

Please note: the substantive content of the 2026 NRI Roadmap Survey begins at Question 20 (with prior questions dealing with administrative and other information).

As such all submissions that are published include the responses submitted from Question 20 onwards only.

Q20.

Part 2: Research themes

2.1 NRI comprises the assets, facilities and associated expertise to support leading-edge research and innovation in Australia and is accessible to publicly and privately funded users across Australia and internationally. We are seeking your input on possible directions for future national-level investment - i.e., where the requirements are of such scale and importance that national-level collaboration and coordination are essential.

The [2021 Roadmap](#) used a challenge framework to support NRI planning and investment. With this in mind, consider likely future research trends in the next 5 - 10 years, and with respect to one or more of the 8 challenge areas identified in the 2021 Roadmap as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale and
- describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities.

Q21.

Resources Technology and Critical Minerals Processing

Research Directions and Needs In response to the Critical Minerals Strategy, there has been a significant increase in state and federal government funding into critical minerals research and development over the last three years. The federal government alone has promised \$7.1 billion over 11 years to support the refining and processing of critical minerals. However, research intensity generated by these programs is rapidly outpacing investment in the critical national research infrastructure needed to support them. This is a serious gap between policy intent and capacity to deliver. The microscopes and associated expert staff are not at sufficient scale to support this increase in critical minerals research. At Microscopy Australia we've seen the direct impact of this in the blow-out of wait-times for techniques that are critical to R&D in mineral exploration, processing and refining. Last year, researchers and companies were waiting on average four months to access one of our high-sensitivity microanalysis techniques developed by our platform scientist, in collaboration with the MinEx Cooperative Research Centre, to meet the needs of the resources community. MinEX CEO Prof. Richard Hillis said "Adelaide Microscopy was key research infrastructure that drove a paradigm shift in how we needed to sample". Industry partners who backed the development of this technique include Geological Surveys of NT and WA, SA Department of Energy and Mines, and many mining companies including BHP, Teck and Santos. Overseas companies are contacting our Adelaide facility to access this world-leading technique but encounter extensive delays that they find difficult to accommodate. Similarly, there is now an average of wait time of 4-6 months for resources companies to access expertise for the development of tailored automated mineralogy microscope workflows. While they can afford to access the microscopes, the companies need access to the decades of high-level scientific expertise provided by our platform scientists to train them, help them develop workflows for their instruments, and explain how to interpret their results. Current wait times are completely unacceptable to companies who often need to make rapid decisions on whether a certain processing approach is economically viable at a given time based on current metal prices. Months of waiting is incompatible with this process: more microscopes and experts are needed. This mismatch between the need for timely analysis, and the lack of capacity for Australia's research infrastructure to provide it, is stifling research and the success of our resources companies. This is a significant risk to the large amounts of funding currently being granted for critical minerals research at the state and federal levels. There is an urgent need for investment into research infrastructure to support the boom we are currently seeing in critical minerals research to make the most of this coordinated funding effort.

Q22. Food and Beverage

Research directions Food security is an important challenge, especially in the face of a changing climate and the need for greater sovereign capability in the sector. Innovative research addressing challenges in the agriculture is likely to focus on: - Developing targeted approaches to dealing with pests and delivering fertiliser. These minimise waste and wider environmental damage. Nanoparticles and RNA technology are emerging as viable, effective targeting approaches, e.g. Spinout company Nanosoils is delivering fertiliser release technology and RNA-based pesticides are specific for whitefly, while other RNAs have also been developed to uniquely target other diseases. There are also protein-coated nanoclays for carrying DNA or RNA for modifying plants. This RNA/nanotechnology approach is starting to be developed further for more widespread applications. - Better approaches to making fertiliser, including the optimisation and commercialisation of local, energy-efficient, methods of ammonia production for on-farm production of fertiliser. - Understanding soils better to enable targeted approaches to cultivation and fertiliser use. - Engineering improved crops – to improve pest resistance, tolerance to climate fluctuations and improved yield. Better and more sustainable packaging is also essential to the industry and there is an increasing demand, and now capacity to produce, inbuilt sensors that can be incorporated into the packaging to indicate freshness. Needs Additional capacity to deliver outcomes for Australia: - Advanced electron microscopy is required to understand nanoscale plant structures and pathogens. 60% of our facilities' advanced electron microscopes will be reaching their ends of life by 2030. - Volume electron microscopy and dynamic microCT, and analysis tools to understand plant, microbe, and soil interactions in 3D and over time. - High sensitivity microanalytical tools to track trace elements through eco-systems. A number of different types of microscopes are used for this kind of analysis and 60–80% of them will reach their end of life by 2030.

