



Australia's National  
Science Agency

# COVID-19: Recovery and resilience

Opportunities for Australia to leverage science and technology  
to support economic recovery and resilience



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# Contents

Foreword .....	3
1 Introduction .....	4
2 Industry opportunities .....	6
Digital .....	8
Energy .....	10
Food and agribusiness .....	12
Health .....	14
Manufacturing .....	16
Mineral resources .....	18
3 Strengthening the foundations for growth .....	20
4 Conclusion .....	23



# Foreword

Science and technology have always been vital for Australia's economy, creating economic growth and opportunity for all Australians. At this pivotal time in our history, the inclination is to batten down the hatches and postpone investments or actioning new ideas while riding out the storm. But actually, we need to double down on Australian innovation, because science and technology guide our ship into better waters with sails intact – it could even add an Australian-invented carbon fibre mast for more speed to outpace competitors.

In the past, our Aussie ingenuity has reinvented wool in the face of synthetics entering the fabric industry, it's reinvented cotton for an Australian climate, and it's reinvented connectivity with fast WiFi. In fact, the same expertise that reinvented wool went on to reinvent carbon fibre, securing Australia's own secret recipe for the next-generation material. We've supported existing industries to pivot, small and medium businesses to grow, and new start-ups to thrive. We've created jobs, built careers, and inspired generations to change the world around them through science and technology. We've been proud innovators.

Today more than ever, science and technology are vital to drive our recovery from the pandemic-led recession and build our future resilience. Crucially, investment in innovation can deliver both short-term shots in the arm from commercialisation of market-ready technologies, and longer-term job creation and growth from burgeoning breakthroughs and nascent new industries. COVID-19 has disrupted every element of our lives, and while the devastating loss of life can't be understated, we do now have an opportunity – indeed, a responsibility – to determine the kind of Australia we want to emerge. This COVID-19: Recovery and resilience report brings together key insights from CSIRO's landmark reports in recent years with the latest insights into the impact of the pandemic, to recommend a path forward for Australia. We have all the foundations to accelerate critical Australian industries by building on our world-class scientific expertise, high-value workforce, and national advantages if we make the right investments now.

This report identifies a number of growth industries, including energy, food and agribusiness, health, and mineral resources, together with underpinning capabilities like advanced manufacturing and digital technologies, where Australia has an opportunity to build on our current strengths to differentiate and lead internationally. Importantly, the report makes a case for five key foundations for this growth, from investment in science and adoption of technology; to growth of tech-based export industries; to cultural shifts needed, including workforce development, collaboration across research and industry, and stronger emphasis on triple-bottom-line outcomes. Science excellence can only be translated into national benefit when it's surrounded by a strong innovation ecosystem of partners working together on taking solutions from science to customers in market.

As the national science agency, CSIRO is a proud advocate and catalyst for these core foundations Australia needs for social, environmental and economic benefits from its research excellence. Most recently, CSIRO launched a program of missions, designed to bolster Australia's COVID-19 recovery and build long term resilience. CSIRO will partner with businesses, government, universities and communities to solve some of Australia's greatest challenges through these missions, focused on outcomes that lead to positive impact, new jobs and economic growth. These missions rally Australians around big, bold, exciting ideas of what's possible when we work together, much as the original Moon mission did many decades ago. The pandemic is testing us as a nation, but we get to decide how we respond, and what kind of Australia we want to live in as we drive our recovery and build our resilience for the next disruptions on the horizon.

**Larry Marshall**  
Chief Executive, CSIRO

# 1 Introduction

Science and technology have been critical in supporting the immediate response to COVID-19 and will continue to play a vital role in Australia's economic recovery and long-term resilience.

The unprecedented COVID-19 pandemic has disrupted global supply chains and major Australian industries, halted travel and migration, and impacted huge segments of the global and Australian workforce. Numerous sectors are facing permanent structural shifts due to this economic shock and some may never fully recover.

Science and technology have played a critical and publicly visible role in supporting the immediate response to COVID-19, including guiding the public health response, virus suppression, treatment and testing. For example, the work carried out at CSIRO's Australian Centre for Disease Preparedness and its biologics manufacturing facility is contributing to global efforts to develop and trial COVID-19 vaccines. Science and technology have also always played a key role in supporting Australia's economy, by helping to improve productivity, providing social and environmental benefits, building resilience, and enhancing international competitiveness. This report shows how CSIRO's work extends to the economic recovery phase of the pandemic, by illustrating the importance of science and technology in supporting Australia's economic recovery and resilience.



This report identifies opportunities for Australian businesses to leverage science and technology, drive economic recovery and resilience, and realise positive economic impacts starting now.

The report consolidates previous CSIRO publications, such as the industry roadmaps,<sup>1</sup> the Australian National Outlook 2019,<sup>2</sup> the Artificial Intelligence Roadmap<sup>3</sup> and the CSIRO Economic Outlooks.<sup>4</sup> CSIRO conducted additional desktop research and targeted consultation with business, government and research leaders to examine the trends and national advantages that are most relevant now, and how COVID-19 has created, altered or intensified opportunities for growth.

In pursuing recovery and resilience, the report also leverages CSIRO's new program of missions aimed at meeting Australia's major challenges and supporting a future economy augmented and accelerated by technology.

"We will commit at least \$100 million annually to this program, and we are... working with government, universities, industry and the community to co-create and deliver these missions... These missions build a future where our children have rewarding and sustainable jobs, in unique and resilient industries, that secure Australia's wellbeing and prosperity for generations to come."<sup>5</sup>

Six sectors that realise significant economic value from science and technology are the focus of this report. These include agriculture and food, energy, health, and mineral resources, underpinned by the horizontal and cross-cutting digital and manufacturing sectors. Each of the opportunities in this report also focus on realisable economic impacts, including increased productivity and cost efficiencies as well as additional revenue from existing or new products, services and markets.

This report identifies three broad phases to Australia's economic journey through COVID-19 and beyond, and outlines the medium and long-term growth opportunities associated with them:

- *Short-term response (0-6+ months)*: This is the immediate response to the pandemic starting from mid-March 2020, including the initial public health response, economic stimulus packages and measures to support the supply of critical goods across Australia. Although health, economic and other measures will continue beyond the initial 6 months, this immediate response has been publicly visible and widely discussed elsewhere and is not the focus of this report.
- *Medium-term recovery (6-24 months)*: This phase is about supporting the recovery of industries core to the Australian economy, including through improved health and safety measures (e.g. diagnostics, detection and traceability), digitalisation, and other economic growth opportunities. Medium-term recovery opportunities involve deployment-ready technologies that could have positive economic impacts (jobs and returns on investment) in the next 24 months.
- *Long-term resilience (24+ months)*: This phase is about building a resilient economy and reducing the economy's exposure to future disruptions (e.g. health, climate and geopolitical risks). Long-term resilience opportunities involve technologies that are, in some cases, still in development and that require further investment, technical and commercial testing, and scale up before their economic potential is realisable.

Finally, the report poses challenging questions on issues that lie at the nexus of science, technology and economics and that intend to motivate further discussion. Part of these future discussions could include topics such as technology integration into industries and existing operations.

At the time of writing this report there is still significant uncertainty about the scale of COVID-19's impact on Australia's society and economy. However, the three phases and timeframe estimates are intended to help support strategic discussions and decisions in the Australian business community.

# 2 Industry opportunities

Significant cost efficiencies, jobs and growth can be realised over the next few years by pursuing value-adding opportunities domestically and abroad. Although the digital and manufacturing sectors have their own opportunities to capitalise on, they will also be integral in supporting the opportunities identified for other sectors.

