Australian Prime Minister's Science Prize winner.

Plants that do their own weeding

Professor Leslie Weston holds patents for bioherbicides in grass and is working toward turf and pasture grasses that would directly suppress weeds—a lawn that weeds itself. Previously based at Michigan State University, Professor Weston is the Strategic Professor of Plant Biology at Australia's rural Charles Sturt University. She has become an expert on the ecology and biology of invasive weeds and their long-term impact on Australian ecosystems.

Fighting mosquitoes with bacteria

An entomologist from Queensland, Ms Bodil Cass was part of a team led by Professor Scott O'Neill at the University of Queensland that showed the bacterium *Wolbachia* could be introduced into and shorten the lives of the mosquitoes that carry yellow fever and dengue fever viruses. This restricts the capacity of these mosquitoes to transmit disease. Because of this potential, the project has received funding from the Bill and Melinda Gates Foundation. Ms Cass is studying for her PhD at the University of Arizona, investigating the interactions of symbiotic bacteria living inside insect pests and their impact on biocontrol programs.

IMAGE CREDITS: PHD STUDENT ELENA VIRTUE AT THE AUSTRALIAN ANIMAL HEALTH LABORATORY, CSIRO; COTTON FIELD READY FOR HARVEST IN VIRGINIA, ISTOCKPHOTO; RED-EYED TREE FROG, ISTOCKPHOTO; EVERGLADES NATIONAL PARK, ISTOCKPHOTO.

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UNDERSTANDING AND RESPONDING TO CHANGING CLIMATE

From the poles to the tropics, researchers from Australia and the US are working together to watch and understand our changing natural world. America's constellation of earth observation satellites plays a critical role in monitoring Australia's changing climate and land use. **During bushfire, flood and cyclone emergencies the information they provide is critical to Australia's emergency response.** The air sampled at remote Cape Grim on Tasmania's northwest coast and Australia's ice core research are two examples of Australia's contribution to NASA and the US National Oceanic and Atmospheric Administration (NOAA) efforts to understand and predict the planet's changing climate. **Australia and the US both encompass a huge range of terrestrial and marine ecosystems.** Australia's experiences in dealing with fire, drought and natural disasters are helping to give US researchers a different perspective on some of the challenges of America's changing climate and environment.

Remote sensing in natural disasters

Emergency response managers are able to track the course of natural disasters such as fires, floods, earthquakes and storms and plan with increased accuracy thanks to software developed by Associate Professor Linlin Ge and his team at the University of New South Wales in Sydney. The software allows data from interferometric synthesis aperture radar (INSAR) satellites to be pulled together rapidly and automatically to generate high-resolution maps. The maps reveal ground movements, and predict likely damage to vital infrastructure such as buildings, roads, railways and bridges.

The team's work has led to the establishment of an international network of national remote sensing agencies that collaborate in times of emergency management. The network began spontaneously in 2008 when Associate Professor Ge and his team, confronted by the enormity of the Sichuan earthquake in China, helped local rescue workers by providing satellite images constructed from Japanese data.

Cape Grim's clean air—monitoring global climate change

Australia provides baseline climate data to the rest of the world through its monitoring station at Cape Grim at the extreme northwest tip of Tasmania. As well as monitoring carbon dioxide, methane and a range of atmospheric trace gases, scientists at Cape Grim measure concentrations of natural and pollutant particles. Because of Cape Grim's remoteness from population centers (Argentina is the only landmass west of the Cape), the collected data represents as close as scientists can measure to a global average. The monitoring station is managed jointly by Australia's Bureau of Meteorology and CSIRO.

Keeping a weather eye out

In addition, CSIRO has made a long-term contribution to improved climate prediction through monitoring the Southern Ocean since 1994. The world's largest current, the Antarctic Circumpolar Current, flows around the Southern Ocean connecting the three major ocean basins—Pacific, Indian and Atlantic—redistributing heat, affecting temperature and rainfall, and making a huge impact on the world's climate.

Through agreements with NOAA, NASA, and the Scripps Institution of Oceanography in San Diego, a ground station in Hobart in the southern island state of Tasmania, operated by the Australian Centre for Remote Sensing, has been downloading climate-relevant data from passing US polar orbit satellites.

One thousand new species found—understanding coral reefs

In the tropics, researchers at the Australian Institute of Marine Science (AIMS) are working with counterparts in the US to discover and document life on coral reefs and monitor the impact of climate change. AIMS, NOAA and the Smithsonian Institution lead the three nodes of CReefs, the coral reef component of the Census of Marine Life. CReefs aims to discover and explain the diversity, distribution, and abundance of life in coral reef ecosystems, and improve access to and unify this information. Already, more than 1,000 previously undocumented species have been discovered on Australia's Great Barrier Reef, along the east coast, and Ningaloo Reef, off the west coast, as part of the project.

