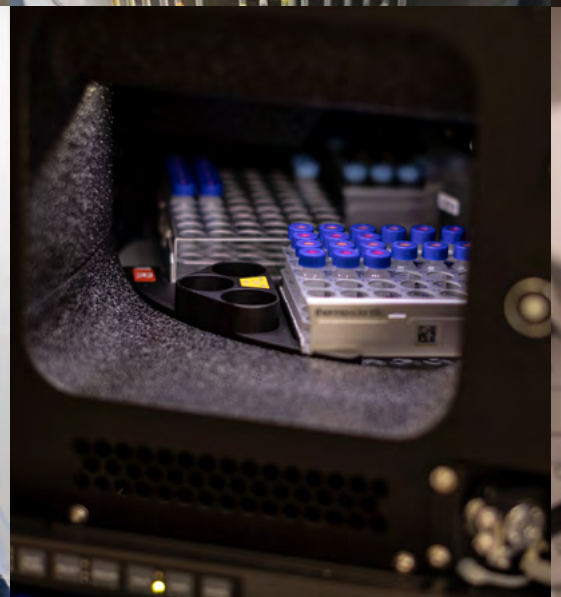
Core Research Facilities
Research Highlights 2025-26

THE UNIVERSITY OF SYDNEY






The University of Sydney's Camperdown campus sits on the lands of the Gadigal people with campuses, teaching and research facilities on the lands of the Gamaraygal, Dharug, Wangal, Darkinyung, Burramadagal, Dharawal, Gandangara, Gamilaraay, Barkindji, Bundjalung, Wiradjuri, Ngunawal, Gurend Gureng and Gagadju peoples. We recognise and pay respect to the Elders and communities of these lands, past present and emerging, who for thousands of years have shared and exchanged knowledges across innumerable generations, for the benefit of all.

Cover: People, processes, equipment and research from across the University of Sydney's Core Research Facilities. Clockwise from top left: Sydney Informatics Hub, Sydney Manufacturing Hub, Sydney Analytical, Sydney Nano Foundry, Sydney Microscopy and Microanalysis, Sydney Mass Spectrometry, Sydney Imaging, Sydney Cytometry.

Core Research Facilities

Research Highlights 2025-26

Contents

About us

Find out about the University's Core Research Facilities. Discover what we do, who we partner with and the vision guiding our evolution and growth.

Mission and vision

World-class capabilities driving transformative research

The University of Sydney's Core Research Facilities play a central role in enabling world-class research. Spanning 27 sites across our campuses, these eight facilities provide researchers and industry partners with access to more than 500 state-of-the-art instruments, supported by a team of over 100 expert platform scientists and technical staff.

Established as a University-wide initiative in 2014, the Core Research Facilities have grown significantly and continue to evolve in response to emerging research needs. New facility nodes are planned within the Sydney Biomedical Accelerator, a visionary partnership with Sydney Local Health District that will bring a new 36,000m² health, education and research complex to life later this decade. Our growth is further driven by collaborations with international partners, national platforms such as the National Collaborative Research Infrastructure Strategy (NCRIS), and NSW-based initiatives, ensuring we remain at the forefront of research infrastructure.

Sydney Research Infrastructure encompasses not only the Core Research Facilities but also Research Service Units such as Laboratory Animal Services, alongside rapidly advancing digital capabilities including Sydney Research Cloud. Together, this ecosystem is designed to deliver seamless, high impact support to our research community. This document focuses specifically on the Core Research Facilities.

Our facilities are helping shape a vibrant research environment. One that empowers discovery, drives innovation, and enables solutions to society's most pressing challenges. We invite you to explore the capabilities highlighted in this brochure and connect with us to discuss how we can support your research goals.

Professor Simon Ringer
Pro-Vice-Chancellor (Research Infrastructure)

"The University of Sydney's Core Research Facilities are foundational to our research excellence. They enable our researchers and partners to move from insight to impact by providing access to sophisticated capability and expert staff with deep technical expertise, within an environment that encourages collaboration across disciplines and sectors.

Sustained, strategic investment in this shared capability is essential to advancing knowledge and translating research into outcomes that matter both locally and globally."

Professor Mike Ryan
Deputy Vice-Chancellor (Research)

Who we are and what we do

The University of Sydney's Core Research Facilities provide world-class equipment and expertise to support researchers and industry as they tackle some of today's greatest challenges.

As a central part of the University's research support structure, the facilities operate independently of faculties, schools, and research initiatives, and are openly accessible to researchers across the University and to external collaborators.

Our eight facilities are supported by expert platform scientists and technical staff, and host a constantly evolving suite of advanced capabilities, including several first-in-country technologies.

The Core Research Facilities specialise across three foundational pillars of research and development: modelling, making, and measuring. They are central to advancing knowledge and driving breakthroughs across a wide range of disciplines, including medicine and health, advanced manufacturing, quantum technologies, biomedical engineering, life and earth sciences, digital humanities, cultural heritage, and more.

Quick stats

Our current footprint

8
facilities

27
sites

500+
instruments

100+
onsite experts

We have supported*

3,525
facility users

3,363
projects

431,735
equipment hours

46
industry clients (75 individual industry users)**

*in 2025
**2024-2025 financial year

Core Research Facilities

Modelling, Making, Measuring

Together, the Core Research Facilities' specialisations cover three foundational areas of research and development: *modelling*, *making* and *measuring*.

Modelling

Sydney Informatics Hub
Research data analysis and training

Making

Sydney Manufacturing Hub
Advanced manufacturing

Sydney Nano Foundry*
Fabrication at micro and nano scale

Measuring

Sydney Analytical
Chemical, biological and materials analysis

Sydney Cytometry
Quantitative cell sorting and analysis

Sydney Imaging
Biomedical imaging

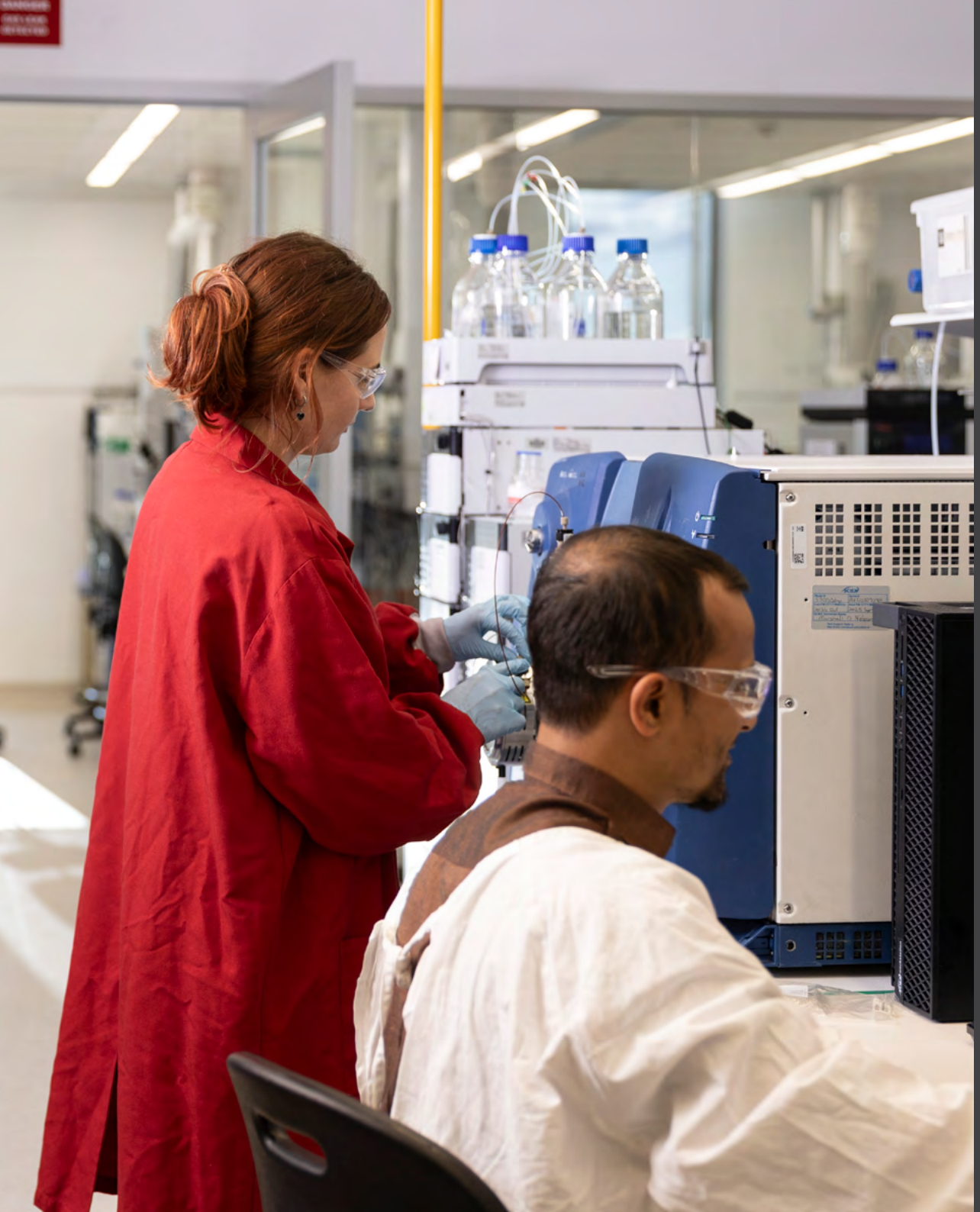
Sydney Mass Spectrometry
Proteomics, metabolomics, lipidomics and spatial omics analysis

Sydney Microscopy and Microanalysis
Micro, nano and atomic-scale exploration

*Formerly Research and Prototype Foundry

Our partners

Our facilities are underpinned by partnerships with leading research and industry organisations, and are proudly integrated with the Australian government's national research infrastructure framework. Below are some of our partners.