Q23. Medical Products

Research directions In line with the Health and Medical Research Council's health priorities for 2024–2027 and the MRFF 2024-2026 Australian Medical Research and Innovation Priorities, medical research will focus on: Building the big picture Acceleration of the 'spatial-omics' revolution to localise the molecules associated with normal and disease states within the cell will need the latest advanced super-resolution microscopes, advanced cryo electron microscopes, and emerging techniques such as imaging mass spectroscopy to see multiple individual molecules within cells simultaneously. Drug and vaccine development Researchers continue to build and use a library of protein structures to identify new drug targets to tackle infectious and chronic diseases and advance personalised medicine approaches. New platforms for rapid vaccine development against infectious diseases is vital. Platforms emerged during Covid-19 and this technology is developing rapidly. It is also essential to develop new approaches to anti-microbial resistance. The current MRFF National Critical Research Infrastructure Grant Opportunity identified equipment to accelerate the development of mRNA-based vaccines and therapeutics as an area of unmet medical need. Innovative devices New and smart biocompatible materials to address specific functional needs will be a focus. New experimental models These are being developed using human cells in structures and devices that mimic human tissues, providing viable alternatives to animal models for drug and fundamental studies. Needs To enable these medical advances a range of microscopes will be essential. Access to advanced cryo electron microscopes must be increased to enhance drug and vaccine development. More access to the advanced microscopes needed for 'spatial-omics'. There is significant researcher demand for new super-resolution microscopes to enable crucial breakthroughs in medical treatments and fundamental knowledge to inform future innovation. These are essential to track both molecular interactions and cell behaviours as they happen. There are new types of advanced light microscopes are specifically designed for making dynamic observations of living cells with unparalleled spatial and temporal resolution. These capture rapid changes of cell and molecular behaviours in real time. These microscopes are not currently available through Microscopy Australia. Integrated workflows for correlative and multimodal microscopy are needed to align detailed cellular structures with protein and drug locations and interactions. Being able to bring different microscopes to bear on a problem leads to results greater than what can be delivered by one microscope technique on its own. New X-ray microscopes for whole cells are a capability gap in Australia. Advanced electron microscopes, some of which are not currently available through Microscopy Australia are needed for the development of innovative new materials for medical devices.

Q24. Defence

The 2024 National Defence Strategy (2024 NDS) and Integrated Investment Program will invest up to \$3.8 billion over the next decade guided by the 2024 NDS and AUKUS Pillar II research priorities. Both emphasise quantum technologies and hypersonics as priorities for increased research. These rely heavily on advanced microscopy, as such Microscopy Australia expects to see a surge in demand for infrastructure. Hypersonics: Hypersonic weapons and vehicles travel faster than the speed of sound and require new lightweight materials, such as alloys, ceramics, and composites to withstand extreme temperatures. Atomic scale microscopy is essential for researchers to understand the atomic structures of these materials: e.g., Microscopy Australia's atom probe and atomic scale electron microscopes were featured in a recent Nature Materials paper funded by the Department of Defence. It demonstrates the ability of atom probe to accelerate the development of medium- and high-entropy alloys, which offer exceptional strength and ductility for defence applications (DOI: 10.1038/s41563-024-01912-1). However, two of the three microscopes in Microscopy Australia's atom probe suite will reach end-of-life by the end of the next roadmap period, presenting a looming capability gap. The remaining instrument could not meet current research demand, let alone increased future demand. The extensive training times needed for ultra-high resolution atomic scale electron microscopy also pose a bottleneck. Emerging advanced analytical electron microscopes with increased automation can now deliver results in days rather than months but they are not available within Australia. Quantum Technologies: Quantum research heavily relies on high-resolution atomic scale microscopes. Changes in atomic properties – charge, spin, orbit, and lattice – result in complex electronic states like superconductivity, magnetism, and topological insulation, which define quantum materials. Advanced electron microscopes enable researchers to visualise lattice structures, quantum spin, and charge states. Recent advances in time-resolved atomic scale microscopy allow real-time observation of changes in quantum properties and enable atomic-scale alterations to study their effects. Core Defence Needs: Advances in core defence areas, including shipbuilding, weapons development, satellites, and aviation remain high priorities. Microscopy Australia supports researchers from industry, government, and universities in these fields. Clients include ASC Shipbuilding, Thales, BAE Systems, Lockheed Martin, and Boeing, and many Defence-funded researchers. However, systemic underinvestment in microscopy and microanalysis means many existing capabilities across Microscopy Australia's network, including 61% of electron microscopes, will reach end-of-life over the next roadmap period, with limited replacement options, underscoring the urgent need for investment in advanced microscopy.

