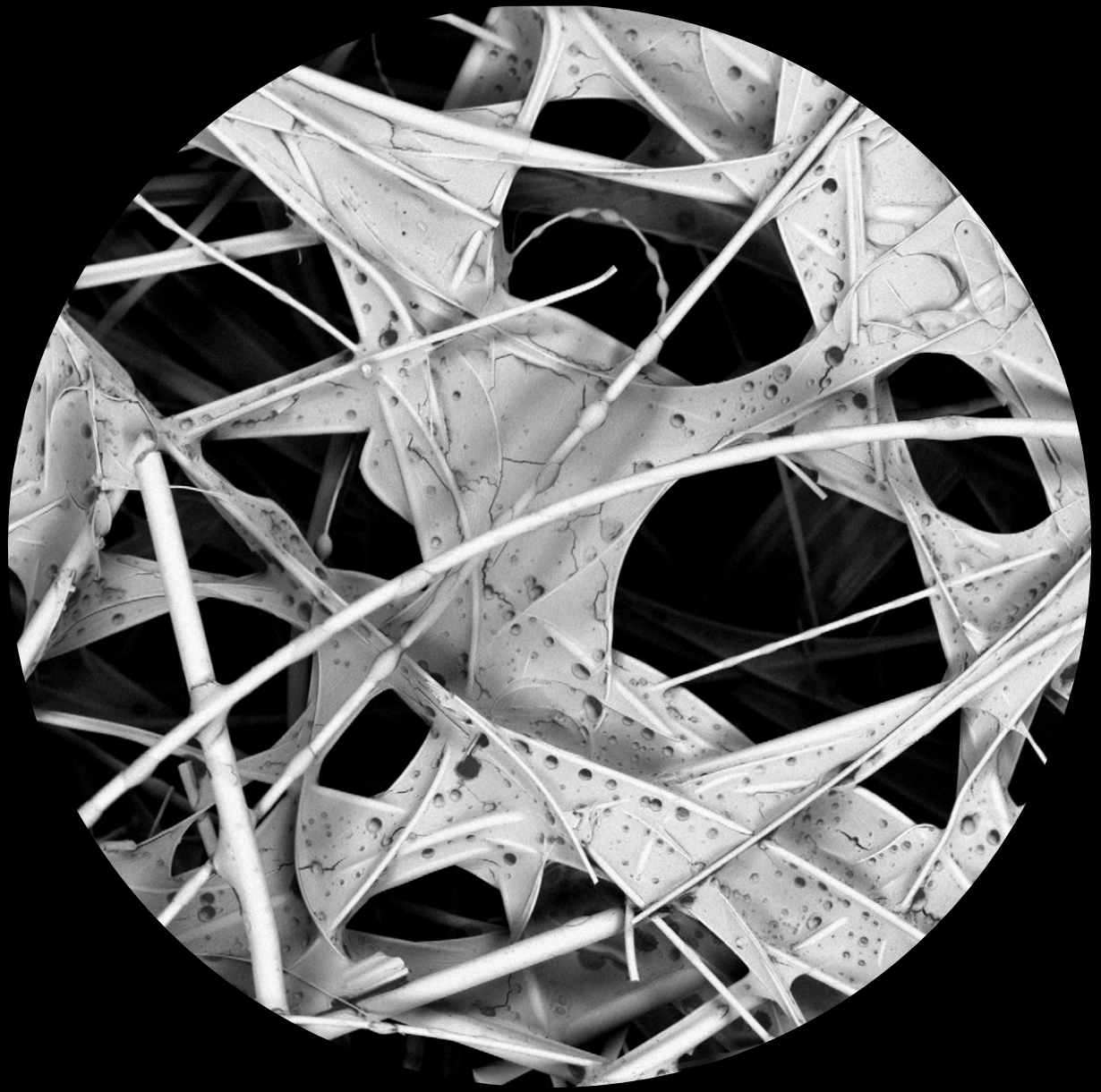
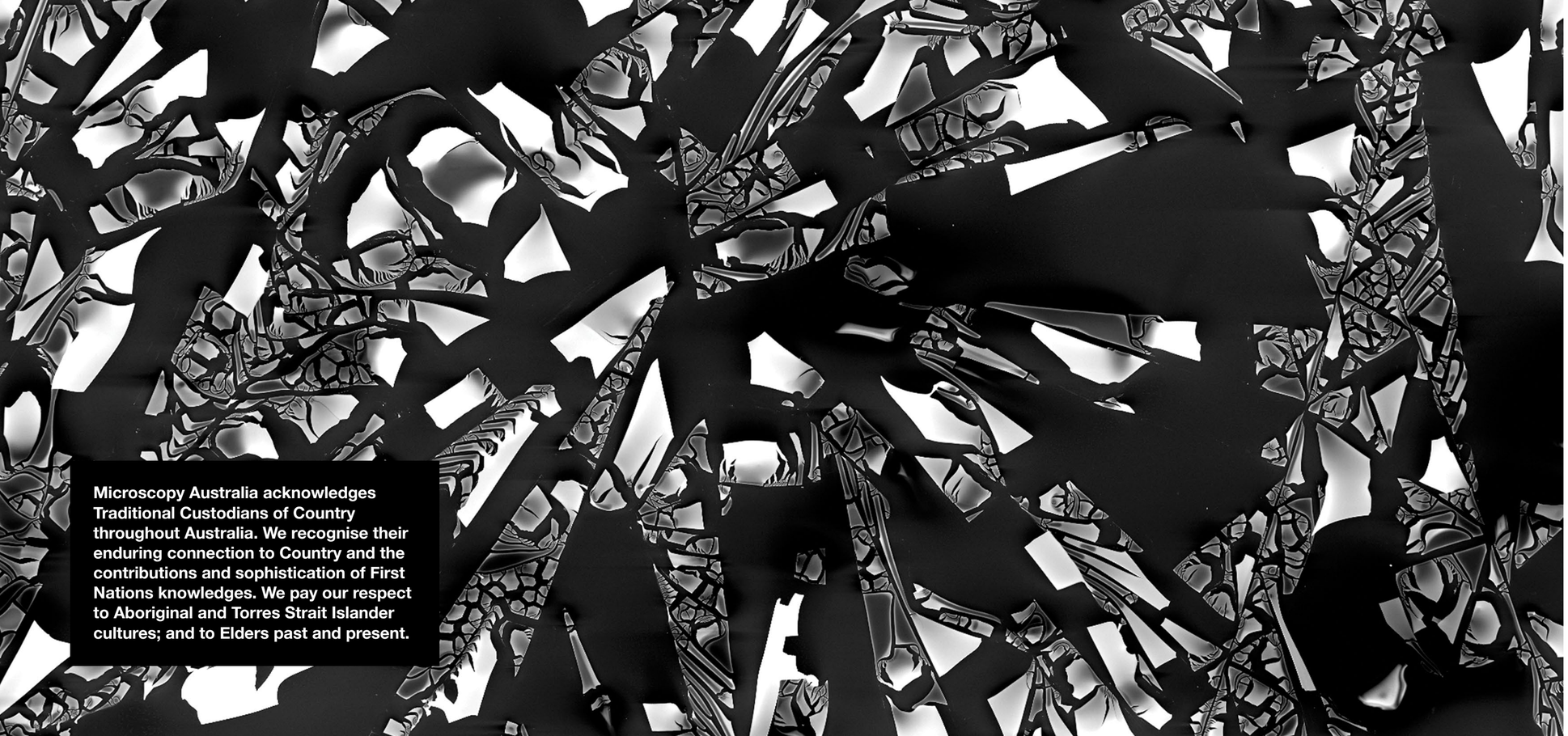
MICROSCOPY AUSTRALIA RESEARCH HIGHLIGHTS 2024





Microscopy Australia acknowledges Traditional Custodians of Country throughout Australia. We recognise their enduring connection to Country and the contributions and sophistication of First Nations knowledges. We pay our respect to Aboriginal and Torres Strait Islander cultures; and to Elders past and present.

Microscopy Australia enables access to high-end microscopes and expertise to underpin Australian discovery and innovation.

CONTENTS

Cover: Scanning electron micrograph of part of a new lateral flow test (RAT) for mosquito-borne flaviviruses. It shows glass fibre paper infused with 40-nanometre gold particles attached to an antibody against a range of flaviviruses. Image taken by Ryan Johnston at the Centre for Microscopy and Microanalysis, University of Queensland.

Left: Ln^{3+}-doped titanium dioxide imaged using scanning electron microscopy by Tahnim Sultana at the RMIT Microscopy and Microanalysis Facility.

YEAR IN REVIEW

CEO REPORT

Dr Lisa Yen
Chief Executive Officer

It is a delight to share this incredibly diverse collection of research and innovation stories in the 2024 Research Highlights.

Throughout the year, Microscopy Australia has provided expertise and enabled impact across the broad research areas and industry sectors that rely on advanced microscopy. As part of Australia's strong research infrastructure ecosystem, we were a key mover in establishing the 'Made to Measure' group with fellow NCRIS projects that enable access to measurement, characterisation and fabrication capabilities.

Looking forward, into the new year and beyond, Microscopy Australia will continue to develop future investment plans with our stakeholders and research communities. This ensures Microscopy Australia is best positioned to drive innovation, through new technologies, a highly skilled expert workforce and increased support for automation and AI-enabled data analysis.

I am sure that you will enjoy reading through the amazing collection of discovery and translation stories that span critical areas for Australia's future success.

CHAIR REPORT

Dr Gregory R. Smith
Board Chair

This year Microscopy Australia continued to operate very effectively, with 2024 facility metrics achieving similar results to previous years.

Microscopy Australia contributed significantly to the strategic planning needed for future Australian research infrastructure. There was a focus on research translation; particularly as that relates to microscopy and microanalysis across various fields of Australian academic and industry research endeavours.

Microscopy Australia engaged significantly through international conferences, including the European Microscopy Congress 2024 and the International Conference on Research Infrastructures that featured the re-signing of its collaboration agreement with the European BioImaging initiative.

The Microscopy Australia Board re-examined its governance framework. The Board's Audit Committee reviewed Microscopy Australia's governance structure and the balance of Board membership, representation and skills.

During the year, Prof. Julie Cairney, Chief Scientific Advisor, announced her retirement from that role. Ultimately, the Microscopy Australia Board decided not to appoint a replacement, but to distribute her responsibilities among its facility directors.

After serving as the Independent Chair of the Board of Microscopy Australia (and its predecessors) for the surprisingly long period of 22 years, I announced my intention to retire from the role in 2025. An Independent Board Chair recruitment process is now underway.