Common good, locally and globally

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Our Core Research Facilities contribute to building a better, more sustainable society. Explore how the research we enable aligns with local and global frameworks, and translates into economic, social, and environmental value.

Ambitious Australia: *Strategic Examination of Research and Development*

Our Core Research Facilities support a broad cross-section of research that is spearheading advances in areas of national strategic importance, including the six National Innovation Pillars outlined in the *Ambitious Australia: Strategic Examination of Research and Development* report. Look for the Innovation Pillar symbols in our featured research highlights to see how each project aligns with these national priorities.

National Innovation Pillars

Health and Medical	Agriculture and Food	Defence
Energy and Environment	Resources	Technology

United Nations Sustainable Development Goals

Our facilities enable research that addresses internationally recognised goals for creating a better world. Look for the UN Sustainable Development Goal symbols in our featured research highlights to see how each project aligns with these global priorities.

Enabling research excellence

—

Each year, our Core Research Facilities underpin thousands of research and industry projects, supported by our frontier capabilities and expert technical staff.

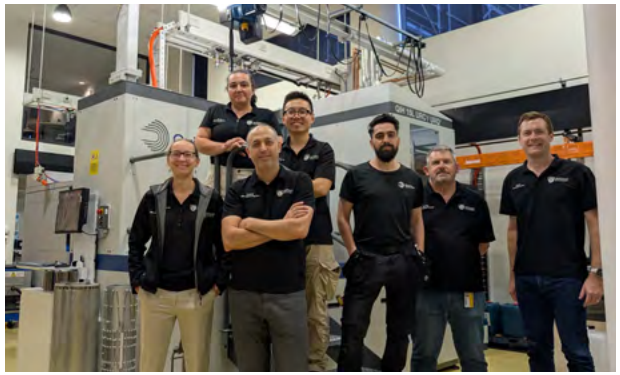
Capabilities highlights

A $9 million strategic research partnership was unveiled with Siemens Healthineers centred on the opening of Cima.X 3T MRI Clinical Research Facility within **Sydney Imaging**.

Sydney Cytometry and **Sydney Mass Spectrometry** launched the *Spatial Pan-Omics Initiative* with one of the most extensive and integrated collections of spatial multi-omics platforms in Australia.

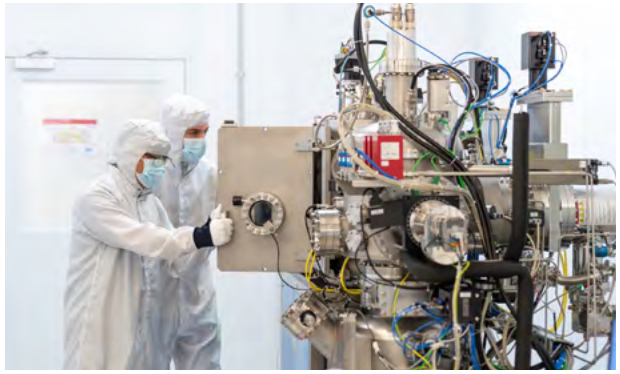
Sydney Microscopy and Microanalysis launched a new node in the Engineering and Technology Precinct housing Atomic Force Microscopes, a Scanning Electron Microscope and a High Resolution Plasma FIB system, many being first-in-country instruments.

The New South Wales Organoid Innovation Centre launched its Sydney node within **Sydney Analytical's** Drug Discovery lab spaces.

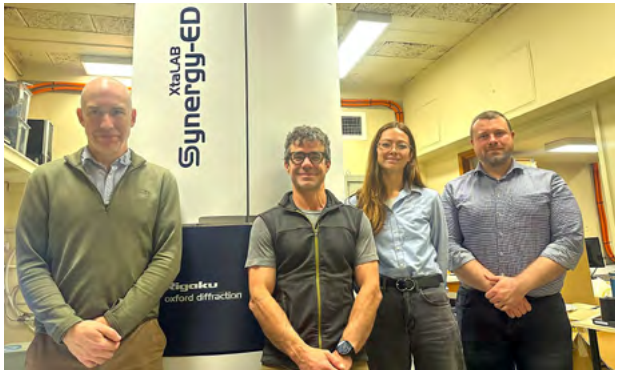


The **Sydney Manufacturing Hub** has installed a Hot Isostatic Press (HIP) to support high-performance materials processing and strengthen its offering in additive manufacturing and advanced materials research.

The ACRF Single Cell Cancer Proteomics Laboratory will be located within **Sydney Mass Spectrometry**. It is the first of its kind dedicated to cancer research and houses an Orbitrap Astral Zoom.



The **Sydney Nano Foundry** (formerly Research and Prototype Foundry) has installed an ultra-high-vacuum deposition system enabling the fabrication of advanced materials and nanoscale devices for quantum technologies, semiconductors, and photonics.



Sydney Analytical installed the first dedicated electron diffractometer in Australia and the southern hemisphere: the Rigaku XtaLAB Synergy-ED.

A new partnership was signed with the Pawsey Supercomputing Research Centre to give our researchers dedicated access to Australia's most powerful supercomputer, Setonix. Access is supported by the research computing experts at **Sydney Informatics Hub**.


FJD:32B

Sydney Informatics Hub

Research data analysis and training

Sydney Informatics Hub enables excellence in computational and data-driven research by providing support, training, and expertise in high-performance computing, AI, data analytics, bioinformatics, statistics, and strategy to University researchers and external collaborators.

Australian BioCommons

APPN Australian Plant Phenomics Network

Find out more

sydney.edu.au/informatics-hub

Automating agricultural research

Agriculture and Food | Technology

Challenge

Conventional approaches to plant science research continue to be relatively slow, labour-intensive and often non-digital. This presents a significant challenge in accelerating the pace of genetic and crop management improvements – progress that is increasingly vital in the face of rising global demand, rapidly changing environments, tighter regulatory requirements and growing input costs.

To overcome this, the Australian Plant Phenomics Network (APPN) has developed and adopted infrastructure which can underpin, automate and improve the way we tackle agricultural research and crop improvement.

Research

The APPN is part of Australia's National Collaborative Research Infrastructure Strategy (NCRIS). It aims to transform Australian plant and agricultural science through innovative phenotyping, automation and data science, with translational and transformational impacts to the agriculture sector.

The University of Sydney node, which is part of the Sydney Informatics Hub, is based in Narrabri, a major agricultural region of New South Wales. The node focuses on field phenomics, delivering new capabilities to support researchers with non-destructive and efficient estimation of plant traits and environmental conditions at the plot-field level.

The team provides access to state-of-the-art sensors (including high-resolution RGB, hyperspectral, thermal, LiDAR, gas analysis) mounted to aerial and ground-based platforms, alongside powerful ground-based tools for measurement of plant and soil properties and environmental conditions (using weather stations and an eddy covariance flux tower). The team assists researchers with the processing, analysis and interpretation of data using advanced data science approaches to improve insights for their research goals and heighten impact.

Results

Established in late 2024, the Sydney node has supported researchers across academia and industry including Australian Research Council, Grains Research and Development Corporation and Cotton Research and Development Corporation, state governments and internationally funded research programs. The node has contributed to studies on heat and drought tolerance in chickpea and wheat, crop disease phenotyping, cotton breeding and crop nutrient use efficiency.

By enabling high-resolution, real-time phenotyping that links genetic traits to field performance, the work is empowering researchers and growers to make data-informed decisions on variety selection, input timing, and stress management, accelerating innovation across the agricultural sector.

Left: Sunrise field operations: APPN and Sydney Informatics Hub staff supporting DairyUp research with UAV-based LiDAR phenotyping in maize.

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Precision diagnostics for aquaculture

Challenge

Aquaculture is increasingly vulnerable to the impacts of climate change, which is accelerating the emergence and spread of infectious diseases, threatening both animal health and food system resilience.

To address this, Dr Francisca Samsing (Faculty of Science) and her team combine traditional molecular biology and microbiology with bioinformatics to identify and characterise pathogens affecting aquaculture productivity. This supports early detection and tracking of emerging pathogens, enabling better-informed biosecurity and treatment responses.
However, existing bioinformatics methods were time-consuming and difficult to reproduce and scale, hampering timely decision-making.

Research

In partnership with Australian BioCommons, Sydney Informatics Hub bioinformaticians Dr Georgie Samaha, Mr Frederick Jaya, Dr Mitchell O'Brien and Dr Michael Geaghan developed an automated bioinformatics pipeline that sped up time to results from days of manual coding to less than three hours.

The pipeline leverages one of Australia's largest supercomputers, NCI Gadi, and integrates open-source software to enable the rapid identification of species, strains and key resistance and virulence genes, supporting faster, data-driven diagnostics and outbreak response in aquaculture settings.

Results

The pipeline has been published as an open-source module and is freely available online, enabling access to an automated and pragmatic bioinformatics solution for bacterial profiling across many host organisms. Using the pipeline, Dr Samsing's team successfully sequenced and analysed the first reported case of a novel *Flavobacterium* strain in Australia. It has also been applied to bacterial surveillance in companion animals and livestock across the Sydney School of Veterinary Science, leading to further funded research engagements.

Funding sources include:

- Sydney Infectious Diseases Institute
- Australian BioCommons

Left: Dr Francisca Samsing, School of Veterinary Science, Faculty of Science.

Technology

AI in law

Challenge

Legal research involves analysing large volumes of complex documents, from public materials like legislation and case law, to highly sensitive sources such as interview transcripts. Academics using generative AI to accelerate research of this kind need to balance the power of Large Language Models to effectively search, extract from and summarise documents, with the requirement that sensitive documents be stored and analysed on appropriate platforms.

Research

Two researchers from Sydney Law School are applying generative AI in different legal contexts. Associate Professor Carolyn McKay leads the *Digital Criminal Justice Project*, which examines how remote communication technologies – such as videoconferencing – impact vulnerable prosecution witnesses (including complainants or victims) as well as vulnerable defendants and offenders when they need to participate in criminal court proceedings or engage in conferencing with lawyers.