Fixing the plumbing—water conservation

Along with susceptibility to forest fires, large areas of Australia and the US also are prone to drought and water shortages and the two countries have long collaborated on water research. The recent development of a Memorandum of Understanding on Environmental Water Cooperation between the two countries tackles an interesting consequence of water conservation. As the water efficiency of plumbing fixtures increases, there has been a significant reduction in the flows moving through the sewer system, increasing the concentration of waste and creating challenges for existing processing facilities. The memorandum covers joint research to be conducted in this area.

Elvis to the rescue

Each year, the 'Elvis' air-crane and other giant firefighting helicopters migrate south from America to Australia, where they have saved many Australian lives and properties. American fire fighters and fire investigators have also been helping on the ground, especially following Victoria's Black Saturday bushfires in 2009. And the cooperation works both ways, with Australia contributing both firefighting expertise and research support in response to recent Californian wildfires. A meeting organized by Australia's Bushfire Cooperative Research Centre in June 2010 has helped to broaden and formalize this collaboration, as researchers and fire managers from the US, New Zealand and Australia came together to share their knowledge and plan future collaborative work.

People

Fishy business

Dr Beth Fulton, based at CSIRO Marine and Atmospheric Research in Hobart and a former winner of the Prime Minister's Life Scientist of the Year award, is a world leader in modeling marine ecosystems. Dr Fulton works regularly with researchers from NOAA and US universities. Together they have developed management models for marine life along much of the west and east coasts of continental US, and now are studying the Gulf of Mexico and Hawaii.

Snow complications

The US and Australia maintain significant collaborative research programs in Antarctica, drilling ice cores that provide a detailed historical record of climate, and measuring the extent and thickness of the sea-ice, which has a major impact on climate. Fulbright scholar and University of Tasmania PhD student Ms Natalia Galin has been collaborating with researchers at the University of Kansas to measure snow thickness from a helicopter. An error in snow measurements above the water can be magnified by eight or nine times in estimating ice thickness below the water. However, the team's specialized radar equipment provides accurate readings of snow thickness on sea ice—information that will be used to calibrate satellite remote sensing data.

The long-term view

An Australian paleontologist, who uncovered the earliest fossil of live birth in fishes, a key to our understanding of reproduction in animals with backbones, is now Vice-President Research and Collections at the Natural History Museum of Los Angeles County. Dr John Long was formerly Head of Sciences at Museum Victoria.

IMAGE CREDITS: ANU'S CHRIS FULTON MEASURING REEF FISH AT LIZARD ISLAND, NEAL CANTIN; ANTARCTIC RESEARCH AND RESUPPLY SHIP *AURORA AUSTRALIS*, NATALIA GALIN; TROPICAL CYCLONE YASI, NASA GSFC/ JEFF SCHMALTZ; EXPERIMENTAL BUSHFIRE SET IN MCCORKHILL, WESTERN AUSTRALIA, CSIRO.

Australian Government

TRAVELING AT MACH 5: DEFENSE AND MATERIALS SCIENCE IN ACTION

Blink and you'll certainly miss it. Australian and US defense scientists have conducted two of 10 test flights of rockets that use revolutionary scramjet propulsion at the Woomera Test Range in South Australia. **The rockets travel at hypersonic speeds of more than Mach 5—that's well over 3,000 miles per hour.** More conventionally, an Australian-designed missile that masquerades as a ship has been selected to protect US aircraft carriers. **But it's not just rocket science where Australian and US collaborations have raced ahead.** Artificial intelligence research could see manned and unmanned aircraft fly in the same airspace. Australian materials have been incorporated into the latest American aircraft. **And quantum computers could soon be solving the knottiest of problems, now that Australian scientists have pointed the way to building them.**

Missile technology to protect Nimitz aircraft carriers

An Australian designed and developed decoy rocket, built with the help of the US, now protects hundreds of US, Australian and Canadian warships against incoming missiles.

Known as Nulka, it hovers in mid-air while seducing the incoming anti-ship rockets away from their target. It's Australia's most successful defense export.

In 2012, Nulka will be installed on one of the giants of the US Navy, the Nimitz-class aircraft carrier USS Abraham Lincoln, followed by the remaining nine Nimitz-class super-carriers. Nulka was invented by Australia's Defence Science and Technology Organisation (DSTO) and is made in Australia by BAE Systems Australia.

