BIOTECH NEW ZEALAND

AOTEAROA NEW ZEALAND BOOSTED BY BIOTECH
Innovating for a Sustainable Future

An analysis of the state of biotechnology in New Zealand and its impact and benefits for the economy and society.

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Biotechnology in New Zealand 2020

New Zealand's thriving biotech sector includes companies working on products and technologies to help improve our lives and our planet, plus supporting services. The biotech sector is highly innovative, research and development intensive and is constantly evolving with new companies. This map will be regularly updated, so please contact us with your suggested additions: info@biotechnz.org.nz

MARINE BIOTECH

Seperex Nutritionals, AgriSea New Zealand Ltd, Pacific Harvest, Tahi NZ Grown Spirulina, Seadragon, Sanford

AGRICULTURE BIOTECH

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HUMAN HEALTH BIOTECH

ENVIRONMENTAL + INDUSTRIAL BIOTECH

RESEARCH + EDUCATION

Produced by:

BIOTECH NEW ZEALAND

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The many biotech practitioners, CEOs, MPs, Government agencies, researchers, business people and investors that we spoke to for this report.

BIOTECH NEW ZEALAND

About BioTech New Zealand

BioTech New Zealand's (BioTechNZ) vision is to create a healthy, clean and prosperous New Zealand, boosted by biotechnology.

We are a purpose driven, membership-funded organisation. Biotechnology is a platform technology, therefore our members are diverse, with research and development at the heart of their business. They have the desire to collaborate to maximise the ways biotechnology can help address many of the world's agricultural, environmental and health problems.

BioTechNZ is a neutral centre of gravity for biotechnology discussion, debate, policy development and collaboration in New Zealand. We also help raise awareness and increase understanding of biotechnology to enable our nation to embrace the best opportunities biotechnology offers to us daily, helping us live better, healthier and more productive lives.

We are aware the global challenges will not be solved by a single technology and will require collaboration to ensure greater sustainability and climate compatibility.

We take a practical, but informative and evidence-based approach, drawing on the active contributions from our members. Collectively, we focus on both harnessing the opportunities and addressing the issues.

BioTechNZ (previously NZBIO) joined the New Zealand Tech Alliance in July 2018.

Member of the:

TECH ALLIANCE

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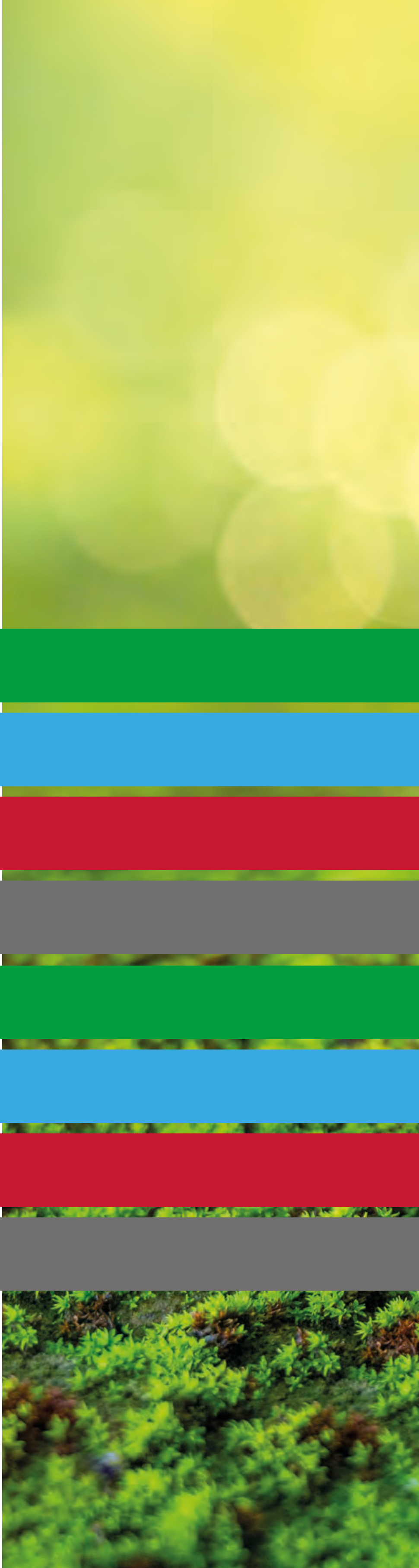


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Introduction: BioTech New Zealand

When BioTechNZ began this report, the world was pre-COVID. At the time, the media featured the demands of increasing global population, the impact of industrialisation and urbanisation on the environment. This included air pollution, water pollution, climate change, global warming, depletion of ground water level, change of biodiversity and ecosystem.

On 22 April 2020, the 50th anniversary of Earth Day, was unlike any other. With COVID-19 causing public health lockdowns around the world, the news showed empty streets, no cars, closed shops and people keeping their distance. Subsequently, the skies were clearing of pollution and wildlife was returning to newly clear waters. A few months ago, environmentalists could only dream of this scenario on the 50th anniversary of Earth Day.

The coronavirus pandemic has displayed a contrasting consequence. It has created a positive impact on the environment, however it has also executed worldwide destruction on human lives.

Due to our relative isolation, New Zealand has experienced a different journey to the rest of the world. However, we are still faced with the same issues as the rest of the world, including keeping New Zealander's safe while moving towards a more sustainable and carbon neutral economy.

For years, the demands of an increasing population, industrialisation and urbanisation have mounted and we are now in crisis. It's time for change, accountability and innovative solutions. Let's learn from this period of disruption and encourage entrepreneurs and innovators to work alongside Government to create the future we want.

MANYA SABHERWAL
Chair
BioTechNZ

BIOTECH NEW ZEALAND

We can use this experience to maximise the opportunity of new ways of working, consuming, travelling and living sustainably. There has never been a more important time to elevate the science of making our world more resilient by sustainably transforming the food system, protecting our environment, and facilitating breakthroughs in health, green energy and biobased manufacturing.

As this research report demonstrates, New Zealand's growing biotechnology sector can make a difference by helping us live better, healthier and more productive lives.

FOREWORD
New Zealand Government

The potential of the New Zealand biotechnology industry is enormous. To truly become a leader in this area, we need to identify and unlock that potential.

KAREN ADAIR
Deputy Director-General Agriculture & Investment Services, Ministry for Primary Industries

New Zealand is recognised globally for our innovation potential in biotech. Scientific American Worldview scored New Zealand's potential as fourth in the world behind the US, Singapore, and Denmark in a range of categories such as IP protection, enterprise support, and policy stability. With the global biotechnology market expected to reach NZD 1.1 trillion by 2025, it makes sense that we explore all possible opportunities.

The Ministry for Primary Industries (MPI) chose to support this report through our Sustainable Food & Fibre Futures fund because we recognised that a review of the biotech sector was well overdue. The last time a similar report was undertaken was in 2008. For a sector that is changing constantly, it's essential we keep pace with the latest developments.

The report looks at the current state of play, identifies future challenges and promising solutions, and surveys what's happening internationally.

In almost all instances, future promising biotech opportunities will deliver high value – this is very much in line with MPI's overall strategy of moving our industries from volume to value. As well as shifting food products into higher value products, biotech has the potential to solve some of our major environmental and health challenges, and address food safety and biosecurity issues. Tapping into this area will open new and diversified revenue streams for farmers, which will lead to more resilient and prosperous rural communities.

We all want to see a healthier, cleaner, and more prosperous New Zealand. This report is an important contribution to the conversation about how we can collectively achieve that.

FOREWORD
AbbVie

"We don't do this because it's easy, we do it because it's hard."

This is the answer given by AbbVie's global CEO, Rick Gonzalez whenever he is asked why we invest in so much primary research for hard to treat diseases, when the risk is so high? Why not just invest when the hard work is done?

Finding treatments for the most serious diseases presents a challenge like no other and while this has always been the case, in the last half century, organisations in both the public and private sector had a tendency to want to go it alone. Well perhaps until now. Finding vaccines, treatments and tests to combat the COVID-19 predicament requires collaboration we haven't witnessed before. To advance medicine at the rate the human race needs, this must continue, because this pandemic is just the tip of the iceberg.

Biotechnology is at the heart of any research and development business and AbbVie is no different. Our discovery research is fundamental to driving the science that will advance our pipeline. Our deep knowledge of basic biology and novel technologies enables us to identify molecules and advance programs with high potential for success. AbbVie invested more than $5 billion in research and development in 2019, which is more than an 80 percent increase since our inception as a company less than a decade ago.

We also bring people together because we know that collaboration is the key to breaking barriers and exploring new frontiers in science. This emphasis on collaboration is an important part of our approach to research and development (R&D). We always look for opportunities to work with external partners who share our goals of addressing serious health issues.

We are building on the latest discoveries in genetics and genomics to develop medicines that are more precisely targeted to the disease and the patient. We focus on discovering, developing and delivering medicines where we have proven expertise and can make an impact.

ANDREW TOMPKIN
General Manager,
AbbVie Limited

Our key areas of focus are immunology, oncology, neuroscience, eye care, virology, women's health and Allergan Aesthetics.

In addition to these key therapeutic areas, we are applying our scientific expertise to discover and develop medicines in other areas where patients still have limited treatment options. For example, acute migraine, ulcerative colitis, overactive bladder, irritable bowel syndrome and cystic fibrosis. Our scientists also dedicate their time, knowledge and talents to addressing neglected diseases such as malaria, onchocerciasis (river blindness) and lymphatic filariasis (elephantiasis).

We understand that tackling the toughest health care challenges requires a dynamic and collaborative approach, both among our own scientists and with partners who share our goals. AbbVie collaborates with hundreds of biotech companies, universities, non-profit and government organisations to advance science every year.

Only with a strong, capable biotech sector can we continue to develop new treatments to tackle the world's most challenging issues and difficult diseases.

Executive Summary

Global megatrends including climate change, overuse of natural resources, water shortages, increasing dependence on fossil fuels, population growth and related healthcare needs are impacting the entire world. These trends are dramatically impacting all economies, driving demand for technologies, including biotechnology, to help mitigate these challenges. Biotechnology specifically, has been identified as critical in finding innovative solutions to some of these global challenges.

Biotechnology is defined as harnessing cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet.

For thousands of years, humans have manipulated biological processes to make beer, bread, cheese and preserve dairy products. Traditional biotechnology includes activities such as selective breeding of plants and animals for desired traits. Meanwhile, the era of modern biotechnology began with the discovery of deoxyribonucleic acid (DNA) in the 1950's.

As the pace of population growth and climate change has accelerated, biotechnology has been identified as a critical technology. Its wide application illustrates how a country's success may largely depend on the national capabilities in mastering production and innovation in these crucial areas.

The growing global demand for biotechnology has led to the development of a global market that is expected to be worth US$729 billion by 2025. New Zealand is positioned well in the world, ranking fourth for innovation potential in biotechnology.

Currently, our vibrant biotech sector is small but growing, including 211 companies and $2.7 billion revenues. Nearly half of the sector, 45 percent, is based in regional New Zealand.

As shown throughout this report, there is increasing global demand across the biotechnology spectrum for solutions to health, agri-food and environmental challenges. This is presenting New Zealand with multiple economic opportunities. For example, bark biorefinery could add $1.8 billion to GDP and clinical trials could create an additional $880 million in GDP. Added to this, is the role that biotechnology

plays in enabling and growing New Zealand's critical bioeconomy, worth $49.4 billion. In addressing these challenges, it is clear how important a thriving biotechnology sector is for our future.

In **Part One: The Biotech Landscape**, we introduce biotechnology concepts and examine definitions. The growing importance of biotechnology is explored, followed by the examination of New Zealand's biotechnology landscape. Part One also includes the results of the 2020 New Zealand Biotechnology Sector Survey and an analysis of the economics of the sector.

In **Part Two: Biotechnology Opportunities for New Zealand**, the economic opportunities are analysed in detail. This includes opportunities for gaining more value from the agriculture sector, improving health and wellness, and facilitating a low-emission future.

In **Part Three: Boosting New Zealand with Biotechnology**, the opportunities and challenges are further investigated, with accompanying recommendations.

The following recommendations are made with a view to collaboration between the biotechnology sector and the Government. Our forthcoming recommendations, include the creation of a coordinated national biotechnology strategy, increasing the visibility of biotechnology in New Zealand, new approaches to support commercialisation, increasing public awareness of genetics, talent attraction and fostering connections between Māori and biotechnology, to increase opportunities for Māori science and innovation.

Our research has identified a number of barriers that need to be overcome to enable the growth of the New Zealand biotechnology market. These constraints include access to capital, access to skills and talent. The current regulatory framework governing genetic modified organisms (GMO) is also a major barrier to growth for the New Zealand biotechnology sector.

BioTechNZ plans to continue working closely with the Government to ensure New Zealand is boosted by biotechnology and innovates for a sustainable future.

Summary Recommendations

The Aotearoa New Zealand Boosted by Biotechnology study has reinforced the critical role that biotechnology has to play in the economic, environmental and health outcomes of New Zealand.

To best enable the biotechnology sector to reach its potential and maximise its positive impact for New Zealand the following recommendations have been developed, based on research insights.

The full recommendations page 61.

1

Create a Coordinated New Zealand Biotechnology Strategy

1.1 Create a national biotechnology strategy as a framework that aligns and connects policy and investment across bioeconomy, environmental policy and health.

1.2 Develop a high level bioeconomy plan for New Zealand.

1.3 Re-introduce measurement of the biotechnology sector.

2

Increase the Visibility of Biotechnology in New Zealand

2.1 Identify, track and profile biotechnology organisations via an annual study of New Zealand's most successful biotechnology companies and organisations.

2.2 Showcase New Zealand biotechnology to the public and the world through a coordinated campaign to tell New Zealand's biotech story.

3

Establish New Approaches to Support Commercialisation and Scale-up

3.1 Better expose intellectual property (IP) developed by Crown Research Institutes and universities.

3.2 Invest in a bio-pilot plant to provide shared, open facilities to help entrepreneurs technically derisk, prove at scale and interest investors.

3.3 Develop a specialist biotech fund to attract international biotech investors that are used to larger, longer term investments associated with biotechnology.

4

Drive Change in New Zealand's Approach to Genetics

4.1 Increase public discussion and understanding of genetic modification and its various methods, their safety and practical application.

4.2 Undertake review of regulations relating to biotechnology and genetics.

5

Explore Indigenous and Diverse Knowledge to Unlock the Potential to Contribute to Economic Growth

5.1 Foster connections between Māori, Government, industry and the science system to create sustainable outcomes for our people, land and sea.

5.2 Improve access for diverse communities to business skills programmes to help biotechnology entrepreneurs build their startup's.

Key Highlights

Growing global demand for biotechnology

Global market worth
US$729b
by 2025, Global Market Insights

New Zealand positioned well

Ranked 4th
in the world for innovation potential in biotechnology.

New Zealand has a small, but growing and vibrant biotech sector

211	**$2.7b**	**45%**
Companies	*Revenues*	*Based regionally*

Biotechnology underpins New Zealand

$49.4b
Bioeconomy

Plenty of local opportunities from biotech

Bark Biorefinery could add:
$1.8b to GDP

Human Clinical Trials could add **$880m** *to GDP*

Growth constrained by:

Capital access | GMO regulations | Access to skills

Part One:

The Biotech Landscape

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What is Biotechnology?

There is global interest in biotechnology as a means of altering biological processes to improve human health, food production and environmental sustainability.

There are many definitions for biotechnology spanning traditional to modern biotechnology. At its simplest is the definition used by the world's largest biotechnology trade association, Biotechnology Innovation Organization (BIO). BIO define biotechnology as technology based on biology that harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet.[1]

The Organisation for Economic Co-operation and Development (OECD) also apply a broad definition of biotechnology as the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.[2]

For the purpose of this study, we apply a similar definition where biotechnology is the application of science or technology to living organisms to alter biological processes to produce new products or knowledge.

BIOTECHNOLOGY IS THE APPLICATION OF SCIENCE OR TECHNOLOGY TO LIVING ORGANISMS TO ALTER BIOLOGICAL PROCESSES TO PRODUCE NEW PRODUCTS OR KNOWLEDGE.

Traditional vs Modern Biotechnology

Humans have manipulated biological processes since the dawn of time. Traditional biotechnology encapsulates activities such as selective breeding of plants and animals for desired traits, brewing beer, cheese production and the development of penicillin.

The era of modern biotechnology began with the discovery of deoxyribonucleic acid (DNA) in the 1950's. Modern biotechnology refers to techniques for the manipulation of genetic material and the fusion of cells beyond normal breeding barriers.

For example, genetically engineered bacteria create insulin to treat diabetes, and larger, more complex proteins like hormones or antibodies can be made in mammalian cells. Currently, new gene therapies are being used to target cancer and treat diseases like Parkinson's disease and cystic fibrosis. Other new tools include CRISPR–Cas associated nucleases, that enables the modification of specific genes within an organism's genetic material with greater precision and with fewer unintended changes elsewhere in the genome. These new technologies enable modifications to individuals, for example CAR T-cell therapy, which helps the immune system target and remove harmful substances in the body, including cancer. Modern biotechnology also includes selective breeding in plants and animals for particular traits through DNA profiling, to produce plants resistant to insects, livestock with better meat or wool quality, or microorganisms that can clean up pollution in soil, air or water.

1 https://www.bio.org/what-biotechnology

2 Second OECD Ad Hoc Meeting on Biotechnology Statistics, OECD, May 2001.

Classification of Biotechnology

Biotechnology is a broad technology, often referred to as a technology platform, rather than a sector. This has led to the use of a colour coded common classification terminology to describe various types of biotechnology, by sectors.

RED

BIOTECHNOLOGY (BIOPHARMA)

This includes producing vaccines and antibiotics, developing new drugs, molecular diagnostics techniques, regenerative therapies and the development of genetic engineering to cure diseases through genetic manipulation, in both medicine and veterinary. In this report we have included human clinical trials companies, as they are an essential part of the product development cycle.

GREEN

BIOTECHNOLOGY (AGRIBIO)

Selective breeding, genetic engineering, molecular markers, molecular diagnostics, vaccines, and tissue culture, to alter living organisms, or parts of organisms, to improve plants or microorganisms for specific agricultural uses. Green biotechnology also includes producing biofertilisers, biopesticides and designing of transgenic plants that grow in the presence or absence of some chemicals. Also, the creation of crops with desirable characteristics in terms of flavour, enhanced micronutrients, colour of flowers, growth rate and size of harvested products.