It has been a great privilege to work with Australia's microscopy and microanalysis community for such a long and enjoyable period. "I am extremely pleased that leadership experience gained at Microscopy Australia has offered a career springboard for its previous leaders. For example, I am especially proud of the career successes of: Rosie Hicks, the first COO of the NCRIS period and later the CEO of other NCRIS facilities; Prof. Simon Ringer, the first CEO of NANO and the AMMRF who is now the PVC Research Infrastructure at The University of Sydney; Dr Miles Apperley, the next CEO who has become a senior executive at ANSTO; and finally, Prof. Julie Cairney, who has just been announced as the interim DVCR at The University of Sydney.

Lastly, it would be remiss of me not to acknowledge the excellent work of Microscopy Australia's current CEO, Dr Lisa Yen; the leadership and collegiality of whom I will certainly miss once my work with Microscopy Australia ends in mid-2025.

2024

BY THE NUMBERS

300 INSTRUMENTS

183 EXPERTS

3,867 USERS SUPPORTED

374K HOURS BEAMTIME

402 INDUSTRY CLIENTS

121 PATENTS SUPPORTED

1,381 PUBS & BOOKS

88K YOUTUBE VIEWS

98% OF USERS REPORTED OUR FACILITIES WERE VALUABLE TO THEIR RESEARCH

98% OF USERS WOULD RECOMMEND OUR FACILITIES TO A COLLEAGUE

93% EXPECT THEIR USE OF MICROSCOPY WILL INCREASE OR STAY THE SAME

Data from 2023 (2024 collection)

37%
OF PUBLICATIONS WERE IN THE TOP 10% MOST CITED JOURNALS

RESEARCH COMMUNITY

49% MATERIALS & ENGINEERING
39% BIOLOGICAL & MEDICAL
12% GEOSCIENCE & ENVIRONMENT

INDUSTRY USERS

39% RESOURCES & ENVIRONMENT
33% MANUFACTURING
21% BIOMEDICAL
7% OTHER

OUR STRATEGY

Microscopy Australia's mission is to empower Australian science and innovation by making advanced microscopes and expertise accessible to all.

VALUES

EXCELLENCE | INNOVATION | ACCESSIBILITY | COLLABORATION

PRIORITIES

1
SUPPORT EXCELLENT RESEARCH & QUALITY DATA

Target research areas where Australia leads, or has the potential to lead, world-class research. Facilitate quality research with open learning tools that enable efficient infrastructure use. Improve data processing, handling and analysis.

2
ENABLE INNOVATION & TRANSLATION

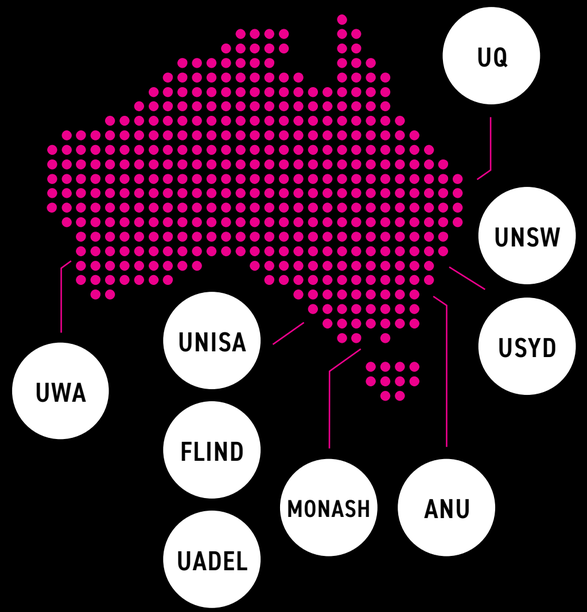
Support translation and industry innovation by providing enabling infrastructure and expertise for researchers, government and industry to deliver real world outcomes.

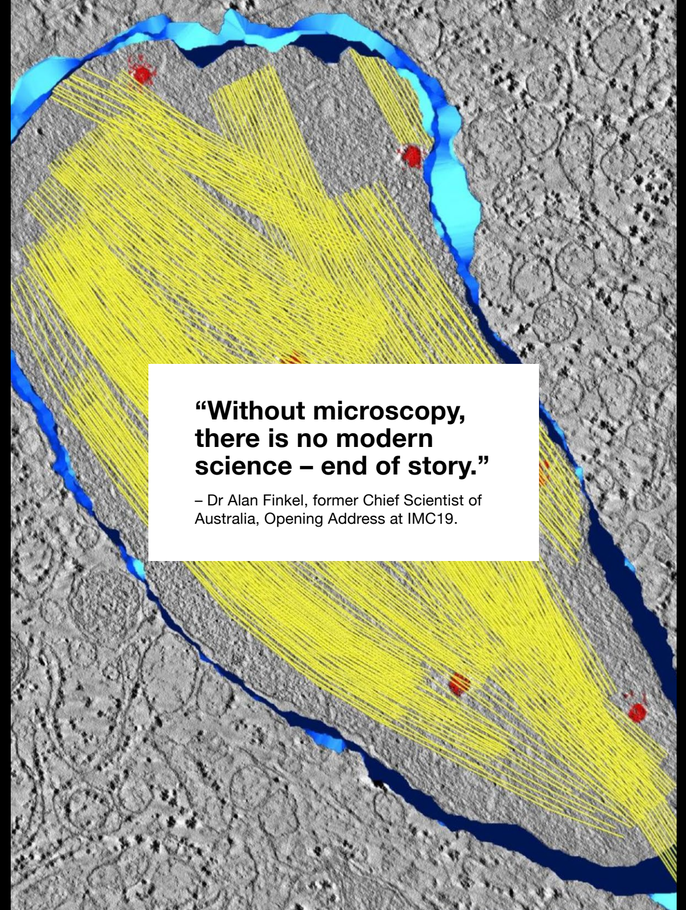
3
DELIVER ACCESSIBLE INSTRUMENTS

Identify microscopy and microanalysis infrastructure that is required to enable world-class research in Australia. Strategic placement of instruments that considers the expertise required, anticipated volume and location of potential researchers and industry users.

4
EMPOWER FACILITY STAFF

Inspire highly skilled platform scientists by developing their scientific and professional skills and expanding connections with leading national and international facilities.





“Without microscopy, there is no modern science – end of story.”

– Dr Alan Finkel, former Chief Scientist of Australia, Opening Address at IMC19.

Transmission electron tomography image of a giant mitochondrion (outlined in blue) from a diseased human liver showing bundles of linear inclusions (yellow) and enlarged granules (red). Generated by Dr Gerry Shami at Sydney Microscopy & Microanalysis, The University of Sydney.

OPEN ACCESS MICROSCOPY

We are Australia’s leading microscopy and microanalysis infrastructure, sharing resources to enable research excellence for over 15 years.

Microscopy Australia is a consortium of university-based microscopy and microanalysis facilities open to all Australian researchers and businesses. We provide access to an array of high-end microscopy and microanalysis platforms, and the expertise needed to get the most out of them. These technologies are placed in strategic locations to most efficiently enable high-impact research, and reduce duplication around the country.

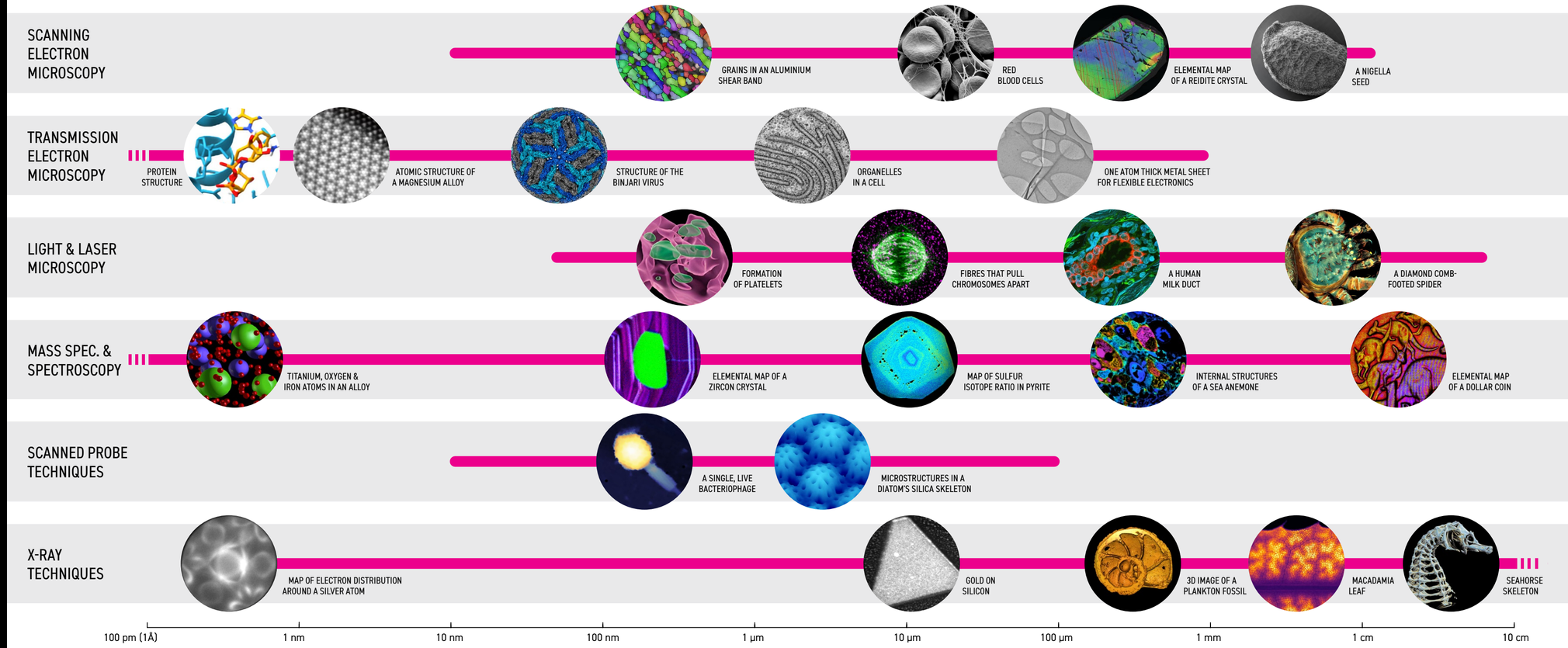
WHY IS MICROSCOPY SO IMPORTANT?

Microscopy is a core scientific technique. It reveals the fundamental building blocks of materials and living systems at unimaginably tiny scales, down to individual atoms.

Microscopy is an essential tool in the creation of new knowledge in many fields from medicine and engineering to art and archaeology: without microscopy, scientific knowledge as we know it would not be possible.