	Digital	Energy	Food and agribusiness
TRENDS	<p><b>Digital interaction is increasing</b> with a shift to remote learning and working</p> <p><b>Transformed supply chains</b> are bringing businesses and consumers closer</p> <p>Companies are looking to digital for <b>efficiency</b> gains</p>	<p><b>Decarbonisation goals</b> continue to be set and pursued</p> <p>Global energy demand is increasing, creating a <b>power hungry planet</b></p> <p>Transition to <b>renewable energy</b> generation requires new solutions</p>	<p>Supply of limited resources is fragile in a <b>less predictable planet</b></p> <p>Consumers have <b>health on the mind</b> with a focus on wellbeing</p> <p><b>One world</b> trading means supply chains are interdependent</p>
ADVANTAGES	<p>World-leading <b>research expertise and workforce skill</b></p> <p><b>Established and successful sectors</b> ripe for digital</p> <p>Sound regulatory environment and <b>robust testing ground</b></p>	<p>Exceptional <b>natural resources and geography</b></p> <p>World-leading <b>human capital and skills</b></p> <p><b>Established export facilities</b> and existing trading relationships</p>	<p><b>Clean and green</b> brand and reputation for high-quality food and agribusiness exports</p> <p><b>Unique geography</b> and range of climates with proximity to Asian markets</p> <p>History of <b>world-class research and adoption</b> in agriculture</p>
CROSS-CUTTING DIGITAL OPPORTUNITIES			
MEDIUM-TERM	<ul style="list-style-type: none"> <li>• Data utilisation</li> <li>• Data proliferation and sharing</li> <li>• Risk management and business continuity</li> </ul>	<ul style="list-style-type: none"> <li>• Energy efficient technologies</li> <li>• Reliable and secure energy systems plan</li> <li>• Hybrid energy systems</li> </ul>	<ul style="list-style-type: none"> <li>• Alternative protein sources</li> <li>• High-value health and wellbeing food products</li> <li>• Smarter value chains</li> </ul>
LONG-TERM	<ul style="list-style-type: none"> <li>• Highly automated systems and workplace distribution</li> <li>• Quantum technology growth</li> </ul>	<ul style="list-style-type: none"> <li>• Hydrogen industry</li> <li>• Environmental solutions and processes for hard-to-abate industries</li> </ul>	<ul style="list-style-type: none"> <li>• Traceability and provenance</li> <li>• Sustainable production chains</li> </ul>

## Health

**Global biosecurity** is front and centre

A **digital and data-driven future** is upon us

Tailored medical responses are increasingly provided through **precision healthcare**

High standards and regulations, fostering a **global reputation for quality**

**Strong research community**

**Highly skilled and educated workforce**

## Manufacturing

**Agile and bespoke solutions** are reacting to local supply needs

Demand for **local and sustainable manufacturing** is increasing

**Data capture and analytics** are maximising efficiencies

Trusted, premium goods and services made with **quality and standards**

Untapped **education and research skills**

Nimble and flexible **small and medium enterprises**

## Mineral resources

Demand for **productivity and sustainability improvements** is increasing

Stakeholder expectations are increasing in an **era of accountability**

Digital innovation requires all to be **plugged in and switched on**

Endowment of **natural resources**

**Highly skilled and experienced workforce**

**Innovative research** and global excellence in mining and metallurgical research

TRENDS

ADVANTAGES

## CROSS-CUTTING MANUFACTURING OPPORTUNITIES

- Sector-wide digital health integration
- Diagnostics and informatics products and services
- Personalised digital medical and therapeutic solutions
- Advanced medicinal product development
- High-value medical technology (medtech) manufacturing

- Maximisation of local manufacturing capabilities
- Superior componentry
- Sustainable and agile manufacturing
- Value-adding downstream processing of minerals

- Automation and remote operations
- Orebody knowledge and process control
- Exploration technology
- Selective extraction
- Net zero emissions

MEDIUM-TERM

LONG-TERM



The digital sector, comprising information, media and telecommunications, and computer system design and related services, contributes **\$122B** in Gross Value Added (GVA) to the economy (6.6% of GDP)<sup>6</sup> and the broader tech sector employs **580,000 workers**.<sup>7</sup> Digital innovation can deliver **\$315B** in gross economic value to Australia over the next decade if Australia catches up to global leaders.<sup>8</sup>

In response to COVID-19, Australia has shown agility in adopting digital technologies, setting an encouraging precedent for utilising digital systems and solutions in the future. At the firm level, five years of progress has been made in consumer and business digital adoption in just eight weeks<sup>9</sup> and 38% of Australian businesses changed their delivery method and moved their business online.<sup>10</sup> The adoption of digital technologies can be utilised by all of Australia's sectors to gain productivity and unlock wealth.



## Trends

Of the several trends identified in the CSIRO-commissioned AlphaBeta Digital Innovation Report<sup>11</sup> and CSIRO's Cyber Security Roadmap,<sup>12</sup> three trends have been highlighted by the COVID-19 pandemic.



### Increased digital interaction

The way we interact and the volume of data being exchanged is changing rapidly. With a **shift to working and learning remotely**, the methods and pathways of this data exchange have shifted in a short period of time, bringing with it cyber security implications.

### Transformed supply chains

Digital technologies, such as blockchain, are transforming supply chains, creating **greater transparency and increasing efficiencies**. This is removing the barriers between business and consumers, creating opportunities for collaboration and specialisation and encouraging localisation.

### Efficiencies sought

As companies reassess their business model in the wake of COVID-19, they are looking for digital solutions that will bring **efficiencies and reduce costs**.

## National advantages

The digital sector continues to operate strongly in Australia despite the pandemic, and several key national advantages will continue to support its recovery and resilience development into the future.



### Research expertise and skilled workforce

Australia is among **leading countries** when it comes to **volume and quality of research published** in the fields of artificial intelligence (AI) and computer science research. Leveraging this know-how is key to taking advantage of digital's offerings.

### Established and successful sectors

With strong institutions, natural resources and an **established trading base**, Australia is home to a wide range of industries that can benefit from a digital transformation to drive productivity and prosperity.

### Robust testing ground

Australia's **sound regulatory environment** and **unique geography** provide a robust testing ground for digital technology development for roll out to other countries.

## Medium-term (6-24 months) recovery

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Data utilisation</b></p> <p>Australian businesses can better leverage technologies to utilise and monetise the data they already collect. Well utilised data can help inform decision-making and improve processes, drive new efficiencies and improve safety. With increased data utilisation comes a heightened need to ensure that it remains secure and private by applying cyber security measures.</p>	<ul style="list-style-type: none"><li>• AI including machine learning</li><li>• Cyber security and privacy</li><li>• Robotics</li><li>• High performance computing</li><li>• Decentralised storage</li></ul>
<p><b>Data proliferation and sharing</b></p> <p>There is also the opportunity to generate and share more data. New data can be gained by using technologies to collect data from operations and equipment, and to share data throughout the supply chain including with customers and competitors. Again, with increased data collection and sharing comes an increased need for cyber security measures.</p>	<ul style="list-style-type: none"><li>• Robotics and autonomous systems</li><li>• Sensors and internet of things</li><li>• Image analytics and geospatial intelligence</li><li>• AI including machine learning</li><li>• Cyber security and privacy</li></ul>
<p><b>Risk management and business continuity</b></p> <p>COVID-19 has highlighted the importance of risk management and business continuity planning. Risk-based assessment technologies can increase operational understanding and improve risk recognition and mitigation. Scenario planning and modelling can assist business to understand risks and plan contingencies to mitigate their impact. These technologies can also be used more broadly – e.g. in modelling potential impacts for disaster resilience to improve alert notifications and response effectiveness.</p>	<ul style="list-style-type: none"><li>• High performance computing</li><li>• Data visualisation and modelling</li><li>• Natural language processing</li><li>• AI including machine learning</li><li>• Cyber security and privacy</li><li>• Digital twinning</li></ul>

## Long-term (24+ months) resilience

**Long-term vision:** A sector of *highly skilled* professionals at the *frontier* of innovative science and technology, whose solutions are invested in and adopted by *bold leaders* and *trusted* by the Australian community.

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Highly automated systems and workplace distribution</b></p> <p>Although AI and automation are already available, there is still major scope to automate routine and some non-routine tasks. As well as freeing up existing capital and resources to re-invest in growth, this can create complementary jobs in automation design and development, data analysis, monitoring and evaluation. It will require an understanding of how AI can be applied across industries and the development of ethical safeguards.</p>	<ul style="list-style-type: none"><li>• AI including machine learning</li><li>• Digital twinning</li><li>• Digital simulations</li><li>• Human language technologies</li></ul>
<p><b>Quantum technology growth</b></p> <p>The emerging quantum technology industry has the potential to generate over \$4B in revenue and create 16,000 new jobs.<sup>13</sup> Quantum could help future-proof the digital sector, enhance productivity and unlock new capabilities such as in early disease detection, material science, defence applications and ore discovery. Although the benefits are longer-term, investment now can prepare Australia to compete globally.</p>	<ul style="list-style-type: none"><li>• Quantum computation</li><li>• Quantum sensing and imaging</li><li>• Quantum enhanced information security</li><li>• Quantum-safe cryptography</li><li>• Quantum communication systems</li></ul>

## Questions and considerations going forward

- **A digital nation:** How can the sector assist communities and businesses, especially small and medium-sized enterprises (SMEs), in digital transition and build trust in the equitable use and adoption of digital technologies?
- **Growing and training the sector workforce:** How can businesses ensure that their workforce is able to adapt and take full advantage of rapidly evolving technologies and techniques?
- **A resilient and globally connected digital sector:** How can Australia balance sovereign capability, national security, digital connectivity and continued participation in global supply chains?