High-tech materials and alloys for the Joint Strike Fighter

The Australian company Ferra Engineering will be manufacturing titanium components for the F-35 Joint Strike Fighter using techniques developed in association with Australia's CAST Cooperative Research Centre. The two are now working with US manufacturer Lockheed Martin on developing laser machining for titanium to reduce costs further.

Australia also has a long history of expertise with composite materials. US aircraft giant Boeing manufactures many of its composite aircraft components in Melbourne including some for the company's latest aircraft, the 787 Dreamliner.

Fifty plastics patents

Joint research between CSIRO and US-based company DuPont for more than 20 years has generated over 50 patents. The association stemmed from a mutual interest in the formation of plastics, and has led to the innovative mechanism for generating purpose-built plastics known as RAFT (Reversible Addition-Fragmentation chain Transfer). Already this has led to new products such as environmentally friendly automotive paints and advanced photo imaging materials.

Diagnostic tear sensor

Melbourne company MiniFAB developed and now manufactures a disposable nanofluidic diagnostic tear sensor for TearLAB Corporation of San Diego. The sensor is used to diagnose dry eye disease, a disorder that affects millions of people worldwide and can be severely disabling.

Scramjet technology

The Hypersonic International Flight Research Experimentation (HIFiRE) project undertaken jointly by the US Air Force Research Laboratories and DSTO is exploring the rigors, needs and possibilities of hypersonic flight for both military and civilian purposes. It could make air travel between the two countries a matter of a few hours.

Scramjet technology uses available oxygen in the atmosphere to burn fuel in an air flow travelling at supersonic speeds. That means the scramjet doesn't have to carry oxygen as a component of its fuel, which should help it reach a projected top speed of between Mach 12 and Mach 24. Already, Australian and US researchers have achieved Mach 10.

At present, the scramjet rockets fire only for a few seconds, but the researchers hope to make that a minute or more, demanding new materials to withstand the heat. In parallel with HIFiRE, another international consortium, headed by the University of Queensland and including the University of Minnesota is investigating the development of Scramjet technology for civilian purposes.

Switching to autopilot

Artificial intelligence is at the heart of the Smart Skies initiative to develop the technology that will allow manned and unmanned aircraft to fly in the same airspace. Based in the state of Queensland, the project brings researchers from Boeing in the US and Australia together with specialists from CSIRO, the Australian Research Centre for Aerospace Automation and the Queensland University of Technology.

Practically, they will seek to develop enabling technologies including an automated separation management system for aircraft, robust collision avoidance systems, and mobile aircraft tracking systems. Trials already are being conducted in Queensland.

Wedgetail AWACS

Boeing and CSIRO have had a partnership which extends well over 20 years, and involves joint research in the areas of advanced materials, complex systems, information and communication technologies and advanced platform systems, such as developing the Australian version of the US Airborne Warning and Control System (AWACS), known as Wedgetail.

CSIRO has a permanent representative seconded to Boeing in Seattle, and Boeing has a permanent branch of its advanced research and development unit in Australia, Boeing Research and Technology-Australia.

A new synchrotron and a research reactor

For many years Australian scientists packed up their experiments and headed to Argonne National Laboratory and other large American facilities. Today, Australia has an enviable suite of large facilities of its own. The Australian Synchrotron in Melbourne and Open Pool Australian Lightwater (OPAL) research reactor in Sydney together represent an unprecedented investment by Australia in major research facilities for materials research. Synchrotron x-ray and neutron beam techniques are complementary for materials analysis and novel materials development, giving information from atomic scale to macroscopic materials properties such as stress and strain.

The area surrounding Monash University in Melbourne's southeastern suburbs is developing as a significant concentration of materials research. It not only contains the Australian Synchrotron, but also several CSIRO divisions focused around materials science. The research arms of many materials-based companies are located nearby, and the University itself supports much materials-related research.

Putting nuclear waste in its place

Early in 2010, the US Government announced a decision to use Hot Isostatic Pressing (HIP) technology to treat reprocessed defense waste at the Idaho National Laboratory (INL) site. This decision followed two years of paid demonstration testing that Australian Nuclear Science and Technology Organisation (ANSTO) had performed for the US Department of Energy (DOE) to validate the efficacy of ANSTO's HIP technology.

This technology is a central part of the Synroc process that can be tailored to immobilize a wide variety of radioactive wastes. Synroc is a ceramic material made from natural minerals which together can incorporate into their crystal structures nearly all of the elements present in the different types of high level radioactive waste. ANSTO also operates the OPAL research reactor in Sydney's south. HIP technology will save the US Government billions of dollars.