Q25. Recycling and Clean Energy

Research Directions In line with the National Battery Strategy, Net Zero Economy Authority's aims, ARENA's Strategic Priorities and Australia's Circular Economy Framework, innovation in clean energy and recycling will be a major area of focus for research over the next 5–10 years. We expect it to have a major focus in a range of areas, including: Development of new, cheaper and more efficient solar and battery materials and devices such as: - The optimisation of silicon solar cells and combining them with other photovoltaic technologies to make improved and tandem solar cells for more efficient energy capture and conversion. - Development of new flexible, cheaper photovoltaic materials such as kesterite, that use cheap, earth-abundant materials. - Printable solar cells using perovskites and quantum dots. These will expand the range of surfaces that can hold solar cells and therefore increase uptake and application of clean energy. - Development of new battery materials and combinations for applications in mobile devices, electric vehicles (including aerospace) and stationary power storage. - Better catalysts for fuel cells, hydrogen evolution, oxygen evolution, biomass oxidation, water splitting, and ammonia generation and other innovative "green chemistry" processes. - Development of new materials and catalysts for as-yet-unknown innovative new applications such as the one that uses CO₂ to generate electricity. - Hydrogen for energy generation and storage and for small-scale power e.g. powered by hydrogen from the air/surrounding environment for more efficient and life-long operations. - Approaches to recycling current energy infrastructure, e.g. wind turbines, solar panels, batteries - Development of new green applications and materials made from major waste streams, to produce products such as concrete, ceramics, metal coatings, polymers and value-add products from agricultural waste. Needs Advanced electron microscopes are essential for analysis of these newly designed materials, many of which need microscopes able to visualise and track the light elements that these materials use. Some of these advanced electron microscopes are not currently available through Microscopy Australia, and 61% of our facilities' advanced electron microscopes will be reaching their ends of life by 2030. Other types of microscopes are not available at sufficient scale to meet the demand. Instruments that can analyse chemical processes and device operation at ultra-low temperatures (for quantum computing) and observe dynamic in-operation testing (for batteries and fuel cells) are essential to drive innovation in the next 5–10 years.

Q26. Space

Research directions Future technology for space research and applications overlaps significantly with the Defence sector: - Lighter, stronger materials will be needed for space vehicles and satellites. - Innovative heat- and radiation-resistant materials for heat shielding and protection from radiation damage encountered once spacecraft leave the Earth's atmosphere. - Solar and other power sources to power space vehicles, satellites and exploratory probes. - As it becomes available, researchers are increasingly using data collected on our microscopes from samples brought back to Earth from space missions to help understand the properties of asteroids to help develop mitigation strategies for potential asteroid collisions. This area of research has similar microscope needs to those used in the Resources sector. Needs Advanced electron microscopy and high-sensitivity analytical microscopes are critical to advance material sciences. Within Microscopy Australia, 65% of advanced electron microscopes will reach their end of life by 2030. Atomic scale microscopy is fundamental to the development of these kinds of materials. The arrangement of atoms gives materials their properties and atomic scale microscopes give researchers the ability to examine the atomic structure of new materials. Emerging microscope technologies also allow these materials to be altered and tested in different environments, such as high temperatures, within the microscope while observing them at the atomic scale. This reveals un-paralleled information that researchers use to design and create lighter, stronger alloys, ceramics and composites for the future. Exciting new technologies, like those developed by our Platform Scientist to date 'difficult-to-date' rocks are also necessary for analysing extra-terrestrial samples.

Q27.