# Energy

Energy demands are growing globally. Despite a short-term demand plateau as a result of COVID-19's disruption to workplaces, growth will return as the recovery continues. The International Energy Agency estimates that, if the world continues its present path, global demand will rise by 1.3% each year to 2040.<sup>14</sup> Greenhouse gas emissions are also rising, leading to a range of impacts to the climate, health, agriculture, water security, disaster risk management and the economy.<sup>15</sup> Meeting global energy demand in a clean and cost-effective manner will be a major global challenge and Australia has an opportunity to leverage its abundant natural resources and extensive know-how to become a world-class clean energy and technology provider.

In 2017-18, Australia's energy consumption by fuel type was comprised mainly of oil (38.7%), coal (29.9%) and gas (25.2%) while renewables (mainly biomass, hydro, wind and solar) made up 6.2%.<sup>16</sup> Australia's total electricity generation in 2019 was mainly sourced from coal (56.4%), natural gas (20.5%) and renewable sources (20.9%).<sup>17</sup> Australia's energy commodity exports were worth over **\$132.7B** in 2018-19.<sup>18</sup>

Energy consumption   
**6.2%** renewables

 Electricity generated  
**20.9%** renewables

**\$132.7B**   
exports

## Trends

Energy megatrends identified in CSIRO's Low Emissions Technology Roadmap,<sup>19</sup> the Oil and Gas Roadmap<sup>20</sup> and the Australian National Outlook 2019<sup>21</sup> are taking on a new dimension as the world looks to recover and build resilience.



### Pursuit towards decarbonisation

As renewable energy prices fall, the scale of viable applications increase and public pressure persists, governments and private sector players will likely continue to **set and pursue decarbonisation targets**. Some are even seeing the pandemic-induced disruption as an opportunity to pursue a 'green recovery'.

### Power hungry planet

**Global energy demand is increasing** due to rapid urbanisation, population growth and an expanding middle class. This is certainly the case for the Asia-Pacific region and our key trading partners. Australia can influence how this demand is met, including aligning the energy mix to decarbonisation goals.

### Shift towards renewables

Electricity systems are shifting away from centralised thermal power plants toward **variable renewable energy** generation. This brings **new technological challenges** around forecasting, grid conditions and storage to match supply and demand.

## National advantages

Further, the pandemic has also revealed that the sector remains strong, with key national advantages that will enable Australia to recover and develop resilience going forward.



### Natural resources and geography

Australia has **world-class energy resources** and the highest average solar radiation per square km of any continent.<sup>22</sup> The value of these resources is enhanced by Australia's **proximity to major trading economies**.

### Human capital and skills

Australia has many **strengths in energy technology research** as well as education and skills, particularly technical skills. This is matched by **world-leading capabilities** in off-grid renewables.

### Established export facilities

Australia has a **long history of energy exports** and has developed extensive infrastructure and trading relationships that can be leveraged to meet the region's demand for low emission energy. Plans to export clean hydrogen energy by ship (for carrier compounds) and cable (for electricity) has the potential to create new export markets for Australia.

## Medium-term (6-24 months) recovery

### OPPORTUNITIES

#### Energy efficient technologies

Increased energy efficiencies can reduce energy costs, emissions and demand on the grid, while creating local jobs. Increased productivity from high efficiency and electric technologies in buildings, industry and transport is an opportunity that utilises mature technologies that are readily adoptable.

#### Reliable and secure energy systems plan

As variable renewables increase, thorough grid planning and dynamic operation of the grid is required to maintain reliability, reduce costs and ensure an optimised grid. Building on the AEMO Integrated System Plan,<sup>23</sup> this opportunity includes planning for decentralised generation and a truly bi-directional grid. Additionally, technologies to lower the cost of gas production and improve recovery rates can better secure domestic gas supply.

#### Hybrid energy systems

Hybrid energy systems can deliver improvements in energy performance, efficiency and reliability, as well as increased flexibility. By combining two or more energy generation, storage or end use applications, these systems have the potential to play a role in residential, commercial and remote sites to reduce reliance on the grid and/or fossil fuels. This transition is already underway but could be expanded, and fast-tracked, providing jobs and upskilling opportunities.

### SCIENCE AND TECH ENABLERS

- Sensors, networks, analytics and machine learning
- Smart and energy efficient appliances and their manufacture
- Electric vehicles
- Vehicle telematics
- Sensors, networks and data analytics
- AI including machine learning
- Digital twinning of energy assets
- Demand management technologies
- Enhanced natural gas productivity
- PV, wind and tidal
- Hydrogen energy systems
- Battery energy storage
- Smart systems and metering

## Long-term (24+ months) resilience

**Long-term vision:** A sector that extracts and produces from low emission energy sources, supporting *local jobs* and a *resilient* electricity grid, where surplus energy is *exported* to clean-energy-seeking trading partners.

### OPPORTUNITIES

#### Hydrogen industry

Australia has an opportunity to develop a local market and the world's first clean hydrogen energy export industry, with a combined value of about \$11B a year in GDP by 2050.<sup>24</sup> As production scales up locally, it can help decarbonise hard-to-abate industries, power transport and reduce dependence on foreign energy imports, increasing energy security and resilience. Access to large scale, low-cost hydrogen can open new industry opportunities like manufacturing green steel and hydrogen technologies and components.

#### Environmental solutions and processes for hard-to-abate industries

Managing the environmental impact of industry and fossil fuel power generation creates opportunities to develop new technologies and reduce operating costs. Developments in energy efficiency, basin and process productivity and energy optimisation will all contribute to this goal. This also includes managing water quality, reuse and efficient and environmentally-sound decommissioning of extraction sites.

### SCIENCE AND TECH ENABLERS

- Hydrogen hubs to support integrated technology scale up
- Generate local hydrogen demand with technology demonstrations
- Advanced manufacturing of production, storage and utilisation technologies and components
- Sophisticated impact modelling
- Long-term monitoring and sensors
- Fugitive flaring and venting management
- Carbon capture storage and utilisation
- Energy optimisation

## Questions and considerations going forward

- **A resilient renewable energy sector:** How can the innovation system support healthy competition between renewable resources while the sector transitions to electrification and renewable power?
- **Supporting decarbonisation:** In addition to hydrogen, how else can science and technology help to manage the greenhouse emissions associated with fossil fuel use?



# Food and agribusiness

The food and agribusiness (F&A) sector is a vital contributor to the Australia economy. It has a strong export orientation and is a driver of prosperity for many parts of regional and rural Australia.

A purchasing surge at the start of the pandemic led to disruptions to supermarket stocks for basic food items but this has since abated. However, F&A has been negatively impacted in the short-term by a struggling hospitality industry, with reduced domestic demand for restaurants, cafes, bars, accommodation and other services.

In 2019, agricultural, forestry and fishing employed nearly **325,900 workers**<sup>25</sup> and contributed **\$9.6B** in GVA (2.0% of GDP).<sup>26</sup> Food and beverage manufacturing contributed nearly **\$6.6B** in GVA (1.4% of GDP). Combined, their exports were worth approximately **\$49.1B** in 2019.<sup>27</sup>



## Trends

Of the megatrends identified in CSIRO's Food and Agribusiness Roadmap,<sup>28</sup> the COVID-19 pandemic has emphasised the relevance of three major trends.



### A less predictable planet

COVID-19 has further shown how the supply of limited resources is constrained by **severe and unpredictable events** such as extreme weather (e.g. droughts, floods and storms), economic disruption and geopolitical uncertainty. Under these uncertain conditions, businesses are seeking ways to improve the efficiency and circularity of their food production activities, and consumers are seeking foods that are ethically and sustainably sourced.