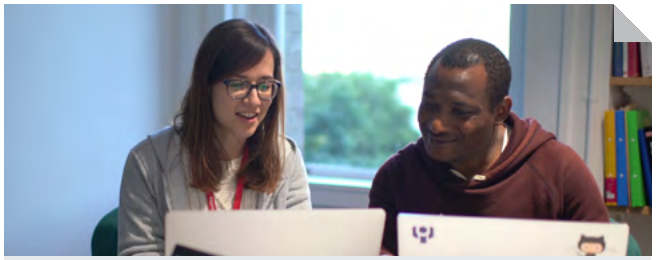
Associate Professor Ben Chen is studying the *Behavioural Economics of Inheritance Litigation*, using empirical methods to analyse case law and identify patterns in how estate size and relationships influence dispute outcomes, with the aim of informing fairer and more cost-effective legal processes.

Results

Sydney Informatics Hub assisted these researchers in applying generative AI tools to suit their distinct needs. Associate Professor McKay collected 175 fieldwork interview transcripts and surveys. Considered highly protected data, she could not send it to cloud providers for analysis. Sydney Informatics Hub provided a semantic search tool. This enabled her to identify themes across her dataset directly on her laptop, without sensitive data ever leaving the computer.

For Associate Professor Chen, Sydney Informatics Hub developed a toolkit to automatically extract structured data from publicly available legal judgments using cloud AI providers and collated the structured results into a spreadsheet for further analysis. This has evolved into *LawToData*, a web application to help other legal researchers to provide their own prompts for working with large selections of case law.

Right: An AI generated image.



Training

Upskilling researchers

On top of its data analysis services, Sydney Informatics Hub runs a wide range of introductory to advanced training courses spanning data science, AI, statistics, bioinformatics, research computing, and research data management. Many services are available free of charge to University researchers, research students, and affiliates.

In 2025, the Sydney Informatics Hub team delivered 80 training workshops, including Generative AI, statistics, data science and bioinformatics training for more than 3,000 researchers and staff, and onboarded 1,130 researchers to our Tier 1 national supercomputers and the Sydney GPU Cluster.

sydney.edu.au/informatics-hub/training

80
workshops

3,000+
upskilled

1,130
onboarded


Versaflo
M-300
3M

Sydney Manufacturing Hub
Advanced manufacturing

Sydney Manufacturing Hub specialises in cutting-edge additive manufacturing and materials processing of metals, ceramics and polymers, and offers researchers and industry access to concept-to-production capabilities supported by design and technical expertise.

Find out more

sydney.edu.au/manufacturing-hub

Redesigning rockets with 3D printing

Challenge

The USYD Rocketry Team comprises student engineers who design and manufacture high-power rockets and space technologies. They faced key limitations in the design of their Truss Transfer Structure. The initial version was machined from aluminium using Computer Numerical Control (CNC), a subtractive process which had two major constraints.

First, the design was limited by the size of the aluminium billet available. Second, machining a geometrically optimised truss structure using CNC was prohibitively expensive and time consuming. These challenges ultimately led to a structure with oversized parts that compromised performance.

Research

To overcome these constraints, the team turned to aluminium 3D printing, a process that offers significant design flexibility and material efficiency. Unlike CNC machining, which removes material from a solid block, metal 3D printing builds structures layer by layer, with minimal waste. Unused powder can even be recycled for future use.

Working with the Sydney Manufacturing Hub, the team used generative design software to create a design where structural members of the truss were placed at positions that maximised the overall structure's stiffness and buckling resistance.

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Results

The resulting 3D-printed truss was four times lighter than the CNC-machined version, while maintaining comparable compressive strength and delivering improved torque resistance.

The USYD Rocketry Team won the 2025 International Rocket Engineering Competition, the world's largest university rocket engineering competition with more than 150 international teams.

Right top: Truss 3D printed at Sydney Manufacturing Hub.
Right: The USYD Rocketry Team, overall winners of the 2025 International Rocket Engineering Competition.

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3D printing stronger copper alloys

Challenge

Copper and its alloys have excellent electrical and thermal conductivity as well as corrosion resistance, making them essential for applications in electrification, aerospace, maritime and renewable energy sectors.

However, 3D printing copper with a conventional laser beam remains difficult. Its high reflectivity and thermal conductivity limit laser absorption, preventing effective melting of powder particles during processing. Additionally, developing pre-alloyed powders is often costly and time-consuming. These challenges underscore the need for continued research and development to advance the additive manufacturing of copper alloys.

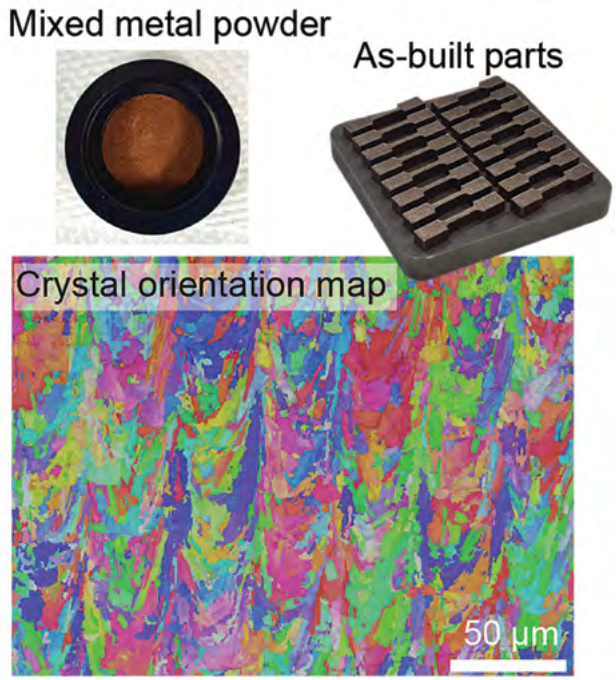
Research

Siyu Sun, a PhD student in the Faculty of Engineering, is tackling this challenge by developing high-strength, high-conductivity copper-nickel-silicon (Cu-Ni-Si) alloys. The project utilises elemental powder mixing and Laser Beam Powder Bed Fusion (PBF-LB) additive manufacturing, which selectively melts and fuses thin layers of metal powder layer by layer. A key part of this strategy is the use of a TURBULA powder mixer at the Sydney Manufacturing Hub to blend elemental metal powders, which is a simple yet highly effective approach that enables flexible alloy design and efficient material development in additive manufacturing.

Results

Siyu successfully fabricated dense Cu-Ni-Si alloys using the mixed Cu-Ni-Si powders. The 3D printed parts showed nearly full density and excellent mechanical properties, including a tensile strength approximately 35% higher than that of copper-tin bronze.

This work highlights a promising path forward for high-performance copper alloys in additive manufacturing. The research is ongoing, with a focus on understanding the relationship between microstructure and performance.



Above: Mixed metal powder and as-built Cu-Ni-Si alloys. Bottom: The crystal orientation map reveals a unique microstructure, different colours represent different crystal orientations within the material.

Energy and Environment

Technology

Exploring ocean life in 3D

Challenge

Dr Claire Reymond (Faculty of Science; Sydney Environment Institute) is conducting research in marine biodiversity. Her project aims to enhance taxonomic research in foraminifera to help support the accessibility of rare and archived material to researchers in a non-destructive way and promote awareness of these microscopic yet vital marine organisms.

To improve scientific communication and educational outreach, the ability to physically hold and examine these single-celled organisms without the need to use a microscope would be immensely helpful.

Research

To overcome this, Dr Reymond explored the use of micro-CT scanning to non-destructively capture detailed internal and external structures of foraminifera. Micro-CT data not only supports advanced morphological analysis but also produces digital 3D models.

She worked with Sydney Microscopy and Microanalysis for scanning, and the Sydney Manufacturing Hub to 3D print enlarged, tangible replicas. Each organism was printed in two interlocking halves, allowing users to see and handle both interior and exterior features.

Results

Dr Reymond has now created several high-resolution 3D-printed foraminifera models that bring invisible marine life to light. These replicas are powerful tools for education and outreach, helping researchers, students, and the public understand the structure and significance of these vital organisms without the need for a microscope.

This innovative approach is enhancing both accessibility and communication in marine biodiversity research.

Images: Foraminifera models 3D printed at Sydney Manufacturing Hub.

Sydney Nano Foundry

Fabrication at micro and nano scale

Technology

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

The Sydney Nano Foundry, formerly Research and Prototype Foundry, enables researchers and industry to fabricate and prototype technologies at the micro- and nanoscale. It provides advanced fabrication, packaging and characterisation capabilities supporting semiconductor, quantum, photonic, microfluidic and advanced materials innovation.

ANFF

Find out more

sydney.edu.au/nano-foundry

Scaling the future of quantum computing

Challenge

Quantum computers have the potential to transform fields ranging from materials discovery to optimisation and cryptography. However, one of the greatest challenges facing the industry is how to scale quantum processors from today's experimental systems to the millions of qubits required for practical applications. A key bottleneck is the need to control and read out each qubit. Current architectures rely on complex external wiring and electronics, creating limits due to connection density, heat generation and system complexity as devices scale.

Research

Researchers from the University of Sydney, led by Professor David Reilly (Faculty of Science; Sydney Nano Institute), in collaboration with UNSW and industry partners Emergence Quantum and Diraq, demonstrated a breakthrough approach for controlling silicon spin qubits using cryogenic CMOS electronics operating at temperatures close to absolute zero.