Environment and Climate

Research directions Microscopy Australia makes significant contributions to research aimed at preserving and restoring our unique environment and to developing approaches to mitigate the impacts of climate change. The demand for research that finds solutions to tackle these problems will increase as our climate and environment continue to change and have major impacts on Australia's population, agriculture and natural environment. Our microscopes enable emerging research projects aimed at understanding the unique features and properties of our native plant and animal species in the face of climate change and other human impacts. This extends to understanding Australia's rich biodiversity both to protect it and to learn from it as design inspiration for new materials, useful chemicals and to understand how our plants and animals manage harsh environmental conditions. Our microscopes also enable technical innovations such as the development of new polymers made from waste that absorb oils, heavy metals and toxic chemicals that help clean up damaged and contaminated environments (such as mine sites and spill locations). These are in the process of commercialisation and their R&D will continue over the coming years. Other supported research is exploring the use of hyperaccumulator plants to remove toxic metals from the ground for environmental remediation and to generate 'bio-ore' to extract valuable critical metals for the Net Zero transition. We also enable many other projects that are leading the transition to a circular economy that aims to reuse waste to produce innovative and beneficial products. New approaches and solutions will also rely on our microscopes to visualise and analyse progress and quality. Needs - More advanced electron microscopes: 65% of our current suite will reach the end of their lives by 2030. - More high-sensitivity analytical microscopes: 78% of our current suite will reach the end of their lives by 2030.

Q28.

Frontier Technologies and Modern Manufacturing

Research Directions For a Future Made in Australia, developing the technologies of tomorrow needs the new materials researchers develop now and over the next decade. These will enable innovation for an expanded manufacturing sector in Australia. - New materials for 3D printing will allow an increasingly diverse range of products to be manufactured by additive manufacturing (3D printing). These could include a range of alloys, ceramics and new polymers and composites. - New, devices driven by nanotechnology, such as portable X-ray units for medical and defense applications are being designed and built in Australia. - Solar and battery materials as described above for achieving Net Zero - Smart materials that change shape or behaviour in response to different stimuli. These have a wide range of applications from artificial muscles and sensors to colour-changing camouflage materials. - Graphene is only beginning to reveal its potential in a huge range of applications at the frontier of technology. Examples include use in batteries and thermal conduction coatings for energy savings, both of which help us towards Net Zero. It can also be used in fire retardants and medical devices. - The medical technologies, developments and products described above will also lead to increased potential for advanced Australian manufacturing industries. Needs Advanced electron microscopes and advanced super-resolution microscopes are essential for development and quality testing across the breadth of technologies and materials needed for frontier technologies and advanced manufacturing. Building capacity for manufacturing will need an increased capacity for microscopes to enable feed-in research and development, and quality testing. Especially testing new materials and devices in operation and under various testing conditions and simulated environments.

Q29.

2.2 The 2024 statement of National Science and Research Priorities (NSRPs) includes outcomes linked to each priority to assist in identifying critical research needed in the next 5 to 10 years.

Consider the priority statements and, with respect to one or more of the 5 priority areas as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or
- not at sufficient scale and describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities, and where relevant, refer to the underpinning outcomes and research identified in the NSRPs document.

Q30.