### Health on the mind

COVID-19 is accelerating a heightened consumer **focus on health and wellbeing**. There has also been a broader global consumer trend of **caution and selectiveness** towards brands that demonstrate purpose, transparency and alignment with their values.

### One world

Global food and beverage chains are accompanied by greater competition, supply resilience risks, and risks around the politicisation and protectionism of trade. The sector relies on **global markets and supply chains** for many inputs which COVID-19 has disrupted, particularly migrant labour and packaging.

## National advantages

Further, the pandemic has also revealed that the sector remains strong, with some key national advantages that will enable to recover and develop resilience going forward.



### Clean and green

Australia's **clean and green brand** and its reputation for **high-quality, trusted and verifiable F&A export products** is globally well-regarded. This is supported by the country's low prevalence of food-borne illness, high safety standards, and a strong biosecurity system that supports our 'pest and disease free' status.<sup>29</sup>

### Unique geography

Australia is one of the most food secure countries in the world.<sup>30</sup> It hosts a diverse range of agroecological zones and is close to growing Asian markets that are counter-seasonal, giving a distinct advantage in **supplying major economies** as they recover from COVID-19.

### World-class research and adoption

F&A has a **strong research and development (R&D) sector**, enabling it to become more resilient and grow in the global marketplace. Australian R&D is world-leading in pre-farm gate fields including animal production, plant biology and environmental management. This is supported by a highly professional farming industry with strong technology adoption.

## Medium-term (6-24 months) recovery

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Alternative protein sources</b></p> <p>Export opportunities for alternative proteins will grow as the global middle class continues to rapidly expand. More sustainable sources such as plant-based proteins, improved aquaculture products and insect-based ingredients can meet this demand. The Growth opportunities for Australian food and agribusiness report<sup>33</sup> estimates a \$4.1B domestic and \$2.5B export opportunity for alternative proteins by 2030.</p>	<ul style="list-style-type: none"> <li>• Protein extraction processes such as dry milling, hydrodynamic cavitation and ultrasound-assisted extraction</li> <li>• Aquaculture breeding, genomics, nutrition and health</li> <li>• Insect-based ingredients and animal feeds</li> </ul>
<p><b>High-value health and wellbeing food products</b></p> <p>The sector can offer premium, high-value products to the global market beyond basic agricultural commodities. Wealthier consumers are driving higher demand for free-from and natural food products, while increasingly health conscious and time poor consumers are seeking fortified and functional foods and beverages. The Growth opportunities for Australian food and agribusiness report estimates a \$5.8B export opportunity for these products by 2030.</p>	<ul style="list-style-type: none"> <li>• New natural sweeteners, preservatives, supplement sources and nutraceuticals</li> <li>• Allergen free and tolerable alternatives</li> <li>• Selective breeding, fermentation and fortification</li> <li>• New enzyme formulations, synergistic formulations and delivery systems</li> </ul>
<p><b>Smarter value chains</b></p> <p>The sector can improve productivity and reduce costs by optimising operations, streamlining logistics, developing greater scale, agility and efficiency, and more effectively linking together the F&amp;A value chain – from producers through to manufacturers, processors, retailers and distributors – with the support of new technology-enabled processes and systems.</p>	<ul style="list-style-type: none"> <li>• Sensors and data analytics</li> <li>• AI and machine learning</li> <li>• E-commerce digital infrastructure</li> <li>• Efficient transportation and logistics</li> <li>• Crop computer-modelling systems</li> <li>• Weather and climate data systems</li> </ul>

## Long-term (24+ months) resilience

**Long-term vision:** A thriving sector that continues to ensure food security while providing **premium** and **trusted** health and wellbeing products to the global marketplace, produced using **efficient** and **sustainable** production solutions.

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Traceability and provenance</b></p> <p>Product quality, trust and security is critical to Australia's reputation and national advantages in an uncertain world. Technology can enable the sector to validate sourcing claims, meet consumer demand for transparency, efficiently combat food fraud, and support smarter value chains.</p>	<ul style="list-style-type: none"> <li>• Blockchain</li> <li>• DNA-testing</li> <li>• Isotope analysis</li> <li>• Barcoding and image recognition</li> </ul>
<p><b>Sustainable production chains</b></p> <p>Given the risks from climate change, resource scarcity, broader supply chain pressures and perennial climate extremes such as droughts and heatwaves, the sector can continue to develop innovative approaches for effective and sustainable resource use while ensuring the resilience of Australia's natural capital (e.g. water, soil, carbon and animal welfare).</p>	<ul style="list-style-type: none"> <li>• New water management systems</li> <li>• Sustainable feed additives</li> <li>• Sustainable packaging</li> <li>• Precision agriculture systems and vertical, indoor, modular farming and greenhouses</li> <li>• Closed loop production</li> <li>• Sustainable energy and transportation</li> <li>• Climate tolerant cultivars</li> </ul>

## Questions and considerations going forward

- **Resilient supply chains:** How can science and technology best increase resilience across the supply chain, from maintaining a vibrant rural sector to securing supply of imported inputs?
- **Natural capital resilience:** How can science and technology support Australia's natural capital resilience?
- **Supporting systems:** How can innovations in supporting systems such as biosecurity, digital and data infrastructure, trade and logistics, and retail chains improve resilience in the sector?



# Health

The health sector has always been an essential part of Australia's economy and society, and its importance has been further emphasised during the pandemic. A suite of responses has been implemented in the sector, including an expansion of telehealth services, COVID-19 diagnostics and treatment, and vaccine, anti-viral and respiratory medicine research, among many other funding and support initiatives.

Looking forward, and as noted in CSIRO's Future of Health report,<sup>32</sup> the sector has an opportunity to innovate beyond illness treatment and towards managing health and wellbeing to improve the health outcomes of all Australia.

In 2019, Australia's medical technologies and pharmaceuticals sector was worth **\$5.2B** in GVA and employed **68,000 workers**.<sup>33</sup> The broader health care and social assistance sector had a GVA of **\$35.6B** (around 7.5% of GDP)<sup>34</sup> and employed over **1.7M workers**.<sup>35</sup>



## Trends

CSIRO's Medical Technologies and Pharmaceuticals Roadmap<sup>36</sup> and Future of Health report<sup>37</sup> identify several health-related megatrends. Three major trends have been identified as being especially salient in view of the COVID-19 pandemic.



### Global biosecurity

COVID-19 has highlighted, more than ever before, the **globally transmissible nature of diseases** and their severe and unpredictable **impact on society** and regions. This is exacerbated by geopolitical instability, limited access to healthcare technologies and services, a changing climate and anti-microbial resistance.

### A digital and data-driven future

Health professionals are adopting **virtual treatment approaches** to avoid physical meetings with patients, and using digital technology to trace COVID-19 cases and manage the psychosocial impacts of social distancing measures. This **digital adoption requires significant shifts** in how the data generated by the sector is collected, exchanged, processed and used.

### Precision healthcare

The demand for **tailored health responses** for different cohorts in society and for personalised health and wellbeing outcomes means the sector will shift towards **solutions tuned to specific individual patient needs**, such as targeted pharmaceuticals and bespoke medical technologies. Similarly, targeted public health communication and messaging is needed to effectively reach different parts of society.

## National advantages



The health sector is vital to Australia amidst the pandemic and its national advantages will continue to support economic recovery and resilience going forward.

### Strong international reputation for quality

With **stringent regulatory systems**, quality management and standards, and a reputation for highly quality, clean, and safe production processes, the **sector can be differentiated** in its medical product and service exports to a global market that is currently seeking the very best medical solutions for its pressing healthcare needs.

### A strong research community

Australia's medical technologies and pharmaceuticals sector is underpinned by a **strong network** of globally influential research organisations, universities and medical research institutes with a **history of producing high-impact research**. The Australian Centre for Disease Preparedness, for example, is the only high containment biosecurity research facility in the southern hemisphere capable of researching and diagnosing a range of exotic pathogens.

### Highly skilled and educated workforce

Australia is recognised for its diverse, skilled, and **highly educated workforce** that can drive the **development of medical solutions** necessary for economic recovery and continued resilience against global health challenges.