GREY / WHITE

BIOTECHNOLOGY (INDUSTRIAL) / (ENVIRONMENTAL)

The industrial and environmental sector are usually paired together because industrial processes, which often create pollution, directly affect the environment. It includes the application of life science tools to develop green or environmentally friendly solutions by harnessing the ability of microbes and enzymes. It also includes traditional manufacturing and chemical processes to produce biobased or harmless by-products, more sustainable products and materials.

BLUE

BIOTECHNOLOGY (MARINE)

Blue Biotechnology is based on the exploitation of marine resources to create products and applications of industrial and health interest. Due to the diverse and extreme environment, there are novel bioactives, enzymes and marine derived molecules which can be used in many industries to make biopolymers, biomaterials, in food, cosmetics and health.

A History of Biotechnology

Humans begin choosing or altering plants and animals, so they can be domesticated.

Potatoes are the first cultivated crop.

8000BC

Egyptians and Sumerians learn brewing, cheese making and winemaking.

2000BC

Mouldy soybeans become the first antibiotic to treat infections in China.

500BC

Microscope is invented.

1500s

English scientist, Robert Hooke, discovers the existence of the cell.

Bacteria is discovered.

1600s

English physician, Edward Jenner, discovers the process of vaccination and develops smallpox vaccine.

1700s

First enzyme discovered and isolated. French biologist, Louis Pasteur, develops pasteurization by applying heat to kill microbes in food.

Austrian scientist, Gregor Mendel spends seven years cultivating and testing pea plants and discovers hereditary traits.

1800s

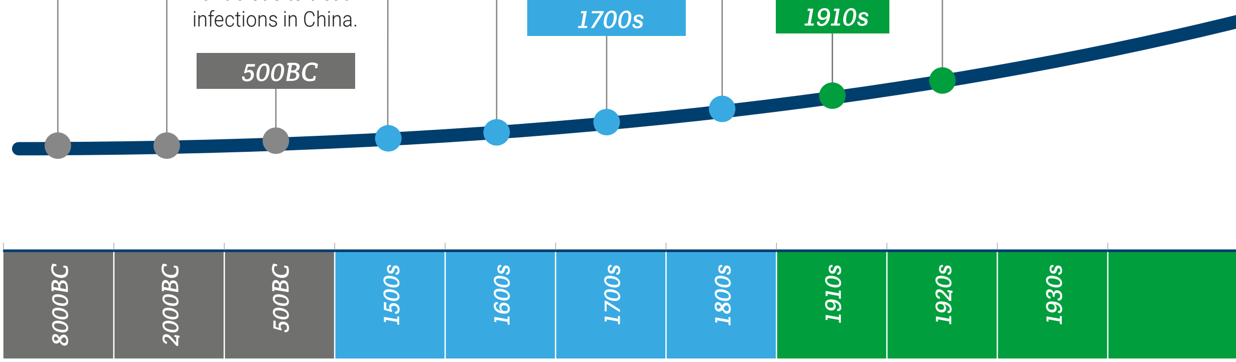
The word biotechnology is used in print for the first time.

Insulin is discovered.

1910s

Scottish physician, Sir Alexander Fleming discovers penicillin as an antibiotic.

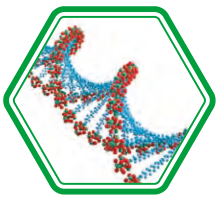
1920s



1940s

The term genetic engineering is introduced and Deoxyribonucleic acid (DNA) is isolated.

1950s



Watson and Crick describe the double helix structure of DNA.

1960s

Ribonucleic acid (RNA) is discovered.

1970s

Enzymes that can cut DNA are discovered and this signals the birth of modern biotechnology.

The New Zealand Government places a moratorium on genetically modified organism (GMO) field releases.

The Advisory Committee on Novel Genetic Techniques (ACNGT) was established to oversee contained laboratory genetic manipulation work.

1980s

The first recombinant DNA vaccine is produced.
The first genetically engineered plants are grown.

The first description of what is later known as CRISPR (clustered regularly interspaced short palindromic repeats) appears.

The first chimeric antigen receptor t-cells (CAR-T cells) are developed.

In New Zealand, recombinant technologies begin to be applied in laboratories, largely for biological and medical research purposes.

1990s

The Human Genome Project is launched – an international research effort to determine the DNA sequence of the entire human genome.

Dolly the sheep is created in Scotland. She is the first mammal cloned from an adult somatic cell.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) adopts the Universal Declaration on the Human Genome.

Zespri begins cultivating a new variety of kiwifruit developed through a natural breeding programme in partnership with New Zealand Plant and Food.

2000s

The first human genome is sequenced at a cost of US$3 billion.

A vaccine for human papillomavirus (HPV) created and is used in 80 countries.

A nanoscale microchip is developed to detect for chemical markers.

A vaccine for influenza A virus subtype H1N1 bird flu is grown in tobacco leaves.

2010s

The first fully synthetic, self-replicating bacteria cells is produced and used to produce alternative fuels.

Vaccines are trialled for malaria parasite and Human Immunodeficiency Virus (HIV) virus.

The first bionic/artificial human eye is created and helps the blind recover partial sight.

The Nobel Prize is awarded for development of invitro fertilisation (IVF).

2018

AgResearch creates a new generation drought resistant ryegrass and runs field trials in The United States of America.

Chinese scientist claims to have used CRISPR gene-editing technology to alter the genetic code of two human babies.

1940s | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2018

Growing Global Importance of Biotechnology

As the pace of population growth and climate change has accelerated, biotechnology has been identified as a critical technology. Its wide application illustrates how a country's success may depend to a large extent on the national capabilities in mastering production and innovation in these crucial areas.[3]

GLOBAL BIOTECHNOLOGY MARKET WORTH

US $729 billion

BY 2025

Increased Global Focus on the Bioeconomy

Many countries have adopted the term 'biobased economy' (bioeconomy) to describe the value chain of sustainable manufacturing using knowledge-based production and use of natural/biological resources, together with biological processes and laws, that allow providing economy goods and services in an environmentally-friendly way. The promotion of a bioeconomy is on the political agenda of more than 50 countries, including the creation of visions, strategies and action plans.[4] Being able to measure, monitor and report on the outcomes of bioeconomy strategies is seen as critical for long term success.

The European Commission defines the bioeconomy as the production of renewable biological resources from land and sea, the conversion of crops, forest, fish, animals, microorganisms and waste streams into value added products (including food, feed, materials, biobased products and bioenergy). The European Commission calculated the European bioeconomy generated 11 percent of GDP in 2015 and approximately €1.4 trillion in value add.[5] Its bioeconomy is creating new markets for agricultural crops, crop residues and waste streams as well as opportunities for innovation in producing consumer goods.

In the United States of America (USA), The White House's National Bioeconomy Blueprint also identifies a bioeconomy touching all parts of the economy, including new drugs and diagnostics for improved human health, higher yielding food crops, emerging biofuels (to reduce dependence on oil) and biobased chemical intermediates.[6]

Global Mega Trends Driving Biotechnology Growth

The world is currently facing unprecedented global challenges with the world's population predicted to grow to 9.7 billion people by 2050.[7] This population growth is stimulating global megatrends including climate change, water shortages, loss of biodiversity, overuse of natural resources, increasing dependence on fossil fuels, an ageing population, and greater expectations of healthcare and health systems. These global trends are dramatically impacting all economies and this is driving demand for technologies, including biotechnology, to help mitigate these challenges. According to research company Global Market Insights, Inc the global biotechnology market could be worth US$729 billion by 2025, up from US$417 billion in 2018.

FEEDING THE WORLD

Increasing demand for food, shortages of natural resources and water and environmental concerns have been driving the growth of biotechnology in agriculture. To date, the success of our agriculture, horticulture, aquaculture and forestry industries has been helped by our ability to identify, select and breed desirable traits into commercial species.

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3 Cimoli, M. et al. Institutions and Policies Shaping Industrial Development: An Introductory Note. In Industrial Policy and Development: The Political Economy of Capabilities Accumulation, 2009.

4 Birner R. Bioeconomy Concepts. In: Bioeconomy. 2018 Springer, Cham.

5 Kuosmanen, T et al. How big is the bioeconomy? EUR 30167 EN, Publications Office of the European Union, Luxembourg, 2020.

6 National Bioeconomy Blueprint Released, The Whitehouse, United States of America, 2012.

7 The World Population Prospects 2019: Highlights, UN Department of Economic and Social Affairs, 2019.

Agricultural biotechnology is beginning to see increased application as genetic engineering, molecular markers, molecular diagnostics and vaccines are increasingly used to create advanced bioagriculture products. Biotechnology crops have genes modified to improve yields, to improve the quality of the product, or to improve resistance to pests to reduce pesticide use.

According to global agri-bio monitoring organisation, The International Service for the Acquisition of Agri-biotech Applications (ISAAA), 1.9 million new hectares of biotechnology modified crops were planted in 2018, across 26 countries, by over 17 million farmers. A total of 5.7 billion acres have been planted with crops modified by biotechnology since the first commercial plantings.[8] Farmers in the USA were particularly rapid at adopting genetically engineered crops. By 2012, 88 percent of the corn, 94 percent of the cotton, and 93 percent of the soybeans planted there were varieties produced through genetic engineering.[9]

The continuous growth in the adoption of genetically modified biotech crops is attributed to the technology being beneficial to both economy and environment. However, globally there are still safety concerns which has had an impact on regulations and approvals.

PROTECTING THE ENVIRONMENT

Increasing pressure on the environment and the threat of global warming has driven a 20-fold increase in the number of global climate change laws since 1997.[10] There are now more than 1,200 relevant policies across the 164 countries which account for 95 percent of global greenhouse gas emissions. Processes to treat waste, before or after it has been introduced to the environment, are of growing interest to advanced economies, as they manage the impact of waste and emissions.

Applications of biotechnology in environmental protection can play a big role in adopting a sustainable development pathway in developing products and processes that generate less waste, use less non-renewable resources and consume less energy. Also, the use of bioenzymes in pollution management, developing chemical-free biopesticides, and biofertilsers to reduce reliance on agrochemicals, while exploring the use of gene-editing as a conservation tool gives a new dimension to the efforts of environment protection.

8 Global Status of Commercialized Biotech/GM Crops: 2018. ISAAA Brief No. 54. ISAAA.

9 Farmer Adoption of Agricultural Biotechnology-Derived Crops, U.S. Department of Agriculture, 2020.

10 Global trends in climate change legislation and litigation, 2017 Update, Grantham Research Institute on Climate Change, 2017.

ENHANCING HUMAN HEALTH

Ageing populations, poor diets and greater expectations of healthcare are common traits in almost all advanced economies. Inequities, especially for indigenous communities, leads to a lack of political, social and economic power. Greater involvement from these communities in the development of solutions will help create significant long term benefits for New Zealand.

The increasing number of chronic and rare diseases across the globe is anticipated to fuel the international red biotechnology market. This demand is boosting the investment in biopharmacy, which is now the largest application of biotechnology accounting for 50 percent of the global market in 2018.[11]

Polarised Perspective Inhibiting Full Benefits

As biotechnology evolves, ethical discussion relating to genetic modification, is migrating from the scientific community into wider society.

Unfortunately, the global food challenge debate has polarised conventional agriculture and global commerce against local food systems and organic farms. Those who favour conventional agriculture, discuss how modern gene technology, irrigation, fertilisers and improved genetics can increase yields to help meet demand. Meanwhile, proponents of local and organic farms counter that small farmers could increase yields by adopting techniques to improve fertility without synthetic fertilisers and pesticides.

However, biotechnology is not an 'either or' situation. There will continue to be demand for smaller local produce alongside a need to reduce environmental impact of larger scale farming required to feed our growing world population.

Likewise in health, there is growing misinformation about the efficacy and risks of the medical use of recombinant DNA by anti-vaccination proponents. Despite the availability of vaccines, the refusal to vaccinate threatens to reverse progress made in tackling preventable diseases. Vaccination is one of the most cost effective ways of avoiding disease. Current vaccination programmes prevent two to three million deaths a year, and a further 1.5 million could be avoided, if global coverage of vaccinations improved.

Any new technology must be trialled and understood by the public, before providing mainstream benefit. To avoid polarisation of perspectives in New Zealand, open public debate is recommended, with the Government ensuring the public have access to the facts, to reduce the risk of misinformation and fake news.

11 Biotechnology market size by application: Market share and forecast 2019-2025, Global Market Insights, 2018.

New Zealand's Biotechnology Landscape

History of Biotechnology in New Zealand

New Zealand has a strong agricultural history with an economy built on primary production. The nation is known for its sustainable resource management and has a skilled, educated workforce. Local biotechnology has developed strengths in niche fields within human health and animal research.

New Zealand's bioeconomy is built on over a century of world class biological research. Notable successes include:

gsk

Glaxo, now part of GSK, was founded in New Zealand by **Joseph Nathan**.

The disposable plastic syringe was invented by New Zealander **Colin Murdoch**.

New Zealand born **Maurice Wilkens** shared the 1962 Nobel Prize with Watson and Crick for discovering the molecular structure of DNA.

New Zealand's bioeconomy is underpinned by a tradition of applying research to pastoral and arable farming, horticulture, forestry and human healthcare. In the mid-1970s, institutional management of genetic modification technologies began to emerge at a Government level.

In 1978, the Government placed a ten year moratorium on field releases. At the same time, an Advisory Committee on Novel Genetic Techniques (ACNGT) was established to oversee contained laboratory and glasshouse genetic manipulation work. In 1996, the Hazardous Substances and New Organisms (HSNO) legislation became law, although it was not officially in operation for a further two years. Recombinant technologies began to be applied in laboratories in New Zealand, largely for biological and medical research purposes.

In the 1980s, scientists at the now defunct Department of Scientific and Industrial Research (DSIR) explored the chemistry of seaweed polysaccharides, noticing the similarity between a patented herbicide and levoglucosenone, a compound that could be produced cheaply from waste paper.

In the 1990s, Zespri began cultivating a new variety of kiwifruit developed through a natural breeding programme in partnership with Crown Research Institute (CRI) New Zealand Plant and Food. This new yellow fleshed gold variety was less furry than the green variety, with a sweeter, more tropical taste.

Another CRI, AgResearch, created a new generation drought resistant ryegrass. In 2018, field trials of the new ryegrass began in the USA.

In 1998/99, the first set of official statistics on the modern biotechnology industry in New Zealand was conducted by Statistics New Zealand.[12] In 2002, biotechnology was recognised as one of three sectors for future development with the potential to make substantial contributions to the social wellbeing and economic growth of the country. A New Zealand Biotechnology Strategy[13] was published by the Government in 2003, with the objective of helping to grow the biotechnology sector.

A 2007 biotechnology survey found agri-biotech the dominant form of bioscience application in New Zealand with 100 of the 168 biotechnology companies identified, engaging in agricultural biosciences.[14]

12 Modern Biotechnology Activity in New Zealand, Statistics New Zealand, 2001.

13 New Zealand Biotechnology Strategy, Ministry of Research, Science and Technology, May 2003.

14 New Zealand Biotechnology Survey 2007, Statistics New Zealand, 2007.

The growth of forestry in New Zealand saw Scion, a CRI, develop the New Zealand Biofuels Roadmap[15] to define optimum pathways for the production and use of liquid biofuels at a large scale in New Zealand.

The 2016 Scientific American Worldwide assessment of innovation potential in biotechnology ranked New Zealand fourth behind the United States, Singapore and Denmark, climbing from 18th position in 2011.[16] The study found that New Zealand has the most PhD graduates in life sciences per capita in the world and the best political stability, both important elements for the long term investment required for successful biotechnology.

However, there are some obstacles to the growth of biotechnology in New Zealand, including the country's relatively small size, distance from global value chains and the lack of multinational companies headquarters in New Zealand. Another potential barrier to growth may be the regulatory environment and New Zealand's approach to genetic modification.

NEW ZEALAND RANKED 4th IN THE WORLD FOR INNOVATION POTENTIAL IN BIOTECHNOLOGY

Genetic Modification in New Zealand

Genetic modification (GM) techniques have been used in research in New Zealand for more than a decade. Research into the social and environmental impacts of GM is also conducted in New Zealand. It is undertaken in contained environments such as laboratories. At present, no genetically modified products manufactured in New Zealand are commercially available. All use of GM techniques must have approval under the Hazardous Substances and New Organisms Act (HSNO) and comply with all necessary requirements.

TABLE 1: RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

APP202371	30/04/19	Approval to import and release, a genetically modified live attenuated vaccine that protects humans against Japanese encephalitis (Imojev).
APP203530	23/04/18	Approval to import a genetically modified live attenuated oncolytic vaccinia virus for conditional release in a phase 1b clinical trial as an experimental therapy for renal cell carcinoma.
APP202854	12/02/18	Approval to import for release, a genetically modified adenovirus (Telomelysin) for use in a Phase II clinical trial for patients with advanced melanoma.
APP202601	28/10/15	Approval to import for release, a genetically modified live attenuated vaccinia virus (Pexa-Vec) for use in a Phase 3 clinical trial for patients with hepatocellular carcinoma.
GMR07001	19/11/08	Approval to import for release, genetically modified vaccines (Proteqflu and Proteqflu Te) to protect horses against Equine Influenza.

Source: Environmental Protection Authority, 2020.

15 New Zealand Biofuels Roadmap: Growing a biofueled New Zealand, New Zealand Forest Research Institute, Scion, 2018.

16 Across the Universe: The 8th Annual Worldview Scorecard, Worldview, Scientific American, 2016.

Before any new organism (including a genetically modified organism) can be imported, developed, field tested or released into the environment, the applicant must get the approval of the Environmental Risk Management Authority (ERMA). The ERMA is an independent, quasi-judicial body established to consider applications on a case-by-case basis, reflecting the fact that each organism is unique and will pose different potential risks and/or benefits.

There have already been five genetically modified organisms approved for release in New Zealand since the passing of the HSNO Act. These releases have presented no issues.

The HSNO Act applies to anything that can potentially grow, reproduce and be reproduced, whether or not it is also a food or a medicine.