TAKE A CLOSER LOOK
OUR EQUIPMENT & EXPERTISE

With the nation's largest range of high-end microscopy and microanalysis platforms, our experts ensure researchers and businesses get the most out of these techniques. Microscopy Australia's facilities can provide solutions across diverse, multi-scale applications. In the graphic to the right you can explore just a fraction of the kinds of samples, scales and techniques our facilities support.



A STRONG AND CORROSION-RESISTANT NICKEL-COPPER ALLOY. TAKEN USING LIGHT MICROSCOPY BY DR OLEXANDRA MARENYCH AT THE UNIVERSITY OF QUEENSLAND.

SEE THE UNSEEN

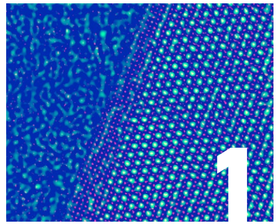
SUPPORTING THE NATIONAL SCIENCE & RESEARCH PRIORITIES

Microscopy Australia is committed to supporting the new National Science and Research Priorities. Providing fundamental research techniques, Microscopy Australia plays a vital role in advancing outcomes across all five national priority areas.

The National Science and Research Priorities aim to guide Australia's science and research efforts towards addressing key challenges for maximum impact that will ultimately benefit the wellbeing and prosperity of all Australians.

FROM CLEAN ENERGY TO MEDICAL ADVANCES, OUR INSTRUMENTS AND EXPERTS ARE SUPPORTING RESEARCHERS ACROSS ALL NATIONAL PRIORITES:

1. TRANSITIONING TO A NET ZERO FUTURE
2. SUPPORTING HEALTHY AND THRIVING COMMUNITIES
3. ELEVATING ABORIGINAL AND TORRES STRAIT ISLANDER KNOWLEDGE SYSTEMS
4. PROTECTING AND RESTORING AUSTRALIA'S ENVIRONMENT
5. BUILDING A SECURE AND RESILIENT NATION

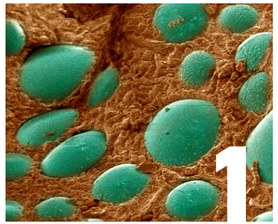


CLEAN ENERGY & STORAGE

We support the development of: cheaper, safer and more efficient solar materials; new batteries for more reliable power; hydrogen production, transport and storage technologies; and emerging energy generation methods such as with enzymes.

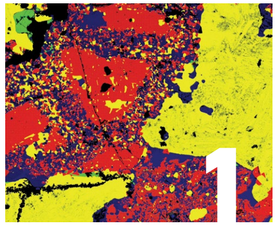
INDIGENOUS KNOWLEDGE

Microscopy is being used by teams turning traditional knowledge into modern technologies, such as spinifex into medical gels; in cultural heritage and archeology projects; and by indigenous artists as a way to explore their connection to Culture.



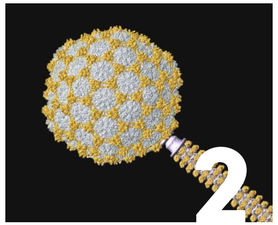
CIRCULAR ECONOMY

We support a large range of circular economy projects including solar cell recycling, purified aluminium from coffee pods, steel refined with tyres, textile-reinforced ceramics from waste glass, and local micro-factories for e-waste recovery.



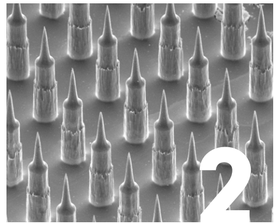
CRITICAL MINERALS

Microscopy is essential for supporting fundamental geosciences research and understanding ore formation pathways, through to helping BHP and Rio Tinto identify ways to improve processing for more efficient exploration.



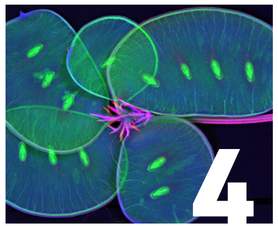
DRUGS & VACCINES

We support the design of better vaccines and drugs to treat and prevent diseases, such as vaccines for tropical diseases, drugs and phages to fight antibiotic resistance, as well as targets for cholesterol management and oral insulin options.



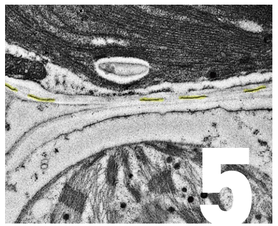
MEDICAL DEVICES

From sticker-like sensors for hydration, now being trialled by F1 drivers, to painless, self-administrable vaccination patches and improved bone and tissue implants, our facilities are an essential tool for medical device research and development.



BIODIVERSITY & REMEDIATION

We enable research that focuses on understanding the unique features and properties of native plant and animal species; including using them to clean contaminated land and water, along with a host of other remediation technologies.

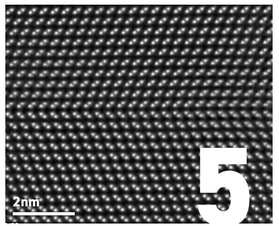


FOOD & WATER SECURITY

We enable research into soil health; crop resistance to pests, diseases and drought; safer pesticides that don't target native species; as well as water desalination and decontamination technologies that don't rely on electricity.

SOVEREIGN CAPABILITY & SECURE INDUSTRIES

Microscopy is an essential tool to accelerate Australian innovation and translation. We provide onshore tools and expertise that enable R&D independent of international supply chains.



ADVANCED TECHNOLOGIES

Microscopy is essential for the development of advanced alloys and composites, semiconductors, nanomaterials for electronics and computing, quantum and optical devices/sensors, and high-tech solutions for space and defence.

SAMSARA ECO: INFINITE FABRIC

Samsara Eco's unique enzymatic approach to recycling plastics gives textiles an infinite life cycle with a minimal carbon footprint. Their technology decouples plastics manufacturing from fossil fuels delivering high-quality new plastics composed of 100% recycled material.

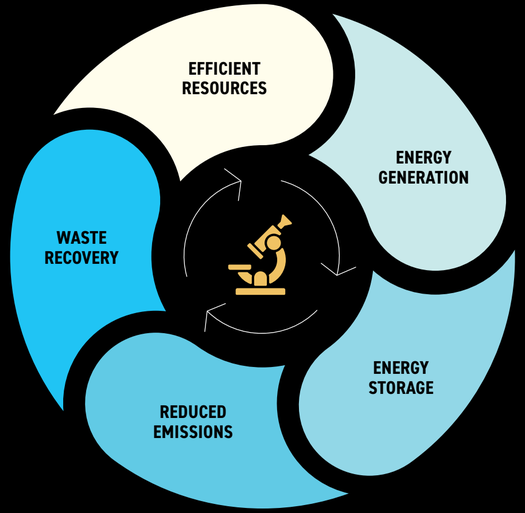
Their optimised enzymes efficiently recycle PET and polyester plastics at scale and Samsara Eco is working to develop a wider range of enzymes to break down other plastics such as those found in textiles, soft plastics, and mixed plastics. Microscopy Australia's facility at The Australian National University has been essential in developing their processes.

Samsara Eco raised $100M in their latest funding round while collaborator lululemon launched its first product made with enzymatically recycled polyester in July (pictured).

"Putting an end to fashion waste is critical to addressing the climate crisis… The [lululemon] Packable Anorak shows the potential to give clothes an infinite life and prevent textiles from ending up in landfills," said Paul Riley, CEO and Founder of Samsara Eco.

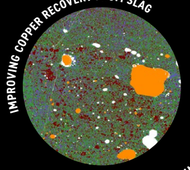
NET ZERO

Microscopy Australia enables innovation across the resources to renewables spectrum. We're not just enabling research; we're helping to shape a greener, more sustainable future by driving innovation in renewable energy, battery technologies, natural resources and waste recovery. Here are some recent outcomes illustrating Microscopy Australia's critical role in transitioning to a Net Zero future.



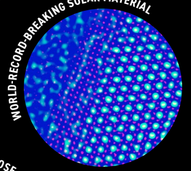
EFFICIENT RESOURCES

Our facilities are used to improve exploration, refine mineral processing, reduce mining waste, and improve land remediation for gold, copper, uranium, silver, lithium and other critical minerals for start-ups up to large multi-national companies. These resources are critical for many renewable energy technologies.



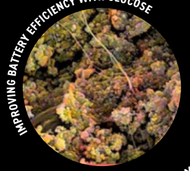
ENERGY GENERATION

Our facilities play a key role both in developing new renewable energy technologies and improving the performance, reliability and longevity of existing ones, as well as contributing to numerous solar efficiency world records.



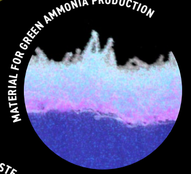
ENERGY STORAGE

Our facilities support the development of new technologies, performance improvement, and transport and storage infrastructure for energy storage solutions such as batteries, fuel cells, hydrogen and ammonia.



REDUCED EMISSIONS

Our facilities enable continual improvements in energy efficiency to reduce carbon emissions. These include the development of new energy efficient methods and materials for ammonia and cement production, which combined account for ~10% of global CO_2 emissions.



WASTE RECOVERY

Our facilities enable advances towards a circular economy by developing ways to ensure the constant use, recycling, and regeneration of materials and products. Examples of waste recovery projects include using tyres instead of coal for steel making and extracting aluminium from coffee pods.

ELECTRALITH: LOW-IMPACT LITHIUM EXTRACTION

ElectraLith, a spin-out from Monash University backed by Rio Tinto, is commercialising a membrane-based extraction system that filters high-quality lithium from brine, allowing the critical mineral to be extracted from salt lakes, mine tailings and other brine solutions.

ElectraLith's method uses only small amounts of solar-generated electricity and no added chemicals or water. Eliminating the need for water is key in arid areas rich in lithium such as in Australia, Chile and Bolivia. This single-step, modular and scalable method not only provides unmatched speed and yield, but is expected to have the lowest energy requirement and environmental impact of all approaches to lithium refining.

ElectraLith was recently named the 2024 Australian Financial Review BOSS Most Innovative Company in the Agriculture, Mining, Engineering and Utilities sector. Microscopy Australia's Monash University facility was crucial to the development of the filtration material on which the process depends.

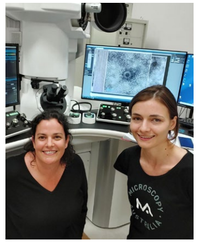
BUILDING KNOWLEDGE & SKILLS

Microscopy Australia is actively engaged in teaching and training researchers to achieve excellent results from our instruments. To complement our courses, masterclasses and one-to-one training sessions, we provide various online tools and resources.