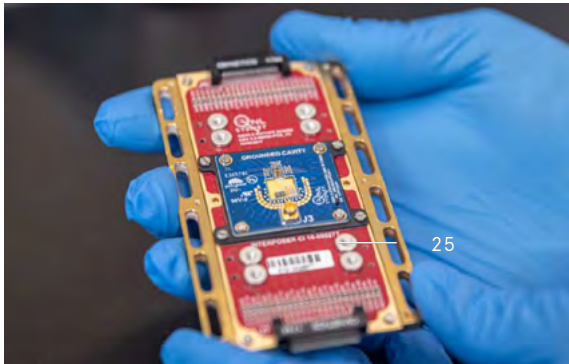
The team developed a silicon control chip capable of operating at milli-kelvin temperatures with extremely low power consumption, enabling control of spin qubits while preserving their performance. By integrating control electronics in close proximity to the qubits, the work addresses a critical scaling challenge while minimising heat and electrical interference.

Sydney Nano Foundry supported the fabrication and prototyping activities underpinning this research through its advanced micro- and nanofabrication infrastructure. As part of the Australian National Fabrication Facility (ANFF), the facility provides researchers and technology companies with access to the specialised capabilities required to develop next-generation quantum devices.

Results

Published in *Nature*, the breakthrough demonstrates that complex cryogenic control electronics can be integrated directly with silicon spin qubits without significantly degrading their performance, enabling reliable qubit operations. Importantly, the research provides a pathway to scale quantum processors from fewer than 100 qubits today to the millions required for practical applications.

The work also highlights the strength of Sydney's quantum ecosystem, bringing together leading universities, national research infrastructure and industry partners to advance technologies that could underpin future fault-tolerant quantum computers.



Right: Quantum control chip developed by Professor David Reilly's team. Photo: Fiona Wolf.

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High-efficiency photovoltaics for space and advanced electronics

Challenge

Next-generation energy systems for satellites, space missions and advanced electronics demand photovoltaic devices with exceptional efficiency, stability and energy density. Conventional single-junction solar cells are constrained in how much of the solar spectrum they can convert into electricity, limiting their ultimate performance. Overcoming these limits requires new materials and fabrication approaches capable of integrating multiple photovoltaic layers into high-performance tandem or multi-junction architectures.

Research

Professor Anita Ho-Baillie (Faculty of Science; Sydney Nano Institute) and her team are advancing high-efficiency photovoltaic technologies using advanced materials and device engineering approaches. Sydney Nano Foundry's specialised nanofabrication and characterisation infrastructure enabled the fabrication and testing of complex photovoltaic structures based on perovskite materials and silicon.

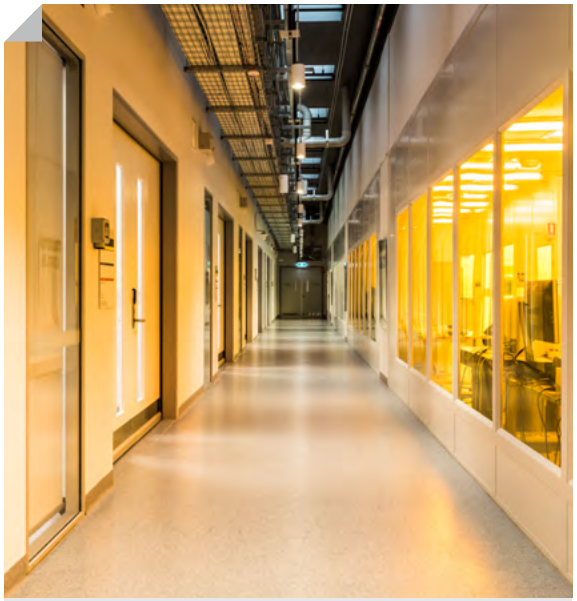
Using precision thin-film deposition and device fabrication techniques, researchers developed perovskite–perovskite–silicon triple-junction solar cells designed to capture a broader portion of the solar spectrum than conventional single-junction devices. These structures combine multiple light-absorbing layers in a single integrated device, enabling significantly higher theoretical efficiencies.

Sydney Nano Foundry's infrastructure supported the fabrication, optimisation and characterisation of these advanced photovoltaic architectures, enabling researchers to explore device stability and performance under conditions relevant to environments such as space.

Results

This work resulted in record-performance triple-junction photovoltaic devices and received major national recognition, including honours at the NSW Premier's Prizes for Science and Engineering. The research, which has also been supported by Sydney Analytical and Sydney Microscopy and Microanalysis, demonstrates the potential of multi-junction perovskite technologies to deliver high-efficiency solar power systems for space applications and next-generation electronics.

Left: The research team holding the 1 centimetre square perovskite cells.



The Cleanroom

At the heart of Sydney Nano Foundry is a purpose-built cleanroom where researchers and industry partners transform ideas into functional devices using advanced micro- and nanofabrication technologies.

Accelerating semiconductor innovation

Defence | Technology | 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Challenge

As semiconductor devices become increasingly complex, advanced packaging technologies are emerging as a critical enabler of next-generation computing, artificial intelligence, sensing, and quantum systems. However, developing and validating new manufacturing approaches requires access to specialised fabrication infrastructure, technical expertise, and rapid prototyping capabilities that are often beyond the reach of early-stage companies.

Research

Sydney-based semiconductor company Syenta is developing a breakthrough manufacturing platform known as Localised Electrochemical Manufacturing (LEM), a technology designed to create high-density chip interconnects through a simplified and scalable fabrication process.

Working with Sydney Nano Foundry, Syenta gained access to advanced micro- and nanofabrication infrastructure, specialised engineering expertise, and precision characterisation capabilities. This collaboration enabled rapid prototyping, process optimisation, and technical validation, helping to accelerate the development of the company's technology from concept towards commercial deployment.

Results

The partnership demonstrated how research infrastructure can play a vital role in supporting Australia's deep-technology ecosystem. By providing access to world-class fabrication capabilities, Sydney Nano Foundry helped reduce technical barriers, accelerate innovation, and strengthen pathways from laboratory research to industrial adoption.

Syenta has since secured significant investment to support the commercialisation and scale-up of its technology, highlighting the importance of advanced manufacturing infrastructure in enabling globally competitive Australian semiconductor companies.

Right: Researcher operating an Electron Beam Lithography System at Sydney Nano Foundry.


Rack 5
5 mm (Rack 2)

Sydney Analytical

Chemical, biological and materials analysis

Sydney Analytical is the University's flagship facility for chemical, biological and materials analysis, supporting capability in vibrational spectroscopy, magnetic resonance, X-ray diffraction and scattering, protein production and characterisation, and drug discovery.

Australian Government | ANSTO

Find out more

sydney.edu.au/sydney-analytical

Probing nanoscale therapeutics

Health and Medical

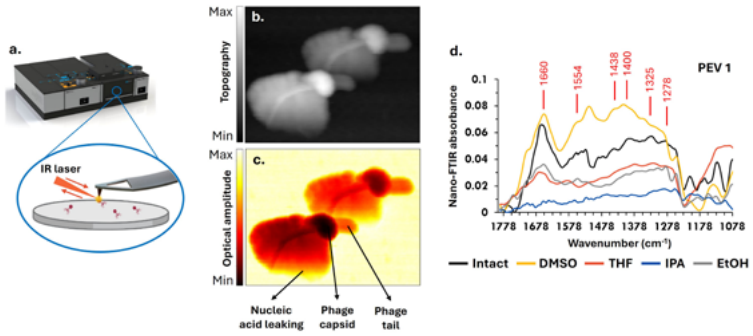
3 GOOD HEALTH AND WELL-BEING

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Challenge

Bacteriophages are viruses that infect and destroy bacteria, and are emerging as promising therapeutics against multidrug-resistant infections. However, their successful development into pharmaceutical formulations requires a deep understanding of their chemical composition and how they respond to formulation conditions such as solvents, pH balance and temperature.

Conventional spectroscopic techniques lack the spatial resolution needed to analyse individual bacteriophages at the nanoscale. This is a major hurdle for researchers aiming to ensure the stability and efficacy of these biological agents prior to formulation.



Above: a) Instrument and basic illustration of the interaction between the IR laser, AFM tip and sample. b) AFM topography and c) optical amplitude images of PEV 1 phages. d) Average nano-FTIR spectra collected from PEV 1 phages under different conditions.

Research

To address this challenge, Professor Hak-Kim Chan, Dr Yue Cao and Dr Dipesh Khanal (Faculty of Medicine and Health) used nano-Fourier Transform Infrared (nano-FTIR) spectroscopy at Sydney Analytical. Nano-FTIR spectroscopy combines the chemical specificity of infrared spectroscopy with the spatial resolution of atomic force microscopy, making it uniquely suited to analyse nanosized biological entities like bacteriophages.

The technique was applied to probe the chemical composition of individual bacteriophages and to assess their structural stability when exposed to formulation-related stressors. This high-resolution insight is critical for identifying the most stable and effective formulations for therapeutic use.

Results

The research revealed how different formulation conditions impact bacteriophage stability at the molecular level – information that is otherwise inaccessible using traditional tools.

These findings provide a strong foundation for designing effective and stable bacteriophage formulations, contributing to the global fight against antibiotic-resistant infections. The work also showcases how the advanced capabilities at Sydney Analytical can accelerate pharmaceutical innovation at the nanoscale. The results were published in *International Journal of Pharmaceutics* and *Analytica Chimica Acta*.

Targeting ALT cancers with precision peptides

Health and Medical

Challenge

The Alternative Lengthening of Telomeres (ALT) pathway is active in 10–15% of all cancers. Crucially, this pathway is absent in healthy cells, making it a highly specific and attractive therapeutic target. However, developing cell penetrating drugs that target ALT-related pathways with high affinity and specificity still remains a major challenge.