Transitioning to a net zero future

Microscopy Australia is a key national research infrastructure for the Net Zero transition. Our microscopes support the development of numerous innovative solar energy materials and technologies as well as development of new battery and hydrogen technologies and greener methods for manufacturing ammonia and other significant chemicals. These are complemented by new knowledge on ore formation to develop new exploration approaches, and innovative extraction and processing strategies for the critical metals needed to develop these net zero technologies. Research in line with major government strategies, including the National Battery Strategy and ARENA's Strategic Priorities, will include development of: -New, cheaper and more efficient solar and battery materials and devices including optimised silicon solar cells and combinations of new and traditional solar materials to make improved and tandem solar cells for more efficient energy capture and conversion, and new flexible, cheaper photovoltaic materials from cheap, earth-abundant materials. -New battery materials and combinations for applications in mobile devices, electric vehicles (including aerospace and defence) and stationary power storage will also emerge -Better catalysts for innovative "green chemistry" processes, and as-yet-unknown innovative new applications such as the one that uses CO₂ to generate electricity. -Ways to produce and store of hydrogen for energy generation and for small-scale power e.g. powered by hydrogen from the air/surrounding environment for more efficient and life-long operations. -Approaches to recycling current energy infrastructure, e.g. wind turbines, solar panels, batteries -Development of new green applications and materials made from major waste streams, e.g. in concrete, ceramics, metal coatings and polymers will all aid a move towards a circular economy. In response to the Critical Minerals Strategy, there has been a significant increase in state and federal government funding over the last three years into critical minerals research and development to power the transition to Net Zero. This R&D is rapidly outpacing investment in the critical national research infrastructure needed to support them. This is a serious gap between policy intent and capacity to deliver. The microscopes and associated expert staff are not at sufficient scale to support this increase in critical minerals research. Last year, researchers and companies were waiting on average four months to access one of our high-sensitivity microanalysis techniques developed by our platform scientist, in collaboration with the MinEx Cooperative Research Centre, to meet the needs of the resources community. Advanced electron microscopy is essential for analysis of new materials, many of which need microscopes able to visualise and track the light elements that these materials use. Some of these are not yet available in Australia while others don't have capacity to meet demand.

Q31.

Supporting healthy and thriving communities

In line with the National Health and Medical Research Council's health priorities for 2024–2027 and the MRFF 2024-2026 Australian Medical Research and Innovation Priorities Microscopy Australia's instruments play an essential role in enabling new vaccines, drugs, innovative medical devices for preventing, sensing and treating a wide range of infectious and chronic diseases. New approaches to combating antibiotic resistance, along with synthetic biology and traditional approaches to precision medicine, all rely on advanced microscopes. Acceleration of the 'spatial-omics' revolution to localise the molecules associated with normal and disease states within the cell will need the latest advanced super-resolution microscopes, advanced cryo electron microscopes, and emerging techniques such as imaging mass spectroscopy to see multiple individual molecules within cells simultaneously. New platforms for rapid vaccine development against infectious diseases emerged during Covid-19 and the technology to progress these is developing rapidly. The current MRFF National Critical Research Infrastructure Grant Opportunity round identified equipment to accelerate the development of mRNA-based vaccines and therapeutics as an area of unmet medical need. New experimental models are emerging that use human cells in structures and devices that mimic human tissues, providing viable alternatives to animal models for drug and fundamental studies. To enable these medical advances a range of advanced microscopes will be essential: - Access to advanced cryo electron microscopes must be maintained to verify AI-led models such as alphaFold and to map all the proteins within cells. - More access to advanced super-resolution microscopes will be essential for spatial 'omics' and to observe how new drugs and drug candidates function at the molecular level. There is significant researcher demand for new super-resolution microscopes to enable crucial breakthroughs in medical treatments and fundamental knowledge to inform future innovation. These are essential to track both molecular interactions and cell behaviours as they happen. There are new types of super-resolution microscopes are specifically designed for making dynamic observations of living cells with unparalleled spatial and temporal resolution. These capture rapid changes of cell and molecular behaviours in real time. These microscopes are not currently available through Microscopy Australia. Integrated workflows for correlative microscopy are needed to align detailed cellular structures with protein and drug locations and interactions. Being able to bring different microscopes to bear on a problem leads to results greater than what can be delivered by one microscope technique on its own. Advanced electron microscopes, some of which are not currently available through Microscopy Australia are needed to support the development of innovative new materials for medical devices.

Q32.

Elevating Aboriginal and Torres Strait Islanders knowledge systems

Microscopy Australia supports and will continue to support projects that elevate Aboriginal and Torres Strait Islander knowledge including the partnership between the University of Queensland (UQ) and the Dugulungi Aboriginal Corporation mentioned above, to harvest spinifex grass for the production of super-strong carbon nanofibres, and the subsequent spin out of Trioda Wilingi from the UQ to develop medical gels from the nanofibres. Our microscopes are involved in a number of projects that work with Aboriginal groups, including: with the Murujuga Aboriginal Corporation, to help date important rock art sites in the Murujuga area and aid their preservation. They also support research by Aboriginal researchers such as that on historical banana cultivation in the Torres Strait. Research directions Projects that work in partnership with Indigenous communities to: - Understand important cultural heritage sites - Aid in the development and application of potential resources and associated products arising from Indigenous knowledge Needs - Advanced electron microscopes - High sensitivity analytical microscopes for dating and understanding cultural heritage sites and collections - Metadata standards for sensitive data management, including indigenous and cultural heritage

Q33.