MyScope is the cornerstone of our online learning resources, providing comprehensive training through a website developed by our experts. Since it was launched in 2011, it has grown from six to thirteen modules, reducing hands-on training time for new users of our microscopy facilities around Australia. Since then, it has become the world's premier online training program in microscopy, averaging ~50,000 users each year from around the globe. Training is delivered through technique-specific modules with well-illustrated and clear theory, realistic but brand-agnostic microscope simulators and self-assessment quizzes. These resources are all freely available, not only to our immediate users, but to all.

Additionally, **MyScope Explore** introduces young scientists to the microscopic world by taking students through the basics of magnification and electron microscopy. It also includes lesson plans based on the Australian science curriculum.

INTERNATIONAL INITIATIVES

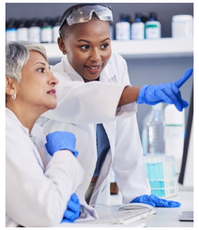


JOB SHADOWING PROGRAM

Available through Microscopy Australia and Global BioImaging, this program provides scientific and managerial staff of imaging core facilities with the opportunity to experience working in an imaging facility abroad where they can learn from their peers while on-the-job. Microscopy Australia staff have been abroad as recipients, and our facilities have hosted international visitors through the scheme.

AU–NZ KNOWLEDGE EXCHANGE SCHEME

Microscopy Australia, with Microscopy New Zealand and the Australian Microscopy and Microanalysis Society, offer an AU–NZ Knowledge Exchange scheme to enable Australian and NZ microscopists to visit microscopy facilities to share experiences, learn new techniques or technologies and, importantly, to expand their professional network of contacts and collaborators.



IMAGING 4 ALL (i4A)

Funded by Wellcome Trust, i4A is designed to empower imaging scientists from low- and middle-income countries. It provides technical and financial support to access cutting-edge imaging tools and world-class training opportunities anywhere in the world. As a partner in Global BioImaging, Microscopy Australia is looking forward to hosting and supporting researchers funded by i4A who want to use our facilities.

UPSKILLING OUR EXPERTS FOR THE AI REVOLUTION

Artificial intelligence (AI) and, more specifically, deep learning, has the potential to make significant inroads into data and image analysis. Microscopy Australia has supported its staff to push forward their use and understanding of current and emerging techniques in this area.

Supported by the International Job Shadowing Program, Microscopy Australia expert Dr Chad Moore recently attended the EMBO-sponsored Deep Learning for Microscopy Image Analysis course in Italy to expand his knowledge of AI-assisted image analysis. The course covered a wide range of deep learning approaches for dealing with diverse microscopy image datasets including deep learning models, image regression and restoration, segmentation and more, all using open-source software.

Dr Moore is now sharing these learnings with the wider Australian research community. He recently presented a webinar, 'Deep learning denoising for volume microscopy' (watch it on YouTube) with one of the instructors from the course, Dr Ben Salmon, to Volume Imaging Australia, a special interest group of the Australian Microscopy and Microanalysis Society. This illustrates not only the value of the learnings, but also of the international connections made during the job shadowing program.

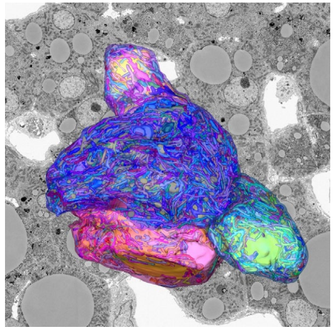
Also part of the Sydney Microscopy and Microanalysis team, Dr Gerry Shami has been working on improving image analysis efficiency in volume electron microscopy (VEM). VEM allows ultra-high resolution 3D imaging of biological materials. It also produces notoriously large datasets that are time-intensive to analyse. Dr Shami's deep learning approach, developed in collaboration with Zeiss, led to an almost ~1,000-fold increase in analysis speed. Previously, it took six months to annotate approximately 12,000 features. Now, with this new method, they can annotate around 500,000 features in just one week.

"Undoubtedly, AI solutions are having a tremendous impact not only in volume electron microscopy but microscopy more broadly. I believe the greatest advantages are the large volumes that can be probed and the high throughput that can be obtained. These factors ultimately lead to meaningful quantitative results that would otherwise be unachievable with conventional approaches."
– Dr Gerry Shami, The University of Sydney

"IT WAS INVALUABLE TO BE PRESENT IN PERSON TO PICK THE BRAINS OF THOSE DEVELOPING THE OPEN-SOURCE SOLUTIONS THAT WE CAN ALL UTILISE, FROM GETTING ADVICE ON APPROACHING PARTICULAR TYPES OF DATA TO INSIGHTS INTO WHERE THE FIELD IS HEADING OVER THE COMING 2–3 YEARS."

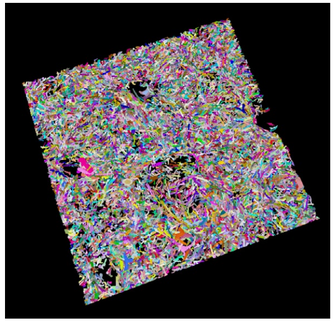
– Dr Chad Moore, The University of Sydney

MANUAL SEGMENTATION



6 months to annotate ~12,000 features

AI SEGMENTATION



1 week to annotate ~500,000 features

Mitochondria in human metabolic fatty liver disease imaged using volume electron microscopy at The University of Sydney.

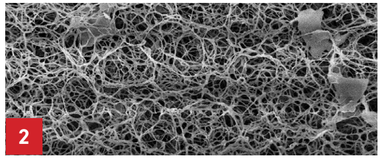

GEOLOGICAL SLAB IMAGED USING X-RAY FLUORESCENCE MICROSCOPY BY DR ANTONY VAN DER ENT
AT THE CENTRE FOR MICROSCOPY AND MICROANALYSIS, THE UNIVERSITY OF QUEENSLAND
DISCOVER DEVELOP DELIVER
500 nm

RESEARCH OUTCOMES & IMPACT

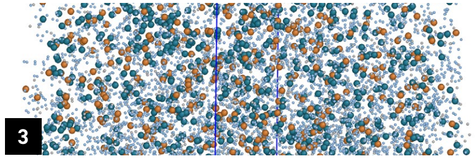
Take a closer look at the 2024 research highlights – all enabled by Microscopy Australia. With over 3,500 researchers accessing our facilities annually, here are just a few of their recent findings.

IMPACT STORIES

NEEDLE-FREE INSULIN

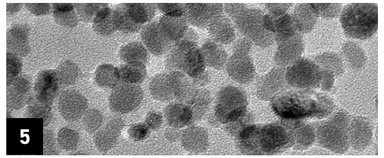


GENERATING ELECTRICITY FROM CARBON DIOXIDE

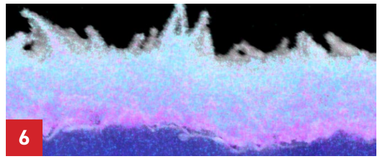


SMALL SPECK, BIG DISCOVERY: STARDUST THAT'S OLDER THAN THE SUN

BREAKTHROUGH IN MYRTLE RUST TREATMENT

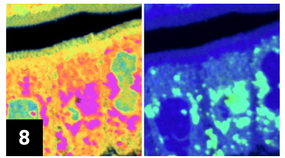


FERRONOVA: TRANSLATING RESEARCH FOR BETTER CANCER OUTCOMES

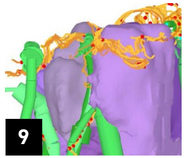


BRINGING GREEN AMMONIA TO MARKET

ARE EARTHQUAKES THE KEY TO GOLD NUGGETS?

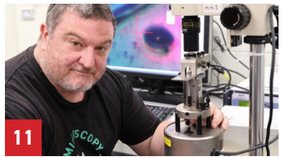


NEW DRUG TARGET FOR CHOLESTEROL REDUCTION

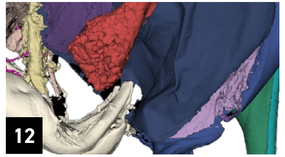


HOW CENTIPEDES CONTROL THEIR VENOM

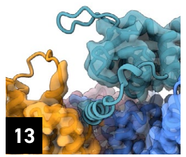
AUSTRALIAN MEGAFAUNA: MARSUPIAL LION'S MEGA BITE



REWRITABLE POLYMERS: INNOVATION FOR DATA STORAGE



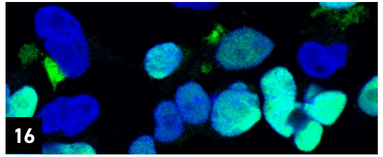
PIERCING AND PUMPING: BEE STINGER ANATOMY



HOW CHOLESTEROL CONTROLS CELL GROWTH

DATING MURUJUGA'S ROCK ART WITH DESERT VARNISH

WORLD-LEADING SOLAR RESEARCH



PROTEIN DISCOVERY FOR BETTER BOWEL CANCER TREATMENTS

EVEN MORE GREAT OUTCOMES...

Dr Nicholas Hunt and Professor Victoria Cogger.
Credit: The University of Sydney/Stefanie Zingsheim

1

NEEDLE-FREE INSULIN

CHALLENGE

It is estimated that 422 million people worldwide have diabetes, and approximately 75 million inject themselves with insulin several times each day or have a permanently attached pump to keep their glucose levels within a healthy range and keep them alive.

If ingested, insulin is broken down so needs to be injected to be effective. Injectable insulin also needs to be kept cold, making it difficult to manage in hot or less developed countries or when travelling. The other drawback of injectable insulin is that it has the risk of causing glucose levels to crash leading to life-threatening hypoglycaemia (low blood sugar).

RESEARCH

A team of researchers from The University of Sydney led by Dr Nicholas Hunt, Prof. Victoria Cogger, and Prof. David Le Couteur AO along with a Norwegian collaborator, have developed a way to protect insulin so it is no longer broken down in the gut.

They attached the insulin to quantum dots made of silver sulfide and then coated them with a shell that protects the insulin from the digestive processes, allowing it to accumulate in the liver. An enzyme in the liver, whose levels fluctuate in response to glucose levels, breaks down the coating releasing the insulin in the liver when glucose levels are high. As glucose levels fall, so do those of the enzyme, reducing the amount of insulin released from the nanoparticles. The team showed that this responsiveness to glucose levels appears to eliminate the occurrence of life-threatening hypoglycaemia.

Transmission electron microscopy at our University of Sydney facility was used to confirm the structure of the quantum dots and the assembled nanoparticles.

Phase 1A clinical trials will begin in March 2025 to test the product's safety, with Phase 1B trials following in August to test its effect in patients with type 1 diabetes.