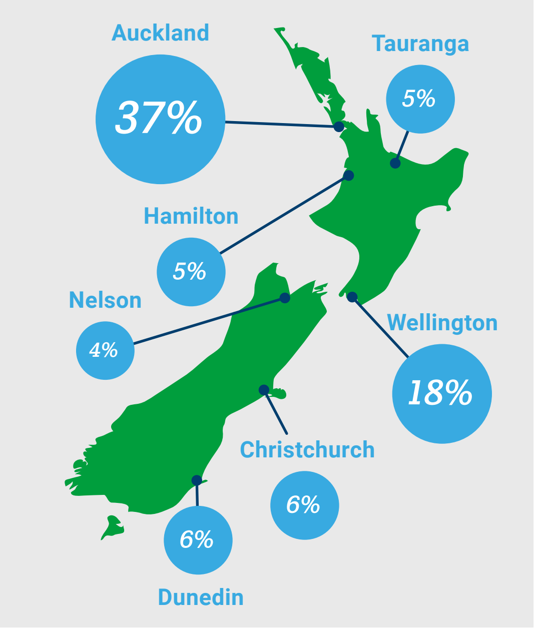
There are currently no genetically modified commercial crops in New Zealand, and no fresh produce (fruit, vegetables, meat or milk) sold that has been genetically modified. Some processed foods may, however, contain genetically modified ingredients sourced from overseas (for example, GM enzymes are used in cheese production, GM soymeal and GM cotton meal are imported for use as animal feed and animal vaccines).

In New Zealand, there have been calls for wider public discussion about gene-technology and a review of the current regulations by multiple parties in recent years.[17] An expert panel established by The Royal Society Te Apārangi to consider the implications of new technologies that allow controlled and precise 'editing' of genes, concluded that it is time for a regulation overhaul. There is also an urgent need for wider discussion and debate about gene editing, within and across all New Zealand communities.[18]

The New Zealand Biotechnology Survey

New Zealand's bioeconomy is underpinned by a long tradition of applying research to wide ranging issues in human and animal health, food, agritech and energy. The New Zealand biotechnology ecosystem

FIGURE 1: NATIONAL DISTRIBUTION OF BIOTECHNOLOGY ORGANISATIONS



17 Time to reignite GE debate in NZ says Sir Peter Gluckman, NZ Herald, July 2018.

18 Calls for over-haul of gene technology regulations. Royal Society Te Aparangi, August 2019.

is made up of biotechnology companies, universities, Crown Research Institutes (CRIs), independent research institutes, accelerators, support services, and investors with growing expertise in biotechnology. This small but vibrant biotechnology community is increasingly yearly with a growing number of high-tech companies whose core business is biotechnology.

BioTechNZ recently undertook a national survey of the New Zealand biotechnology sector, using a selection of the questions used by Statistics New Zealand during their 2009 and 2011 analysis. The survey methodology and definitions are detailed in the appendix.

45%

OF BIOTECHNOLOGY ORGANISATIONS ARE LOCATED IN REGIONAL NEW ZEALAND

The BioTechNZ 2020 survey identified a national distribution of biotechnology companies (using both traditional and modern biotech, however, these companies are research and development intensive) with 37 percent located in Auckland, 18 percent in Wellington and the remaining 45 percent located in regional New Zealand. There is a strong correlation between biotechnology company locations, research institutes and universities.

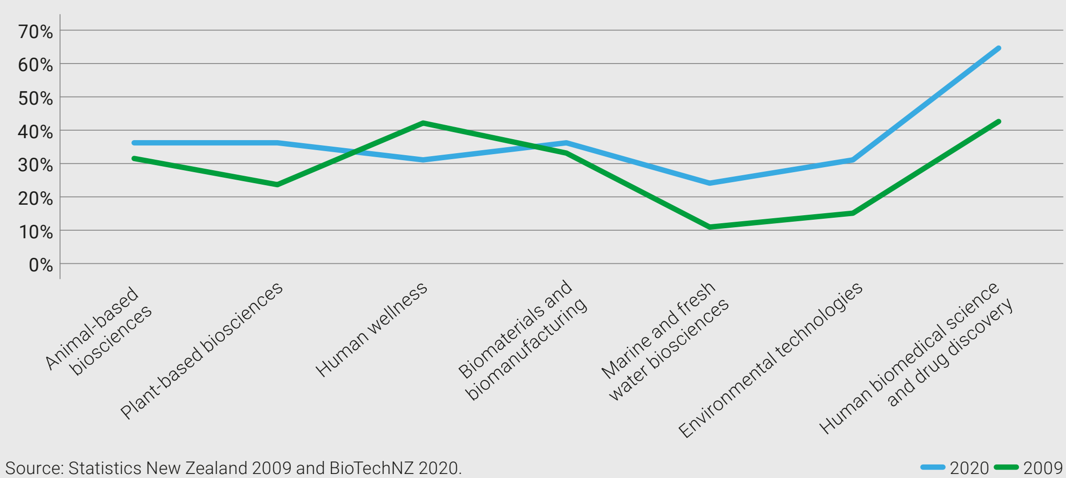
EMPLOYMENT

Most of these firms are small, with 67 percent having fewer than 10 employees. A small number (less than 10 percent) of biotechnology focused organisations in New Zealand have over 100 employees.

Biotechnology companies are by default hi-tech and knowledge intense. The survey found that over 1000 employees have post graduate qualifications or PhD’s. The knowledge sectors are made up of highly skilled individuals who hold higher degrees and qualifications leading to high salaries. Higher education is one of the key drivers of growth

FIGURE 2: TYPES OF BIOSCIENCE UNDERTAKEN

Percentage of organisations undertaking each type of biotechnology, 2020 verses 2009



Source: Statistics New Zealand 2009 and BioTechNZ 2020.

performance, prosperity, and competitiveness in national and global economies. However, there were some limitations on access to the expertise needed causing 24 percent of firms to recruit international staff into New Zealand in the past two years.

TYPES OF BIOTECHNOLOGY ACTIVITY

Over time there has been a subtle shift in the areas of bioscience work undertaken by New Zealand biotechnology organisations. A decade ago, the largest proportion of biotechnology firms were engaged in innovative foods and human nutrition. However, by 2020 this has declined, and work in plant-based biotechnology, water biosciences, environmental technologies and human biomedical science has increased. This may be reflective of a societal move towards environmental and health concerns, plus the increasing desire for natural foods.

RESEARCH

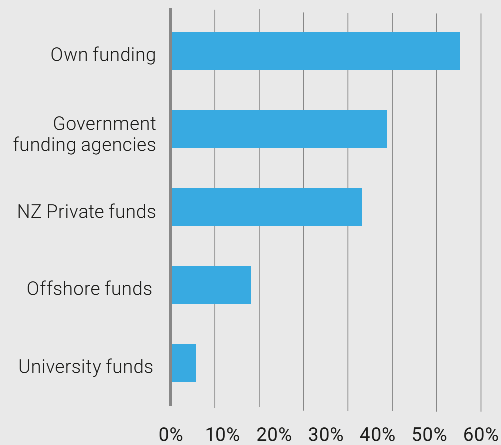
New Zealand biotechnology companies predominantly conduct their research and development (R&D) in New Zealand, with only 16 percent engaging in R&D outside of New Zealand. The companies also diligently protect their intellectual property (IP) with 47 percent having patents. According to a global analysis by Scientific American, New Zealand ranks 2nd out of 54 countries for the number of biotechnology patents filed – as a percentage of all patents filed with PCT.[19]

The most significant constraints on R&D, according to respondents to the BioTechNZ 2020 survey, is the access to capital and current regulation of genetic modification. Based on the data, the New Zealand science system appears to create a great foundation for the sector, however, the commerical constraints are holding back the sector.

FINANCES

Most New Zealand biotechnology firms are at an early stage commercially, with 30 percent of respondents either pre-revenue or earning less than $1 million in annual revenues. However, the organisations who reach commercialisation, often grow to a substantial size. Ten percent of survey respondents earn over $75 million annually. For these larger organisations, on average, 70 percent of their revenues was directly attributed to biotechnology.

FIGURE 3: RAISING FUNDS FOR GROWTH

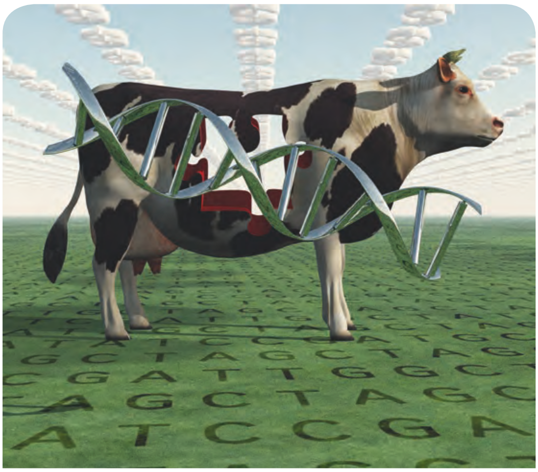


Source: New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.

According to research by the Technology Investment Network, biotechnology companies accounted for 7.1 percent of the revenues of the top 200 New Zealand technology exporters.[20] These largest New Zealand biotechnology firms revenues have been growing at a rate of 9.3 percent compound annual growth rate (CAGR) over the past five years.

During the past 12 months, most biotechnology organisations have relied on their own funding (56 percent). However, 42 percent have received some form of funding from the Government. Many firms also undertook capital raising in the past year, either via New Zealand funds (37 percent) or offshore funds (16 percent). There are firms at each stage of funding from pre-seed, seed, series A, B, C and above. Seven of the respondents were publicly listed and three were beyond their series C capital raise.

19 Across the Universe: The 8th Annual Worldview Scorecard, Worldview, Scientific American, 2016.
20 TIN Report 2019, Technology Investment Network, 2019.



Size of the Biotech Sector

Economic consultancy Sapere Research was engaged to conduct an analysis of the economic value of biotechnology for New Zealand. As part of this research, Sapere estimated the size of the biotechnology sector in New Zealand based on data from the BioTechNZ 2020 survey and previous research by Statistics New Zealand.

Our primary observation is a lack of current data available on the New Zealand biotechnology sector. Additionally, there was no available data on Māori biotechnology companies. Subsequently, this report was unable to comment on Māori company statistics. Prior to 2011, a bioscience survey conducted by Statistics New Zealand every other year, providing a range of useful information on the sector and its key performance metrics. However, funding for this was tied to a specific programme that was discontinued, so this survey also ceased.

While there is currently a dearth of good quality data, the 2020 Biotechnology Sector Survey by BioTechNZ, provides some information on biotech firms in New Zealand. Sapere noted that it is possible to use this data, and the more detailed data gathered before 2011, to explore and interpolate what the characteristics of the New Zealand biotechnology sector might be today.

As shown below, Table 2 shows the number of core biotechnology firms in 2020, 2011 and 2009. Core biotechnology firms are those with most of their revenues derived from biotechnology activities.

211

BIOTECHNOLOGY FIRMS IN NEW ZEALAND

The BioTechNZ 2020 survey made contact with 58 core biotechnology firms and the BioTechNZ ecosystem mapping project identified 211 core biotechnology firms (see appendix).

Within the survey, a lesser number of 43 firms were happy to provide information on their annual revenues,

TABLE 2: NUMBER OF CORE BIOTECH FIRMS IN NEW ZEALAND

Year	2020 BioTechNZ Survey	2011 StatsNZ Survey	2009 StatsNZ Survey
Estimated total core biotech firms	211	147	108
Core biotech firms in survey	58	-	-

Source: BioTechNZ, 2020. Total 2020 estimate based on BioTechNZ ecosystem mapping project.

collected in revenue bands. This represents just over 20 percent of the estimated total core biotechnology firms in New Zealand. This data is set out in Table 3.

ANNUAL REVENUE ESTIMATE

Sapere used this information to infer that the total revenue of the 43 New Zealand biotechnology firms who indicated their annual revenues in the 2020 BioTechNZ survey could be in the order of $550 million[21] but probably more. If it were assumed that these firms were representative of all New Zealand biotechnology firms, then the annual revenue of the whole biotechnology sector in New Zealand could be approximately $2.7 billion.

In 2010, the then Ministry of Science and Innovation published the 2010 Bio Science Industry report. This estimated the 2009 total revenue for core New Zealand biotech firms at $600 million.[22] This suggests that the sector's annual revenues have grown significantly over the last 11 years as the compound average growth rate (CAGR) between, 2009 and 2020 has been in the order of 14.5 percent per annum. Even if the 2020 estimate of the total annual revenue of the sector is overstated by half, the CAGR would still be circa 7.6 percent per annum.[23]

NET PROFIT ESTIMATE

The Ministry of Science and Innovation's 2010 Bio Science Industry report also estimated the annual

TABLE 3: REVENUES OF NEW ZEALAND BIOTECH FIRMS, 2020

Annual Revenue Bands	Percent Revenue from Biotech Activity	Number of Firms
Greater than $75m	100%	1
Greater than $75m	80%	2
Greater than $75m	60%	2
Greater than $75m	1%	1
$50m to $75m	100%	1
$50m to $75m	80%	1
$50m to $75m	5%	1
$20m to $50m	50%	2
$5m to $20m	100%	9
$5m to $20m	20%	2
$1m to $5m	100%	4
Less than $1m	100%	17

Source: BioTechNZ, 2020

21 This was inferred by conservatively assuming that firms either earned $75 million per annum or the midpoint of the revenue bands. The earnings of firms deriving less than half their earnings from biotech activities were not included as these do not fit the definition of core biotechnology.

22 Ministry of Science and Innovation, 2010 Bio Science Industry report, Page 38.

23 The estimate of the annual revenue of the biotech sector in 2020 could be overstated if, for example, the 43 firms which provided revenue data were not representative of the sector as a whole and overrepresented the larger firms with revenues in excess of $75 million per year.

net profit of the New Zealand biotechnology sector in 2009. This was $121 million per year or 20 percent of annual estimated sector revenues. This was estimated from a low base and was growing rapidly over the preceding three years. If this net profit to total revenue percentage were assumed to hold today, current net profits for the core biotechnology sector in New Zealand might be in the order of $540 million per annum. However, as Sapere noted earlier, there is a lack of good quality data so these estimates should be considered thought experiments that are seeking to explore what the current performance of the sector might be.

URGENT NEED TO COLLECT BETTER DATA

This analysis emphasises the scarcity of data on New Zealand's biotechnology sector and that more detailed and useful data used to be collected regularly. Given the importance of the sector to New Zealand's economy, it may be time to devote greater resources to gathering this information again.

Human Health Biotechnology in New Zealand

New Zealand has a small number of established human health biotechnology companies and an increasing number of emerging firms. Generating value from human health biotechnology is challenging as the commercialisation pathway from discovery to market products is long. Mature bio-pharmaceuticals businesses have developed following the success of sustainable generic manufacturing operations. Emerging human health biotechnology companies tend to target niche market opportunities such as biomarkers, cannabinoid therapeutics and regenerative tissue substitutes.

Approximately 52 percent of New Zealand biotechnology organisations operate in the human health space.[24] These companies cover a range of biomedical science areas with 57 percent engaged in medical diagnostics, 33 percent undertaking product

24 New Zealand Bioscience Survey, Statistics New Zealand, 2011.

development in oncology, 32 percent in immunological diseases and 31 percent in infectious diseases. Drug discovery is being undertaken by 29 percent.[25]

Agri-biotechnology in New Zealand

New Zealand's primary sector is a large part of the economy accounting for 11 percent of GDP and 15 percent of employment.[26] The Government has operated research organisations specialising in the science and research of animal health and productivity since 1926. Consequently, New Zealand has developed strengths in agri-bio, with approximately 38 percent of biotechnology companies operating in animal based biosciences and 27 percent in plant based biosciences.[27]

TABLE 4: EXAMPLES OF NEW ZEALAND HUMAN HEALTH BIOTECH COMPANIES

DOUGLAS PHARMACEUTICALS	NEW ZEALAND PHARMACEUTICALS	AFT PHARMACEUTICALS
Development and manufacture of generic pharmaceuticals including undertaking clinical trials for novel indications of repurposed molecules. • Auckland • Private ownership • 755 employees • $236m revenues (2019)	Development and manufacture of generic pharmaceuticals. • Palmerston North • Investment backed private • 156 employees • $97m revenues (2019 estimate)	Development and manufacture of generic pharmaceuticals including clinical trials. • Auckland • Public ownership • 83 employees • $85m revenues (2019)
AROA BIOSURGERY	**PACIFIC EDGE**	**CANNASOUTH**
Development and manufacture of regenerative tissue substitutes Endoform® Natural Dermal Template and Endoform® antimicrobial. • Auckland • Public ownership • 110 employees • $24m revenues (2019)	Cancer diagnostics with a genetic biomarker based suite of bladder cancer diagnostic tools. • Dunedin • Public ownership • 58 employees • $3.8m revenues (2019)	Development of next generation cannabinoid therapeutics to support patient health outcomes. • Hamilton • Public ownership • 10 employees • $53k revenues (2019)

Sources: TIN Report 2019, Cannasouth Annual Report 2019, Scale-Up New Zealand website.

25 New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.
26 Agritech in New Zealand, Industry Transformation Plan, New Zealand Government, 2020.
27 New Zealand Bioscience Survey, Statistics New Zealand, 2011.

Firms operating in animal health include a range of animal biosciences including animal therapeutics (37 percent), animal diagnostics (34 percent), biomanufacturing (28 percent), animal tissue and blood products (25 percent), antimicrobials (25 percent) and animal vaccines (25 percent). In plant health, the focus is on plant improvement science (57 percent). However, others are working in plant genomics (53 percent), plant growth science (53 percent) and bioprocessing and fermentation science (50 percent).[28]

Environmental and Industrial Biotechnology in New Zealand

Environmental and industrial biotechnology is a smaller field with a few large organisations and a growing number of early stage organisations. New Zealand's clean green reputation, combined with unique microbes and novel research has resulted in some unique industrial and environmental microbe based applications, from waste streamed derived biofuels to thermophilic enzymes.