IMAGE CREDITS: US AIRCRAFT CARRIER USS NIMITZ, WHICH WILL BE PROTECTED BY NULKA, U.S. NAVY/JAMES MITCHELL;
BOEING'S WEDGETAIL AIRCRAFT, RAAF/CPL CLINT MCKAY; AT WORK ON THE HIFIRE SCRAMJET TESTBED, UNIVERSITY OF QUEENSLAND;
F-35 LIGHTNING II FIGHTER AIRCRAFT, USAF/JULIUS DELOS REYES.

Australian Government
Department of Innovation
Industry, Science and Research

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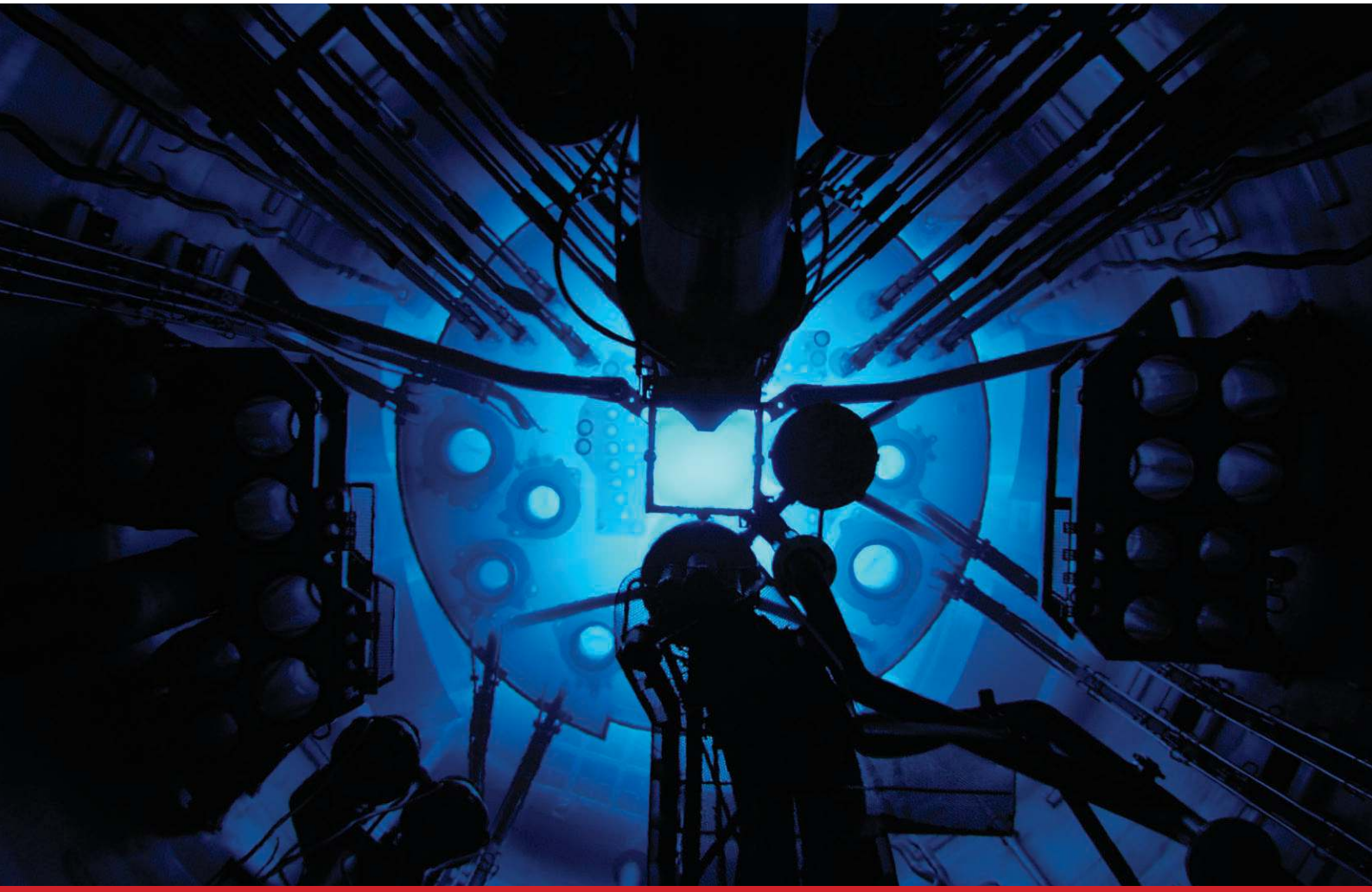