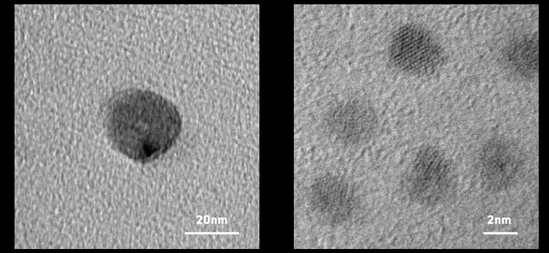
IMPACT

This oral insulin opens a path to safer, temperature-stable, and needle-free treatment for diabetes sufferers worldwide. The researchers are now commercialising their formulation through Sydney-based spin-out Endo Axiom, tapping into the $30 billion global insulin market.

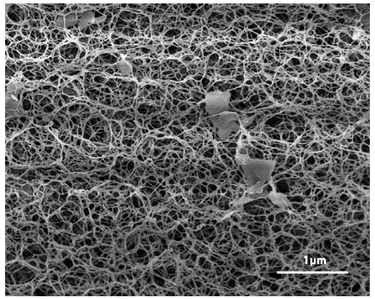
N. Hunt et al., Nature Nanotechnology 2024
DOI: 10.1038/s41565-023-01565-2

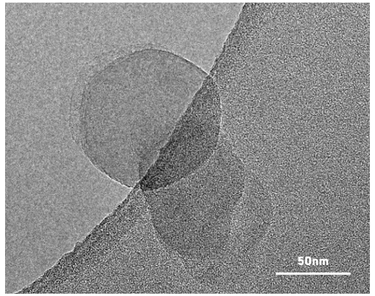
"The ability to validate that individual nanoparticles were of a uniform size and shape using microscopy was critical for publications, but even more for chemistry manufacturing and control processes that enable manufacturing for clinical trials."
– Dr Nicholas Hunt

Research and development version of the oral insulin capsule. Credit: USyd / Stefanie Zingsheim



Transmission electron microscope images. Left: showing the structure of the insulin encapsulated nanoparticles, including the quantum dot (dark). Right: Crystalline structure of the quantum dots.





Scanning (top) and transmission (bottom) electron microscope images of boron nitride nanosheets.

2

GENERATING ELECTRICITY FROM CARBON DIOXIDE

CHALLENGE

Carbon dioxide emissions are the primary cause of global warming, with energy generation being a major source. If carbon dioxide could be harnessed to produce energy instead, it would be a major step towards a Net Zero future.

RESEARCH

A collaboration between the research teams of Prof. Xiwang Zhang at the University of Queensland and Prof. Huanting Wang from Monash University has led to a breakthrough in generating electricity from carbon dioxide.
In biological systems, selective transport of positive and negative ions efficiently converts food into energy and drives signalling within and between cells. The researchers have copied this approach by building a proof-of-concept generator that uses carbon dioxide and water as a feedstock. It uses nanosheets of boron nitride embedded in a hydrogel matrix.

The generator operates under alkaline conditions, where CO_2 and H_2O react with amine groups on the nanosheets to produce HCO_3^-. This moves freely across the hydrogel device, while the positive charges produced by the reaction remain anchored to the immobile nanosheets embedded in the hydrogel. This movement of the negative ions, but not the positive ones, establishes a charge gradient, generating an electrical current. Over time, as the system absorbs more CO_2, the pH gradually shifts towards acidic conditions, which ultimately signals that the generator is 'full'. It can then be regenerated by restoring the pH to the alkaline range, enabling the system to restart the energy conversion process. This regeneration process releases the CO_2, which can either be reused in the rejuvenated generator or captured by calcium to lock it away as calcium carbonate. In this second case more CO_2 can be taken up by the generator.

Electron microscopy at our Monash University facility was instrumental in understanding the nano- and micro-structures of the generator and will continue to help the team as they work to improve the efficiency of their process.

IMPACT

This technology has the potential to transform CO_2 from a problem into a valuable resource. Two potential applications are currently envisaged by the researchers. "We could make a slightly bigger device that is portable to generate electricity to power a mobile phone or a laptop computer using CO_2 from the atmosphere.

"A second application on a much larger scale, would integrate this technology with an industrial CO_2 capture process to harvest electricity," Prof. Zhang said.

The development of the nanogenerator will continue through the ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide (GETCO2).

The team was a Eureka Prize finalist for their invention.

Z. Wang et al., Nature Communications 2024
DOI: 10.1038/s41467-024-47040-x

3 SMALL SPECK, BIG DISCOVERY: STARDUST THAT'S OLDER THAN THE SUN

A team of researchers at Curtin University, led by Dr Nicole Nevill, has made an extraordinary discovery: a tiny dust particle trapped inside a meteorite that originated from a star that predates our sun. This particle, known as a presolar grain, acts as a "celestial time capsule" offering a glimpse into the life of its parent star.

Meteorites usually consist of material formed within our solar system but may contain presolar grains formed by stars that existed long before our sun. These particles are identifiable by their unique elemental composition, particularly the ratios of isotopes (elements with differing numbers of neutrons).

Analysis of the particle using atom probe tomography at our Curtin linked laboratory revealed an unprecedented magnesium isotope ratio, the highest ever recorded. This exceptionally high ratio indicates that the particle came from a recently discovered type of star – a hydrogen-burning supernova.

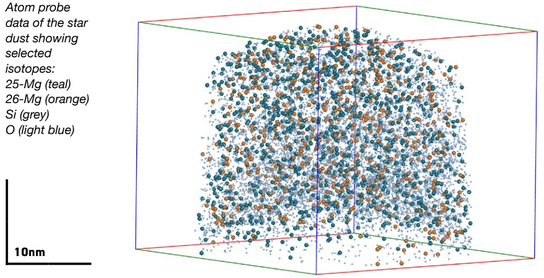
Further analysis using NanoSIMS at our University of Western Australia facility found the isotopic signature of oxygen was consistent with the particle having originated outside of our solar system.

"A hydrogen-burning supernova is a type of star that has only been discovered recently, around the same time as we were analysing the tiny dust particle. The use of the atom probe in this study, gives a new level of detail helping us understand how these stars formed," said Geoscience Atom Probe expert and co-author Dr David Saxey.

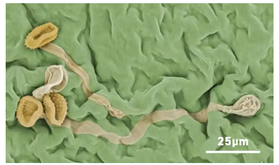
The research challenges existing stellar models and provides essential insights into the evolution of our solar system and the universe at large.

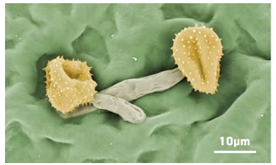
N. Nevill et al., The Astrophysical Journal 2024
DOI: 10.3847/1538-4357/ad2996

"It is simply amazing to be able to link atomic-scale measurements in the lab to a recently discovered type of star" – Prof. Phil Bland, co-author



Atom probe data of the star dust showing selected isotopes:
25-Mg (teal)
26-Mg (orange)
Si (grey)
O (light blue)





Top: Melaleuca leaf infected with myrtle rust by Dr Louise Shuey. Bottom: Scanning electron microscope images of untreated (left) and treated (right) myrtle rust spores on rose apple leaves.

4 BREAKTHROUGH IN MYRTLE RUST TREATMENT

Researchers at the University of Queensland have made a significant breakthrough in the fight against myrtle rust, an invasive fungal disease that has been devastating native Australian plants in the myrtle family such as eucalypts, bottlebrushes and paperbarks.

Rebecca Degnan, Dr Anne Sawyer and Prof. Neena Mitter worked with the Department of Primary Industries to develop an environmentally friendly spray that uses RNA technology to both prevent and cure myrtle rust infection. The spray works by using double-stranded RNA (dsRNA) to target and block essential fungal genes. This uses the same underlying patented RNA technology as the whitefly pesticide we have previously reported and demonstrates the ability for rapid adaptation of this technology to important new targets.

The dsRNA spray was effective in laboratory trials and when applied to healthy trees, it prevented infection. Remarkably, when applied to infected plants as late as two weeks post-infection, the plants recovered.

Scanning electron microscopy at Microscopy Australia's University of Queensland facility was used to visualise the myrtle rust infection on leaves and the effects of both preventative and curative dsRNA treatments.

Since myrtle rust was first detected in New South Wales in 2010, it has spread up the east coast and into the Northern Territory, Western Australia and New Zealand. The researchers will now test the RNA treatment for effectiveness in field trials to see if it works in a real-world setting. They will also test the spray's longevity and whether the initial dose can protect new growth that emerges after spraying.

R. Degnan et al., Communications Biology 2023
DOI: 10.1038/s42003-023-05618-z

5 FERRONOVA: TRANSLATING RESEARCH FOR BETTER CANCER OUTCOMES

Microscopy Australia provides critical long-term support for translation throughout the research, development, and deployment cycles. A great example of the long-term nature of this support is Ferronova Pty Ltd, launched in 2016 to commercialise magnetic nanoparticles designed to improve the detection and treatment of cancer by tracking the spread of cancer to lymph nodes.

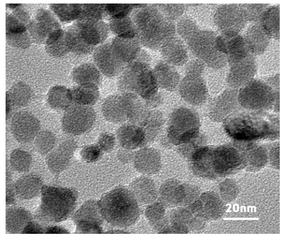
Microscopy Australia's facilities supported many aspects of Ferronova's technology from fundamental discoveries to batch production. It has allowed a detailed understanding of nanoparticle structure and is now used to monitor every batch of tracer produced. Below are some key milestones that were supported.

Ferronova brings together technologies from three independent research projects. At the University of South Australia, Prof. Benjamin Thierry was developing a patented sensor to detect magnetic nanoparticles for cancer diagnostics in collaboration with surgeons in head, neck and gut cancers. Simultaneously, Prof. Richard Tilley, director of our UNSW Sydney facility, was commercialising magnetic nanoparticles that he developed at Victoria University of Wellington. Realising they had complementary technologies they collaborated to form Ferronova in 2016. Development of their technology relied on microscopy at our University of South Australia and UNSW Sydney facilities.

In 2017 Ferronova began collaborating with Prof. Brian Hawkett's team at the University of Sydney, eventually licensing a key patented technology Prof. Hawkett had adapted from an earlier discovery by CSIRO. This polymer stabilisation technology was used to coat Ferronova's magnetic nanoparticles, enhancing their functionality. This combination of technologies enabled Ferronova to move their nanoparticles to preclinical studies, including large animal imaging enabled by the National Imaging Facility.

Ferronova has now completed its first clinical trial on 15 patients with oral cancer and 40 patients with other cancers. It has also established collaborative programs involving Siemens and other research partners for new medical applications of the technology.