TABLE 5: EXAMPLES OF NEW ZEALAND AGRI BIOTECH COMPANIES

LIVESTOCK IMPROVEMENT CORPORATION	ARGENTA	LONZA
Develop agricultural solutions and software including artificial breeding, herd testing, diagnostic testing and farm automation. • Hamilton • Public ownership • 771 employees • $246m revenues (2019)	Development of animal health products. • Auckland • Private ownership • 420 employees • $114m revenues (2019 estimate)	Chemical company developing products to meet specific agrichemical and timber treating requirements including crop protection products. • New Plymouth • Foreign ownership • 54 employees • $35m revenues (2019)
SOUTH PACIFIC SERA	**BIOSTART**	**MASTAPLEX**
Animal derived biologicals and pharmaceutical contract manufacturer. • Timaru • Private ownership • 57 employees • $10m revenues (2019 estimate)	Biological fermentation products for use in agriculture and horticulture. • Auckland • Private ownership • 15 employees • $3.9m revenues (2019 estimate)	Developed a patented system for mastitis milk tests on-farm or in vet clinics. • Dunedin • Private ownership • >10 employees • Early Stage

Sources: TIN Report 2019, Scale-Up New Zealand website.

28 New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.

An estimated 26 percent of biotechnology firms in New Zealand are engaged in industrial or environmental biotechnology.[29] Most environmental biotechnology work is focused on biosecurity and pest control (63 percent) and biodiversity (54 percent). The firms engaged in industrial biotechnology are focused on improving industrial processes (58 percent), undertaking biomanufacturing (54 percent), waste reduction (42 percent), bio-pesticides and herbicides (42 percent) and reducing carbon emission (32 percent).[30]

TABLE 6: EXAMPLES OF NEW ZEALAND ENVIRONMENTAL AND INDUSTRIAL BIOTECH COMPANIES

Z ENERGY

New Zealand fuel distributor that has developed the first biodiesel plant in New Zealand.

- Auckland
- Public ownership
- 2,656 employees
- $269m revenues (2019)

LANZATECH

Manufactures low-carbon fuels made from the industrial waste of steel mills, oil refineries and chemical manufacturers.

- United States
- Private ownership
- 170 employees
- Not disclosed

ADURO POLYMERS

Develop and manufacture a range of bio-derived polymers and materials for use in plastics, agriculture, manufacturing and construction.

- Hamilton
- Private ownership
- unknown
- Not disclosed

LIGAR

Develops and manufactures Molecularly Imprinted Polymers (MIPs) for use in commercial scale filtration and extraction.

- Hamilton
- Private ownership
- 11-50 employees
- Early stage

MINT INNOVATION

Uses biometallurgy to recover valuable metals from various feedstocks, including gold from electronic waste.

- Auckland
- Private ownership
- 11-50 employees
- Early stage

FUTURITY

Developing technology to break down pine into lignins, cellulose and hemicellulose to replace oil in packaging, paints and other products.

- Gisborne
- Private ownership
- >10 employees
- Early Stage

Sources: Company websites, Dun & Bradstreet and Scale-Up New Zealand website.

29 New Zealand Bioscience Survey, Statistics New Zealand, 2011.

30 New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.

Marine Biotechnology in New Zealand

Marine biotechnology involves using marine bioresources, as either the source or target of biotechnology applications. It is a small, but emerging part of the New Zealand biotechnology ecosystem with 11 percent of biotechnology firms working in marine biosciences.[31]

Firms working in marine biosciences are engaged in bio-extraction (78 percent), bio-processing (52 percent), waste stream research (48 percent) and marine sourced bioactives (39 percent).[32]

The global market for marine biotechnology was worth US$3.5 billion in 2017 and is expected to grow by US$2.5 billion during 2020-2024, progressing at a CAGR of eight percent during the forecast period.[33]

TABLE 7: EXAMPLES OF NEW ZEALAND AGRI BIOTECH COMPANIES

SANFORDS	AGRISEA	SEA DRAGON
A large and long established fishing company devoted entirely to the harvesting, farming, processing, storage and marketing of quality seafood. • Auckland (Head Office) • Public ownership • <100 employees • $545m (2019)	High value nutrition products for the primary sectors including soil, plant, animal and bee nutrition, utilising the brown kelp Ecklonia radiata. • Paeroa/Waikato • Private ownership • 18 employees • $6.2m (2019 estimate)	Refiner and blender of high-quality, internationally-certified Omega fish oils; supplying nutraceutical and food manufacturers. • Nelson • Public ownership • 11-50 employees • $6.6 million
ALARON PRODUCTS	**SEPEREX NUTRITIONALS**	**CH4 GLOBAL**
Good Manufacturing Process (GMP) and Therapeutic Goods Administration (TGA) certified contract manufacturer of natural health products including marine based ingredients. • Nelson • Private ownership • >100 employees • $5.3m (2019 estimate)	Biological fermentation products for use in agriculture and horticulture. • Auckland • Private ownership • 15 employees • $3.9m revenues (2019 estimate)	Aquaculture startup harvesting seaweed and commercialising production of methane reducing feedstock from seaweed. • United States / Wellington • Private ownership • >10 employees • Early Stage

Sources: TIN Report 2019, Scale-Up New Zealand website.

31 New Zealand Bioscience Survey, Statistics New Zealand, 2011.

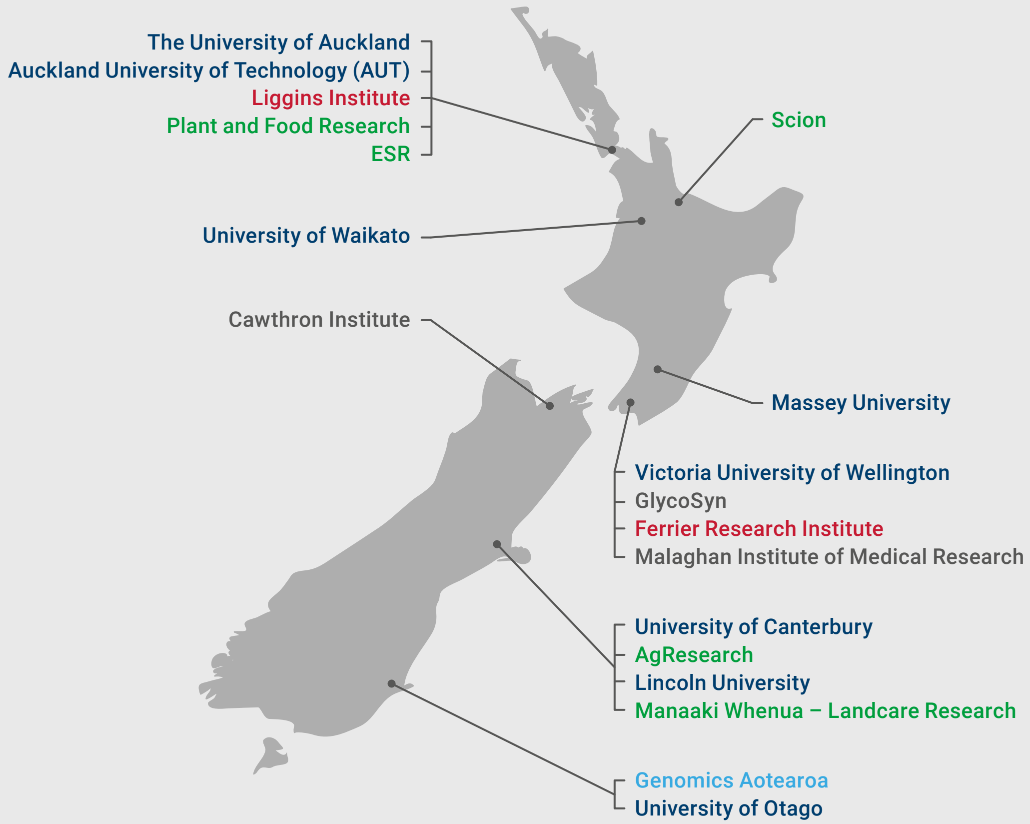
32 New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.

33 Global Marine Biotechnology Market 2020-2024, Technavio Market Research, 2020.

Underpinned by Science

The depth and strength of the New Zealand science system underpins New Zealand's ranking as the number four in the world for biotechnology innovation potential.[34] The biotechnology research and science system is made up of eight Universities, two specialist University Research Institutes, five of the Crown Research Institutes and a number of private research facilities.

FIGURE 4: NEW ZEALAND'S BIOTECHNOLOGY RESEARCH INSTITUTES



KEY:

• Universities • University Research Institutes • Crown Research Institutes • Private Research Institutes • Collaborations

Source: BioTechNZ, 2020.

34 Across the Universe: The 8th Annual Worldview Scorecard, Worldview, Scientific American, 2016.

Part Two:

Biotechnology Opportunities for New Zealand


39

New Zealand Strengths in Biotechnology

New Zealand has a rich history in agriculture and forestry, approaches resource management sustainably and has a skilled, educated workforce.

These macro factors have supported the development of New Zealand's biotechnology sector in niche fields within human health, plant and animal research.

In addition, New Zealand has a number of competitive strengths supporting its global growth in biotechnology, including geographic location, business environment, research excellence, international collaboration and excellent animal health status.

These competitive strengths are detailed below in Table 8.

Geographic Location

Geographical isolation supported by strict quarantine standards and strong biosecurity, protects New Zealand's natural biodiversity. Our relative isolation has enabled the country to remain free of many of the economic crop pests, weeds and diseases affecting animals in other parts of the world.

New Zealand's temperate land mass enables a great capacity for food production. In fact, New Zealand produces enough food to feed 40 million people worldwide – almost 10 times its own population.[35]

TABLE 8: NEW ZEALAND'S BIOTECHNOLOGY STRENGTHS

Geographic Location	Business Environment	Research Excellence	International Collaboration	Excellent Animal Health Status
• isolated island • strict quarantine standards and border security • temperate environment	• ranked number 1 for ease of doing business • least corrupt country in the world	• 2nd in top 100 life sciences universities • most PhD graduates in life sciences per capita	• high level of international research co-authorship	• highest livestock disease free status globally • free of prion diseases
Dairy Protein Development	**Animal Sourced Biologicals**	**Plant-based Technologies**	**Environmental Microbiology**	**Biomedicals & Drug Discovery**
• more than 100 years of research into dairy proteins	• high quality, disease free animal materials	• world leader in pasture research • expertise in forest genetics biotech • high level of biodiversity and rich in bioactives	• unique industrial and environmental microbe based applications from waste stream-derived biofuels to thermophilic enzymes	• strong biomedical research base for drug discovery innovations • robust clinical trial environment

Source: BioTechNZ, 2020.

35 KPMG Agribusiness Agenda, KPMG, 2017.

Business Environment

New Zealand is currently the top ranked country for ease of doing business and for starting a business by the World Bank[36] and the least corrupt country in the world by Transparency International.[37] The Scientific American Worldview Scorecard for biotechnology places New Zealand fourth in the world.[38] The Scorecard evaluates countries on their innovation potential in biotechnology through an analysis of productivity, IP protection, intensity, enterprise support, education/workforce, foundations, policy and stability.

Research Excellence

New Zealand is home to two of the world's top 100 life science and medicine universities, the University of Auckland and the University of Otago.[39] New Zealand also has the most PhD graduates in life sciences per capita.[40] The country has a number of niche research institutes, centres of research excellence and CRI's. Together, these help develop a highly educated life sciences workforce for an increasing number of local biotechnology businesses.

The percentage of publications in the top one percent most-cited worldwide is higher in New Zealand compared to the OECD benchmark.[41] Large numbers of translational research projects are now beginning to mature with many potential opportunities for licensing or spinout transactions.

International Collaborations

New Zealand has high international collaboration rates. The proportion of publications with international co-authorship is higher in New Zealand (54 percent) compared to the OECD benchmark (29 percent). The top ranking countries include the USA, Australia, the United Kingdom, Germany and China.[42]

Excellent Animal Health Status

New Zealand's livestock has one of the highest disease-free status levels globally. From land use availability, animal health services and a highly skilled workforce to innovative agricultural technology and world-class agri-bio research and manufacturing facilities, New Zealand has the capability to support international companies developing human therapeutics that require animal-derived ingredients. Most notably, prion diseases (a family of rare progressive neurodegenerative diseases) such as bovine spongiform encephalopathy (BSE) are not present in New Zealand. Comprehensive programmes are in place to prevent unwanted diseases, including transmissible spongiform encephalopathies (TSEs-BSE, scrapie), foot and mouth, and avian flu.

36 Doing Business 2020: Comparing Business Regulation in 190 Economies, World Bank Group, 2020.
37 The Transparency International Corruption Perceptions Index.
38 Across the Universe: The 8th Annual Worldview Scorecard, Worldview, Scientific American, 2016.
39 QS global life science and medicine university rankings, 2018.
40 Across the Universe: The 8th Annual Worldview Scorecard, Worldview, Scientific American, 2016.
41 Research, Science and Innovation System Performance Report, MBIE 2018.
42 Across the Universe: The 8th Annual Worldview Scorecard, Worldview, Scientific American, 2016.

Dairy Protein Development

New Zealand's renowned dairy expertise has resulted from generations of dairy farming and is enhanced by a R&D philosophy, established more than 100 years ago. New Zealand has a proficiency in enabling platform technologies for protein. This aligns with one of the most significant global nutrition trends – a rapidly increasing demand for high quality protein production.

Animal Sourced Biological Material

Due to New Zealand's excellent health status, animal materials (including animal tissues, organs and pharmaceutical animal ingredients) are generally being used by the biopharmaceutical industry, biotechnology R&D and manufacturers of medical devices.

Plant Based Technologies

New Zealand is a leader in pasture research and development with regard to seed production. New Zealand produces 6.7 percent of the world's perennial ryegrass seed and 38 percent of the world's white clover seed.[43]

Forestry is a significant industry for New Zealand as wood products are a $6.7 billion export earner.[44] New Zealand has expertise in forest genetics biotechnology techniques to improve growth rates, wood quality and modified biomass such as bioplastics and biofuels.

A high level of biodiversity and home to many indigenous plants provides an environment rich in desirable bioactives, for product ranges from high value nutritional food products through to functional foods, ingredients and medicines. Natural products have long been regarded as 'nature's medicine chest' providing a rich source of lead compounds as invaluable platforms for developing front-line drugs. Dame Margaret Brimble at the University of Auckland, focuses on making and modifying naturally occurring bioactive compounds that have been isolated from plants, animal tissue, microbes or marine and soil organisms, which are rare or hard to isolate in abundance.

Environmental Microbiology

Unique microbes combined with New Zealand's clean green reputation and novel research have resulted in many unique industrial and environmental microbe based applications, from waste stream-derived biofuels to thermophilic enzymes.

Biomedical Science, Drug Discovery and Clinical Trials

Changes in the traditional model of drug development, from inhouse work to more collaborative outsourced approaches, have created opportunities for New Zealand's drug development industry. Large pharmaceutical companies are forming alliances and partnerships with smaller specialist firms and university based groups undertaking drug discovery research as a source for innovation. Additionally, there is a focus on reducing the extraordinary costs associated with drug development, by conducting clinical trials in different locations and outsourcing specialised components of R&D projects.

New Zealand has a robust clinical trial environment, underpinned by an efficient ethics and regulatory framework which results in fast startup speeds. New Zealand also has high quality research facilities, a diverse participant recruitment pool, well respected physicians and hospitals.

New Zealanders participate in over 100 clinical trials each year. Clinical trials employed more than 700 people and contributed over $150 million per year on average to New Zealand's GDP in the period 2013 to 2018. With investment, it is estimated that the clinical trials sector's economic contribution could, by 2025, increase to $860 million and create 4640 jobs.[45]

43 Pastoral industry Forage-Discussion Document 2016-2036, November 2017.

44 New Zealand's Forest Industry – Fact Page, Ministry for Primary Industries Website. www.mpi.govt.nz

45 The value of clinical research with modern medicines in New Zealand, NZIER, 2020.

Economic Opportunities for New Zealand

There are a growing number of global opportunities for New Zealand biotechnology.

New Zealand's biotechnology strengths allow scientists and companies to identify global niche opportunities, particularly in the animal sciences, horticulture, marine and biomedical industries. Additionally, the Māori economy has been estimated by Business and Economic Research (BERL), as having a $42 billion asset base. This, coupled with the potential of a te ao Māori approach to biotechnology may create new and unique opportunities for New Zealand. Combined with the expertise and leadership within our biotechnology companies and research organisations, this could provide New Zealand with the opportunity to successfully commercialise novel ideas.

> *"Our future lies in the niches of a world economy 500 times bigger than our own".* **SIR PAUL CALLAGHAN**

Turning Waste into Value

Increasingly, consumers are demanding ethically focused products with the least waste or environmental impact. This is creating new markets for biotechnology that can help reduce waste or create value from waste.

BIOREMEDIATION

Bioremediation stimulates the growth of specific microbes that use contaminants as a source of energy. Local research has identified opportunities to take waste and convert it into valuable products. Examples include LanzaTech, who use bacteria to extract valuable chemicals from carbon emissions secreted by factories. Also, Mint Innovation, who use microbes to extract precious metals from waste electronic equipment. The global bioremediation market is forecast to be worth US$186 billion by 2023. This is driven by China, Japan and South Korea's focus on reducing man made pollutants.[46]

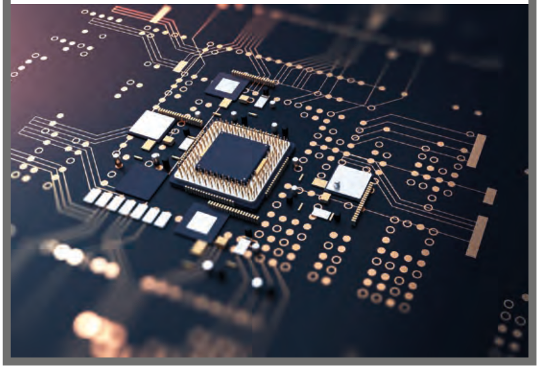
Mint Innovation – Converting Electronic Waste to Gold

Mint Innovation was co-founded in 2016 by Dr Will Barker, formerly a senior executive at LanzaTech and Matthew Rowe.

The Auckland based company has developed a biotechnology solution that uses chemicals and microorganisms to extract precious metals, including gold, palladium and copper, from printed circuit boards salvaged out of old electronics, such as computers, televisions and mobile phones.

The Mint biorefinery technology enables increasing volumes of electron waste to be processed in an environmentally responsible manner. The recovered precious metals can be re-used in exactly the same way the conventionally mined metals are used to create new electronics, jewellery or held for investment.