Research

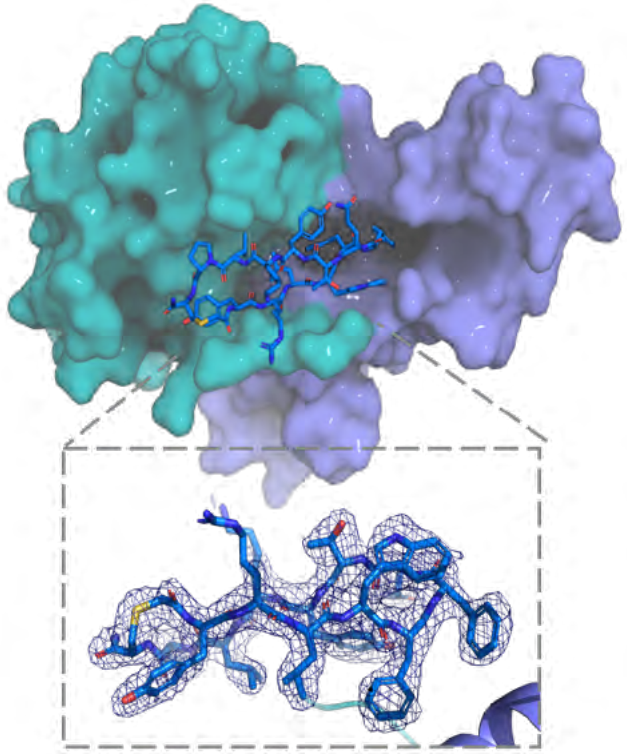
Associate Professor Yu Heng Lau (Faculty of Science) and his team are studying the FANCM-RMI protein-protein interaction. It is a critical binding event which maintains genome stability in cancers that depend on the ALT pathway for survival.

Working with Sydney Analytical staff, the team performed an mRNA display cyclic peptide screen – which rapidly identifies high-affinity cyclic peptides by creating a large library of candidates, containing over a trillion of random cyclic peptides each linked to its corresponding mRNA – and then screening them against the target RMI protein, with the aim of identifying peptide binders to disrupt the FANCM-RMI interaction. A fluorescence polarisation competition assay confirmed that three of the top four peptide hits were able to target the FANCM-RMI interface.

Surface plasmon resonance analysis also indicated these peptides bound RMI with nanomolar affinity. X-ray crystallography and alanine scanning analysis revealed novel binding modes and interactions between the cyclic peptides and RMI, driving high potency inhibition. Furthermore, the use of co-immunoprecipitation studies confirmed disruption of the native FANCM-RMI interaction in whole osteosarcoma cell lysates – preparations made from the contents of osteosarcoma cells – a demonstration that these peptides can target this interaction in the complex internal environment of cancer cells.

Results

This work provides novel chemical tools for interrogating genome stability in ALT pathway cancers, and the first chemical validation of FANCM-RMI inhibition as a viable therapeutic strategy for targeting the ALT pathway. The research has been published in the *Journal of Medicinal Chemistry*.



Above: The X-ray co-crystal structure reveals the novel binding mode of the peptide RMI-L3 to the RMI1/2 protein.

Controlling CO_2 conversion for a low-carbon future

Energy and Environment

7 AFFORDABLE AND CLEAN ENERGY

Challenge

Electrocatalytic CO_2 reduction reaction (CO_2RR) offers a promising pathway to convert carbon emissions into valuable fuels and chemicals. However, controlling product selectivity - whether CO, formic acid, or other products are formed - remains a major challenge. This is driven by complex and poorly understood interactions at the catalyst–electrolyte interface, particularly the structure and behaviour of interfacial water and transient reaction intermediates. Without the ability to directly observe these dynamic processes in real time, it has been difficult to rationally design catalysts that favour specific, high-value products.

Research

This work, led by Yu Yang under the supervision of Associate Professor Fengwang Li (Faculty of Engineering), addressed this challenge by probing the interfacial microenvironment of a silver catalytic surface during CO_2RR.

Sydney Analytical provided a comprehensive suite of advanced spectroscopic tools to enable real-time monitoring and mechanistic validation. In situ Raman and FTIR allowed direct observation of surface bound intermediates and evolving reaction species under applied potential, while quantitative ^2H NMR confirmed the mechanism by providing definitive isotopic evidence of hydrogen incorporation pathways. X-ray photoelectron spectroscopy and X-ray diffraction confirmed the surface and bulk structure of the silver surface before and after the reaction.

These capabilities enabled researchers to "listen in" on the reaction as it occurred, capturing transient intermediates and revealing how interfacial water structure governs hydrogenation pathways.

Results

Published in the *Journal of the American Chemical Society*, the study demonstrates that the presence of a polymeric cation at the silver surface actively drives selective formic acid production over CO during CO_2 electroreduction by influencing the interaction of water molecules on the silver surface.

This work establishes a new strategy for tuning product selectivity via interfacial engineering, enabling more efficient and targeted CO_2 conversion technologies.

Right: Yu Yang in the Sydney Analytical facility.


10x
GENOMICS

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Unlocking T cell therapy's full potential

Health and Medical

3 GOOD HEALTH AND WELL-BEING

Challenge

T cell immunotherapy is one of the most promising treatments for cancer, but its success is often limited by the tumour microenvironment (TME), which is the ecosystem of cells, molecules and signals surrounding the tumour. TME plays a crucial role in suppressing T cell function, yet the signals responsible for this suppression are not well understood. Without this knowledge, T cell therapies cannot be used to their full potential.

Research

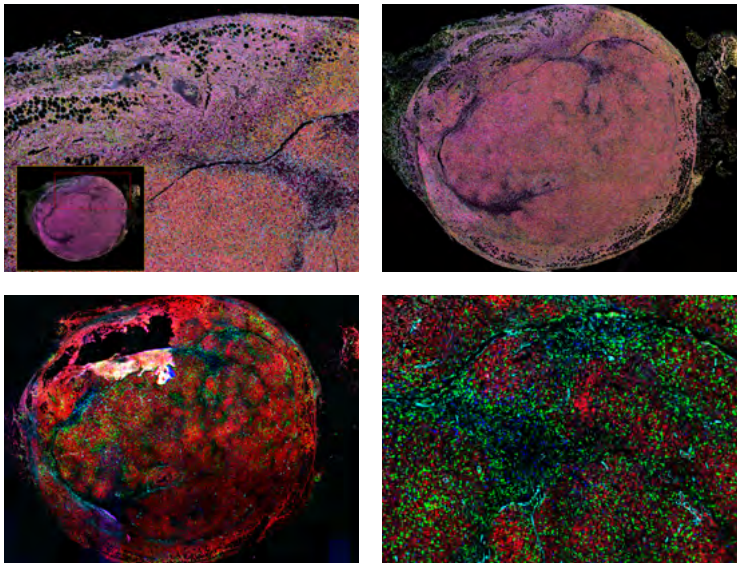
To better understand how TME influences T cell responses, a multidisciplinary research team led by Professor Cameron Turtle (Faculty of Medicine and Health; Charles Perkins Centre) and Professor Jean Yang (Faculty of Science; Charles Perkins Centre) are studying tumour biopsies from patients with haematological malignancies, a diverse group of blood cancers that affect blood, bone marrow and lymphatic systems.

Using multiplexed immunohistochemistry (IHC) and Xenium, enabled by Sydney Cytometry, the team is mapping the complex cellular and molecular interactions within TME. These platforms allow the precise identification and spatial mapping of immune and tumour cell populations at the single-cell level.

Results

This work is ongoing, laying critical groundwork to uncover how TME suppresses immune responses. By identifying the mechanisms that limit T cell therapy success, researchers aim to design next-generation, curative T cell therapies that can overcome these barriers.

Understanding TME at this level could transform the future of immunotherapy, offering hope for more effective treatments across a broad range of cancers.



Right: Red - CD79a (B-cell lymphoma cells), Green - CD68 (macrophages), Dark blue - CD3 (T cells), Light blue - podoplanin (lymphatic vessels).

Health and Medical

Personalising melanoma immunotherapy

Challenge

Neoadjuvant immunotherapy (NeoIT) using immune checkpoint blockade – a cancer treatment before surgery to shrink the tumour and enhance the body's immune response – has transformed the treatment for patients with resectable clinical stage III melanoma, which has spread to nearby lymph nodes or into the skin. Still, many patients experience disease recurrence, and current biomarkers are insufficient to predict who will respond to treatment or relapse. A key challenge is understanding how different PD-1-based therapies (which block the programmed cell death protein PD-1) impact systemic immunity and how these changes relate to treatment outcomes and long-term survival. Tackling this requires deep longitudinal immune profiling across large patient cohorts.

Research

A collaborative team from Melanoma Institute Australia and the University of Sydney, led by Professor Georgina Long and Associate Professor Ines Pires da Silva (Faculty of Medicine and Health) undertook a comprehensive longitudinal analysis of peripheral blood from over 200 patients receiving anti-PD-1 based NeoIT. Samples were collected before treatment and six weeks later (prior to surgery), across multiple investigator-led neoadjuvant clinical trials, forming the basis of the NeoPlatform translational research program.

To analyse immune responses at the single-cell level, the team used a 39-marker Cytometry by Time of Flight (CyTOF) panel at Sydney Cytometry. The facility provided critical expertise in panel design, sample processing, and advanced data analysis. Sydney Cytometry's unique CyTOF capabilities and deep technical expertise were key reasons for choosing this facility.

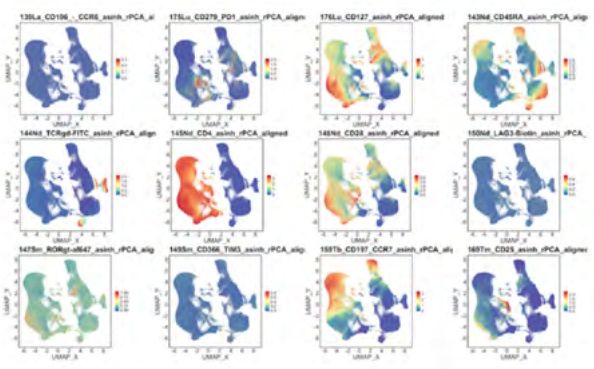
Results

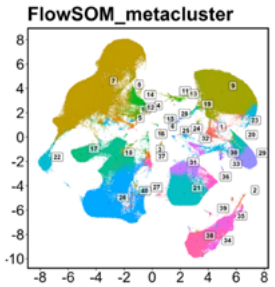
The research to date has revealed distinct immune alterations associated with anti-PD-1 based neoadjuvant therapy, including changes in regulatory T cells (Tregs), cytotoxic T cells and monocyte subsets. Combination therapies, including some with targeted therapies, were associated with more robust and diverse systemic immune activation, with distinct immune changes based on treatment response.