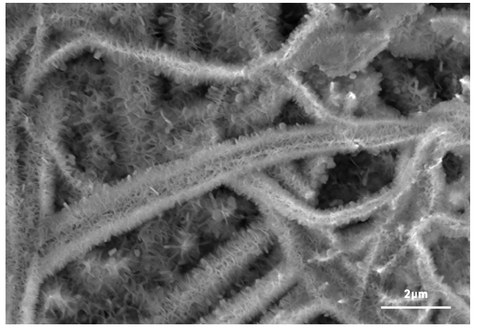
Profs Hawkett, Tilley and Thierry are all Scientific Advisors of Ferronova and continue to be heavily involved in the technology's ongoing development as it moves towards FDA approval and release onto the market.



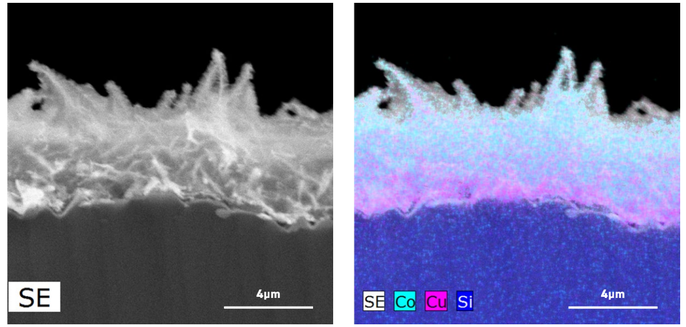
Transmission electron microscope image of Ferronova's nanoparticles.

6

BRINGING GREEN AMMONIA TO MARKET



Scanning electron microscopy (SEM) image showing the network of the cobalt-coated copper nanowires.



Left: SEM of a cross section of one of the nanowires. Right: Elemental mapping of the same part of nanowire showing the cobalt (Co) coating on the underlying copper (Cu) and silicon (Si).

CHALLENGE

Ammonia is the second most-produced chemical globally, and its use in fertiliser feeds half of the world's population. However, current production methods are energy intensive, accounting for 1% of greenhouse gas emissions and consuming 2% of global energy. Despite this fact, ammonia is an efficient way to store renewable energy.

A number of approaches to greener ammonia production are being developed with the help of our microscopy, and their commercialisation has the potential to revolutionise this critical global industry.

RESEARCH

Microscopy Australia's University of Sydney, UNSW Sydney and Monash facilities were essential to the development of several innovative green ammonia technologies.

UNSW Sydney researchers Prof. Rose Amal, a green ammonia expert, and Prof. Xiaojing Hao, a solar expert, have collaborated to develop a new method for producing green ammonia. It uses a specially designed and adapted solar panel that works like an artificial leaf using sunlight to turn nitrate-containing wastewater into ammonium nitrate for fertiliser. Unlike traditional methods, this system works under ambient conditions. It depends on a very efficient nanostructured catalyst made of copper and cobalt hydroxide incorporated into a traditional silicon solar panel. Prof. Amal is now seeking industry partners to further develop the process into a fully viable commercial system.

In our 2021 Research Highlights we reported on the energy-efficient plasma reactor that Prof. Amal also contributed to. It generates nitrites and nitrates, which are then converted to ammonia by copper nanowire catalysts. This process is now being commercialised by NSW spin-out PlasmaLeap. They have now scaled up production rates to make their process economically viable.

Another emerging approach, covered in our 2022 Research Highlights, developed at Monash University uses just air, water, and renewable energy in a patented electrochemical process that rearranges nitrogen and water atoms to produce ammonia. The process is being commercialised by Jupiter Ionics who recently raised $9M in series A funding for the scale up of their self-contained system.

All three of these approaches can be implemented on-site in agricultural locations, decentralising the production process, reducing CO_2 emissions from transport and eliminating the need for large scale storage and the risk of explosion that comes with it.

IMPACT

Both large and small scale green ammonia production will allow:

- export of Australian renewable energy as ammonia
- export of the production devices
- significant reduction of CO_2 emissions from manufacture
- localised production of ammonia on farms to reduce the need for transport and storage, eliminating a major safety risk, associated costs and emissions, bringing benefits to farmers and horticulturalists globally.

C. Han et al., Energy & Environmental Science 2024 DOI: 10.1039/D3EE03836J

7

ARE EARTHQUAKES THE KEY TO GOLD NUGGETS?

CHALLENGE

Gold is a rare metal in the Earth's crust, yet it is sometimes found in surprisingly large nuggets. How these nuggets form is a long-standing geological puzzle. Traditional explanations suggest that gold is deposited from hot fluids as they cool or undergo chemical changes. However, this theory doesn't explain:

- **why gold nuggets are predominantly found in quartz and not other minerals**
- **how such large nuggets can form from fluids that typically contain very low concentrations of gold**
- **why the nuggets form where they do within the quartz when evidence is lacking for a chemical or physical trap.**

RESEARCH

New research led by Dr Chris Voisey from Monash University points to a surprising answer: electricity. Quartz, when subjected to stress, such as during an earthquake, can generate electrical currents. This property is called piezoelectricity (piezo coming from the Greek word "to press").

The team's laboratory experiments demonstrated that stressed quartz can electrochemically deposit gold from solution and accumulate gold nanoparticles. The electrical potential generated by the quartz causes the existing gold to act like a lightning rod, attracting more gold to be deposited around it, leading to the formation of larger nuggets over time.

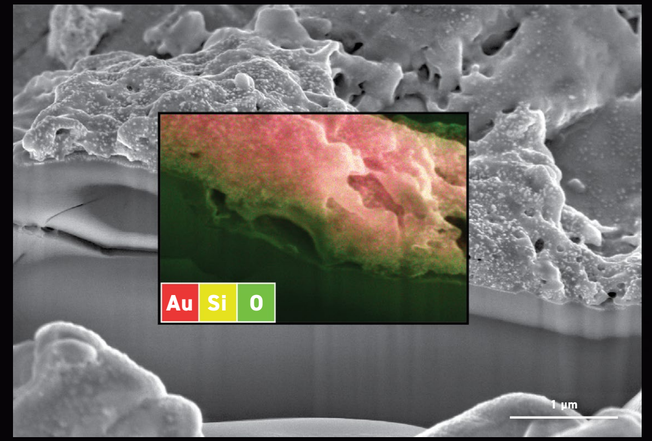
Scanning Electron Microscopy at Microscopy Australia's Monash University facility was used to examine the gold deposits on quartz surfaces, revealing their distribution, shape, and chemistry. The team observed that gold preferentially deposited on existing gold grains, supporting their hypothesis.

IMPACT

This research provides a plausible explanation for the formation of large gold nuggets in quartz and could have important implications for gold exploration and mining. It highlights the role of earthquakes in gold deposit formation, suggesting that areas with a geological history of seismic activity could be a target for gold exploration. The findings could also lead to the development of new techniques for gold ore processing, potentially using piezoelectricity to extract gold more efficiently.

The research also raises several lines of inquiry for future research such as what earthquake duration is needed to create gold nuggets, why these deposits form in only some quartz veins, and whether the piezoelectric effect can explain the deposition of other metals.

C. Voisey et al., Nature Geoscience 2024
DOI: 10.1038/s41561-024-01514-1



Scanning electron microscope image with elemental mapping of gold (red) deposited onto quartz (yellow and green) via piezoelectric reactions during experiments.

8 NEW DRUG TARGET FOR CHOLESTEROL REDUCTION

In a major study published in *Science*, researchers identified a potential new drug target for lowering blood cholesterol, offering hope for better cardiovascular health. It was enabled by two of Australia's national research infrastructure facilities, Microscopy Australia and ANSTO's National Deuteration Facility.

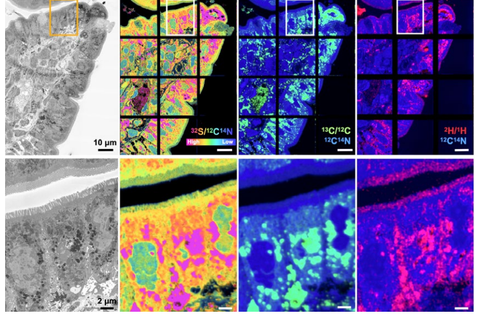
Cholesterol is crucial to our cells' membranes and is essential for proper brain function. It is also the precursor of vitamin D and hormones such as oestrogen, testosterone and stress hormones. Cholesterol is made by the body and absorbed from food, however, high blood cholesterol is linked to heart disease. Cholesterol in the intestine attaches to a protein called NPC1L1 on the surface of intestinal cells. This new study explored how this cholesterol moves inside the intestinal cells for further processing.

To visualise and track cholesterol in gut tissue, it must be labelled. An international research team led by Dr Peter Tontonoz from the University of California Los Angeles used the National Deuteration Facility to label cholesterol with a heavier form of hydrogen (deuterium). This was detected by Dr Haibo Jang using the NanoSIMS instrument at Microscopy Australia's University of Western Australia facility.

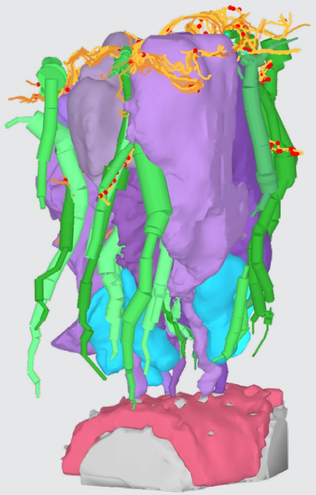
Using this approach, the team identified that key proteins called Asters link the NPC1L1 on the intestinal cell surface to the interior of the cell, facilitating the movement of cholesterol into the cell. There, it is processed in a compartment called the endoplasmic reticulum before being transported through the blood to the tissues.

Mice without Asters had less cholesterol in their endoplasmic reticulum and were protected from the effects of high cholesterol in their diet. These findings suggest that the Aster pathway could be a new target for drug development to reduce cholesterol absorption.

A. Ferrari et al., Science 2023
*DOI: 10.1126/science.*adf0966



NanoSIMS images showing the distribution of labelled cholesterol and fatty acids in intestinal cells.



3D electron microscopy reconstruction showing the muscle-triggered cells (purple), muscle fibres (green), nerves (yellow), hormone-triggered cells (blue) and venom duct (pink).

9 HOW CENTIPEDES CONTROL THEIR VENOM

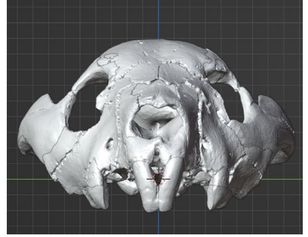
Venoms contain a complex suite of toxins with enormous potential as new medicines, insecticides, or as structural inspiration for functionally related products.