THE AUSTRALIAN SCIENCE AND TECHNOLOGY SYSTEM

With 22.5 million people, Australia has only about one-fourteenth the population of the US. However, Australia is as big in land mass as the 48 contiguous US states and as geographically diverse. **Publicly funded science is targeted at many of the same strategic challenges as in the US—particularly, health and medical research, marine science, climate change, agriculture, energy, resources and defense.**

National science agencies

Helping drive solutions to these challenges in Australia is the national research body known as CSIRO (Commonwealth Scientific and Industrial Research Organisation). One of the world's biggest government research agencies, it has an annual budget of close to AU$1.4 billion (2010-11), of which the Government provides about half directly. There is a separate body devoted to defense matters, the Defence Science and Technology Organisation (DSTO), which receives a budget appropriation of about AU$440 million. Other Government agencies include the Australian Nuclear Science and Technology Organisation, ANSTO (AU$369 million in 2010-11), the Australian Institute of Marine Science (AIMS) based near Townsville in north Queensland (AU$66.2 million in 2010-11), Geoscience Australia (AU$156 million in 2010-11) and the Bureau of Meteorology (AU$345.3 million in 2010-11).

Funding bodies

In Australia, the National Health and Medical Research Council (NHMRC) and the Australian Research Council (ARC) are the two most significant agencies that administer competitive research grants on behalf of the government. NHMRC, which focuses on health and medical research, had a 2010-2011 budget allocation of nearly AU$792 million. The Australian Research Council (ARC), a general research granting agency, had a 2010-2011 budget allocation of more than AU$700 million.

There are many scholarship programs available to researchers in Australia. One of the best known and most distinguished is the educational exchange program of Fulbright scholarships. These are an important mechanism for generating collaboration between Australian and US scientists.

The Australian component for 2011 has been boosted with the announcement of up to 15 'clean tech' Fulbright scholarships for those interested in renewable energy and climate science research.

About two-thirds of the Australian Government's science and technology budget is administered by the Innovation, Industry, Science and Research portfolio. The other third is administered by other government portfolios: the DSTO, for instance, is managed by the Department of Defence; and the NHMRC by the Department of Health and Ageing.

In addition, each of the eight state and territory governments has its own administration dealing with science and technology, focused on areas of specific interest. Traditionally, because of their constitutional responsibilities, all states have been interested in public health, education, and agriculture. But some states, such as Victoria and Queensland, have made research and development (R&D) itself a specific economic focus, and have put significant funding into developing research infrastructure.

Universities

Research is a focus at all of Australia's 41 universities, only two of which are private. About twice as much is spent on R&D by Australia's universities and medical research institutes as is spent directly by federal government science agencies. Much of the sector's research funding is provided in the form of competitive grants and block grants designed to support the indirect costs of research. In total, the Australian Government provides about AU$2.5 billion to universities to support their research and research training activities, and this is complemented by research funding from the private sector, non-profit organizations and state governments.

While there is not a strong history of philanthropy or endowments in Australia, universities are increasingly undertaking their own fund-raising, and tapping into new sources of non-government funding.

Medical research institutes

Australia has about 40 independent medical research institutes in addition to its universities and hospitals. As well as tapping into philanthropic money, and being eligible for competitive grants, these institutes are supported directly by about AU$650 million a year from the Australian Government towards infrastructure, and more from the state and territory governments.

Business investment in research and development

While in the US, business has accounted consistently for about 70 per cent of total R&D expenditure, the role of private enterprise in research in Australia historically has been limited. That picture is now changing: the share of national R&D financed by business over the past 25 years has risen from 30 per cent to about 60 per cent in 2008-09. This has been supported by a range of government programs, including an R&D tax concession now worth around AU$1.6 billion a year. The Australian Government is involved strongly with particular agricultural industries in 15 Rural R&D Corporations. These corporations are financed through industry levies matched dollar for dollar by the Australian Government.

Cooperative Research Centres

Making a strong contribution in terms of practical research is the Cooperative Research Centres (CRCs) Program. The program supports end user driven research collaborations to address clearly articulated, major challenges facing Australia, many of which are global. CRC activities include research, utilization and commercialization, education and engagement with small and medium enterprises.

There are 42 active CRCs that operate across four broad industry categories: agriculture, forestry and fishing (11 CRCs), manufacturing (5), mining (4) and services (22). Since 1991, the Australian Government has committed more than AU$3.4 billion in CRC Program funding. Participants in CRCs have committed a further AU$11 billion in cash and in-kind contributions.