This work represents one of the most comprehensive longitudinal immune profiling efforts of neoadjuvant melanoma to date. Findings are informing the development of predictive immune signatures and enhancing the design of next-generation clinical trials. This NeoPlatform has been presented internationally and is now a globally recognised research initiative advancing neoadjuvant immunotherapy.

Funding sources include:

– Melanoma Institute Australia, NHMRC





Left: Images derived from mass cytometry shows the heterogeneity of cells in patient blood samples.

Health and Medical

3 GOOD HEALTH AND WELL-BEING

Optimising nanoparticles for mRNA delivery

Challenge

Lipid nanoparticles (LNPs) are at the forefront of mRNA-based therapeutics and played a pivotal role in creating COVID-19 vaccines. However, while widely used, LNPs still face significant limitations in delivery efficiency: only a fraction of the administered mRNA successfully enters cells and produces the intended effect. Improving LNP performance is essential to unlock the full potential of mRNA therapies for a broader range of applications.

Research

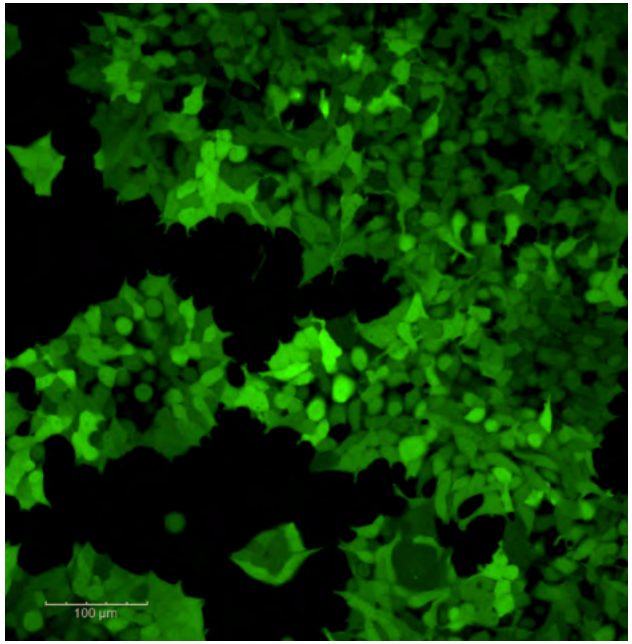
A team led by Professor Greg Neely (Faculty of Science; Charles Perkins Centre) is working to develop optimised LNP formulations to enhance their delivery efficiency. Their approach involves formulating next-generation LNPs and rigorously testing their performance.

The team uses state-of-the-art cytometry platforms including the Melody, Aurora 3L and the Phenix imaging systems at Sydney Cytometry. These tools enable researchers to quantify the expression of enhanced green fluorescent protein (eGFP) in transfected cells – a technology that allows researchers to track gene expression, protein localisation and protein-protein interactions in real-time – providing a reliable measure of mRNA delivery efficiency.

Results

The project is generating promising data. The Phenix imaging system has been particularly useful in visualising eGFP expression at the cellular level, supporting quantitative analysis of mRNA delivery success.

Insights have been published in the *Journal of Clinical Investigation* and have the potential to inform improved mRNA therapeutic platforms beyond vaccines.



Right: HEK293T cells expressing eGFP, images captured with the Phenix.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Safely imaging cancer in vulnerable patients

Health and Medical

3 GOOD HEALTH AND WELL-BEING

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Challenge

PET/CT imaging plays a critical role in cancer staging, but its use of ionising radiation poses risks, especially for vulnerable patients such as those who are pregnant. In these cases, clinicians must carefully balance the need for accurate cancer staging with the imperative to minimise foetal radiation exposure. Until recently, no widely adopted clinical protocol existed to safely image pregnant patients without compromising diagnostic quality.

Research

Dr Georgios Angelis (Sydney Imaging) and Professor Dale Bailey (Faculty of Medicine and Health; Northern Sydney Local Health District) addressed this need by developing an ultra-low-dose PET/CT protocol leveraging the advanced capabilities of the Australian National Total Body PET Facility.

The scanner is jointly operated by the University of Sydney and Northern Sydney Local Health District, supported by the NCRIS National Imaging Facility. Its exceptional sensitivity enabled the team to reduce the radiopharmaceutical dose to approximately 15% of standard levels. CT acquisition parameters were further refined using a tin filter in the path of the X-ray beam to reduce unnecessary exposure to low-energy X-rays. Dosimetry modelling was performed to confirm the safety of the protocol for both mother and foetus.

Results

The final combined radiation dose was approximately one millisievert, which is comparable to a year's worth of background radiation in Australia. Despite the drastically reduced dose, diagnostic image quality was maintained, enabling critical cancer staging.

This case exemplifies how translational research embedded in clinical environments can deliver immediate patient benefits. It also highlights the strategic importance of investing in research-enabled infrastructure capable of driving healthcare innovation.

Right: The Australian National Total Body PET Facility located at the Royal North Shore Hospital.

Health and Medical

Advancing vascular grafts

Challenge

Small-diameter vascular grafts hold promise for treating cardiovascular disease, but their development depends on accurate preclinical testing in large animal models. Sheep are commonly used; however, their carotid arteries are prone to severe spasm during surgical procedures, which can compromise both graft implantation and computed tomography angiography (CTA) assessments. Despite the routine use of sheep models, there is limited research on preventing these spasms, creating a significant barrier to advancing vascular graft technologies.

Research

Dr Robert Hume (Faculty of Medicine and Health; Charles Perkins Centre) led a cross-disciplinary team from the University of Sydney and affiliated hospitals – including biomedical engineers, surgeons, cardiologists, and imaging specialists – to address this issue. The team tested multiple vasodilator protocols and CTA approaches, combining CTA with surgical graft placement.

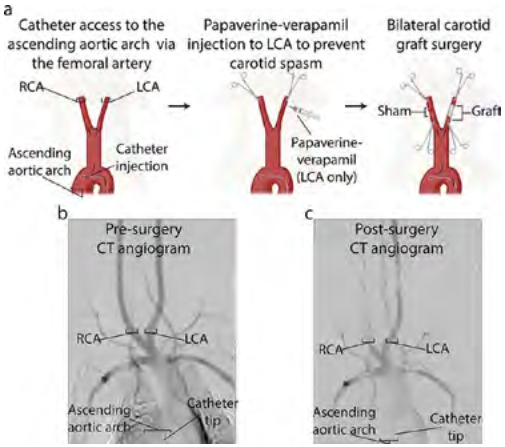
Critical to the success of this study was the use of the Sydney Imaging Hybrid Theatre, enabling real-time intraoperative vascular imaging and high procedural precision. CTA was performed via either carotid (CA) or femoral access, and several vasodilators including papaverine hydrochloride and verapamil were administered locally to prevent arterial spasm during surgical manipulation.

Results

Femoral CTA access proved effective in preserving blood flow and preventing pre-surgical spasm, unlike CA access, which frequently induced vasoconstriction. Most notably, local delivery of papaverine and verapamil significantly reduced intraoperative CA spasm, enhancing the accuracy of graft performance evaluation.

These findings offer a practical, reproducible method for improving the reliability of the sheep model in vascular surgery research, providing a clearer pathway for translating graft technologies into human trials.

Top: Preventing sheep carotid artery spasm for vascular graft surgery and computed tomography angiography. Below: The Hybrid Theatre in the Charles Perkins Centre.



Health and Medical

Advancing brain tumour detection

Challenge

Glioblastoma is the most aggressive and common form of malignant brain cancer, with a median survival of just one year. Its diffuse, infiltrative nature and inconsistent disruption of the blood-brain barrier (BBB) make it exceptionally difficult to detect and treat. Standard MRI using gadolinium-based contrast agents (GBCAs) only highlight areas with significant BBB breakdown – leaving infiltrative tumour regions with an intact BBB largely invisible. This limitation poses a significant barrier to early diagnosis and treatment planning.

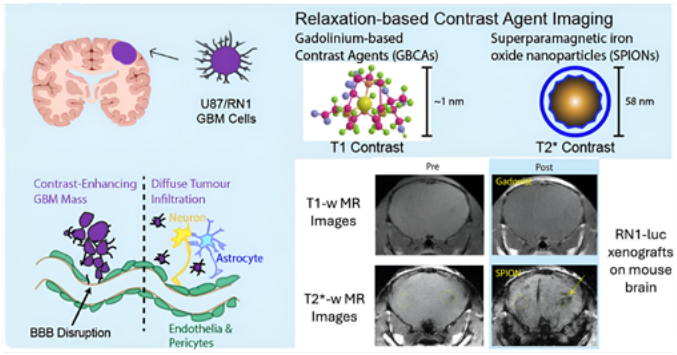
Research

Dr David Waddington (University of Sydney's Image X Institute; Faculty of Medicine and Health), and Dr Phillip Janowicz in collaboration with Imagion Biosystems Ltd, explored the use of functionalised superparamagnetic iron oxide nanoparticles (SPIONs) as a novel MRI contrast agent. The team used Sydney Imaging's Preclinical Imaging Facility and its advanced 7T MRI scanner to image mouse models of glioblastoma.

The study assessed the pharmacokinetics, biodistribution and tumour-targeting capabilities of SPIONs in both intact and disrupted BBB models. Post-processing techniques, including susceptibility gradient mapping, were employed to overcome traditional limitations of SPIONs as 'negative' contrast agents and enable positive tumour visualisation.