Protecting and restoring Australia's environment

Research directions Microscopy Australia makes significant contributions to research aimed at preserving and restoring our unique environment and to developing approaches to mitigate the impacts of climate change. The demand for research that finds solutions to tackle these problems will increase as our climate and environment continue to change and have major impacts on Australia's natural environment. Our microscopes are required for enable emerging research projects aimed at understanding the unique features and properties of our native plant and animal species in the face of climate change and other human impacts. This also extends to understanding Australia's rich biodiversity both to protect it and to learn from it as design inspiration for new materials, useful chemicals and to understand how our plants and animals manage harsh environmental conditions. We have helped reveal why gravel soils are underperforming, helping farmers to more efficiently manage water and fertiliser use, and maximise their crop yields in gravel soils. Our microscopes also enable technical innovations such as the development of new polymers made from waste that absorb oils, heavy metals and toxic chemicals that help clean up damaged and contaminated environments (such as mine sites and spill locations). These are in the process of commercialisation and their R&D will continue over the coming years. Other recent research is exploring the use of hyperaccumulator plants to remove toxic metals from the ground for environmental remediation and to generate 'bio-ore' to extract valuable critical metals for the Net Zero transition. We also enable many other projects that are leading the transition to a circular economy that aim to reuse waste to produce innovative and beneficial products. Even approaches that have not yet been conceived off are likely to also rely on our microscopes to visualise and analyse progress. Needs More advanced electron microscopes: 61% of Microscopy Australia's current suite will reach the end of their lives by 2030. Similarly, our ageing suite of high sensitivity microanalytical tools are facing mass retirements. For example, 75% of microprobes around the network will reach end of life over the next five years. Another emerging need globally is increased investment in 3D and time-resolved imaging, including dynamic and spectral micro-CT platforms for mineral-based research, along with volume electron microscopy and soft X-ray microscopy for 3D and correlative microscopy of whole cells. While the Australian Synchrotron provides soft X-ray imaging capabilities, it is extremely expensive, time consuming and competitive for researchers to access. Recently the use of soft X-ray technology has been developed to operate in lab-scale microscopes. This is a significantly cheaper and faster solution for researchers and allows for much larger samples than corresponding electron microscope techniques. Australia currently lacks this.

Q34.

Building a secure and resilient nation

Research Directions Australia's ability to respond to shocks such as climate change, pandemics and other natural and manmade disasters will drive many areas of research over the next 5–10 years that all contribute to the creation of a more resilient Australia for the future. These will include the development of: - Pest and drought-resistant crops support food security. - New technologies that provide innovative water purification systems and fire protection to help respond to disasters. - Innovative products made from waste that contribute to a sustainable circular economy. - New background knowledge for more efficient discovery and extraction of our own natural resources, including the critical minerals to power us towards Net Zero. - Diverse products enabled by advances in materials for additive manufacturing (3D printing) such as alloys, ceramics, and new polymers and composites. - New devices driven by nanotechnology such as portable X-ray units for medical and defence applications are being designed and built in Adelaide. - Solar and battery materials as described above for achieving Net Zero - Smart materials that change shape or behaviour in response to different stimuli. These have a wide range of applications from artificial muscles and sensors to colour-changing camouflage materials. - Graphene is only beginning to reveal its potential in a huge range of applications at the frontier of technology. Examples include use in batteries and thermal conduction coatings for energy savings, both of which help us towards Net Zero. It can also be used in fire retardants and medical devices. - The medical technologies, developments and products described above will also lead to increased potential for advanced Australian manufacturing industries. - Quantum sensors and computing is also an area important for home-grown technologies including essential cyber security applications. Needs Advanced electron microscopes and advanced super-resolution microscopes are essential for the breadth of technologies contributing to this area. Building capacity in advanced microscopy is vital for underpinning research, industry R&D, quality assurance, and failure analysis. This infrastructure will support the development of resilient technologies and ensure Australia's preparedness for future challenges.

Q35.

2.3 The case for a new NRI capability, or enhancements to existing capabilities, typically emerges through advocacy from research communities clustering around rigorously identified needs and goals. Such a concept could respond to a requirement for novel or expanded capacity within a domain, or across domains, and must be such that it could only be made available with national-level investment.