## Medium-term (6-24 months) recovery

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<b>Sector-wide digital health integration</b> Underpinned by strong digital infrastructure, the health sector can improve its system-level integration to provide evidence-based and continually improving care across preventative/predictive health tracking, chronic disease management, decision support and rehabilitation.	<ul style="list-style-type: none"><li>• Telehealth and telemedicine platforms</li><li>• Cybersecurity and data interoperability</li><li>• Electronic health records</li><li>• Cloud computing</li><li>• Secured datasets and databases</li></ul>
<b>Diagnostics and informatics products and services</b> Driven by the need for efficient healthcare delivery, including the recent demand for rapid COVID-19 viral detection and response, there are opportunities to build point-of-care diagnostics, and preventative and precision medicine solutions through the sophisticated collection, interrogation, interpretation and packaging of medical and population data.	<ul style="list-style-type: none"><li>• Cybersecurity</li><li>• Dynamic de-identification systems and privacy preserving data analytics</li><li>• Bioinformatics tools</li><li>• New data storage approaches</li><li>• Optimised analysis algorithms</li><li>• High performance computing</li></ul>
<b>Personalised digital medical and therapeutic solutions</b> Improved clinical outcomes for individuals, particularly those with limited access to specialist services, can be achieved with digital medical and therapeutic solutions. These offer efficient, personalised health treatments, interventions, management and prevention options with the use of personal health data, point-of-care diagnostic devices and digital applications.	<ul style="list-style-type: none"><li>• Digital diagnostics and biomarkers</li><li>• Wearables, connected devices and personal monitoring systems</li><li>• Remote patient monitoring</li><li>• Mobile health applications</li></ul>

## Long-term (24+ months) resilience

**Long-term vision:** A sector that *protects* Australians from global health challenges such as antibiotic resistance and infectious diseases and creates *trusted* and *world-leading* medical solutions for global health needs.

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<b>Advanced medicinal product development</b> With speed a critical factor in global healthcare efforts, Australia can create a high-quality and efficient early-stage development environment for vaccines and pharmaceutical drugs, as well as produce high-value and niche pharmaceuticals such as novel biologics and biosimilars.	<ul style="list-style-type: none"><li>• Integrated research, trials and care-based information systems and platforms</li><li>• Toxicology and drug candidate optimisation</li><li>• Improved product manufacturing systems and transport techniques</li><li>• Advanced analytical instruments and sterilisation techniques</li></ul>
<b>High-value medical technology (medtech) manufacturing</b> With renewed interest in local manufacturing, Australia can support new skilled jobs and agile medtech companies by designing, testing and producing high-value medical devices, such as advanced monitoring devices, imaging equipment, wearables and implants.	<ul style="list-style-type: none"><li>• Wearables and smart implants</li><li>• Biocompatible materials</li><li>• Biosensors and bioelectronics</li><li>• Data capture, analysis and communications</li><li>• Advanced materials manufacturing</li><li>• Additive manufacturing</li></ul>

## Questions and considerations going forward

- **Reaching all Australians:** What sector innovations and advancements will help bridge existing equity divides and improve quality and access across the entire national healthcare system?
- **Maintaining and investing in trust:** How can trust and health literacy be maintained and developed, particularly as services become more personalised, digitally enabled and driven by data sharing?
- **Broader wellbeing and resilience:** What role can science and technology investments play in improving broader health and wellbeing supports, such as mental health and preventative services?



# Manufacturing

Manufacturing is a significant contributor to the Australian economy and can support the other sectors outlined in this report to process raw materials and intermediate inputs further up the production chain and provide more value-added goods and services. In 2019, the sector had a GVA of **\$26.1B** (almost 5.5% of GDP)<sup>38</sup> and employed **890,500 workers**.<sup>39</sup> Manufacturing exports totalled **\$127.1B** that year.<sup>40</sup>

The effects of COVID-19 have renewed interest in the sector, highlighting the importance of trusted local manufacturing in times of supply chain fragility and sudden soaring global demand, evidenced in the required pivot to hand sanitiser and face masks production. A modernised manufacturing sector can generate economic growth opportunities in the medium-term as well as equip the nation to better respond to future crises.



## Trends

Of the megatrends identified in CSIRO's Advanced Manufacturing Roadmap,<sup>41</sup> three trends have been particularly highlighted under the COVID-19 pandemic.



### Agile and bespoke solutions

Advanced additive manufacturing, materials and digital design and controlled processes are enabling the **production of bespoke solutions**. The ability to adapt and pivot production locally to **react to changing supply** needs will become more important, prompting a new look at how to integrate more advanced design and build technologies into the production line.

### Sustainable operations

Resource scarcity, climate change and community expectations are driving a **move to sustainable operations**. This continues to be a high priority for government and industry and with a **renewed interest in local manufacturing**, traceable and sustainable processes and operating models will be critical.

### Data capture and analytics

**Maximising efficiency and connectivity** will remain important during and following the pandemic. The convergence of technologies like sensors, automation, intelligent robotics, embedded electronics and their internet connectivity will drive **optimised operations and trusted supply chains**.

## National advantages



Further, the pandemic has revealed that the manufacturing sector remains strong, with some key national advantages that will enable the sector to recover and develop resilience going forward.

### Quality and standards

Australia has a strong **reputation for quality and safety**. In a time when exported products and services are coming under more intense scrutiny, and there is greater demand for supply chain integrity, Australia can further **leverage this advantage** to sell its trusted premium goods and services to the world.

### Education and research skills

This is a relatively untapped advantage at present, as many of the best graduates choose career pathways outside of manufacturing. The disruption caused by COVID-19 provides an **opportunity for business to co-design programs** for students to gain industry experience and exposure to manufacturing.

### Small and medium enterprises

Being flexible and nimble in an uncertain economic environment is critical. Most Australian manufacturers are small and medium-sized enterprises (SMEs) and are well placed to be **agile and responsive to global demand** changes through the application of innovation.

## Medium-term (6-24 months) recovery

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Maximisation of local manufacturing capabilities</b></p> <p>Local manufacturing is a cross-cutting capability that can be expanded to add value to Australia's growth sectors. Specific examples are detailed in the respective sector sections and include pharmaceutical, and food and beverage manufacturing.</p> <p>Additional examples include developing Australia's aerospace industry which will build local manufacturing jobs across the value chain, including for aircraft components, miniaturised spacecraft, object tracking and earth imaging technologies. Similarly, manufacturing can be used to develop technologies that support the Australian Defence Force which will expand local manufacturing jobs and support sovereignty and self-sufficiency.</p> <p>Current product offerings can also be further enhanced to provide additional services, such as incorporating sensors into mining or medical equipment, increasing the usability and value of the product to the user.</p>	<ul style="list-style-type: none"><li>• Additive manufacturing</li><li>• Sensors and data analytics</li><li>• Robotics and automation</li><li>• Advanced materials manufacturing</li><li>• Absorbent materials manufacturing</li><li>• Advanced prototyping and scale-up capabilities</li></ul>
<p><b>Superior componentry</b></p> <p>The production and integration of advanced materials will be key to the development of new high-value manufacturing sectors. Opportunities include developing specialised components with unconventional and new feedstocks like lightweight materials, carbon fibre, biological materials, pharmaceuticals and the printing of prosthetics, dental and bone implants.</p>	<ul style="list-style-type: none"><li>• Advanced materials manufacturing</li><li>• Additive manufacturing</li><li>• Flow chemistry</li><li>• Absorbent materials manufacturing</li><li>• Catalyst development</li><li>• Advanced prototyping and scale-up capabilities</li></ul>

## Long-term (24+ months) resilience

**Long-term vision:** An *agile* Australian sector that reacts quickly to changing markets to supply *high-value* exports and support future industries. The sector's workforce is informed, experienced and passionate about *closed loop*, *sustainable* manufacturing systems that leverage recycling and green energy.