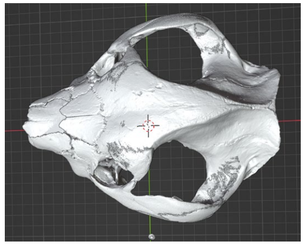
Most venomous animals use their venom for either predation or defence. Venoms for predation generally contain toxins that quickly paralyse prey, while defensive venoms contain pain-causing toxins to fend off predators. Some however, use their venom for both purposes and can control which toxin combinations to use in a specific situation.

How the different toxins are produced, stored and delivered has been studied in the red-headed centipede (*Scolopendra morsitans*) by a research team led by Dr Vanessa Schendel and Dr Eivind Undheim. A combination of 3D electron microscopy and 3D mass spectroscopy imaging at our University of Queensland facility revealed the detailed cellular anatomy and complex distribution of the different venom components within the centipede's relatively simple venom gland. This shed light on how *S. morsitans* can fine-tune the secretion of different combinations of its multiple venom components.

The 3D mass spectroscopy imaging showed that the centipede stores some of its toxins in different parts along the length of the venom gland. The team also discovered that there are pairs of cells that release their toxins by one of two mechanisms. One cell type is surrounded by muscle fibres and nerves which, when triggered, cause the venom to be squeezed out. The other cell type appears to respond to hormones or neurotransmitters that cause granules full of venom components to fuse with the cell membrane and release their contents into the venom duct. These processes enable different types of environmental stimuli to trigger release of venom profiles appropriate for the situation.

V. Schendel et al., Nature Ecology & Evolution 2024
DOI: 10.1038/s41559-024-02556-9





Left: Illustration of T. carnifex by Peter Schouten. Centre: A 3D reconstruction of the skull from Micro-CT scans. Right: Dr Aaron Camens setting up the force test with the 3D-printed skull and a kangaroo leg, photo by John Nicol.

10 AUSTRALIAN MEGAFAUNA: MARSUPIAL LION'S MEGA BITE

Thylacoleo carnifex, the 'marsupial lion', was the largest mammalian predator ever to evolve in Australia. An apex predator in the late Pleistocene, it was still present here when humans first arrived.

To understand what *T. carnifex* was eating and how it caught its prey, Flinders University palaeontologists, Dr Aaron Camens and Fraser Brown, recently surveyed more than 18,000 bones of prey animals across southern Australia. Their analyses of the bones and the bite marks they exhibited showed that *T. carnifex* specialised in hunting kangaroos, including extinct giant short-faced kangaroos, often disabling them with a strong bite to the ankle.

Earlier studies suggest it had one of the strongest bites of any mammal, living or extinct. It had distinctive and unique teeth with a single, long-bladed premolar instead of the separate molars and premolars seen in other mammals

To determine the forces involved in producing the characteristic bite marks on the bones, the team collaborated with platform scientist Dr Sophie Rapagna at Microscopy Australia's Flinders University facility and others to create a 3D-printed *T. carnifex* skull for testing. As a complete *T. carnifex* skull and jaws has never been found, they used the large volume Micro-CT scanner to scan the most complete skull and jaws that were available. Combining this data with existing scans of other near-complete skulls from the Virtual Australian Museum of Palaeontology, a complete composite scan was made and 3D printed in nylon with the teeth in steel. These materials were a good match to some of the relevant properties of bone and teeth.

The force exerted by the 3D-printed skull was tested on kangaroo legs in the Australian National Fabrication Facility at Flinders University. They found that the force required to replicate the marks found on the fossils was much higher than they imagined. Simulations conducted by their collaborator, suggested that the force exerted could be closer to that of a crocodile.

THIS RESEARCH FEATURED IN THE ABC DOCUMENTARY 'MEGAFAUNA: WHAT KILLED AUSTRALIA'S GIANTS?'

SCAN TO WATCH IT ON IVIEW

11

REWRITABLE POLYMERS: INNOVATION FOR DATA STORAGE

CHALLENGE

Photolithography transfers patterns onto surfaces using light, usually high-powered laser light. It is widely used to make electronic devices, and modified surfaces for biomedical science, smart materials, and optics applications. However, many photolithographic processes are time consuming, expensive, and require high temperatures. The base materials can also be expensive. In addition, most photolithography is subtractive: once formed it cannot then be easily erased, making rewritable storage difficult. Erasable pattern making is a gap in current processes and could provide new solutions for information storage.

RESEARCH

PhD student Samuel Tonkin and Prof. Justin Chalker at Flinders University have recently developed a polymer that can be rapidly and reversibly modified with low-cost, low-power lasers at room temperature.

The serendipitous discovery was made by Dr Christopher Gibson, Director of our University of Adelaide facility, during what he thought would be a routine atomic force microscopy (AFM) analysis session at the Microscopy Australia facility at Flinders University.

Dr Gibson explained: “When I exposed the polymer to the low-power laser built into the AFM, the result was a surprise. It was immediately modified, indicating an unusual response not seen when other common polymers are exposed to these lasers. We realised that this phenomenon might be useful in a number of applications, so we built a research project around this discovery.”

By altering the power and wavelength of the laser, the polymer could be precisely modified, generating either swollen or etched regions. They found the swollen regions could be erased with heat. This makes them highly suitable for applications such as direct laser lithography and rewritable information storage systems.

PhD student Abigail Mann and the team have recently explored other ways to use this polymer for rewritable data storage. By using a nanoscale AFM tip to make tiny indents into the polymer, they were able to have a higher density of information, not only in 2D but in 3D, by precisely controlling the depth of the indents. These too can be erased by heat to provide nanoscale, rewritable data storage.

The project team also included Dr Lynn Lisboa and Dr Jason Gascooke. The Flinders branch of the Australian National Fabrication Facility also contributed to this work.

IMPACT

These findings enable a variety of novel applications in rewritable information storage, and direct laser lithography for biomedical, electronics and optics applications. These are rapid, one-step, safe, cheap and easy processes that compare favourably to other methods of lithography that require complex polymer structures, high-power lasers, and multi-step masking, developing and washing protocols.

A. K. Mann et al., Angew. Chem. Int. Ed. 2024
DOI: 10.1002/ange.202404802

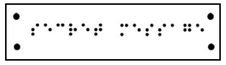
A. Mann et al., Advanced Science, 2024
DOI: 10.1002/advs.202409438

Images: Treated polymer before and after heating.

REFERENCE IMAGE

OPTICAL MICROSCOPY

STYLUS PROFILOMETRY



BEFORE HEATING

AFTER HEATING

BEFORE HEATING

AFTER HEATING

BEFORE HEATING

AFTER HEATING

Dr Chris Gibson at the atomic force microscope on which the phenomenon was observed.

12 PIERCING AND PUMPING: BEE STINGER ANATOMY

When a bee stings, its barbed lancets firmly attach the stinger to the victim's skin making it very hard to remove. An autonomous pumping system then injects the pain-causing venom into the victim, even when the stinger is separated from the bee. These observations inspired researchers at UNSW Canberra to learn more about how this complex system works with a view to designing securely attached, self-pumping medical devices for delivering hormones and drugs.

Dr Fiorella Ramirez-Esquivel and Dr Sridhar Ravi from the Australian National University (ANU) and UNSW Canberra have built on historical descriptions of the stinger by using the complementary microscopy techniques of scanning electron microscopy and micro-CT at our ANU facility. This was combined with high-speed video, producing data that allowed the complex 3D anatomy and motions of the stinger to be understood. Earlier work enabled by our University of Queensland facility, showed that the lancet component of the bee stinger is strengthened with manganese.

The entire stinger is only 2.5mm long yet consists of a complex arrangement of moving parts including sections of the cuticle that pierce the highly elastic skin of vertebrates; muscles to insert the stinger and pump the venom; nerves to coordinate the process; and glands to make and store the venom and the alarm hormones that alert other worker bees.

The researchers are now developing 3D printed larger prototype needles and pumping devices to identify the key design features that give the stinger its unique properties. This will help to design simplified bioinspired devices that can then be manufactured in smaller sizes.

F. Ramirez-Esquivel & S. Ravi, iScience 2024
DOI: 10.1016/j.isci.2023.107103

Image: A 3D reconstruction of a stinger from micro-CT data showing the different components in different colours. The stinger is 2.5mm long.

13 HOW CHOLESTEROL CONTROLS CELL GROWTH

Cholesterol uptake and processing is of great interest to medical science as cholesterol is not only a key component of proper brain and hormone function but when its levels are too high it is associated with cardiovascular disease. Cholesterol is also a crucial component of cell membranes. For cells to grow, there needs to be enough cholesterol in the cells. How the amount of cholesterol is detected by cells is the subject of research by A/Profs Michelle Halls and Andrew Ellisdon from Monash University, recently published in *Nature*.

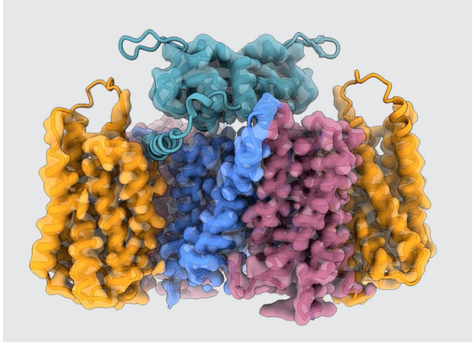
By using cryo-electron microscopy at our Monash University facility the team has determined the structure of a human protein called LYCHOS. This protein acts as a cholesterol sensor and, by understanding its structure, the team has worked out how it drives cell growth and which parts of the protein could potentially be targets for new drugs. Altering regulation of cell growth is an important way of treating diseases such as cancer.

"Cryo-EM has revolutionised drug discovery by enabling researchers to determine the 3D structure of molecules previously too difficult to observe," A/Prof. Halls said.

"This state-of-the-art technology has provided us, and drug discoverers around the world, with a precise structural description of the crucial role of LYCHOS as a cholesterol sensor and regulator… the new structural information about LYCHOS opens up a whole new world for drugs designed to block abnormal cell growth and target things like tumour growth and spread, or impaired cholesterol metabolism resulting in neurological conditions," he continued.

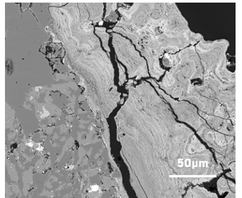
Bayly-Jones et al., Nature 2024
DOI: 10.1038/s41586-024-08012-9

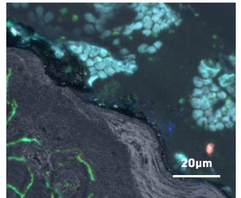
PUBLISHED IN NATURE



Reconstruction of the LYCHOS protein from cryo-EM data showing the major regions in different colours.

Bilby motif engraved into panel coated with desert varnish on Enderby Island by Jo McDonald, reproduced with permission of MAC. Below are images of desert varnish taken with electron (left) and light (right) microscopy.