MINT innovation



46 Bioremediation Global Markets and technologies to 2023, BCC Research, 2019.

BARK BIOREFINERY COULD CONTRIBUTE AND ADDITIONAL

$1.8 billion

TO NEW ZEALAND'S GDP

Globally, around 150 million tonnes of CO_2 (around 6 percent of global CO_2 emissions) could be avoided by re-using steel mill gases alone.[47]

BIOREFINERY

Globally, the sustainable processing of waste biomass into a spectrum of marketable products and energy is a rapidly growing sector. The global biorefinery market is currently worth US$606 billion and is forecast to grow at 7.1 percent to be worth $653 billion by 2026.[48]

Across the New Zealand agricultural and forestry sector, a considerable volume of waste biomass is produced. The CRI, Scion, has been researching opportunities for bark biorefinery to convert underutilised forestry waste into high value materials. Bark biorefinery alone is estimated to be worth an additional $400-$600 million per annum and could contribute $1.8 billion to New Zealand's GDP.

New Zealand startup Futurity are working on commercialising a biorefinery process, to convert pine trees to chemicals, to be used for foams, packaging, paints and other everyday applications.

In addition to bio-fuels, biorefinery projects use forestry and biological technology to create value added products. In turn, these can be used globally in other products that outperform and replace oil.

ANIMAL DERIVED BIOLOGICAL

Free of almost all World Organisation for Animal Health listed animal diseases[49] New Zealand originated animal by-products are highly sought after and considered among the safest ingredients

LanzaTech – Converting Waste Gas to Fuel

LanzaTech was founded in 2005, in response to a growing demand for sustainable fuel. LanzaTech developed and scaled a low cost, low carbon fuel production process with no impact on availability for food or land.

LanzaTech's gas fermentation process uses microbes that consume the gases and convert them into usable by-products such as ethanol or commodity chemicals.

Having raised US$350 million to date, the company is now building commercial plants with partners in several countries. The plants are converting gases from Chinese steel mills into household cleaning products.

LanzaTech

47 Case study of LanzaTech, Pure Advantage, 2015.

48 Global Biorefinery Products Market 2020-2026, Industry Research Biz, 2020.

49 The World Animal Health Information System, World Organisation for Animal Health, 2020.

Futurity – Outperforming Oil Based Materials with Trees

Futurity Bio-Ventures is changing how plastic is made, used and recycled.

Their mission is to help move the world past oil dependency. The company has developed a process that can break down pine trees into base chemicals (lignin, cellulose and hemicellulose) to be reused in the creation of plastics, resins and other applications currently provided by oil-derivaties.

Futurity are in the process of establishing New Zealand's first advanced commercial biorefinery in Tairāwhiti-Gisborne. This plant will be the first of a number of biorefineries to be constructed around New Zealand.

FUTURITY

available for developing human therapeutics that require animal derived ingredients. Approximately 60 percent of the cow goes towards products (other than meat consumption), creating more than 350 co-products. For example, South Pacific Sera use blood products in vaccine development. Soft tissue regeneration company, Aroa Biosurgery, use ovine (sheep) forestomach to create wound healing products and ANZCO pioneering innovative healthcare solutions including biotissues, bioculture and nutrition. In 2019, animal by-products generated $728 million in export revenue for New Zealand.[50] Market demand for high quality animal derived products for use in human therapeutics is growing. The global market for bovine blood product derivatives alone is forecast to be worth US$2.2 billion by 2025.[51]

Gaining More Value From Our Agricultural Sector

Population growth, demand for food, environmental and animal welfare concerns are driving the demand for new ways to create more agricultural output with less impact. Agriculture biotechnology includes animal and crop diagnostics, molecular markers, vaccines and genetic engineering. The global animal biotechnology market was worth approximately US$33 billion in 2018 and is forecast to grow at 10.7 percent to 2025 and be worth US$67 billion.[52] These biotechnologies are being used to improve water quality, reduce animal methane production, decrease nitrogen use, reduce carbon dioxide emissions and improve the quality and output of animals and plants.

ANIMAL BIOTECH

New Zealand has a long history of sheep, dairy and beef farming that has given rise to world-class science and technologies in genomics, animal reproduction and molecular approaches to enhance animal productivity and health. Leading New Zealand companies operate in this market including Livestock Improvement Corporation (LIC) with their herd improvement genetics and Argenta with animal pharmaceutical discovery and manufacturing. The global animal

50 Situation & Outlook for Primary Industries: Online data for SOPI, Ministry for Primary Industries, March 2020.

51 Global Bovine Blood Plasma Derivatives Market: Snapshot, Transparency Market Research, 2017.

52 Agriculture Biotechnology Market by Type: Global Analysis and Forecast 2018-2025, Zion Research, 2019.

Aroa Biosurgery – Turning Tripe into Wound-healing Scaffold

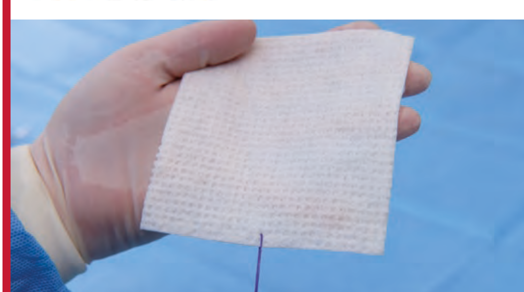
With $1.5 million of seed funding, Aroa Biosurgery was founded in 2007 to commercialise technology to improve the rate and quality of healing in complex wounds and soft tissue reconstruction.

Aroa's products are developed from the proprietary Endoform® extracellular matrix technology platform, a biomaterial, derived from ovine (sheep) forestomach. Aroa's soft tissue regeneration platform acts as a scaffold for the patient's cells to rebuild missing or damaged tissue in applications such as diabetic foot ulcers, hernias and breast reconstructions.

Aroa Biosurgery now has five commercial products that are available in 17 countries including the USA where Aroa's products have been used in more than four million procedures to date and are used in over 600 hospitals to treat complex wounds and during surgical reconstructions.

Aroa's products are covered by a patent portfolio that includes 10 patients and 25 pending patent applications. Aroa is headquartered in Auckland, New Zealand and was listed on the Australian Securities Exchange (ASX:ARX) in July 2020.

AROA



Livestock Improvement Corp – Producing More Milk From Fewer Cows

Livestock Improvement Corporation (LIC) is a New Zealand multinational farmer-owned co-operative which, for more than 100 years, has provided genetics expertise, information and technology to the dairy sector, aimed at improving the prosperity and productivity of farmers.

LIC has a long history of providing world leading innovations for the dairy industry with origins dating back to 1909, when the first organised routine herd testing service commenced. Since 1961, more than 10,000 bull calves have been tagged as part of its Sire Proving Scheme (SPS).

One of the largest private investors in research and new product development in the New Zealand agritech sector, LIC works on a number of projects including genomic selection and sequencing, reproduction improvement and animal health.

LIC®

genetics market was worth US$6 billion in 2018 and is driven by increasing demand for healthier food and milk products.[53] The focus on animal health is even greater with US$74 billion expected to be spent globally on animal health by 2027, due to increasing demand for veterinary vaccines and pharmaceuticals, as farming intensifies throughout the world.

Synthetic Meats: Considerable research is occurring internationally on potentially replacing traditional meat and dairy products with lab grown substitutes New Zealand's agricultural sector is key to the economy. It very important that this topic is debated in New Zealand as substituting meat and dairy, with synthetic foods could potentially reduce the amount of land, water, energy, and greenhouse gas emissions.

PLANT BIOTECH

New Zealand pastoral, arable and horticulture farmers have relied on new plant breeding innovations for their success. New Zealand products such as the JAZZ™ brand apple and ZESPRI® GOLD Kiwifruit ($187 million export revenue in March 2020)[54] are well known worldwide. New Zealand has been investing in genetics and varietal development on a range of crop types including onion, pea, wheat, barley, clover and ryegrass.

With the opportunity to use new gene-editing technologies, it would enable New Zealand to speed up innovation in alternative proteins, increase crop yields, reduced costs for food production, reduced need for pesticides, enhanced nutrient composition and food quality, resistance to pests and disease.

BIOBASED NATURAL SOLUTIONS

A growing global recognition of the harmful effects of agrochemicals and consumer demand for healthy food is underpinning demand for natural solutions, delivered by plant biotechnologies. The European Union (EU) has recently developed a series of targets to dramatically reduce the amounts of chemicals used on European farms by 2030. These include reducing the use of chemical and hazardous pesticides by 50 percent and reducing the use of fertiliser by 20 percent.

Biotelliga – Biological Crop Protection

New Zealand company Biotelliga develops agricultural crop protection technologies that minimise environmental and toxicological impacts while maximising crop performance and yield. With expertise in fungal biology and active biomolecules the firm designs foliar applied biological products and seed integrated solutions.

Biotelliga undertakes research, development and commercialisation of biological products that provide crop protection from biotic and abiotic stress through active biomolecules coated onto see, or through bioprotective organisms that are inoculated into seed.

With rising demand for biological based crop protection products over synthetic chemistry-based pesticides, Biotelliga is in a position to secure substantial value from its technology development in the large global crop protection market.

BIOTELLIGA

53 Animal Genetics Market Size and Forecasts 2019-2026, Grand View Research, 2019.

54 Overseas Merchandise Trade: March 2020, Statistics New Zealand, 2020.

a2 Milk Company – From Biotech Startup to Global Presence

The a2 Milk Company (a2MC), formerly New Zealand A2 Corporation, was founded in 2000 by Dr Corran McLachlan, who was researching health effects of A1 beta-casein, and Howard Paterson, a significant dairy farmer and stakeholder in Fonterra.

A1 and A2 beta-casein are genetic variants of the beta-casein milk protein that differ by one amino acid. The A1 beta-casein type is the most common type found in cow's milk in Europe (excluding France), USA, Australia and New Zealand. A genetic test, developed by the a2MC, determines whether a cow produces the A2 or A1 protein in its milk. The test allows the a2MC to license milk producers once proven their cows produce only A2 beta-casein protein in their milk, a superior milk that is easier to digest and may have other health benefits.

In 2018, New Zealand's largest multinational co-operative Fonterra, and the a2MC partnered to market the a2 Milk™. In year to June 2020, a2MC recorded an after-tax profit of $385.6 million, a 34 percent increase on 2019. Revenue increased 32.8 percent to $1.73 billion.

The global biopesticides market is projected to grow at a CAGR of 14.7 percent from an estimated value of US$4.3 billion in 2020, to reach US$8.5 billion by 2025.[55] This is a small, but rapidly growing part of the almost US$60 billion global crop protection market.[56]

HIGH VALUE DAIRY PRODUCTS ALIGN WITH GLOBAL NUTRITION TRENDS

New Zealand's long history in primary production and expertise in platform technologies strongly aligns with the growing demand for high quality protein production. The global market for dairy products is forecast to reach $645.8 billion by 2025.[57]

With increased life expectancy, consumers are becoming increasingly aware of the role of nutrition in ageing and disease prevention. More consumers are buying products that provide additional benefits and this is rapidly increasing demand for high quality protein production.

Development of probiotics, lactose free products and whey proteins are all multi-billion dollar global markets that New Zealand's pedigree in dairy proteins and a strong biotechnology sector can pursue. New Zealand companies like Quantec Biotechnology in Hamilton are isolating milk proteins that have demonstrated anti-microbial and anti-inflammatory properties for potential human and animal products. For example, the New Zealand a2 Milk Company developed genetic tests that enable the production of the a2 milk variant with health benefits. The global a2 Milk Market is expected to reach US$21 billion by 2026.[58]

MARINE BIOTECH

Marine biotechnology, which involves marine bioresources, either as the source or the target of biotechnology applications, is fast becoming an important component of the global biotechnology sector. The global market for marine biotechnology products and processes was valued at US$4.8 billion in 2018[59] and is forecast to add an additional US$2.5 billion between 2020 and 2024.[60]

55 Biopesticides Market by Type and Region Global Forecast to 2025, Markets and Markets, 2020.
56 Crop Protection Chemicals Market Size and Forecasts 2020 - 2027, Grand View Research, 2020.
57 Dairy Products Market Global Forecast to 2025, Meticulous Research, 2019.
58 A2 Milk Market and Forecast 2019 to 2026, Fior Markets, 2020.
59 Global Marine Biotechnology Market – Industry Analysis & Forecast (2019-2026), Maximise Market Research, 2019.
60 Marine Biotechnology Market 2020-2024, Technavio Research, 2020.

CH4 Global – Using Red Seaweed to Reduce Greenhouse Gas

CH4 Global is a New Zealand startup that is addressing agricultural methane emissions. Research led by Australian Government research agency, CSIRO, identified the benefits of Asparagopsis seaweed in reducing methane output from dairy and feedlot beef cows by 60 to 90 percent. This solution is proven to be effective, but the challenge is growing enough seaweed to have an impact.

Partnered with NIWA, the University of Otago and others, CH4 is developing specialised aquacultural techniques to scale production of the native New Zealand seaweed.

First cultivation trials are commencing in 2020, with an aim to demonstrate an end-to-end minimum commercial scale operation in 2021/22. Success could unlock a substantial climate change impact and a multi-billion dollar export market.

CH4 GLOBAL
Zero Methane Agriculture

Marine biotechnology research includes the extraction of nutritional ingredients, development of novel drugs and personal care products, creation of renewable energy products and the development of marine-derived molecules such as enzymes, biopolymers and biomaterials, for use in food, cosmetics and health.

Improving Health and Wellness

The increasing global prevalence of chronic lifestyle diseases is one of the key factors driving the growth of the health and wellness market. Sedentary lifestyles, stress related disorders and the prevalence of diabetes, blood pressure, asthma, arthritis, cancer and dementia has increased significantly. New Zealand's high quality raw materials, innovative farming systems, strong science platforms and well established supply chains support the development of medical and functional foods, nutraceuticals and related products.

For some time, natural products have been a significant source of pharmaceuticals and consumer health products. Depending on definitions, it is estimated that between 25 and 50 percent of all currently marketed drugs owe their origins to natural product sources.[61] It is estimated that the global market for botanical and plant derived drugs will increase from US$29 billion in 2017 to approximately US$40 billion by 2022.[62]

DESIRABLE BIOACTIVES

New Zealand is home to desirable bioactives and can be used to create product ranges from high value nutritional food products, functional foods, ingredients, and medicines. New Zealand's advantages in biodiversity, relatively clean environment, food safety, traceability, ultraviolet (UV) sunlight levels and world class science system are all conducive to the development of a bioactives market. New Zealand is known for its high quality manuka honey, bee venom, blackcurrent, deer velvet, fish oils, green lipped mussel and totarol. Whilst still relatively small, with approximately 150 companies operating in nutraceutical and functional food biotechnology in New Zealand, the opportunity is large. The global bioactive ingredients market is expected to grow to US$52 billion by 2024.[63]

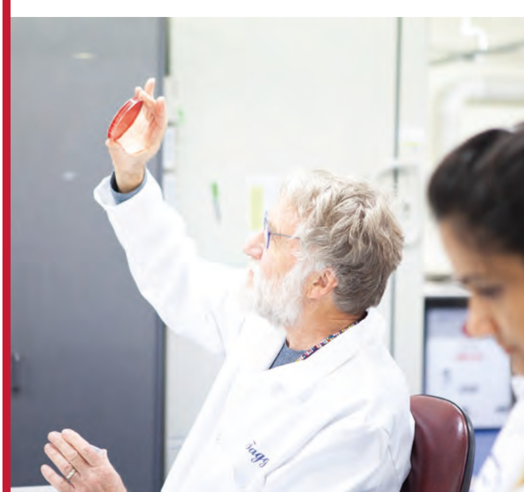
61 Kingston, D. Modern Natural Products Drug Discovery and its Relevance to Biodiversity Conservation. J Nat Prod, 2010.
62 Botanical and Plant-derived Drugs: Global Markets, BCC Research, 2017.
63 Bioactive Ingredients Market by Product and Segment Forecasts to 2024, Grand View Research, 2020.

Blis Technologies – The Healthy Guardians

Blis Technolgies founder, John Tagg was inspired to study throat bacteria after a sore throat left him with rheumatic fever as a child. Thirty years later, he discovered a strain of bacteria in healthy mouths and went on to develop the first oral probiotics.

Patented strains of the bacteria, BLIS K12, were developed into a range of products that support oral health. Blis Technologies have also identified and patented another strain, BLIS M18 that works in a similarly way around the teeth and gums.

The BLIS Probiotics portfolio continues to be strengthened by ongoing scientific trials and new strain discovery to unlock the potential of the human microbiome. All research and development, manufacturing and packaging are undertaken at its headquarters in Dunedin.



SETEK Therapeutics and AFT Pharmaceuticals – Combining Strengths

Founded in 1997, AFT Pharmaceuticals began with husband and wife team Hartley and Marree Atkinson, selling products direct to pharmacies. Twenty years later, they have developed expertise in the development, marketing and distribution of pharmaceuticals and AFT Pharmaceuticals is listed on the New Zealand and Australian stock markets.

In 2019, AFT Pharmaceuticals partnered with SETEK Therapeutics, a sustainable medicinal cannabis company in Taupo. Together, they have combined their expertise in commercialisation and scaling production with SETEK'S expertise in cultivation. Shared experience and knowledge will also help them uncover new medicinal cannabis opportunities.

AFT Pharmaceuticals will conduct any clinical trials and manage regulatory approvals of any product and will be granted exclusive right to sales, marketing and distribution of the medicinal cannabis products in Australia and New Zealand. It will also be granted the right of first refusal to do the same in other territories around the world.

Avalia Immunotherapies – Fighting Cancer, Hepatitis B and Now COVID-19

Avalia was formed in 2015, after a decade long research partnership between Victoria University of Wellington's Ferrier Research Institute and the Malaghan Institute of Medical Research.

The foundation programme focused on developing a vaccine technology that stimulates the most powerful immune cells in the body for a targeted response to disease, with an initial focus on cancer therapies.

Today, the team is progressing multiple preclinical programmes across a range of diseases, from cancer therapies to preventative vaccines for malaria and influenza, and a treatment for people living with chronic hepatitis B.

Avalia initially focused on how this adaptable vaccine platform could be modified to impact different diseases. This allowed the company to start developing vaccine candidates with leading researchers in Australia, New Zealand, Europe and the USA.

avalia immunotherapies

MEDICINAL PLANTS

New Zealand offers many advantages for the production of medicinal plants in the pharmaceutical and consumer health industry. These include a favourable climate and counter seasonal production benefits, risk diversification and experienced growers with well developed relationships with agricultural research organisations. New Zealand growing conditions often result in an increased amount of active ingredients and lower levels of residues that can otherwise be difficult to remove from end products.