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Sustainable and agile manufacturing</b></p> <p>Moving toward closed loop systems with re-cycle, re-use and re-manufacturing principles will enable Australia to offer traceable premium green products and reduce reliance on imported critical parts and materials. The ability to use smart and flexible, digitised manufacturing will also allow manufacturers to pivot their production lines to meet supply shortages in the short-term and then revert production once the shortfall has been met.</p>	<ul style="list-style-type: none"><li>• Systems thinking</li><li>• Industrial ecology</li><li>• Robotics and automation</li><li>• Advanced materials manufacturing</li><li>• Catalyst development</li><li>• Hydrogen-driven green steel</li><li>• Additive manufacturing</li><li>• Flow chemistry</li><li>• Blockchain</li></ul>
<p><b>Value-adding downstream processing of minerals</b></p> <p>By adopting advanced processing and refining, Australia can increase the economic value of its minerals prior to their export, producing refined metals, pre-cursor chemicals, alloys and high-end engineered products. This can create high-technology jobs and industries, strengthen supply chain sovereignty and lower the environmental impact of mined resources.</p>	<ul style="list-style-type: none"><li>• Advanced materials manufacturing</li><li>• Additive manufacturing</li><li>• Sensors and data analytics</li><li>• Robotics and automation</li><li>• Advanced metallurgical capabilities</li></ul>

## Questions and considerations going forward

- **Job creation:** With the growing adoption of robotics and automation, how can science and technology be leveraged to create new jobs in manufacturing?
- **A resilient and globally connected sector:** How can Australia balance sovereign capability with smart specialisation and continued participation in global supply chains?



# Mineral resources

The mineral resources sector is one of Australia's key export sectors and a major driver of economic prosperity for the entire country. Australia has the world's largest resources of minerals such as gold, iron ore, lead, uranium, and zinc, and is one of the largest global producers of key resources such as bauxite, iron ore and critical minerals, including lithium and rare earths.<sup>42</sup>

Although the sector has been moderately affected by the pandemic, with reduced global economic growth and disrupted industrial production causing falls in export demand and revenue, the sector continues to operate strongly in Australia through the pandemic with demand expected to rise as global recovery efforts progress.

In 2019, Australia's mining sector accounted for **\$41.4B** in GVA (around 8.7% of GDP)<sup>43</sup> and employed **246,300 workers**.<sup>44</sup> Resource exports for 2019 were valued at almost **\$235.3B**.<sup>45</sup>



## Trends

CSIRO's Mining Equipment and Technology and Services Roadmap<sup>46</sup> identifies several global mining megatrends that will greatly affect the sector. The COVID-19 pandemic has brought additional attention to three of these trends.



### The innovation imperative

COVID-19 has resulted in falling prices for many commodities, with ongoing uncertainty due to global disruption. This, along with rising costs, declining ore grades, and climate change, means the sector requires **creative and innovative solutions** to become more productive and sustainable, with innovation and R&D focused on long-term sectorial growth.<sup>47</sup>

### The era of accountability

The sector is facing **growing expectations** in terms of accountability, corporate citizenship, and achieving a social licence to operate. Sustainability, climate change, and transitioning to renewables are major considerations for mining operations.

### Plugged in and switched on

The pandemic has accelerated the crucial role of **digital connectivity, data analytics, and automation** across the economy. In mining, these technologies are improving safety and environmental outcomes, increasing productivity and driving disruptions across the minerals value chain.

## National advantages

The mineral resources sector continues to operate strongly in Australia despite the pandemic and several key national advantages continue to support its recovery and resilience into the future.



### Natural advantage

The sector has historically benefited from the country's immense **endowment of mineral resources** and **world-leading production** of various resources. While the sector is dependent on world commodity markets, it can leverage science and technology to optimise operations, identify new reserves, utilise currently uneconomic resources and support the value-adding process to resources, particularly in critical minerals.

### Experienced workforce

The mining sector workforce, along with its supporting mining equipment, technology and services workforce, is **highly skilled and experienced**. The sector, in seeking to become more resilient, can leverage its workforce and continually upskill them to develop and adopt the latest technologies.

### Innovative research

Australia has achieved **global excellence and critical mass in mining and metallurgical research**, drawing on world-class facilities and researchers that can drive significant innovation in the sector.

## Medium-term (6-24 months) recovery

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Automation and remote operations</b></p> <p>The sector can achieve greater business continuity and remote working, while also improving safety and productivity, through increased automation, coupled with data analytics. These systems can support integrated planning and remote operation centres, offering greater control over mine sites, as well as form a platform to better leverage orebody knowledge and selective extraction.</p>	<ul style="list-style-type: none"> <li>• AI and machine learning</li> <li>• High-performance computing</li> <li>• Big data analytics</li> <li>• Automation, control systems and algorithms</li> </ul>
<p><b>Orebody knowledge and process control</b></p> <p>Enhanced decision-making, increased yield and throughput, as well as improved environmental and social performance, can be achieved with advanced sensing and characterisation techniques, combined with next generation data, digital modelling and real-time optimisation of operations.</p>	<ul style="list-style-type: none"> <li>• Advanced sensing and mineral characterisation techniques</li> <li>• New data and digital processes for orebody knowledge</li> <li>• Data integration services and platforms</li> </ul>

## Long-term (24+ months) resilience

**Long-term vision:** A sophisticated sector that leverages its global leadership in production and uses *innovative* and *low-impact* techniques and technologies to produce a *stable* and *reliable* supply of *high-quality* resources, support global supply chains and build national economic resilience.

OPPORTUNITIES	SCIENCE AND TECH ENABLERS
<p><b>Exploration technology</b></p> <p>Mineral exploration will be revitalised as the global economy recovers. Australia's national advantage as a major producer of key commodities can be sustained with the application of new technologies to uncover resources and develop new mining provinces. This can also enable new opportunities such as securing a local critical minerals supply (e.g. in lithium, cobalt and rare earth metals) for energy transition and high-tech applications.<sup>48</sup></p>	<ul style="list-style-type: none"> <li>• Advanced drilling equipment</li> <li>• Downhole sensors and field sampling</li> <li>• New geochemical and geophysical exploration targeting techniques</li> <li>• Deep earth imaging and predictive datasets</li> </ul>
<p><b>Selective extraction</b></p> <p>Improved environmental, financial, productivity and safety outcomes can be realised with targeted and localised ore extraction technologies that reject non-valuable material earlier in the process, improving preconcentration, reducing processing costs and eliminating or reducing waste movement.</p>	<ul style="list-style-type: none"> <li>• Advanced sensing and in-situ measurement</li> <li>• In-situ recovery and environmentally benign and selective leaching systems</li> <li>• Precision drilling, cutting and automation</li> <li>• Optimised blasting processes</li> <li>• Advanced sorting</li> </ul>
<p><b>Net zero emissions</b></p> <p>The sector's social licence to operate, as well as the value and quality of its products, can be enhanced with a suite of traceable green solutions, such as renewable energy generation, battery storage and carbon capture. This can reduce environmental impacts while improving productivity and efficiency.</p>	<ul style="list-style-type: none"> <li>• Carbon capture and storage</li> <li>• Renewable energy generation and storage</li> <li>• Use of green hydrogen, ammonia, and waste heat recovery</li> <li>• Electrification, hybrid and renewables across the value chain</li> </ul>

## Questions and considerations going forward

- **An uncertain global climate:** Even with expectations for global economic recovery, what investments could the sector make in the mineral resources value chain to build resilience against future shocks in the commodity markets?
- **Supporting the sector's innovations:** How can policies, infrastructure, and supporting services and industries enable the mineral resources sector to remain innovative and competitive?
- **Growing and training the workforce:** How can the sector ensure that its workforce is able to adapt and take full advantage of emerging technologies and techniques in mineral resources operations?

# 3 Strengthening the foundations for growth

For science and technology to realise the full potential of medium-term recovery and long-term resilience, it is important to focus on a set of **foundations for growth** – that is, mechanisms for unlocking recovery and resilience opportunities throughout the Australian economy.