14 DATING MURUJUGA'S ROCK ART WITH DESERT VARNISH

Murujuga, the Dampier Archipelago in northern Western Australia, is home to one of the world's largest, densest and most diverse collections of engraved rock art. Rock engravings, made in both deep time and the recent past, reflect the continuing cultural and spiritual connection to Pilbara Traditional Owners and Custodians. In partnership with the Murujuga Aboriginal Corporation (MAC), the Centre for Rock Art and Management at the University of Western Australia (CRAR+M UWA) is working to study, monitor, and care for these engravings.

The engravings are made on rock surfaces by chipping away the weathered crust, revealing the lighter rock below. Some of these engraved surfaces host a thin black coating called desert varnish. This is significant because desert varnish has been observed to form over the top of, and within, older rock engravings. Therefore, studying this varnish might give clues to the minimum and maximum dates of the currently undatable engravings.

To investigate the use of this varnish as a dating method, an interdisciplinary team of archaeologists, geologists, and microbiologists on the Dating Murujuga's Dreaming ARC Linkage Project are using various microscopy techniques at the Microscopy Australia facility at The University of Western Australia to investigate the varnish's microstructure, geochemistry, and biofilms.

Scanning electron microscopy revealed complex layered structures, and elemental mapping showed layers rich in clay, manganese, and iron. Additionally, confocal microscopy showed that the surface of the varnish harbours bacterial biofilms, indicating that the varnish has a biological component. By understanding the detailed structure of the varnish, it may be possible to identify and date constituents that formed when the varnish was developing and therefore help to date the engravings themselves.

The Dating Murujuga's Rock Art is an ARC Linkage Project (LP190100724) between The Universities of Western Australia, Melbourne, and Wollongong, Murujuga Aboriginal Corporation, Rio Tinto and Woodside.

15

WORLD-LEADING SOLAR RESEARCH

CHALLENGE

In a rapidly changing climate the need for clean energy solutions, such as solar, has never been greater. Traditional silicon solar cells, while cost-effective, have limitations in power conversion efficiency. More efficient solar cells and panels will expedite the global transition to a net zero economy but this will require significant advances in renewable energy technologies.

RESEARCH

Prof. Ho-Baillie's research focuses on multi-junction solar cells, which offer higher efficiency than traditional single-junction silicon cells. Solar cells convert solar energy into electricity using semiconductors. While silicon is the primary semiconductor material used in current solar technology, perovskites have emerged as a promising material for realising multi-junctions. By stacking perovskite on top of silicon to form a double-junction solar cell, Prof. Ho-Baillie's team has developed an independently certified 30% power conversion efficiency.

At the time of reporting in July 2024, her team was one of only eight labs in the world to achieve this, and the first in Australia. "There isn't much room for silicon to improve because its theoretical limit is only 30%, but for perovskite–silicon, it is 40%," said Prof. Ho-Baillie. Another double-junction reported by her team is a perovskite–CIGS cell on a flexible steel substrate achieving an efficiency of 18.1%, a record at the time, in March 2024.

Her team uses a range of electron microscopy techniques, from elemental mapping to atomic scale imaging to understand the structure and composition of the solar cells. This understanding enables improvements in their performance and stability including breakthroughs in perovskite cells that passed industry standard tests against heat and moisture. This work led by Prof. Ho-Baillie reporting record durability for perovskite cells was published in the journal *Science* in 2020. Her team regularly accesses our University of Sydney facility and were previously major users of our UNSW Sydney facility.

IMPACT

Recognised by Clarivate as one of the world's most highly cited researchers for six years running, Prof. Ho-Baillie's innovations in solar technology are paving the way for a cleaner, greener world. She is currently collaborating with SunDrive, a Sydney-based company, with the aim of commercialising perovskite–silicon double-junction solar cells. Her work directly supports Australia's net zero emissions targets by providing cost-effective and more efficient clean energy solutions.

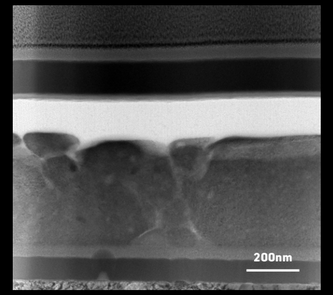
J. Zheng et al., ACS Energy Letters 2024 DOI: 10.1021/acsenergylett.4c00432

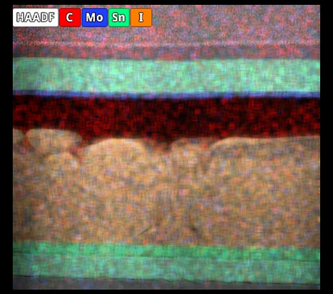
J. Zheng et al., Energy & Environmental Science 2023, DOI: 10.1039/d2ee04007g

M. Mahmud et al., Advanced Energy Materials 2022, DOI: 10.1002/aenm.202201672

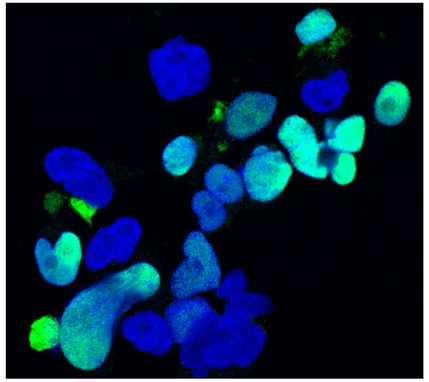
L. Shi et al., Science 2020 DOI: 10.1126/science.aba2412

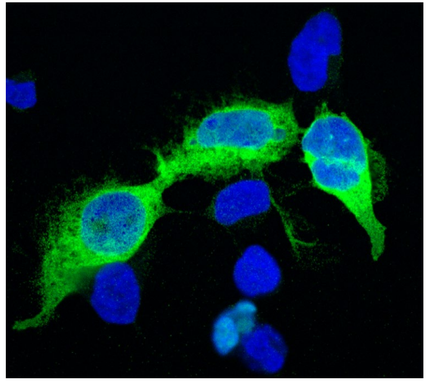
PUBLISHED IN SCIENCE





Transmission electron microscope image of layers within a tandem solar cell, with elemental map overlaid below (C - carbon, Mo - Molybdenum, Sn - Tin, I - Iodine, HAADF - an imaging mode)





16 PROTEIN DISCOVERY FOR BETTER BOWEL CANCER TREATMENTS

Bowel cancer claims more than 100 lives in Australia every week but around 90% of cases can be successfully treated if detected early. Researchers at the Australian National University (ANU) have discovered that an immune protein can slow the division of bowel cancer cells. This is a promising target for both early detection tests and treatments for bowel cancers.

Researchers at ANU led by Dr Abhimanu Pandey and Prof. Si Ming Man are using Microscopy Australia's ANU facility and Phenomics Australia to help them understand the factors affecting initiation and growth of colon cancer, and lead to new diagnostics and treatments.

Uncontrolled cell division is a feature of all cancers but cell division can be controlled differently in different tissues. The ANU researchers are studying those signals in colon cancer.

This team discovered that a protein called Ku70 slows down the signals that activate cell division. In healthy cells, Ku70 helps detect and repair broken DNA in the cell's nucleus. Normally DNA is only present in the nucleus and mitochondria, but when it is found in the cytoplasm, it indicates that something is wrong. This causes Ku70 to move into the cytoplasm, where it can slow down cell division, a crucial factor in slowing cancer growth.

Light and confocal microscopy at Microscopy Australia's ANU facility was crucial to many aspects of this research. For instance, it was used to show that increased levels of DNA in the cytoplasm caused Ku70 to move from the nucleus to the cytoplasm. This demonstrates the potential to 'damp down' colon cancer by manipulating the location of Ku70 with drugs and DNA-based therapeutics.

Prof. Si Ming Man suggested that future bowel cancer screening methods could include checking the levels of Ku70 in pre-cancerous polyps.

It also opens up a new treatment route for colon cancer that could mobilise the cells' own defense mechanisms by using new DNA-based drugs.

A. Pandey et al., Science Advances 2024
DOI: 10.1126/sciadv.adh3409

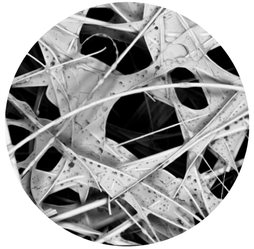
Images: Confocal microscope images. The top one shows normal cells where Ku70 (green) is found in the nucleus (blue). The lower one shows that when DNA is added to the cell cytoplasm the Ku70 moves out of the nucleus into the cytoplasm.

17 EVEN MORE GREAT OUTCOMES...

The previous stories are a tiny subset of the great and diverse outcomes that were enabled by our facilities this year. Here are tasters of a few more.

BLOOD VESSEL ON A CHIP

Researchers at the University of Sydney have successfully created a transparent microchip with tiny channels where human cells can grow, mimicking the structure and function of human blood vessels. It can help researchers test drugs quickly with very small volumes. This will reduce reliance on animal testing.



RAT TEST FOR TROPICAL DISEASE

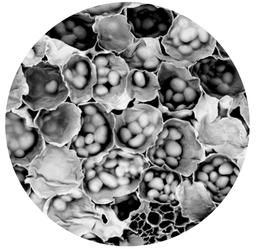
University of Queensland researchers have developed a quick and easy lateral flow test (also known as a rapid antigen test, or a RAT) that has successfully detected West Nile virus in crocodiles. It forms a blueprint for using the same patented platform to detect a wide range of flaviviruses in humans and other animals – this would be widely applicable and is not currently available.

ADDICTION TREATMENT IN CLINICAL TRIAL

Sydney spin-out, Kinoxis, recently raised $14.5M to underpin Phase 2 clinical programs for KNX100, a molecule to treat various neuropsychiatric disorders, including dementia and substance use disorders. They recently announced a collaboration with the U.S. National Institute on Alcohol Abuse and Alcoholism to evaluate KNX100 in alcohol-use disorder. The discovery and development of KNX100 have relied on Microscopy Australia.

COATING TO PREVENT ELECTRONICS OVERHEATING

Graphene Manufacturing Group, whose R&D and QC have been supported by several Microscopy Australia facilities, is developing new potential markets for their thermal graphene coating in heat sinks for electronics that could remove heat 30% more efficiently, enabling the AI revolution.



UNDERSTANDING BEANS TO REDUCE FUEL USE

Monash University researchers are investigating the structural differences between normal and hard-to-cook beans to understand how prolonged storage conditions affect bean cooking times and fuel use: significant factors for low-income communities.

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Right: Confocal microscope image of a fern from the Queensland University of Technology's Garden Point Campus taken by John Griffin.

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