For example, medicinal cannabis is projected to be worth US$97 billion by 2026 and is growing at a compound annual growth rate of 33 percent.[64] Following a 2019 law change, the Medicinal Cannabis Scheme came into effect which enables licensed businesses and individuals to cultivate, export, possess and supply medicinal cannabis products in New Zealand. New Zealand's Ministry of Health anticipates that the New Zealand market for medicinal cannabis will move more swiftly than other markets following similar changes in law.

BIOMEDICAL SCIENCE AND DRUG DISCOVERY

The pharmaceutical industry's profitability depends on identifying and successfully developing new drug candidates while trying to contain the increasing costs of drug development. The industry is actively searching for new sources of innovative compounds and for mechanisms to reduce development costs. As a result, the industry is moving away from its traditional in-house or closed method of drug development. The new, more open approach to drug development involves alliances and partnerships with smaller companies and academic groups to gain access to innovative compounds and complementary expertise.

New Zealand has a number of key opinion leaders in life sciences, as discussed in a previous BioTechNZ report,[65] who are specialists in precision medicine, cancer, respiratory medicine, diabetes, epigenetics and more. With this expertise and a strong science system, New Zealand is well placed to create international partnership for drug discovery.

64 Cannabis/Marijuana Market Size, Share and Industry Analysis and Forecast, 2019-2026, Fortune Business Insights, 2019.

65 New Zealand Life Sciences Key Opinion Leaders, BioTechNZ, 2019.

This market was worth US$55 billion in 2017 and is forecast to be worth US$88 billion by 2022.[66]

GENOMICS

Genomic information is being infused into medical practice. Subsequently, genomics is emerging as one of the main sources of data across many disciplines of medicine and healthcare. Genomics personalised health is growing because of rising competition in the biopharmaceutical and healthcare industries. The global genomics personalised health market is projected to be worth US$95 billion by 2026.[67] The prevalence of cancer, increasing geriatric population, healthcare in developing economies are the other drivers for genomics personalised health.

HUMAN CLINICAL TRIALS

Clinical trials are an integral part of the research and development of new medical treatments, interventions or tests, and the refinement of existing standards of care and clinical practices. As such, they are vital to the future of healthcare. The global market for clinical

Real Time Genomics – Extracting Knowledge From Raw Genomic Data

Real Time Genomics is a private company based in Hamilton, New Zealand, with representatives in San Francisco. The firm has deep computational expertise in algorithms, coupled with extensive product development capabilities and a commercial team with over 100 years of success in bringing genomics' innovation to the life sciences industry. Their vision is to be the analytics engine of genomics, transitioning clinicians, researchers and applied scientists from data analysts into practitioners of timely, accurate biology.

At the heart of their technology architecture is a patented pattern search technology that enables accurate mapping and alignment of next generation sequencing (NGS) data with a unique combination of speed and sensitivity. From there, application specific pipelines deliver results that combine accuracy and speed to provide unparalleled value to researchers and clinicians.

rtg REALTIME GENOMICS™

66 Drug Discovery Technologies, BBC Research, 2018.

67 Global Genomics Personalized Health Market Size, Status and Forecast 2020-2026, QY Research, 2020.

Pharmaceutical Solutions – Trusted Clinical Trial Partners

Pharmaceutical Solutions is considered one of the leading Contract Research Organisations (CRO) in the Australian and New Zealand region.

They provide full-service clinical research and regulatory management for global and local biopharmaceutical clients; from study startup, through to trial completion, for all phases of clinical trials.

Pharmaceutical Solutions strives to work collaboratively with network partners and clients, to consistently deliver rapid recruitment and quality clinical trial results.

Pharmaceutical Solutions
Dedicated to Excellence in Clinical Research

trials has been estimated to be worth US$47 billion in 2019.[68] New Zealand's small domestic market makes it an ideal test market for new biotech products.

New Zealand has a robust clinical trial environment. This consists of an efficient ethics and regulatory framework which enables faster startups, high quality research facilities, a diverse participant recruitment pool, access to pharmacologically naïve patients, well respected physicians and hospitals, and high rates of the ability to recruit ethnically diverse populations.

68 Clinical Trials Market Size, Share & Trends Analysis Report, 2020-2027, Grand View Research, 2020.

Biotechnology for a Low-emission Future

New Zealand is part of the international response to address the impacts of climate change and to limit the rise in global temperature, requiring a transition to a low carbon and climate resilient development pathway.

To make the transition, businesses will need to take decisive action and make numerous changes. Technological advances will be required to meet this challenge and biotechnology plays an important role. Forty-eight percent of New Zealand's greenhouse gas emissions come from agriculture. New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) a joint programme with the Pastoral Greenhouse Gas Research Consortium (PGgRc) is using biotechnology tools to reduce emissions by directly targeting the methane producing methanogens through the discovery of small molecule inhibitors and vaccines and indirectly through feeding and changes in animal phenotype. At least 60% of New Zealand's high-producing grasslands – the research involves identifying and prioritising plant traits for low GHG emissions; mitigation practices to maintain soil carbon and reduce nitrous oxide emissions at paddock scale; and defining the achievable soil C stabilisation capacity of New Zealand grassland soils. AgResearch's development of a new-generation grass is making steady progress, conducting field trials of the genetically modified High Metabolisable Energy (HME) ryegrass, that strikes a balance between reductions in greenhouse gas emissions, greater tolerance to drought and farm productivity. A published paper 2020 "Elevation of Condensed Tannins in the Leaves of Ta-MYB14-1 White Clover (Trifolium repens L.) Outcrossed with High Anthocyanin Lines" out of AgResearch, uses genetic transformation to increase the levels of condensed tannins (CT) as they are highly desirable in forage as they sequester dietary protein and reduce bloat and methane emissions in ruminants. The OECD has calculated that the full climate change mitigation potential of biotechnology processes and biobased products ranges from between one billion and 2.5 billion tons CO2 equivalent per year by 2030.[69]

If for no other reason, biotechnology will be critical technology for New Zealand's future.

BIOTECHNOLOGY PROCESSES WILL REDUCE CO_2 BY UP TO

$2.5 billion tons

PER YEAR BY 2030

OECD2011

69 Industrial Biotechnology and Climate Change, Opportunity and Challenges, OECD, 2011.

Underpinning New Zealand's Bioeconomy

The Bioeconomy and Biotechnology Sector

The bioeconomy is the part of the economy that uses renewable biological resources from land and sea – such as crops, forests, fish, animals and microorganisms to produce food, materials and bioenergy. The biotechnology sector is focused on improving the technology and processes which drive the bioeconomy. As such, biotechnology is the critical underpinning technology for New Zealand's bioeconomy.

GROWING IMPORTANCE OF THE BIOECONOMY

A growing desire to tackle a range of global challenges such as climate change, food security, health challenges and energy security is driving a global trend of measuring the bioeconomy. The bioeconomy is also seen as a source of innovation emerging from research and development in biology and engineering which could lower emissions and overtake fossil resource driven processes and products with a variety of biotechnologies and innovations.

MEASURING THE BIOECONOMY

Definitions and measurement of the bioeconomy are still in their infancy and there are challenges in settling on a widely accepted approach. Currently, some approaches overlap and cover the same sectors of the economy while others seek to capture elements of sectors where biomass is only part of the economic activity. Because of this, the definition of the bioeconomy has evolved with time.

New Zealand's Bioeconomy

While the growth of the biotechnology sector in its own right has been identified as a significant economic opportunity for New Zealand, there is also a multiplier effect that biotechnology has across the New Zealand bioeconomy. Therefore this research project has set out to better understand the scale and importance of the bioeconomy for New Zealand.

Sapere Research, an economic consultancy, undertook to estimate the size of the New Zealand bioeconomy based on a recent European Commission Joint Research Centre technical report. The methodology from this European work provided Sapere with a model to extrapolate and estimate the size of New Zealand's bioeconomy. Details of the methodology and approach can be found in the appendix.

NEW ZEALAND BIOECONOMY WORTH

$49.4 billion

This estimate points to New Zealand's bioeconomy being in the order of 19 percent of GDP or $49.4 billion. Given the range of approaches available, it is possible to estimate New Zealand's bioeconomy in other ways and reach lower values. However, the input and output-based bio-based weights method used in the technical report is likely to provide a better estimate of the value added from the bioeconomy as it is likely to better map the flows of biomass through different sectors of the economy.

These estimates of New Zealand's bioeconomy could be improved by applying New Zealand derived input and output-based bio-based weights to New Zealand's annual contribution to gross domestic product by industry and other economic data. This could be the focus for future investigation. Such further work would also benefit from the finalisation of further work currently being done by the European Commission Joint Research Centre team.

"Bring on New Zealand. The country's isolation has suddenly gone from historic disadvantage to unique selling point."

THE FINANCIAL TIMES, 30 APRIL, 2020.

Part Three:

Boosting New Zealand with Biotechnology


57

Opportunities and Challenges

There is no argument that New Zealand, along with the rest of the world, faces extraordinary global environmental and health challenges. In almost all cases, biotechnology will be used to solve these problems.

Global and Local Challenges Creating Opportunity

On average, people are living longer, busier lives with poorer diets and less exercise. This is leading to increasing rates of diseases and health conditions including cancer, diabetes, dementia, heart disease and obesity. Environmentally, the way New Zealanders live and make a living, is having a serious impact on our natural surroundings. A recent report jointly published by the Ministry for the Environment and Statistics New Zealand[70] identified nine environmental priority issues, including polluted waterways, native ecosystems under threat, the way we fish and use the ocean, greenhouse gas emissions and climate change effects.

However, there are also opportunities. As the global population continues to grow, so does demand for food. Balancing an increasing output of high quality, healthy food with minimal environmental impact will be attractive to a global market concerned about food provenance. Demand for less waste, reduced pollution and cleaner, healthier environments will require radical new technologies and processes.

Globally, biotechnology is playing a crucial role in helping to develop solutions to these and similar challenges.

"New Zealand is known for its innovation. It is the perfect laboratory in which to introduce new biotechnologies to solve big global problems. If we distance ourselves from the biotechnology market, it will be our economic downfall."

QUOTED IN PUBLIC UNDERSTANDING OF BIOTECHNOLOGY IN NZ, LINCOLN UNIVERSITY

New Zealand's small, world class biotechnology sector, will be able to deploy research and biosciences to help address these issues. As we have seen in the previous section of this report, New Zealand has the research capabilities and innovative companies, so what needs to be done to create a better environment for success?

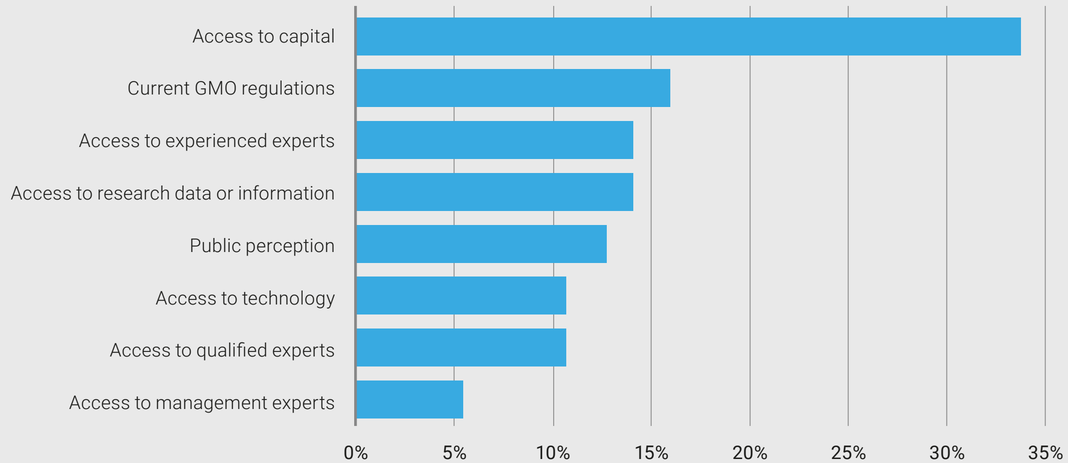
Capital and Regulation Constraints

The 2020 biotechnology sector survey identified a number of constraints impacting on local biotechnology firms. Access to capital was considered by far the most significant constraint for both research and commercialisation activities.

As shown in Figure 5, as well as capital constraints, the current GMO regulations, access to experts with enough experience and access to research data are also considered significant constraints for biotechnology research and development (R&D) in New Zealand.

70 Environment Aotearoa 2019, Ministry of the Environment and Statistics New Zealand, 2019.

FIGURE 5: CONSTRAINTS TO BIOTECHNOLOGY R&D IN NEW ZEALAND



Source: New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.

The Challenges of High Risk Innovation

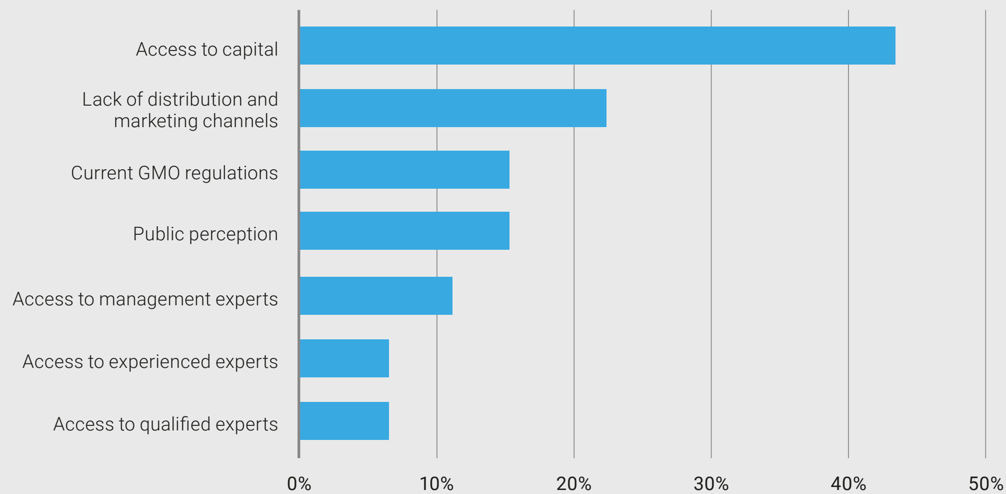
Companies developing bio-based technologies and products encounter significant challenges primarily due to the greater degree of risk, higher level of uncertainty and longer time frames required.

The 2020 Biotechnology Sector Survey found that for organisations trying to grow and commercialise, access to capital is a constraint for almost half (44 percent) of firms. Distance from markets and the difficulties with distribution and marketing channels were also identified as constraints.

These challenges mean there is an even greater need for the Government to support the latter stages of the commercial development and change in policy to support adoption of bioproducts, as well as various forms of networks, such as user-producer relationships, strategic alliances, R&D consortia and collaborative training and marketing schemes.

While New Zealand Government agencies currently engage in these areas in various ways, bio-based

FIGURE 6: CONSTRAINTS TO BIOTECHNOLOGY COMMERCIALISATION IN NEW ZEALAND



Source: New Zealand Biotechnology Sector Survey, BioTechNZ, 2020.

innovation requires longer, more coordinated, inter-agency support. New Zealand will certainly benefit from a national bioeconomy strategy, encompassing bio-based innovation. Biotechnology should also be included as an enabler within each of the Government's Industry Transformation Plans (ITP). For example, agri-bio will play a crucial role in the transformation of the New Zealand agri-sector and should be included in the Agritech ITP. Likewise, the Manufacturing ITP must include bio-manufacturing opportunities.

The Need for Better Global Connectedness

The market for competitive life science innovation is geographically dispersed. This requires multinational corporations to search, recognise, and acquire opportunities outside the geographic footprint of existing subsidiary networks.

Unfortunately, CRI's are funded to look at New Zealand problems and not global problems, which immediately reduces opportunity for partnering and commercialisation. Multinational firms require innovation opportunities to be positively differentiated relative to the global market, while scientific labour in New Zealand is often focused on addressing local problems.

There also appears to be a lack of self-awareness relative to the global market. Survey respondents perceived low numbers of commercially aware researchers and scientists leading commercial development, subsequent over-perception of the readiness, risk and value of early stage innovation and early-stage bottleneck from limited funding. Key elements of the existing innovation and investment environment including insufficient incentives for entrepreneurship in life science are perceived as barriers to the availability of attractive opportunities.

Better global connectedness from both a research and entrepreneurial perspective is needed to improve opportunities for commercial success.

Recommendations

As shown throughout this report, there is increasing global demand across the biotechnology spectrum for solutions to health, agri-food and environmental challenges. This is presenting New Zealand with multiple economic opportunities. Added to this, is the role that biotechnology plays in enabling and growing New Zealand's critical bioeconomy. In addressing these challenges it is clear how important a thriving biotechnology sector is for our future.

Our research and analysis has identified a number of barriers that need to be overcome to enable the growth of the New Zealand biotechnology market. The following recommendations are made with a view to collaboration by the biotechnology sector and the Government.

1 Create a Coordinated New Zealand Biotechnology Strategy

RECOMMENDATIONS

Create a national biotechnology strategy, aligning and connecting policy and investment across bioeconomy, environmental policy and health.

Biotechnology cuts across multiple sectors and Government agencies, creating significant differences requiring specific focus. Additionally, there has been limited understanding of biotechnology, with both GMO and non-GMO technology having a significant impact on the New Zealand economy. However, common challenges are also experienced by early stage biotechnology companies, regardless of the sector they are operating in. In many ways, biotechnology faces similar challenges in coordination and growth as digital technology. Therefore, it is recommended that a process similar to the development of the Industry Transformation Plan (ITP) is used. It is recommended multiple Government agencies collaborate and partner with industry, to develop a framework, shared vision and plan with multiple workstreams.

Develop a high level bioeconomy plan for New Zealand.

