Genetic Engineering

**Key Australian Government Actions**

- **Initiatives**
  - Medical Research Future Fund (MRFF) Priority Mission
  - National Health and Genomics Policy Framework 2018-2021
  - National Manufacturing Strategy – Priority area of Medical Products
  - National Research Infrastructure (NRI) and 2021 NRI Roadmap
  - Agriculture Innovation Policy Statement
  - Various Rural RD&C priority initiatives

- **Regulations**
  - Gene Technology Act 2000
  - Gene Technology Regulations 2001
  - Research Involving Human Embryos Act 2002
  - Defence and Strategic Goods List 2021

**Example Outcomes**

- Pandemic preparedness and response
- Improved individual health
- Improved public health outcomes and medical care
- Better control of invasive species
- Sustainable agriculture through crops and animals that are more disease or stress resistant, or have improved yields
- Discovery of therapeutic targets and novel therapeutics approaches
- Improved food security through crops and animals suited to more variable climates
- Provision of therapeutic and food aid
- Trade and consumer assurance through traceability and authenticity of animals and food

**Underpinning Science**

- ANZ Standard Research Classification Category
  - Agricultural biotechnology
  - Animal production
  - Applied computing
  - Applied ethics
  - Artificial intelligence
  - Biochemistry and cell biology
  - Bioinformatics and computational biology
  - Crop and pasture production
  - Data management and data science
  - Fisheries sciences
  - Forestry sciences
  - Genetics
  - Horticultural production
  - Immunology
  - Industrial biotechnology
  - Machine learning
  - Medical biotechnology
  - Sociology
  - Plant biology
  - Statistics
  - Veterinary sciences

**Example Applications**

- Vaccine development
- Communicable diseases management (e.g. monitoring, tracing and response)
- Mitochondrial donation
- Livestock enhancement for improved productivity or commercial features
- Cell therapies for improved disease treatment (e.g. stem cell treatments)
- Genetic manipulation that introduces or removes genetic traits (e.g. for resistance, yield, performance, etc.)
- Food and animal traceability – authenticity and contamination detection
- CRISPR-Cas9 gene editing

**Key Sectors**

- Health
- Agriculture
- Environment
- Defence & Defence Industry
- Education & Research

**Opportunities and Risks**

Genetic engineering forms the foundation for synthetic biology (the application of engineering principles with genetic components to create new biological products or systems) and has the potential to dramatically improve our agricultural outputs and lead to advances in healthcare and treatment of chronic and debilitating conditions. Challenges remain around establishing appropriate regulatory regimes and the social licence for gene modification, social acceptance of sharing of genetic information, and adequate data infrastructure and governance.

The history of public interactions with genetically modified organisms shows there is a real risk of having insufficient social licence and acceptance of genetic modification, resulting in poor uptake, a lack of return on investment and overall lost opportunities.

For genetically engineered crops and animals there is uncertainty around how to adequately assess and manage unexpected downstream ramifications of, for example, longer-lived plants or animals, or those with slower reproductive cycles, or the impact of engineered crops in the natural. There is also potential for the misuse and diversion of genetic engineering and associated technologies to create biological threats, such as untreatable bacteria and viruses.

Whilst genetic engineering has the potential to overcome diseases and debilitating conditions, there is also the potential to use this technology to introduce desirable traits and create “designer babies”. Australia, in collaboration with the United Kingdom, has been instrumental in developing the Ethical Principles for Human Augmentation Technologies, which are intended to establish a set of principles for best practice design, development genetic engineering technologies.

Many of the risks associated with genetic engineering can be overcome through ongoing social engagement between researchers, industry, government and the public, and by ensuring robust standards and regulatory frameworks that promote access, WHA recognising and managing the associated risks.

**Australia’s place in the world**

Whilst the research landscape is dominated by the USA and China, Australia is ranked 11th for research impact, led by the University of Melbourne. China has significantly more patents in the area, with almost double that of the United States.

The United States dominates venture capital (VC) investment in this area, dwarfing VC investment of the other top 5 countries: China, the Netherlands, Denmark and Japan. Australia is unrated for VC investment.

Australia has well-established research and development capability in genetic engineering. The CSIRO has led development of genetically modified cotton, which accounts for nearly all the cotton varieties in Australia, contributing to a $1.5 billion p.a. export market.

Australia has also developed several world first vaccines using genetic engineering, including the human papilloma virus (HPV) vaccine, Gardasil, and the Hendra vaccine for horses. Australian research involving genetic engineering and modification contributed to the development of COVID19 vaccines.

**Estimated impact on national interest**

<table>
<thead>
<tr>
<th>Economic Prosperity</th>
<th>National Security</th>
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<tbody>
<tr>
<td>Low</td>
<td>X</td>
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<td>Med</td>
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<tr>
<td>High</td>
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</table>
Australia is ranked 11th for research impact internationally, which is led by the United States. Total volume of published research has increased at around 3% p.a. over the 5 year period 2016–2020, with 26% of research involving international collaboration.

Australia is unranked venture capital (VC) investment for genetic engineering, which is dominated by the United States. Since 2016, investment has increased about 62% p.a.

The number of patents filed annually in this field has increased by 7% from 2015 to 2019. Most patents for this technology were filed by Chinese applicants or inventors, almost double that of the United States. Australia ranks 13th.

The research impact provides an indication of the productivity of a country or institution. Here, productivity was assumed to be represented by the volume of publications (i.e. scholarly output) as an indicator of the resources & facilities, and the level of interest in the publications as an indicator of quality.

Research Institutions – International

The United States has 8 of the top 10 international institutions, with China and France filling the remaining positions.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Top International Institution</th>
<th>Research Impact</th>
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<tbody>
<tr>
<td>1</td>
<td>Harvard University</td>
<td>United States</td>
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<tr>
<td>2</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>3</td>
<td>Chinese Academy of Sciences</td>
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<td>4</td>
<td>Howard Hughes Medical Institute</td>
<td>United States</td>
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<tr>
<td>5</td>
<td>Broad Institute</td>
<td>United States</td>
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<td>6</td>
<td>University of California at Berkeley</td>
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<td>National Institutes of Health</td>
<td>United States</td>
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<td>8</td>
<td>Stanford University</td>
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<tr>
<td>9</td>
<td>French National Centre for Scientific Research (CNRS)</td>
<td>France</td>
</tr>
<tr>
<td>10</td>
<td>University of Pennsylvania</td>
<td>United States</td>
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Research Institutions – Australia

Within Australia, the University of Melbourne leads for research impact, ahead of the University of Queensland. There are no Australian institutes in the top 50 international institutions.

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<tr>
<th>Rank</th>
<th>Top Australian Institution</th>
<th>Research Impact</th>
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<tbody>
<tr>
<td>1</td>
<td>University of Melbourne</td>
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<td>8</td>
<td>University of New South Wales</td>
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<tr>
<td>9</td>
<td>Queensland University of Technology</td>
<td>455</td>
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<tr>
<td>10</td>
<td>Australian National University</td>
<td>342</td>
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Patents – International

The Council of the Queensland Institute of Medical Research | 22
Queensland University | 17
University of Sydney | 17
New South Innovations | 12