Academies

Two national academies are associated with science and technology in Australia—the Australian Academy of Science, based in the nation's capital, Canberra, and the Academy of Technological Sciences and Engineering in Melbourne, Victoria. Both have been involved heavily in promoting collaboration with colleagues outside Australia through the Australian Government's International Science Linkages Program.

IMAGE CREDITS: OPAL RESEARCH REACTOR, ANSTO; CSIRO SOLAR TOWER, CSIRO; RV SOUTHERN SURVEYOR, CSIRO; AUSTRALIAN SYNCHROTRON.

Australian Government

SEARCHING THE SOUTHERN SKY, AND UNCHAINING THE INTERNET

Through their unique view of the southern sky, Australian researchers are unraveling the secrets of the cosmos—and they're doing it with a huge helping hand from the US. In return, Australian astronomer engineers have helped change the world via discoveries that have unchained notebook computers, made flight safer, improved CT scans, and delivered clearer sound. **Now, Australia and the US are working together to design the next generation of telescopes: the Giant Magellan optical telescope to be constructed in Chile; the gravitational observatories looking for echoes from the Big Bang; and what will be the world's largest radio telescope—the Square Kilometre Array.**

From hunting bombers to hunting galaxies—the birth of radio astronomy

Australia was one of the pioneers of radio astronomy, literally turning its World War II radar stations to the stars, developing techniques in processing radio signals and making the important discovery of the first radio galaxies outside the Milky Way. The mathematical techniques Australian pioneers used at this time went on to underpin the development of CT and MRI medical imaging as well as modern radio astronomy.

Transmitting the first lunar landing

America took heed of Australia's growing expertise in radio astronomy and contributed to the construction of the Parkes radio telescope in southern New South Wales, which found the first quasar (quasi-stellar radio source). The telescope later helped to track the first lunar landing, delivering pictures of the first moon walk to US television audiences.

Unchaining the computer

Using techniques he developed to clean up the radio waves from exploding black holes, astronomer engineer Dr John O'Sullivan and his team at CSIRO invented the tools needed for fast, reliable wireless computing in the home and office. Their patented ideas are built into almost every modern notebook and smart phone.

From similar origins came: the technology for Interscan, the first microwave-based aircraft landing system to be approved and deployed at US airports; some of the signal processing technology behind the bionic ear; and the consumer sound technology, Dolby Headphone, which was developed in Sydney by Lake Technologies.

Looking over the horizon

Australia's expertise with radio is also demonstrated in the over-the-horizon radar that guards the country's northern approaches—the Jindalee Operational Radar Network—developed over 40 years by DSTO with American support.

Creating tomorrow's telescopes

American and Australian astronomers and engineers are working closely on the development of a new generation of telescopes.

Guiding stars for Gemini

Australia and the US are among the seven national partners involved in building the Gemini Observatory, the world's largest publicly funded optical/infrared telescopes. The twin 8.1-meter telescopes, located at high altitude in Chile and Hawaii, can collectively access the whole sky. Researchers at the Australian National University have built a near infra-red spectrometer for the Hawaii telescope and an adaptive optics imaging system for the Chile telescope which will provide distortion-free images of the sky using natural and artificial guide stars. Other instruments are on the drawing board.

Assisting with the design of the adaptive optics system is Electro Optics Systems (EOS), one of the world's largest installers of medium-sized optical telescopes, which has built telescopes for the Universities of California and Hawaii. The company is also a world leader in laser ranging and targeting, remote weapons systems and the surveillance of space for debris. In 2005, it formed a strategic alliance with global defense company Northrop Grumman.

Starbugs and the Giant Magellan Telescope

Australia, along with seven US research institutions and Korea, is a founding partner in the international Giant Magellan Telescope (GMT) project to be constructed in Chile by about 2018. Of revolutionary design, it will be far larger than any existing optical telescope. Australian technology to be provided to the GMT may well include a light-capturing system incorporating novel robots known as 'Starbugs', being developed at the Australian Astronomical Observatory.

Starbugs will move optical fiber light receivers precisely to locations of interest in the telescope's focal plane. The fibers themselves are an outgrowth of astrophotonics, a field pioneered by Professor Joss Bland-Hawthorn of the University of Sydney. These fibers can selectively absorb unwanted parts of the spectrum to improve the analysis of astronomical objects.