Given the bioeconomy accounts for almost a quarter of the New Zealand economy, it is recommended that a deeper analysis of its scale and component parts is undertaken. As identified in research by Scion and Lincoln University, to enable New Zealand to realise the potential opportunity the bioeconomy offers, a more integrated and cohesive primary sector model will be required that goes beyond the existing (livestock and primary production based) regime towards supporting and developing new niche production sectors, based on a clear vision jointly conceived with wider society.[71] With biotechnology underpinning the development of New Zealand's bioeconomy, such a plan would form a natural pillar to any biotechnology strategy.

Re-introduce measurement of the biotechnology sector.

Biotechnology is an important foundation across multiple sectors of New Zealand's economy. It has also been identified as a critical component of our response to growing environmental and health challenges. However, biotechnology is not measurable using traditional Government statistical processes. The primary sector is a key part of the Māori economy and Iwi and hapū organisations are, en masse, developing strategies and business plans to shape their next 10, 20, 50, 100 years of growth. This report has shown biotech is key to the primary sector and it is recommended that the Government resumes the semi-annual Bioscience Survey that was discontinued in 2011. It also recommends ensuring data on Māori participation is captured. This information will assist the formation of policies and investments that support bioscience business activity.

71 Enabling a transformation to a bioeconomy in New Zealand, Environmental Innovation and Societal Transitions Volume 31, June 2019, Pages 184-199.

2

Increase the Visibility of Biotechnology in New Zealand

RECOMMENDATIONS

Identify, track and profile biotechnology organisations

To address challenges in attracting talent, capital or international partners it is essential we collectively raise the profile of biotechnology in New Zealand. Evidence from the digital technology sector shows that tracking and reporting on the successes of the top 100 firms creates momentum within the sector, helps the sector to coordinate with the Government and attracts international capital. It is recommended that the industry and Government partner on an annual TIN100 Biotechnology Report.

Showcase New Zealand biotechnology to the public and the world

To support the growth of the biotechnology sector and encourage its use and uptake, we need to increase awareness of the positive impact that biotechnology is having on the economy and environment. A strong visible biotechnology sector will also attract international interest including investment opportunities, international R&D partnerships and international talent. It is recommended that industry and Government partner on developing shared key messages. This messaging can be used by biotechnology organisations and Government agencies to share the New Zealand biotechnology story.

3

Establish New Approaches to Support Commercialisation and Scale-up

RECOMMENDATIONS

Better expose IP developed by Crown Research Institutes and Universities

Through New Zealand's Crown Research Institutes and Universities, taxpayers make significant investment in biotechnology research. However, this investment is not resulting in the creation of new companies or product spinouts. This issue was also identified in the Government's Agritech Industry Transformation Plan (ITP). Urgent work is required to ensure our world-class research is well utilised. The Government's draft Research, Science and Innovation strategy proposes to develop a world class research commercialisation system, ensuring knowledge is able to flow easily in domestic and international markets. As noted in the Agritech ITP, part of this will require a better visibility of others' work to encourage collaboration and avoid duplication, and improving mechanisms for companies to access existing infrastructure and equipment within the universities and crown research institutes.

Currently, there is IP in research institutes that has the potential for commercial value. This IP may not have been commercialised due to a number of reasons including undervaluing or overvaluing the IP; lack of effective mechanisms for researchers to transition into and/or back out of a new business; lack of effective commercialisation partners and/or business models. The Commercialisation Partner Network's current work must be prioritised to accelerate the value extraction from already available IP.

Invest in a bio-pilot plant

Many regional towns throughout New Zealand are dependent on pulp and paper mills, in an industry that is struggling globally. However, high value products such as fine chemicals, polymers and biofuels can now be derived from bark and other biomass. Potentially, these biotechnology breakthroughs could revive regional New Zealand, offering substantial economic opportunity. A major barrier is the lack of pilot plants to technically de-risk, prove at scale and interest investors. For example, The FoodBowl, operated by the Government supported Food Innovation Network, provides the food sector an open access facility for trials and scale up. We recommend an equivalent open access bio-pilot facility is established to take advantage of abundant forestry biomass and horticultural waste including kiwifruit and avocado prunings.

Develop a specialist biotech fund

Biotechnology investors are usually specialist investors that understand the demand for higher investment levels, longer time frames and higher risk. Globally, in 2019, over 50 percent of all Series A investments in biotechnology startups came from USA or European specialist biotechnology venture capital firms.[72] In New Zealand, there is no specialisation in Government supported investment schemes. It is recommended that a partnership is developed with an international specialist biotechnology fund via the New Zealand Growth Capital Partners Elevate fund.

4

Drive Change in New Zealand's Approach to Genetics

RECOMMENDATIONS

Increase public discussion and understanding

Greater public discussion will lead to better understanding of genetic modification, safety issues and its practical applications. From a technical point of view, gene editing is a recent addition to the modern biotechnology toolbox, and requires new discussions. Conducting the discussion from the Kaitiakitanga (guardianship) perspective is recommended, as is active engagement with Māori, as we explore how to fully benefit from these new technologies. We need to develop our perspective on how these new technologies should be used, to help meet our aspirations in horticulture and agriculture, protecting our environment, preserving our Taonga (endangered native plants and animals) and addressing human health issues.

The fact base should be supported by an awareness raising campaign focused on the practical application, benefits and risk of different types of genetic modification. Fuelled by facts and not fake news, discussion can then explore the acceptability of various types of genetic modifications and their applications.

Undertake a review of regulations

As public awareness increases and discussion progresses, a review of relevant New Zealand legislation will be required. It is recommended that the Government begins an independent review of the current regulatory regime taking into account modern techniques, safety, evolving public sentiment and relevant applications across health, environmental and food production.

72 Top biotech venture capital funds of 2018, 2019 and 2020, Bay Bridge Bio, Feb 2020.

5

Explore Indigenous and Diverse Knowledge, to Unlock the Potential to Contribute to Economic Growth

RECOMMENDATIONS

Foster connections between Māori, Government, industry and the science system create sustainable outcomes for our people, land and sea.

Creating stronger working relationships with Mātauranga Māori (knowledge), community based knowledge and modern science, will enable us create new added value products. Numerous opportunities exist across all aspects of biotechnology. To provide education that best fits the aspirations of this generation, understand WAI-262 claim on indigenous flora and fauna and Māori cultural and intellectual property rights, to enhance the dreams of future generations. For example, natural health products inspired by traditional Māori herbal remedies and supported by scientific research, creating new Māori businesses and new medicinal health products.

Improve access for diverse communities to business skills programmes to help entrepreneurs build their biotechnology startups.

Access to diverse management expertise was identified as a major constraint. It is recognised that biotechnology company founders are often scientists, with little entrepreneurial experience. The industry is also faced with a lack of female and ethnically diverse leadership at senior levels. It is recommended that an organisation, like Callaghan Innovation, is funded to support research development, commercialisation and management programmes with a focus on women and Māori, to create impactful science leaders. For example, The Institute for Innovation in Biotechnology, The University of Auckland in conjunction with biotechnology incubators (Brandon Capital, Bridgewest Ventures, Sprout). Specific shared working spaces (for example, Level Two in Auckland) may also increase experience sharing, knowledge exchange of commercial experience and research experience.

"Māori entrepreneurs have long been looking for ways to create socially sustainable businesses," Kōkiri business accelerator.

While these recommendations have been distilled from our research, additional ideas will be developed as the sector strengthens its collaborations. Representing the rapidly growing biotechnology ecosystem, BioTechNZ plans to continue working with the Government to ensure New Zealand is boosted by biotechnology and innovates for a sustainable future.

The Research Team

BioTech New Zealand

BioTech New Zealand (BioTechNZ) is a purpose driven not-for-profit, non-governmental organisation (NGO) that is funded by members. BioTechNZ brings together the historical biotechnology association, NZBIO, within the supporting framework of the New Zealand Tech Alliance. BioTechNZ members are a passionate community underpinned by science and technology, joining to solve some of the world's agricultural, environmental and health issues.

BioTechNZ aims to raise awareness and increase understanding, to enable our nation to embrace the best opportunities biotech offers to us daily, helping us live better, healthier and more productive lives

BioTech New Zealand collated, analysed and edited the research.

NZTech

NZTech is the voice of the New Zealand technology sector. NZTech represents over 1,000 organisations across the technology landscape in New Zealand, from startups and local tech firms to multinationals, and from ICT to high tech manufacturing. NZTech's goal is to stimulate an environment where technology provides important productivity and economic benefits for New Zealand.

NZTech provided analysis, peer review and design for this study and report.

BioPacific Partners

BioPacific Partners is a consultancy firm embedded in Australia and New Zealand across health (pharma, consumer health, animal health, medical devices), food, FMCG and agricultural industries. BioPacific Partners provide critical insight into the Australian and New Zealand innovation community, with a strong track record in search and evaluation, business development, and deal making.

BioPacific Partners conducted the analysis of competitive advantages and the health sector analysis.

Sapere Research Group

Sapere Research Group is one of the largest expert services firms in Australasia. Sapere provides independent expert testimony, strategic advisory services, data analytics and other advice to Australasia's private sector corporate clients, major law firms, government agencies and regulatory bodies.

Sapere conducted economic analysis research.

Research Methodology

New Zealand Biotechnology Sector Survey 2020

QUESTION STRUCTURE AND DEFINITIONS

The 2020 New Zealand Biotechnology Sector Survey conducted by BioTechNZ, was designed using the 2011 Statistics New Zealand Bioscience Survey questions and definitions as a template. Statistics New Zealand assisted in the process of designing additional survey questions as required.

The Statistics New Zealand Bioscience Surveys in 2009 and 2011 defined the use, spread, and application of bioscience in New Zealand. The survey used the Organisation for Economic Co-operation and Development's (OECD) definition of biotechnology[73] which includes:

- DNA – the coding: genomics, pharmaco-genetics, gene probes, DNA sequencing/synthesis/amplification, genetic engineering.
- Proteins and molecules – the functional blocks: protein/peptide sequencing/synthesis, lipid/protein glyco-engineering, proteomics, hormones and growth factors, cell receptors/signaling/pheromones.
- Cell and tissue culture, and engineering - cell/tissue culture, tissue engineering, hybridisation, cellular fusion, vaccine/immune stimulants, embryo manipulation.
- Process biotechnologies - bioreactors, fermentation, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation, and biofiltration.
- DNA and RNA vectors: gene therapy, viral vectors.
- Other: bioinformatics, nanobiotechnologies, other.

The OECD defines biotechnology as 'the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services'.

SURVEY RESPONSE RATE

The 2020 New Zealand Biotechnology Sector Survey was conducted during February and March 2020. It was promoted via the BioTechNZ newsletter and social media channels. Follow up phone calls were made to companies to encourage responses.

Ninety four companies responded, 58 of those companies identified as being a biotechnology company and 43 companies identified themselves as a supporting service to the biotechnology sector.

Due to the diverse nature of departments across some of the larger organisations, if more than one person completed the survey per company, these comments were compiled as a single company view.

The New Zealand Biotech Ecosystem Mapping Project

BioTechNZ identified and compiled the list of biotechnology companies in New Zealand from multiple sources, including:

1) Internet search for international companies in New Zealand and New Zealand companies.
2) BioTechNZ membership.
3) AgriTechNZ membership.
4) Callaghan Innovation Scale-up.
5) Tin 100/200 companies.
6) New Zealand Trade and Enterprise (NZTE) customers.
7) Other associations – Bioenergy, Natural Health Products.
8) The Medical Technology Association of New Zealand (MTANZ).
9) Discussions with Crown Research Institutes (CRIs) to identify companies.
10) University departments that have an interest in biotechnology identify companies.

A total of 211 biotechnology organisations were identified, including 71 agriculture and marine companies, 21 environmental and industrial companies, 74 human health companies and 45 nutraceutical and functional food biotechnology companies.

73 A Framework for Biotechnology Statistics, OECD, 2005.

An additional 112 organisations providing biotech support services were also identified. This excludes companies such as insurance, banks, real estate and other general business support which were considered out of scope.

The infographic will be regularly updated as new organisations are identified.

Estimating New Zealand's Bioeconomy

This part of the research was undertaken by Sapere Research, an economic consultancy.

DEFINITIONS

There are a variety of ways of defining and measuring the bioeconomy. One example suggests:

"The bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and microorganisms – to produce food, materials and bioenergy."[74]

Another general definition of the bioeconomy is:

"The bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy. It includes agriculture, forestry, fisheries, food, and pulp and paper production, as well as parts of the chemical, biotechnological, and energy industries."[75]

Many of the definitions and measurement approaches overlap sectors for example agriculture, forestry and fishing. Others also seek to capture elements of sectors where it is more challenging to measure the extent to which biomass is part of the economic activity. Because of this, the definition of the bioeconomy has evolved with time. However, for measurement of the bioeconomy to be useful it is important to know where the bioeconomy starts and where it ends. In many respects, measurement of the bioeconomy is still in its infancy and faces a number of methodological challenges.[76]

The European Commission published a Bioeconomy Strategy in 2012 and refreshed it in 2017. In addition, many European countries have their own bioeconomy strategies with a strong focus on sustainability. The EU's 2018 definition, Finland's definition and a recent Food and Agriculture Organisation (FAO) of the United Nation's report[77] include sentiments about achieving 'sustainable development'. However, a recent European Commission Joint Research Centre (EC JRC) technical report, *How big is the bioeconomy? Reflections from an economic perspective*[78] explained that activities included in the bioeconomy are not always conducted on a sustainable basis. For example, clear felling in forestry or overfishing, as well as nutrient leaching into freshwater and greenhouse gas emissions that can result from intensive agriculture. It also commented that final products of the bioeconomy include alcoholic beverages and tobacco, which cause poor health outcomes.

APPROACHES

A range of methods have been used to estimate the size of countries' bioeconomies. These methods are well canvassed in the EC JRC technical report and covered in the FAO report. The EC JRC technical report stated that commonly, a country's bioeconomy is estimated by adding up all industries that make up the bioeconomy, using sectoral economic data such as GDP data. However, the level of bioeconomy assumed for each industry can vary by country due to different bioeconomy definitions.

74 European Bioeconomy in Figures 2008–2017, nova-Institute for Ecology and Innovation, Olaf Porc, Nicolas Hark, Michael Carus, Lara Dammer (nova-Institut), Dr. Dirk Carrez (BIC), September 2020, Page 4.

75 https://www.nap.edu/read/25525/chapter/5#:~:text=%E2%80%9CThe%20bioeconomy%20encompasses%20the%20production,%2C%20biotechnological%2C%20and%20energy%20industries.

76 Measuring the Bioeconomy: Economics and Policies Annual Review of Resource Economics, Justus Wesseler and Joachim von Braun, Vol. 9:275-298 (Volume publication date October 2017).

77 Bracco, S., Tani, A., Çalıcıoğlu, Ö., Gomez San Juan, M. & Bogdanski, A. 2019. Indicators to monitor and evaluate the sustainability of bioeconomy. Overview and a proposed way forward. Rome, FAO.

78 Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., How Big is the Bioeconomy? Reflections from an economic perspective. EUR 30167 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17858-3, doi:10.2760/144526, JRC120324.

This makes cross-country comparisons challenging. For example, agriculture, forestry, fisheries/aquaculture and the food industry are usually assumed to be 100 percent bioeconomy sectors. Renewable energies/biofuel and the chemical industry can be fully or partially assumed to be part of the bioeconomy. Construction can be fully included, or not included at all, depending on the approach taken by each country.[79]

Despite the common assumption that the agricultural sector, for example, is a 100 percent bioeconomy sector, the key issue is that no sector is purely bio-based and all industries use bio-based materials to some extent in their production process, or as ingredients to the final products. The challenge is to quantify each sector's relative contribution to the bioeconomy. The approach taken in the EC JRC technical report to solve this challenge was to split the economy into six sectors, three bio-based and three not. The bio based sectors were:

- The **primary bio based sector** in which bio based materials from nature are extracted, collected and cultivated to be mainly used as raw materials. It noted that this sector is the one that interacts with the biological processes of nature. It includes crop and animal production, hunting and related service activities, forestry and logging, and fishing and aquaculture.
- The **secondary bio based sector** manufactures goods using bio based raw materials during the production process or as ingredients of the final products. These industries include manufacturing food, beverages, tobacco, textiles, wearing apparel, footwear, wood and cork, pulp, paper and paperboard. However, only portions of these industries are bio based so they are dubbed 'mixed bio based industries'.
- The **tertiary bio based sector** encompassed refining manufactured bio based products such as use of wood in building and construction and services to help final consumption of the bio based goods such as trade and transportation of bio based products. Some activities work across sectors. For example, restaurants which buy inputs from both primary production (fresh fish from fisheries and aquaculture) and secondary production (food manufacturing industry). So, parts of restaurants' activities are based on the primary bioproducts, while other parts are based on secondary bio based products.

MEASUREMENT FOCUS

The EC JRC technical report explained that the indicators most commonly used to monitor the impact of national bioeconomy strategies and to measure the sizes of bioeconomies are gross output (or sales), value added (GDP), investments, exports of bioeconomy goods and employment. It pointed out that gross output was problematic as it can double count the contribution of the bioeconomy as bio based goods move through the supply chain, for example foods and processed foods in restaurants. Despite this, gross output continued to be used by some jurisdictions. To avoid this problem value added or GDP can be used. This is because GDP, is the value generated by production activities minus the value of intermediate activities (goods and services) used in that production.

Different definitions and measurement approaches give varying estimates of the size of a country's bioeconomy. For example, the EC JRC technical report used different methods to calculate the size of Finland's bioeconomy. These were as follows:

- A two sector model using Finnish 2015 input-output tables estimated total value added at €12.3 billion, which was 6.8 percent of the GDP.
- Extending this approach to using three sectors and seeking to include restaurants and retail trade of food increased the estimate of Finland's bioeconomy to €16.7 billion or 9.2 percent of the GDP.
- Finally, including all adjustments discussed in the EC JRC technical report increased the economic size of Finland's bioeconomy to €23.6 billion or 13.1 percent of the GDP.[80]

The report also tackled other measurement issues, including the level of contributions of other industries to the primary production of biomaterials, which many

79 Ibid, Page 7, Table 2.

80 Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., How Big is the Bioeconomy? Reflections from an economic perspective. EUR 30167 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17858-3, doi:10.2760/144526, JRC120324, Page 30.

methods assume is 100 percent. Not all inputs into the primary bio based sector are biomass, for example, fuel. The EC JRC technical report calculated the bio based input shares for Finland's agriculture at 39.7 percent, forestry at 59.5 percent and fishing at 63.6 percent. So, the bio based shares of the inputs and outputs of an industry can differ greatly. The EC JRC technical report proposed to take into account the bio based content in both inputs and the outputs by using a weighted average of those inputs and outputs for each sector. It also addressed adjustments to capture the biomass shares caused by agricultural subsidies, the wholesale and retail trade, sewerage and waste management, and sports and recreational services.