Results

SPIONs successfully revealed tumour regions, including infiltrative areas not visible using GBCAs, by providing clearer visualisation of tumour angiogenesis. The particles also showed expected accumulation in the liver and spleen, with transient vascular and renal presence. This major advance provides new pathways for earlier, more accurate diagnosis and potentially for image-guided treatment strategies. Published in *Scientific Reports*, this major advance provides new pathways for earlier, more accurate diagnosis and potentially for image-guided treatment strategies for brain cancer.



Above: Enhanced detection of glioblastoma vasculature with superparamagnetic iron oxide nanoparticles and MRI. Right: 7 Tesla MRI scanner available at our preclinical imaging facility.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Health and Medical

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Smarter supplementation for healthy ageing

Challenge

Extensive studies have found that nicotinamide mononucleotide (NMN) shows promise in slowing age-related conditions like Alzheimer's disease and heart failure by replenishing levels of NAD^+, a molecule essential for cellular energy and repair. But there's a catch: much of the NMN we consume is quickly broken down by the liver into nicotinamide (vitamin B3), which doesn't deliver the same health benefits. This puzzling difference and the high cost of NMN supplements make it critical to understand how NMN is processed in the body and how its effectiveness could be improved.

Research

A team led by Associate Professor Lindsay Wu at UNSW Medicine & Health has uncovered a surprising mechanism that may explain NMN's unique effectiveness. Their work focuses on CD38, an enzyme known for breaking down NAD^+. But the team discovered that CD38 also plays a previously unknown role in producing NAD^+ – a breakthrough in understanding NAD^+ metabolism.

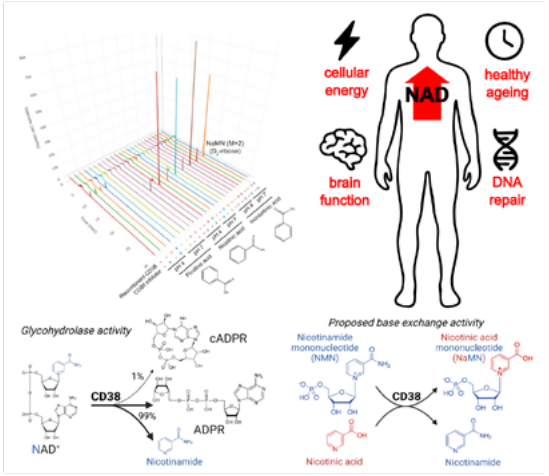
Using cutting-edge metabolomics tools at Sydney Mass Spectrometry, including the Thermo Vanquish-TSQ Altis UHPLC-MS system, the researchers conducted detailed enzyme assays in mice. These tests revealed that CD38 can convert NMN into NaMN through a special reaction known as base exchange, potentially allowing NMN to bypass the liver and boost NAD^+ levels directly in tissues.

Results

These findings, published in the *Journal of Biological Chemistry*, reveal a dual role for CD38 in both NAD^+ consumption and biosynthesis, suggesting a more nuanced function in NAD^+ regulation. The study opens new avenues for optimising NMN-based therapeutic strategies. It also highlights the importance of deeper metabolic understanding in designing more effective interventions for healthy ageing.

Funding sources include:

- Hevolution/American Federation for Aging Research (AFAR)
- National Health and Medical Research Council
- Diabetes Australia Research Program

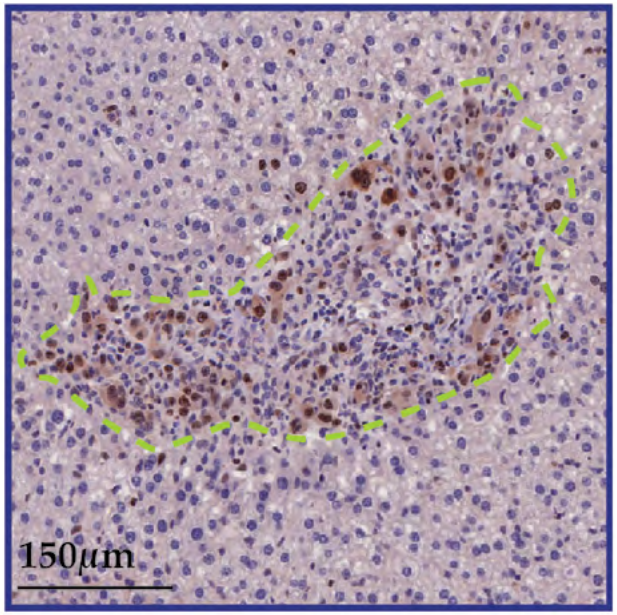


Right: Dual role of CD38 in energy cofactor homeostasis.

Health and Medical

Blocking the spread of pancreatic cancer

Below: The brown staining is Ki67, a cell proliferation marker, seen here in a liver metastasises.



Challenge

Pancreatic cancer is one of the deadliest cancers worldwide, with an estimated five-year survival rate of 13%, dropping to 3% if patients present with metastasis, where cancer cells break away from a primary tumour and spread to other parts of the body. While chemotherapy can slow disease progression, relapse with metastasis is common, highlighting the urgent need for new and more effective treatments to prevent cancer spread.

Research

Dr David Herrmann is a group leader in the Cancer Invasion and Metastasis Lab at the Garvan Institute of Medical Research. He and his team discovered that Neuropeptide Y (NPY) – which is usually involved in energy balance, energy expenditure and feeling full – was also able to promote a novel metastatic mechanism that then drives cancer cells to spread from the pancreas to the liver. The team found that when they inhibit this pathway, they could stop the cancer cells in their tracks, and they observed a decrease in metastasis to the liver.

The team approached Sydney Mass Spectrometry to measure the changes in gene expression upon NPY inhibition, which may contribute to the anti-metastatic effect observed. As one of Australia's largest proteomics research facilities, Sydney Mass Spectrometry provided Dr Herrmann expert advice and a fast turnaround time to reach the team's research goals. The proteomics team at Sydney Mass Spectrometry measured both pancreatic tumour tissue and cell lines, utilising the Exploris480 Orbitrap mass spectrometer coupled with a Vanquish Neo HPLC system.

Results

The study, published in *Science Advances*, showed that the approximately 400 proteins found are differentially expressed upon inhibition, many of which are unexplored in pancreatic cancer. These findings have shown that NPY is a previously understudied target in pancreatic cancer metastasis that can be responsive to pharmacological inhibition. This is a very promising result warranting further assessment of NPY in combination with standard-of-care in metastatic pancreatic cancer.

Funding sources include:

- National Health and Medical Research Council
- Australian Research Council
- Cancer Council NSW
- Cancer Institute NSW
- Pankind, Pancreatic Cancer Australia
- Tour de Cure
- St Vincent's Clinic Foundation
- Sydney Catalyst
- UNSW SPHERE

Unlocking new clues in Parkinson's disease

Health and Medical

Challenge

Neurological disorders are the leading cause of disability worldwide, with none growing at a faster rate than Parkinson's disease. Researchers are looking to identify new treatment targets for slowing brain cell death and improving patient quality of life.

Research

Professor Kay Double (Faculty of Medicine and Health; Brain and Mind Centre) is internationally recognised for her research into the role of copper in healthy brain ageing and brain disorders such as Parkinson's disease. Professor Double and her colleagues determined that copper is reduced within the brain cells that die in Parkinson's disease, leading to abnormalities in proteins which require this metal to function normally.

In a world-first discovery, the team found that one of these proteins – superoxide dismutase 1 (SOD1) – accumulates and deposits in vulnerable brain cells in Parkinson's disease patients in a manner that is thought to contribute to the death of these cells. To confirm the theory, they replicated this abnormal SOD1 protein deposition in 'SOCK' mice, which are engineered to both overproduce human SOD1 and have reduced ability to import copper into neurons. This allowed them to study and develop treatments for this new disease feature.

Results

SOCK mice exhibited significant amounts of abnormal SOD1 protein, which was associated with the death of cells in Parkinson's disease-linked brain regions and abnormal movement function. Working together with Sydney Mass Spectrometry's protein analysis team and state-of-the-art liquid-chromatography mass spectrometry instrumentation, Professor Double's team showed that changes to SOD1 protein in SOCK mice closely matched those occurring in the brains of Parkinson's disease patients. They then showed that increasing brain copper in SOCK mice from early life – using the copper delivery drug CuATSM – prevented these changes to the SOD1 protein, reducing brain cell death and improving the movement function of these mice.

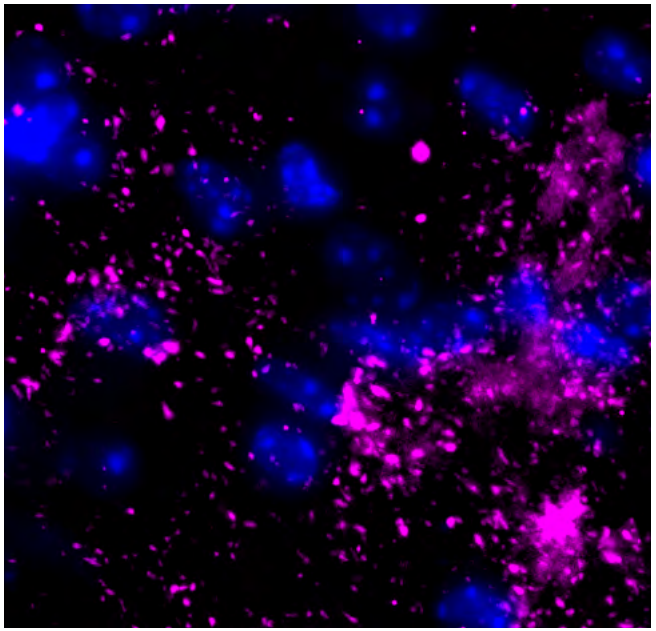
The instrumentation and technical expertise of Sydney Microscopy and Microanalysis were also essential in enabling the team to image vulnerable cell populations and aggregated proteins in their novel SOCK mouse model.