Square Kilometre Array

Australian radio astronomers are working closely with their US counterparts in developing technology to be used in the Square Kilometre Array (SKA), the world's largest radio telescope, to be constructed either in Australia and New Zealand or in southern Africa from about 2016.

The SKA will comprise thousands of separate radio dishes and other antennae in a focal square kilometer, with additional detectors spread across an area the size of a continent. Combining the radio signals received by each of the sensors will effectively create one giant antenna thousands of kilometers across, to provide the sharpest ever radio images of the sky, with incredible sensitivity to faint signals.

Already, two facilities to test technology are underway at Western Australia's radio-quiet Murchison Radio-Astronomy Observatory, Australia and New Zealand's proposed core site for the SKA. The Murchison Widefield Array is being built by an international consortium of US, Australian and Indian research institutions. It has no moving parts, being made up of tile-like detectors that are tuned electronically, and is already collecting data on low frequency radio emissions. The second facility, the 36-dish Australian SKA Pathfinder, is under construction and due to start operating in 2013. It will combine high-speed surveillance of the sky with sensitivity in a search for pulsars, magnetic fields and galaxies.

Quantum computing

In 2010, a team of physicists and engineers at the University of New South Wales in Sydney led by Dr Andrea Morello and Professor Andrew Dzurak announced in the journal *Nature* they had developed one of the key building blocks needed to make a quantum computer using silicon—a 'single electron reader'.

Their work, and research at the Universities of Queensland and Melbourne, have put Australia at the forefront of development of the quantum computer, which promises exponential increases in processing speed over today's computers for tasks including database searches and encryption.

Chief Scientist for Australia

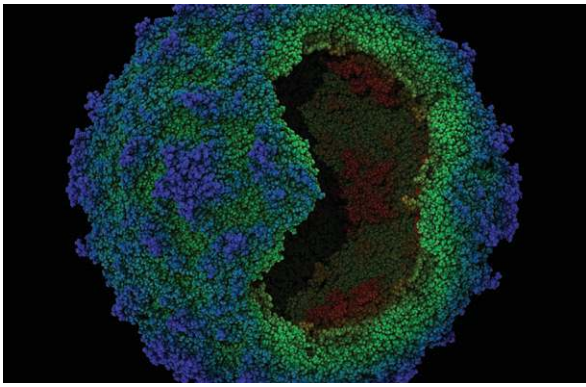
Professor Penny Sackett, a dual US-Australian citizen formerly of the Australian National University, is an authority on the discovery of planets outside Earth's Solar System. In her role as Chief Scientist, Professor Sackett advises the Australian Prime Minister on matters relating to science, technology and innovation.

IMAGE CREDITS: GEMINI NORTH, GEMINI; ARTIST'S IMPRESSION OF SKA DISHES, SWINBURNE ASTRONOMY PRODUCTIONS/ SKA PROGRAM DEVELOPMENT OFFICE; DR TAMARA DAVIS, L'ORÉAL; HORSEHEAD NEBULA, DAVID MALIN/AAO.

Australian Government

SCIENCE COLLABORATION IMPROVES HEALTH

Australia's impact on world health has been profound: from devices helping deaf children hear, to cancer-preventing vaccines and even the development of penicillin. But there is much more to come. Australians are working, often with researchers from the United States, on hundreds of projects including medical spin-outs from genome research, HIV vaccines, the use of phones to diagnose mental illnesses, and a suite of drugs to prevent and treat obesity and diabetes.



From bionic ears to eyes and spines

The first multi-channel bionic ear was invented by Professor Graeme Clark in Melbourne in the 1970s. Today, Cochlear, the Australian company that emerged from that discovery, has an 80 per cent share of the global market. They have brought sound, language, music and ease of communication into the lives of more than 200,000 people worldwide.

The knowledge gained is now leading to a suite of bionic initiatives for spinal cord repair, calming epilepsy storms and the bionic eye. The Bionic Ear Institute (BEI) has strong US links and several National Institutes of Health contracts. BEI's research has also been developed into sound processing technologies used widely in phone headsets, and in a new generation of low cost, self-fitted hearing aids developed by America Hears and Australia Hears.

Vaccines against cervical cancer

Two revolutionary vaccines are now available in America to fight cancer. Gardasil and Cervarix both prevent infection by the virus responsible for most cervical cancers.

Two more vaccines are in clinical trials to treat women who have already been infected.

All four vaccines are largely the invention of Professor Ian Frazer and his team at the University of Queensland in Brisbane.

Professor Frazer worked with Australian biotechnology giant CSL Ltd and US pharmaceutical corporation Merck & Co to commercialize Gardasil. The vaccine is now recommended for adolescent girls by the US Food and Drug Administration as a protection against cervical cancer.