Through previous and highly applicable work such as the Australian National Outlook 2019,<sup>49</sup> CSIRO, in collaboration with leaders from Australia's business, research and community sectors, has identified five key foundations for growth:

## 1 Targeted science and technology investment and increasing technological adoption

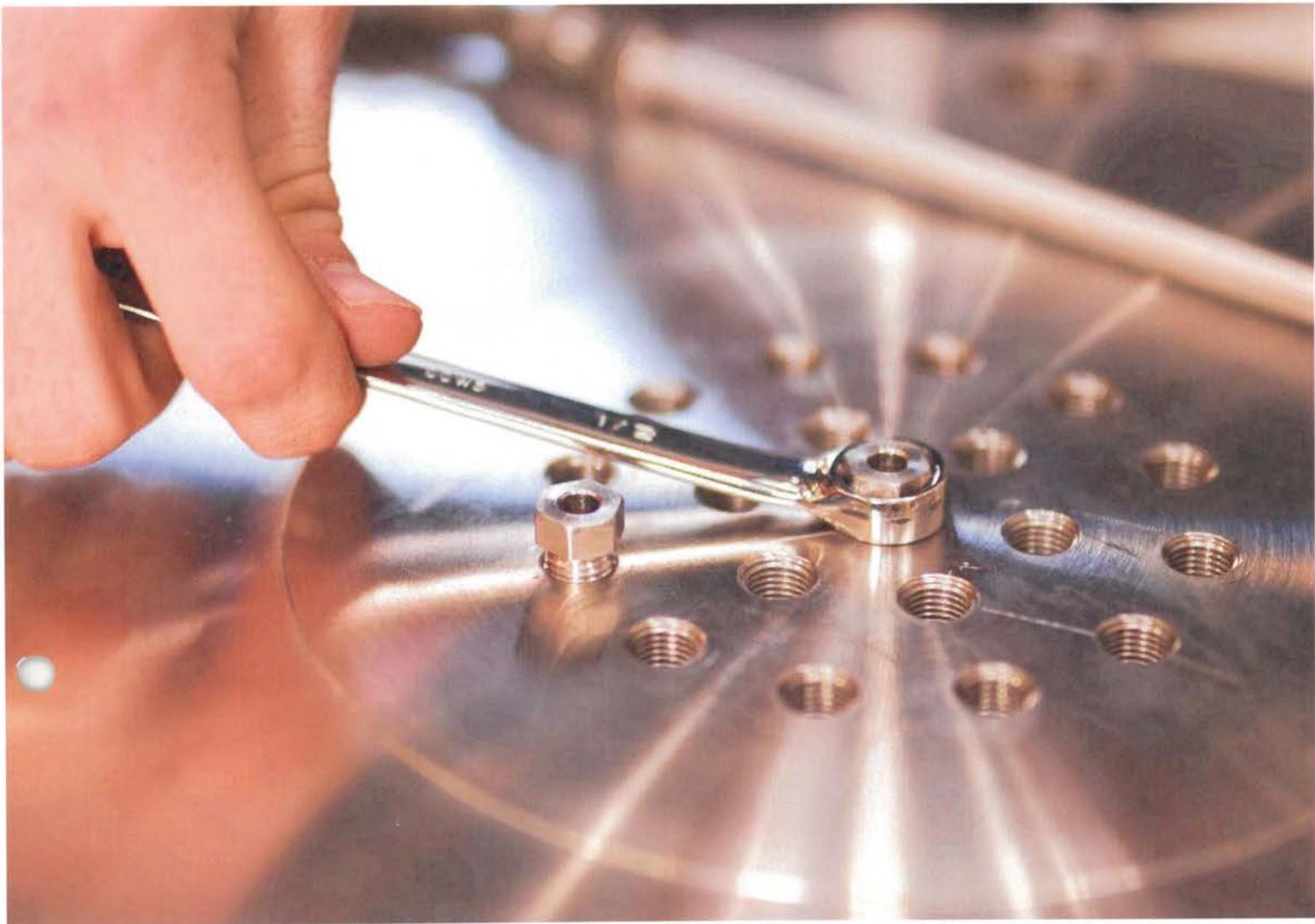
Existing industries can enhance their productivity, jobs and growth if businesses make targeted and evidence-based science and technology investments that leverage national advantages. For example, the Australian National Outlook 2019 reveals that under an 'Outlook Vision' scenario, where Australia achieves its full potential with a technology-enabled workforce and business sector, GDP per capita will be 33-36% higher than under a 'Slow Decline' scenario, with high economy-wide productivity accounting for over half of this increase. Businesses can also accelerate their adoption of new technologies and deepen their participation in global value chains in order to boost their international competitiveness and benefit from world-leading innovations.

## 2 Developing new technology-based, export-facing growth industries

Economic growth can remain strong for Australia if businesses create technology-based, export-facing industries that are highly productive and globally competitive. New and emerging industries, such as hydrogen energy and advanced medtech, can draw on Australia's current natural and human capital strengths, its innovation capabilities and build a strong advantage in global markets and value chains. By working with decision makers across Australia to secure and expand international market access, these industries can play a prominent role in addressing high-impact goals such as net zero emissions, securing critical energy metals and growing trusted agrifood exports.

## 3 Supporting skills and capability development in the workforce

These same technologies that are reshaping existing industries and creating new ones are also changing the skills that will be needed in the workforce of tomorrow. To ensure inclusive economic growth, businesses can invest more in the skills and capabilities of their workforce. This can enable workers to be globally competitive, better prepared for the technology-enabled jobs of the future, and adaptable to future shocks and disruptions. Moreover, businesses themselves can learn how to apply current and emerging technologies, such as new digital technologies and other transformative, cross-cutting scientific and technological capabilities, to enhance and improve their operations, business models and goods and service offerings.

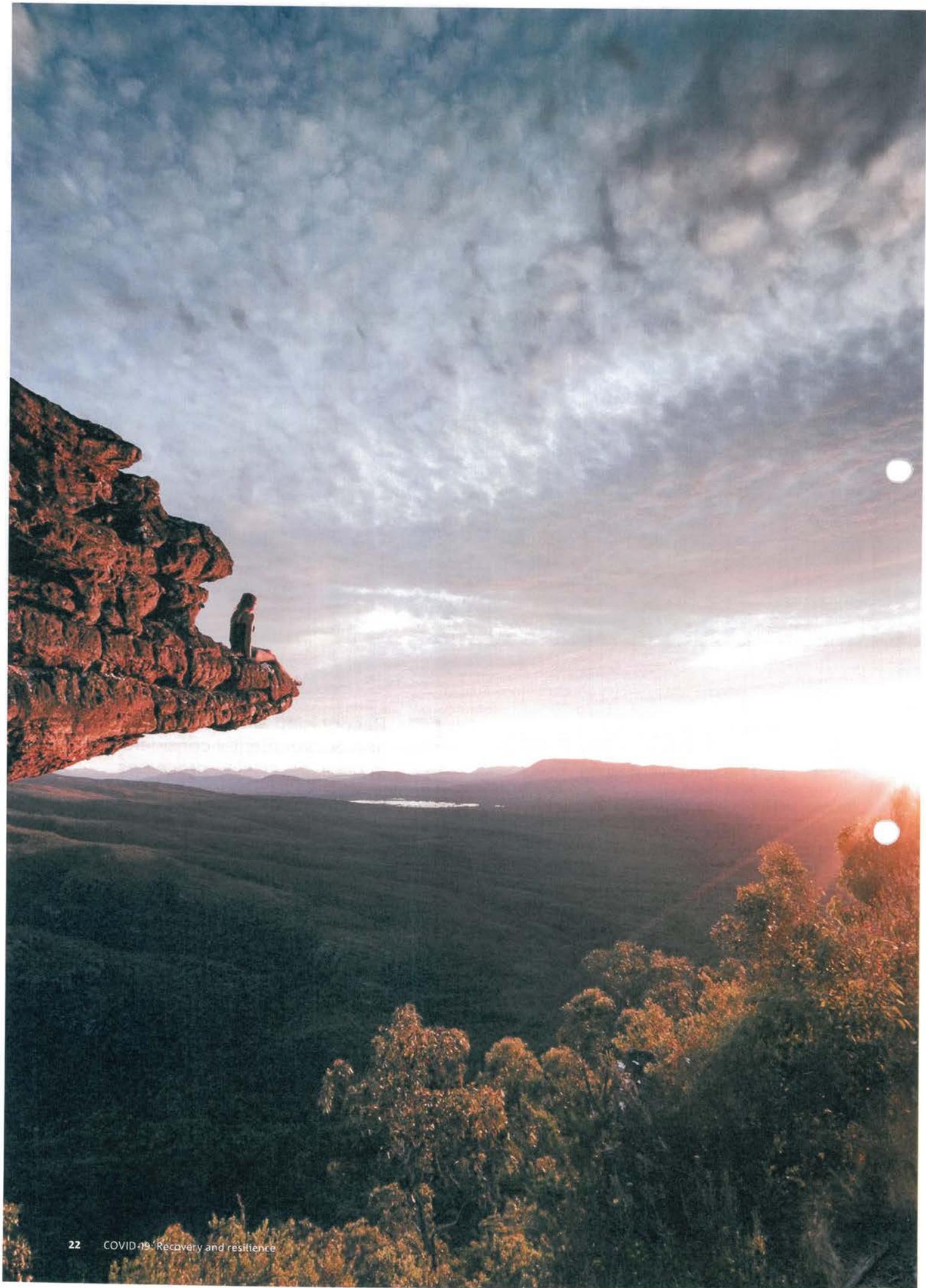


## 4 Supporting an inclusive culture of collaboration and healthy risk-taking

To make ambitious and forward-looking changes across the economy, an inclusive and resilient culture in Australia can be pursued that encourages greater collaboration across sectors and between organisations to understand and respond to global and domestic challenges more effectively. In the immediate response to the pandemic, governments, business and not-for-profit organisations have experienced a surge in collaboration that needs to be continued as the country enters recovery and resilience stages. Collaboration between universities, research organisations and industry can ensure this recovery and resilience is guided by innovation. Furthermore, Australia can benefit from encouraging a healthy culture of risk taking, curiosity and a willingness to learn from failure in all parts of the economy and community. Such a cultural mindset can support greater entrepreneurship, experimentation and innovation.