The results highlight the potential of treatments which reduce abnormal SOD1 in slowing cell death in Parkinson's disease-linked brain regions, which Professor Double hopes may eventually be translated into a new therapy for Parkinson's disease.

Funding sources include:

- National Health and Medical Research Council of Australia
- Michael J Fox Foundation for Parkinson's Disease Research
- Shake It Up Australia Foundation

Below: Visualising SOD1 (pink) and cell nuclei (blue) in a mouse model of Parkinson's disease.



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The shape factor in cancer drug delivery

Health and Medical

Challenge

Effective cancer treatment increasingly depends on targeted drug delivery systems that can selectively enter tumour cells while minimising side effects. However, most nanoparticle drug carriers are spherical, limiting their ability to interact efficiently with cells and control how drugs are released once inside. A key challenge is understanding how particle shape, size and internal structure influence cellular uptake, stability and therapeutic performance, which requires advanced characterisation techniques at the nanoscale.

Research

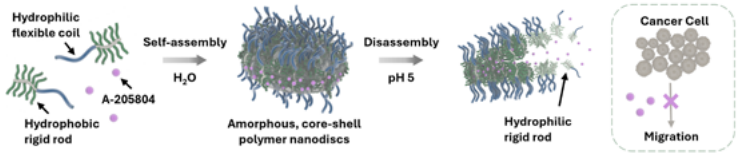
Researchers from the University of Sydney, Yonsei University and collaborators developed a new class of soft polymer "nanodiscs" designed for cancer drug delivery. Led by Ping Zeng, Professor Markus Müllner (Faculty of Science; Sydney Nano Institute) and Professor Byeong-Su Kim (Yonsei University), the team engineered disc-shaped polymer nanocarriers whose size and structure could be precisely tuned to optimise cellular uptake in breast cancer cells.

The nanodiscs remained stable under normal biological conditions but gradually degraded within acidic cellular compartments, enabling controlled release of therapeutic compounds directly inside cancer cells. When loaded with an ICAM-1 inhibitor, which blocks a protein associated with cancer spread, the nanodiscs significantly improved suppression of cancer cell migration compared with the free drug alone.

Sydney Microscopy and Microanalysis played a key role in supporting the research through advanced microscopy and nanoscale characterisation capabilities that enabled researchers to visualise, analyse and validate the structure, morphology and behaviour of the polymer nanodiscs.

Results

Published in *JACS Au*, the study demonstrated that disc-shaped nanocarriers may improve drug delivery performance compared to conventional spherical particles. The nanodiscs remained stable under normal conditions but selectively degraded in acidic cellular environments, releasing therapeutic payloads in a controlled manner. When loaded with an ICAM-1 inhibitor, they showed enhanced suppression of cancer cell migration, highlighting their potential to reduce metastasis and improve targeted cancer therapies.



Above: Co-assembly of BBCs with A-205804 to form pH-responsive nanodiscs that degrade at acidic pH and release the payload for therapeutic effects.

Energy and Environment

Accelerating atomic-scale research with PFIB technology

Challenge

Scanning Transmission Electron Microscopy (STEM) allows scientists to study the composition and structure of materials down to the atomic level. To prepare samples for this detailed imaging, researchers use Plasma Focused Ion Beam (PFIB) instruments. These tools can precisely extract and thin tiny sections of material (called lamellae) to less than 100 nanometres thick. However, preparing high-quality samples is especially challenging for complex materials, such as the metal contacts used in silicon solar cells. These often contain multiple ultra-thin layers, added chemicals (dopants) and porous structures. Creating suitable samples for STEM from such materials, without introducing damage or distortions, requires specialised techniques and great care.

Atom Probe Microscopy (APM) creates 3D maps showing the exact location and type of atoms in a material, almost down to the atomic level, and works for almost every element in the periodic table. To prepare samples for APM, researchers use PFIB instruments, which can shape materials into extremely sharp, needle-like tips with a radius smaller than 50 nanometres. However, for the analysis to be accurate, specific features – like grain boundaries, phase interfaces, or thin film layers – must be carefully positioned within 200 nanometres of the needle tip. Achieving this requires precise control of the ion beam and detailed structural mapping using a method called Transmission Kikuchi Diffraction (TKD) during preparation process.

Research

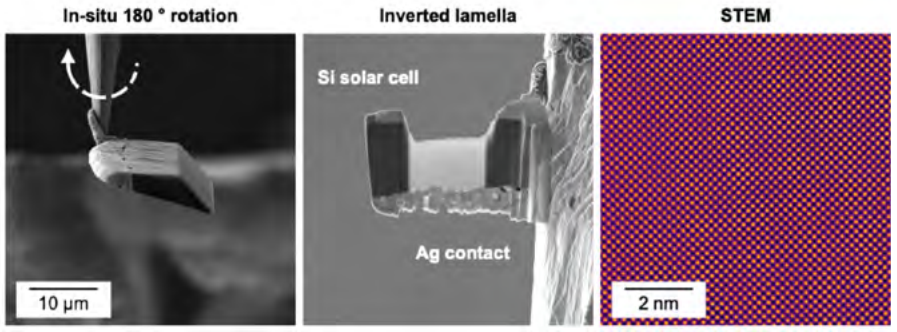
Researchers Dr Chandany Sen and Dr Haoran Wang from UNSW Engineering worked with experts at Sydney Microscopy and Microanalysis to examine tiny defects in the metal contacts of silicon solar cells, defects which can reduce the efficiency of renewable energy systems.

Using the Tescan Amber X PFIB instrument, the team was able to quickly produce high-quality, inverted TEM samples. These had fewer preparation-related artefacts, making it possible to investigate the structure of substrates and thin films at the atomic scale using aberration-corrected STEM.

In a separate project, Gao Huajian from Nanyang Technological University in Singapore collaborated with Sydney Microscopy and Microanalysis staff to study a high-entropy alloy – a new type of metal promising both high strength and flexibility. The Tescan Amber X PFIB, with its advanced TKD features like phase mapping, was used to precisely prepare sections across phase boundaries, achieving a remarkable accuracy of just 10 nanometres.

Results

These projects show how the Tescan Amber X PFIB enables fast and accurate sample preparation for cutting-edge microscopy. By producing samples with minimal artefacts and 10 nanometre precision, researchers can explore the structure and chemistry of materials at the atomic level – driving advances in renewable energy and high-performance materials.



Left: Preparation of inverted TEM specimens from a solar cell metallisation contact: In-situ 180° rotation of a TEM specimen prepared via lift-out allows preparation of inverted specimens with minimal artefacts and high specimen quality. (Courtesy of H. Wang and C. Sen, School of Photovoltaic & Renewable Energy Engineering, UNSW Sydney).

Agriculture and Food

Supercharging photosynthesis for future crops

Challenge

Photosynthesis underpins global food production, yet the process is surprisingly inefficient in many crops. At its centre is Rubisco, the enzyme responsible for capturing carbon dioxide. Rubisco is very slow and often reacts with oxygen instead of carbon dioxide, triggering energy-wasting processes that reduce plant productivity.

To compensate, plants must produce large amounts of Rubisco, consuming valuable energy and nutrients. Improving the efficiency of this enzyme could significantly boost crop yields while reducing demands for water and fertiliser, which is increasingly important as climate change and population growth put pressure on global food systems.

Research

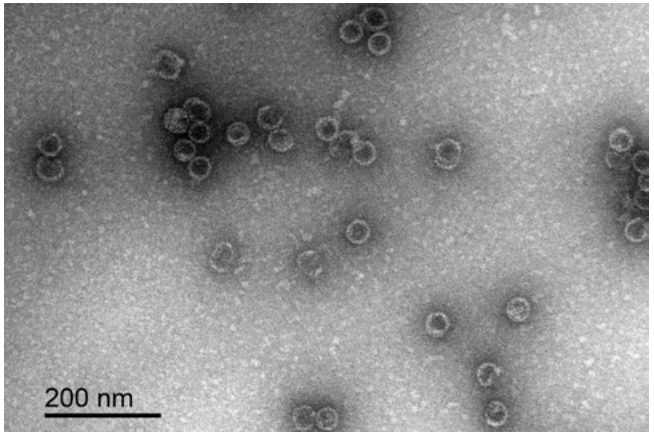
Researchers at the University of Sydney and Australian National University explored a new approach using synthetic biology. Dr Taylor Szyszka (ARC Centre of Excellence in Synthetic Biology; Faculty of Science) and the team engineered nanoscale protein cages called encapsulins to house Rubisco and create controlled environments for carbon fixation.

By attaching a short ‘address tag’ of 14 amino acids to the enzyme, the researchers directed Rubisco to its destination inside the assembling compartment. Dr Errin Johnson from Sydney Microscopy and Microanalysis, assisted the team with negative stain transmission electron microscopy, allowing them to visualise the encapsulin compartments and confirm their structure.

Results

Published in *Nature Communications*, the study demonstrates a proof-of-concept system for programmable carbon-fixing nanocompartments. These structures can concentrate Rubisco while allowing molecules needed for photosynthesis to pass through.

The next step is introducing these engineered compartments into plants. If successful, this approach could enable crops to fix carbon more efficiently and improve agricultural productivity in the future.



Right: A transmission electron microscope image showing encapsulin compartments. Courtesy: Alex Loustau, University of Sydney.

Work with us

Access Core Research Facilities

Consultation

Discuss your needs with the relevant facilities in the planning phase of your project. Work with technical staff to put together a viable project design, taking into account factors such as experimental scope, instrumental requirements, data analysis and budget.

Activation

Facility staff will assist you to register your project in our online booking system and will guide you through any regulatory approvals needed for your work.

Induction

If you need access to the facility yourself, facility staff will organise a bespoke training program specific to your needs. After you complete the training, you will receive access.

Supervision

Specialist staff will be onsite to provide technical and safety guidance.

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Produced by the Office of the Pro-Vice-Chancellor (Research Infrastructure),
the University of Sydney, 2026.
CRICOS 00026A TEQSA PRV12057