If you have identified such a requirement, briefly describe the need, the proposed infrastructure capability, the medium-term goals, impacted research communities, and the timeframe over which you advocate its establishment. Your response can include links to relevant existing reports.

Microscopy Australia's researcher consultations revealed two major needs: an uplift in core capabilities, and a new focus on advanced optical microscopy. Uplift in core capabilities Structural knowledge is the thread that weaves through all knowledge creation. It underpins innovation, validates models, and unlocks new perspectives. At Microscopy Australia, we empower researchers to see and understand the world at its most fundamental levels—whether it's mapping atomic arrangements in next-generation quantum devices, developing sustainable biomaterials, understanding antimicrobial resistance or tracing the origins of critical minerals for green technologies. By mastering matter at the atomic and molecular scale, we drive breakthroughs that reduce energy and resource consumption, accelerate medical advances, and shape the future of materials science. Our facilities and expertise provide the foundation for tomorrow's discoveries. Our consultations of over 200 researchers indicated two core needs: new instruments and more staff. Access to essential microscopes is currently at risk as 60-80% of the microscopes across Microscopy Australia are expected to reach end-of-life by 2030. Without significant investment and careful planning at a national scale there will be significant bottlenecks resulting in unacceptable delays and efficiency reductions in research training and grant outcomes. Molecular-scale light microscopy: In 2023 the Advanced Imaging Center at HHMI Janelia, published a review: "Imaging the future of optical microscopy: everything, everywhere, all at once". This paper sets out the advances needed to see into living cells; anything, anywhere and anytime. These will allow researchers to see sub-cellular molecular movements, actions and processes – critical to tackling many of the world's greatest health challenges. The review identifies significant advances as: light sheet microscopy, super-resolution microscopy (Nobel Prize 2014), label-free microscopy, and machine-learning-controlled and adaptive microscopy. With increasingly constrained resources, Australia must develop a national strategy to ensure life science researchers can access world-class light microscopes, data analysis tools and expertise. In 2007, Microscopy Australia, was tasked to provide coordinated open access to advanced microscopes and highly sensitive microanalytical tools and expertise. This has focussed largely on electron microscopes. The 2016 Roadmap identified an uplift for microscopy and this resulted in expansion into Victoria, but kept the focus on electron microscopes, partly due to their significant cost, \$3-8 million. Numerous international examples exist, including HHMI Janelia (USA) and EMBL (Europe), where significant expertise has been coordinated and harnessed in advanced light microscopy to unlock new knowledge in life sciences and enable biomedical innovation. Recent advances now position advanced optical microscopes alongside electron microscopes as a critical, nationally significant area of research infrastructure, needed to enable our many world-leading biomedical researchers. From the Strategic Examination of R&D discussion paper, Australia's citations for biomedical and clinical sciences is 200% above the world average, indicating Australia's significant research strength in these areas. Advanced optical microscopes have now reached nano-scale resolution and are capable of tracking large numbers of molecules simultaneously and observing their rapid movements. Many new and complementary super-resolution techniques are emerging to tackle different demands in biomedical research. These highly complex technologies enable researchers to observe biological processes in real time in live cells providing vital insights for health and agricultural outcomes. This requires significant expertise for sample preparation, microscope operation and training, data acquisition and analysis. Open access to a nationally significant suite of advanced optical microscopes is a substantial capability gap requiring national coordination. This need was clearly identified by Australian researchers in the 2021 NRI roadmap survey. When asked which NRI capabilities they would use more of in coming years, they identified microscopes and imaging (a term used interchangeably with microscopy in life sciences) as 2 of the top 4 needs. Imaging was also identified as the second highest emerging need, with live-cell imaging – one of the light microscopy techniques described above – highlighted in the survey summary. Despite this clear identification of the need for microscopy, there was no investment in light microscopy over the last roadmap period, and extremely limited investment in all other microscopy and micro-scale imaging techniques, just 1.8% of the total funding pool, despite being identified the highest area of need after HPC/data storage. Delivering national research infrastructure coordination in light microscopy, could be efficiently achieved by expanding Microscopy Australia's scope to include advanced light microscopy, in line with current European and USA strategies. This will ensure the best outcomes for nationally coordinated advanced light microscope technologies and their use in correlative and multi-modal approaches. Microscopy Australia is working with members of the NCRIS Health Group, on synergies and opportunities in light microscopy. This emphasises why the whole NRI ecosystem is critical and must be supported. Many Microscopy Australia users also use other NCRIS facilities (MicroAU has been jointly acknowledged in papers with 18 NCRIS projects). There is clearly a need to accelerate support for potential biomedical advances that build on Australia's strengths. This, combined with the expertise and coordinated approach to training and machine learning tools that Microscopy Australia provides, will increase knowledge generation in health, medical and life sciences.