## 5 Recognising and including social and environmental considerations in decision-making processes

Decision-making processes in government, industry and the community can be broadened to recognise the importance of social and environmental considerations, ensuring that economic development is societally inclusive. Incorporating these considerations can deliver significant commercial value for businesses (such as access to new markets, maintaining social licence and reducing operational risks from increasing environmental, social and governance standards) while building community trust and confidence. For example, this process can embrace sustainable co-development with Indigenous Australia, accelerate and incubate Indigenous knowledge and science, as well as explore innovative economic pathways, ventures and business models for Indigenous knowledge, know-how, practices and values.



# 4 Conclusion

The Australian economy is at a pivotal juncture in its response to the unprecedented COVID-19 pandemic. The imperative for businesses to leverage the full potential of science and technology is now stronger than ever. Beyond the immediate pandemic response, science and technology can play a crucial role in driving Australia through its economic recovery phase, as well as in building its resilience against future shocks.

The groundwork for a successful recovery and a resilient future is already in place. Core sectors of the economy can leverage Australia's national advantages, including its world-class research expertise, high-skilled workforce, rich natural resources, international reputation and strong export focus. These sectors can also identify and effectively respond to major trends and challenges, many of which have been reinforced and accelerated under the pandemic.

By harnessing science and technology enablers, businesses can act now to pursue a suite of value-adding opportunities and realise positive economic impacts over the next 24 months. Through these opportunities, businesses can rapidly adapt to changing conditions, generate new goods and service offerings, achieve significant cost efficiencies and create sustained growth.

Looking beyond the next 24 months, and given the uncertainty in the global outlook, Australian businesses can also adapt and prepare for future shocks, ranging from climate change and health risks to geopolitical and economic challenges. This will require significant expertise and long-term thinking, as well as coordinated effort on the part of both public and private organisations.

This report does not address every question Australia will face on this path to recovery and resilience and does not offer all the solutions. However, this report does aim to motivate strategic discussions and support investment decision-making in the Australian business community.

By leveraging the medium and long-term science and technology-enabled opportunities identified in this report, businesses can support the economy to overcome the challenges of the pandemic and realise long-term prosperity for all Australians.

With the right planning, investments and conversations in the coming months, a resilient, inclusive and innovative future for Australia is fully achievable.

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## Images

Cover: Close up of eye, <https://unsplash.com/@kaleajerielle>

p2: Scientist working in the secure area at CSIRO's Australian Centre for Disease Preparedness, CSIRO

p4: Woman in park enjoying the sunshine, Adobe Stock

p8: Digital – Woman using VR headset, <https://unsplash.com/@jeshoots>

p10: Energy – Wind turbine at CSIRO's Energy Centre, CSIRO

p12: Food and agribusiness – Grapes on vines, <https://unsplash.com/@davidkhlr>

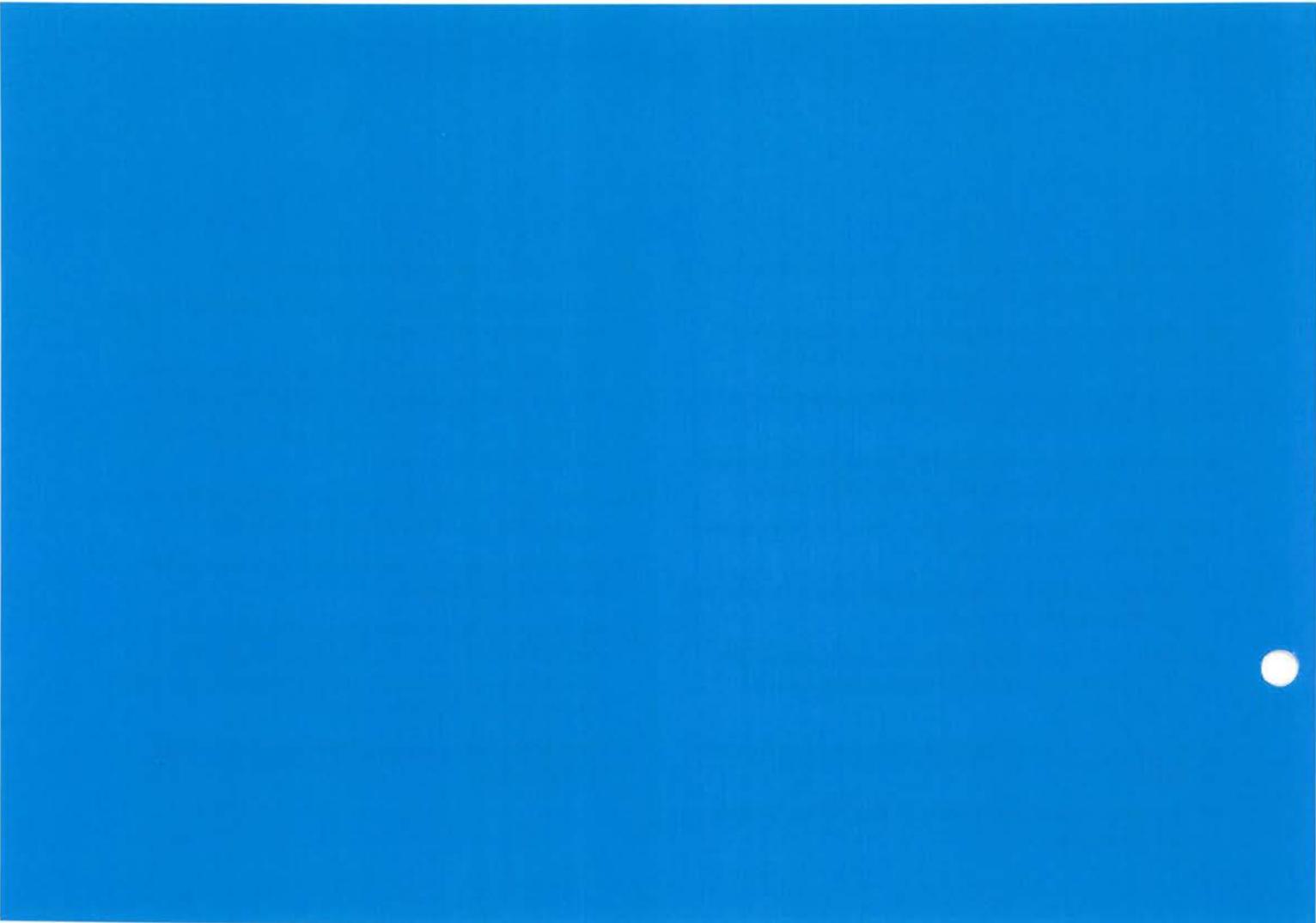
p14: Health – Woman using microscope, <https://www.pexels.com/@edward-jenner>

p16: Manufacturing – Machine cutting metal, [https://unsplash.com/@clayton\\_cardinali](https://unsplash.com/@clayton_cardinali)

p18: Mineral resources – CSIRO's advanced characterisation facility, <https://damiensmithphotography.com.au/>

p21: CSIRO's metal mebrane to produce pure hydrogen, CSIRO

p23: Grampians National park, <https://unsplash.com/@manuelmeurisse>



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