Blood products for rare disorders

CSL is also the world's second biggest manufacturer of blood products with a major research and manufacturing capability in the US, where it collects and fractionates plasma to create highly specialised medicines for people with chronic life-threatening diseases such as primary immune deficiency, bleeding disorders and other rare diseases. CSL offers a broad range of therapies. Some of these treat conditions so rare that CSL provides the only product of their kind available in the US; for example, Riastap is used to treat patients with a congenital deficiency in human fibrinogen.

CSL is also one of five manufacturers that supply seasonal influenza vaccine to the US, and developed and supplied H1N1 vaccine.

Preventing tooth decay

Another product of Australian research is the cow's milk extract known as Recaldent, which can reverse tooth decay, and was developed by Professor Eric Reynolds and co-workers at the University of Melbourne. It is used as an active ingredient in toothpastes, mouth washes and chewing gum. Trident White Gum alone generates more than US$50 million in sales in the US.

Seeing early Parkinson's

Medical trials in the US on a new imaging technique developed by the Australian Nuclear Science and Technology Organisation (ANSTO) could open a window into new diagnostic options for patients with Alzheimer's disease or Parkinson's disease. An agreement with Bayer Schering Pharma stems from studies performed by ANSTO scientists who discovered new ways to obtain images of neuroinflammation, believed to be an early characteristic of these debilitating diseases.

Supercomputing for the biological sciences

IBM is collaborating with the government of the Australian state of Victoria and the University of Melbourne to develop a supercomputer complex for the biological sciences. Known as the Victorian Life Sciences Computation Initiative, the center aims to transform life sciences research by providing computer resources to generate meaningfully complex simulations of biological systems. Already, the program has led to the first simulation of a complete polio virus of more than 3.6 million atoms.

Rapid diagnosis

Staff from the Menzies School of Health Research in Darwin in Australia's Northern Territory are working with colleagues at the Northern Arizona University to develop a test that will enable doctors to diagnose patients with melioidosis more rapidly. First noticed during the Vietnam War, melioidosis is also known as Nightcliff Gardeners disease, because infection generally comes about through contact with the soil in northern Australia and Southeast Asia. The disease was responsible for 10 deaths in the Northern Territory during the 2010 wet season. It is caused by an antibiotic-resistant bacterium, Burkholderia pseudomallei, and listed by the US Department of Homeland Security as a category B potential bioterror threat.

New collaborations

Stem cell research

An AU$28-million Victoria–California Stem Cell Alliance has been formed between the State of Victoria and the California Institute of Regenerative Medicine, one of the world's largest stem cell research organizations. It is funding projects aimed at removing some of the practical barriers to the therapeutic application of stem cells, such as investigating how stem cells might be used to treat multiple sclerosis, Alzheimer's and Parkinson's disease.

New cancer drugs

In 2010, the Walter and Eliza Hall Institute for Medical Research (WEHI) in Melbourne signed a tripartite agreement with the world's oldest biotechnology company Genentech of San Francisco and pharmaceutical giant Abbott of Illinois to develop better cancer drugs. The research will employ WEHI's expertise to specifically target the survival machinery of cancer cells.

Global health

The Bill and Melinda Gates Foundation has invested tens of millions of dollars into Australian studies on topics as diverse as how to eliminate the mosquito-based transmission of dengue fever, the development of vaccines against HIV and malaria, and the production of nutritionally enhanced bananas.

Nobel impact

The close relationship between health and medical research in Australia and the US starts right at the source, with basic studies into human biology. Since World War II, Australians have won seven Nobel Prizes for Physiology or Medicine.

Two of these researchers maintain laboratories in the US. Professor Peter Doherty, who shared the prize in 1996 for the discovery of how the immune system recognizes virus-infected cells, works part of the year at St Jude Children's Research Hospital in Memphis.

Professor Elizabeth Blackburn, who shared the prize in 2009 for work on telomeres, the protective structures at the ends of each strand of our DNA that are thought to play an important role in the ageing process, is Professor of Biology and Physiology at the University of California, San Francisco.

IMAGE CREDITS: DR IAN FRAZER ADMINISTERS THE FIRST AUSTRALIAN GARDASIL VACCINATION, UNIVERSITY OF QUEENSLAND; DENGUE-CARRYING MOSQUITO *AEDES AEGYPTI*, CSIRO; TEETH, ISTOCKPHOTO; VIRTUAL POLIO VIRUS, JASON ROBERTS/VIDRL.