Q36.

Part 3: Industry perspectives

This section is seeking input specifically from industry-based respondents. Other respondents can skip this section.

Recommendation 6 of the [2021 Roadmap](#) related to improvements in industry engagement with NRI. To complement work on this topic that has occurred since then, we are seeking additional advice on NRI requirements as perceived by current or potential industry-based users.

Q37.

3.1 Have you (or your organisation) interacted with or used Australia's NRI?

☒ Yes

☐ No

Q38.

3.2 If so, please briefly outline the NRI capabilities you (or your organisation) have interacted with or used. Do not limit your response to NCRIS capabilities.

Q39.

3.3 Please indicate your (one or more) primary reasons for interacting with NRI:

- ☐ For expertise or advice
- ☐ Access to research resources or products
- ☐ Access to equipment for research
- ☐ Access to equipment for operational reasons
- ☐ Help in translating research
- ☐ Access to data
- ☐ Support for clinical trials
- ☐ Other (please specify)

Q40.

3.4 If you answered no, please indicate your (one or more) primary reasons:

This question was not displayed to the respondent.

Q41.

Part 4: Other comments

4.1 Please elaborate on any of your above responses or add any other comments relevant to the development of the 2026 Roadmap. Your response can include reference or links to existing reports that you recommend be considered during the 2026 Roadmap development process.

The continuation of long-term investment (20+ years) in national research infrastructure through NCRIS, an internationally recognised and highly respected program, is critical. Long-term timeframes ensure continuous high-level support for all Australian researchers across career stages, from academia and industry. To achieve this, the 2026 Roadmap needs to clearly identify what NRI are. We suggest NRI must be: nationally significant and collaborative; leading edge; and open access and includes support for researchers to access the infrastructure (e.g. travel support scheme to access the Synchrotron). Australia is at a critical decision point in its delivery of a national open-access microscopy capability. Over five years, Microscopy Australia's ~30 NCRIS platforms have supported at least \$1 billion in ARC and NHMRC grants. In 2023, 42% of our publications were in top 10% ranked journals, and 25% of Australia's top 100 cited papers relied on microscopy (Scival). In the 2021 NRI Survey, Australian researchers identified imaging (a term used interchangeably with microscopy) and microscopes as two of the top four areas of increased need, and the second highest emerging need. Despite this, only 1.8% of funding was allocated to microscopy. These trends still hold true, in our 2024 consultation 60% of researchers indicated they expected their future use to increase. Current investment levels are insufficient to sustain existing microscopy capabilities, let alone meet growing demand. Without a significant boost to future capital investment, researchers will be unable to access leading-edge microscopes in Australia, leaving sovereign capabilities at risk and creating a critical failure point in knowledge generation and translation. Industry users have highlighted a clear need for rapid, interpreted analyses, but Australia's research infrastructure lacks the capacity to provide timely support. This acts as a hand-break on industry-led research and poses a significant risk to national innovation and funding priorities. There is an urgent need for NRI investment to support the anticipated Australian R&D boom and maximise this coordinated funding effort. Our facilities contain microscopes of varying complexity, sophistication and cost, all of which are vital to Australian research. While the newest, emerging technologies enable breakthroughs at the edge of what's possible, essential preliminary and applied work that industry typically needs requires a variety of different, often basic, microscopes. It is these essential instruments that fall through the gaps; they're not cutting-edge enough for LIEF or NCRIS funding but too expensive for universities, costing millions of dollars for a single instrument once staffing and service contracts are factored in. There are currently no funding avenues to support this basic, but no less critical, research infrastructure, resulting in a systemic gap that leaves all Australian research without sufficient support.