HOW BIG MIGHT NEW ZEALAND'S BIOECONOMY BE?

The EC JRC technical report highlights the challenges in estimating the bioeconomy of countries and the divergent values that can be calculated using different methods. However, the logic of its approach, which is focused on using a weighted average input and output based weights for each sector of the economy, is compelling. This is because it seeks to more accurately measure the actual flows of biomass through the value chains of the sectors that make up an economy and it addresses several issues which could cause material underestimates and overestimates of the bioeconomy.

It is possible to use the data provided by the EC JRC team to extrapolate approximations of the size of New Zealand's bioeconomy. To do this, it is necessary to assume that New Zealand's economy is structurally similar to those investigated by the EC JRC team. Of course, there will be differences between the economies of the EU countries and New Zealand's economy. However, using the sectorial bio based shares of EU economies can provide a ballpark size of New Zealand's bioeconomy.

To avoid double counting, it is best to focus on value added, so Statistics New Zealand's estimates of the contribution to gross domestic product by industry is used. These are the national accounts (industry production and investment) for the year ended March 2018, drawn from economic indicators of the National Accounts – SNA 2008 – SNE.

Another challenge is that the EU and New Zealand use different, but aligned systems of national accounts. The EU uses the statistical classification of economic activities in the European Community (NACE) while New Zealand uses ANZSIC (the Australian and New Zealand Standard Industrial Classification). ANZSIC was developed for the production and analysis of industry statistics in both countries. Helpfully, ANZSIC places a lot of emphasis on aligning with the international standards. The International Standard Industrial Classification of All Economic Activities ISIC Rev. 3 has been used around the world as the international standard for reference purposes. ANZSIC is much closer to ISIC/NACE used by the EU than NAICS (North American Industry Classification System) as its structure broadly follows ISIC. Because of this, conversion of ANZSIC data into ISIC/NACE is possible at a fairly detailed level.[81] However, because the data used in this report is aggregated at a high level, ANZSIC and NACE data is aligned at this level.

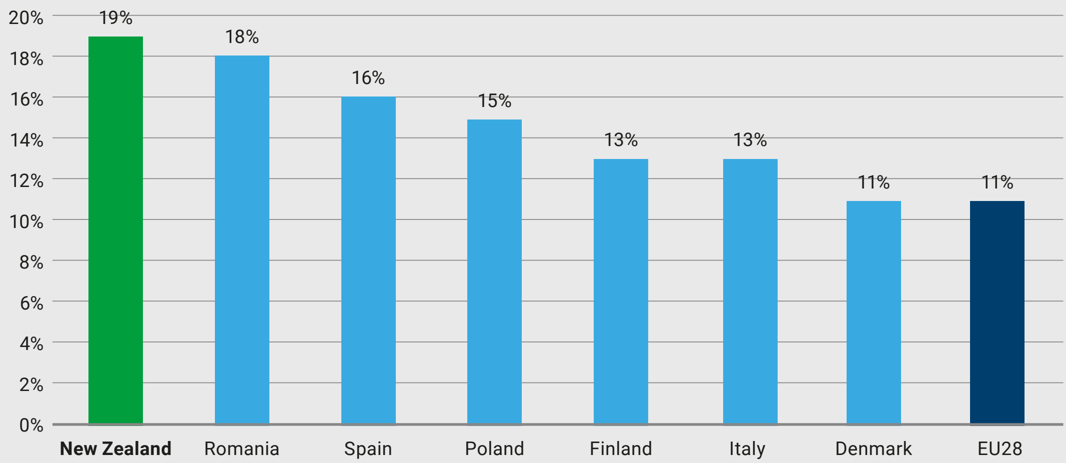
ESTIMATE BASED ON FINLAND'S WEIGHTED AVERAGE INPUT AND OUTPUT BIO BASED WEIGHTS

The EC JRC technical report used its adjusted weighted average input and output bio based shares to calculate the value added from the bioeconomies of Denmark, Finland, Italy, Poland, Romania and Spain and the EU-28. The EC JRC team applied all its recommended adjustments to propose, probably the most accurate estimate for these. For example, it estimated Finland's bioeconomy at €23.6 billion or 13.1 percent of the GDP in 2015 as shown in Figure 6 below.

The weighted average input and output based bio based weights for each sector of these economies used by the EC JRC team are not yet available. However, the EC JRC report did provide these bio-based weights for many of the most relevant sectors in the Finnish economy. It

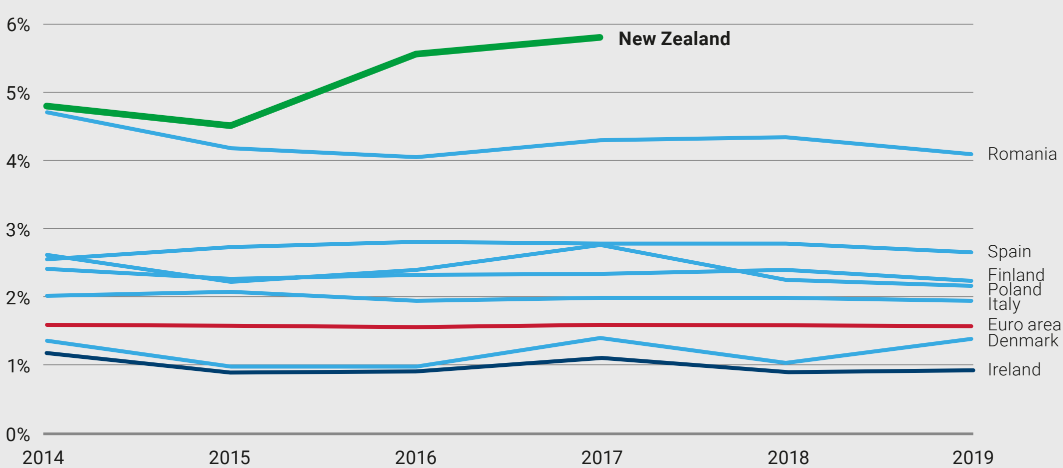
81 NACE Rev. 2, Statistical classification of economic activities in the European Community, Eurostat, Methodologies and Working papers, ISSN 1977-0375, Page 43.

FIGURE 7: BIOECONOMY PERCENTAGE SHARES



Source: The EC JRC Technical Report page 29 and Sapere calculations. Note: New Zealand's GDP data is for the year to 31 March 2018 while the EU data is for 2015.

FIGURE 8: AGRICULTURE, FORESTRY AND FISHING AS A PERCENTAGE OF GDP FOR SELECTED COUNTRIES

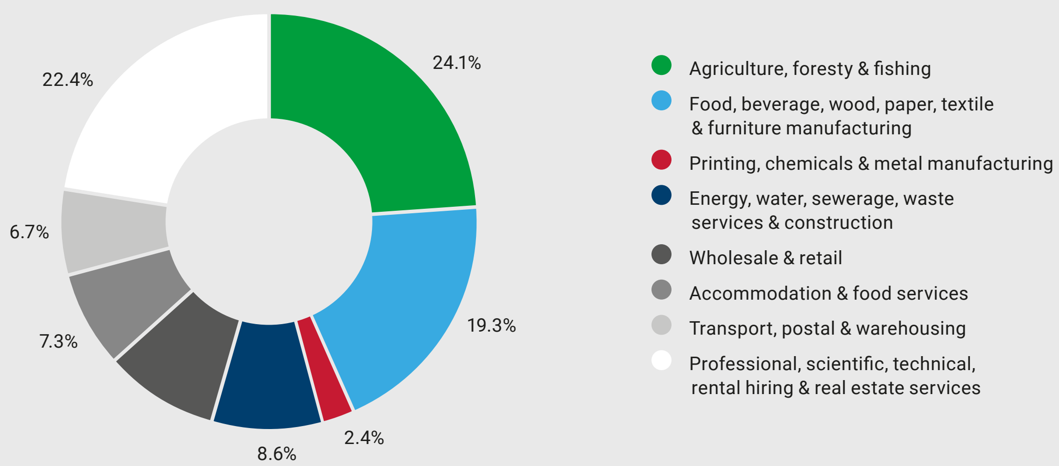


Source: World Bank data see https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS also provided bio based output weights for some other relevant secondary and tertiary bio based sectors.[82] It is possible to apply a mix of these to New Zealand's annual contribution to gross domestic product, by industry, for the year to 31 March 2018[83] and match the NACE and ANZSIC categories to calculate that New Zealand's bioeconomy could be in the order of 19 percent of GDP or $49.4 billion. This approach necessarily assumes that New Zealand's and Finland's economic structures and value chains are similar. As is clear in Figure 7 below, this estimate of the size of New Zealand's bioeconomy shown in the left hand column is high compared to the other EU countries calculated in the EC JRC technical report (the other columns in Figure 7).

While this approximation of the size of New Zealand's bioeconomy should be seen as an estimate, it appears consistent with what could reasonably be expected of New Zealand, given the importance of the primary sector to New Zealand, and the fact that the primary sector is the most important influence on the total value added from bioeconomic activities. The agriculture, forestry and fishing sectors are clearly important to New Zealand, as shown in Figure 8 below. This chart shows the percentage of GDP coming from agriculture, forestry and fishing for the same countries charted in Figure 7. The ranking of these countries in Figure 8 based, on percentage of GDP from the primary sector, is very similar to the ranking in Figure 7 based on the estimated size of the bioeconomies of these countries.

The estimate of 19 percent of GDP from New Zealand's bioeconomy breaks down as shown in Figure 9. Together, the primary sector and manufacturing based on the primary sector, account for 43 percent of New Zealand's total.

FIGURE 9: BREAKDOWN OF ESTIMATE OF NEW ZEALAND'S BIOECONOMY GDP CONTRIBUTION



Source: Sapere analysis

82 Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., How Big is the Bioeconomy? Reflections from an economic perspective. EUR 30167 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17858-3, doi:10.2760/144526, JRC120324, Page 22, Table 5.

83 Statistics New Zealand, National accounts (industry production and investment): Year ended March 2018, Table 2, Contribution to gross domestic product by industry, current prices, 1972–2018.

ESTIMATES BASED ON OUTPUT-BASED WEIGHTS ONLY

The EC JRC team supplied data which calculated the bioeconomy of EU countries using NACE Level 2 and extended an output based weight from just the main manufacturing industries to the remaining manufacturing and service industries. This was termed "extended nova-JRC shares".[84] This output based weighting approach tends to overstate the likely bioeconomy shares of sectors such as food and beverages manufacturing, where it apportions 100 percent of value added to the bioeconomy but understate other areas such as wholesale and retail where it doesn't apportion a sectorial bio-based share. However, using this approach it was also possible to extrapolate what New Zealand's bioeconomy might be worth based on the structures of all the EU economies.

This was done by using the sectorial bio based shares of these economies multiplied by New Zealand's annual contribution to gross domestic product by industry for the year to 31 March 2018, and matching up NACE and ANZSIC categories. These yielded estimates of the size of New Zealand's bioeconomy between 9 percent of GDP or $25 billion of GDP to 12 percent of GDP or $31.1 billion. However, these estimates are likely to be conservative because of difficulties matching NACE and ANZSIC sectors and the fact that the output based weighting approach doesn't capture many of the service sector categories, as well as the EC JRC technical report's adjusted input and output-based bio-based weights for Finland.

OPPORTUNITY FOR FURTHER STUDY OF THE NEW ZEALAND BIOECONOMY USING NEW ZEALAND DERIVED WEIGHTED AVERAGE INPUT AND OUTPUT BIO BASED WEIGHTS

The estimates above of the size of New Zealand's bioeconomy could be improved by applying New Zealand derived input and output based bio based weights, to New Zealand's annual contribution to gross domestic product by industry. This could be the focus for a future and more intensive investigation. Further work could also more accurately match NACE and ANZSIC categories at a more detailed level.

84 Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., How Big is the Bioeconomy? Reflections from an economic perspective. EUR 30167 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17858-3, doi:10.2760/144526, JRC120324, Page 22, Table 5.

New Zealand Biotechnology Companies

Biopharmaceutics

Biopharmaceutics or red biotechnology, is a process that utilises organisms to improve health care and help the body to fight diseases. The following tables list many of the key participants within the sector and recent major milestones.

TABLE 9: KEY PARTICIPANTS

PRIVATE SECTOR		PUBLIC SECTOR
AbbVie Advanced Biotech NZ AFT Pharmaceuticals AMGEN Anagenix ANZCO Aroa Biosurgery Argenta AstaSupreme AstraZeneca AuramerBio Ltd Avalia Immunotherapies Bayer BioCell Corporation Biogen NZ Blis Technologies Ltd Boehringer-Ingelheim Breathe Easy Therapeutics Bristol-Myers Squibb (NZ) Celgene Chitogel CuroNZ Deliveon Health Ltd Douglas Pharmaceuticals Fonterra Co-operative Group GSK Gycosyn Technologies Health Function Hi-Aspect Limited HoneyLab Janssen-Cilag (NZ) Keraplast Manufacturing KODE Biotech	Living Cell Technologies Manuka Bioscience Merck Sharp and Dohme (NZ) ltd MitoQ New Zealand Extracts Ltd. New Zealand Pharmaceuticals Novartis NZeno Pacific Edge Ltd Pfizer New Zealand Phytomed Pictor Polybatics (Massey Ventures) Quantec Revolution Fibres Ltd Roche Diagnostics NZ Silver Fern Farms Snowberry Symansis Synthase Biotech Ltd Theranostics Lab Ltd Thermo Fisher Scientific Totarol (Mende Biotech Ltd) Ubiquitome UniPharm Upstream Medical Technologies Ltd Vifor Pharma Zoetis Bridgewest Ventures Brandon Capital	Liggins Institute Malaghan Institute of Medical Research Auckland Cancer Society The University of Auckland The University of Otago Victoria University of Wellington Gillies McIndoe Research Institute Genomic Aotearoa Centre of Excellences (CoREs) • Brain Research New Zealand – Rangahau Roro Aotearoa, co-hosted by Brain Research Centre - Otago University and Centre for Brain Research - Auckland • The Dodd-Walls Centre for Photonic and Quantum Technologies, hosted by University of Otago • MacDiarmid Institute for Advanced Materials and Nanotechnology, hosted by Victoria University of Wellington • The Maurice Wilkins Centre, hosted by University of Auckland • The Medical Technologies CoRE, hosted by University of Auckland • Riddet Institute, hosted by Massey University • Te Pūnaha Matatini, hosted by University of Auckland

Source: BioTechNZ, 2020.

TABLE 10: RECENT ACHIEVEMENTS

ORGANISATION	ACHIEVEMENT
Avalia Immunotherapies, Malaghan Institute of Medical Research, University of Otago, Victoria University of Wellington, AgResearch.	Government Investment in National COVID-19 Vaccine Strategy.
Avalia Immunotherapies	Receives $100,000 in bridging funding for its vaccine project from the Ministry of Business, Innovation and Employment.
ANZCO	ANZCO completed a seven year PGP project with MPI to produce and launch Bioculture and Biotissue products from traditionally waste products from meat processing.
Aroa biosurgery	Listed on the ASX in $225m IPO.
AFT and SETEK	Memorandum of understanding (MoU) to work together in the research, development and commercialisation of medicinal cannabis products.
BioCell	Stabilitech, a UK biotechnology company developing next generation vaccines and biopharmaceuticals, went into partnership with BioCell to manufacture its oral coronavirus vaccine, OraPro-COVID-19.
HoneyLab	Licencing agreement with American company Taro Pharmaceuticals USA Inc to sell seven of its products in North America.
Pacific Edge Limited	Gained approval from USA regulators to receive reimbursement from US health insurers for its Cxbladder cancer diagnostic tests.
Pictor	Awarded $500,000 from its $25 million COVID-19 Innovation Acceleration Fund to develop tests for both COVID-19 and Mycoplasma Bovis.
Argenta	Work for nine of the top 10 animal health pharmaceutical companies in the world.
NZP	Industria Chimica Emiliana (“ICE”), a global leader, acquired New Zealand Pharmaceuticals Ltd (“NZP”).

Source: BioTechNZ, 2020.

Agri-biotechnology

Agri or green biotechnology refers to biological techniques to plants with the aim of improving the nutritional quality, quantity and production economics. The following tables list many of the key participants within the sector and recent major milestones.

TABLE 11: KEY PARTICIPANTS

PRIVATE SECTOR		PUBLIC SECTOR
A2 Milk Co Advanced Biotech NZ AgBioResearch Ltd. Agrihealth Agrimm Agriseeds Alleva Animal Health Androgenix ANZCO AQUI-S ArborGen Australia Argenta Manufacturing Ltd Asia Pacific Seeds Awatea Biotechnology Ltd Bayer New Zealand Ltd Beef and Lamb Genetics BioBrew Bioconcortia BioFab NZ Biolumic Bio-Start Biotelliga Botry-Zen Catapult Cawthron Institute Chem Laboratories Ltd Dexcel Donaghys Ecolibirium Biologicals Engender Froth Technologies Fonterra Grasslanz Technology Ltd. ICP Bio Reproduction Immune Solutions Indigo Intuit Regulatory Ltd Invetus New Zealand Ltd Lanaco	Leaft Foods Livestock Improvement Corporation Lincoln Agritech Marama Labs Mastaplex Menixis (R&D arm of Techion) Merial New Zealand Ltd. Midlands Seeds Ltd. Monsanto NZ Multiflora Laboratories New Zealand Agriseeds Ngaio Diagnostics Orbis Diagnostics Orico Otakaro Pathways Ovita Consortium ParaCo PGG Wrightson Genomics/Seeds Phamalink Extracts PharmaZen Renco Rocket Global Schering-Plough Animal Health Limited (MSD Animal Health) Silver Fern Farms South Pacific Sera Spring Sheep Milk Co. Synthase Biotech Techion Group Ltd Thompson Seeds Tree Lab, ArborGen Wine Grenade WNT Ventures Zenith Technologies Zespri	The University of Auckland The University of Otago The University of Waikato Victoria University of Wellington Massey University of New Zealand Lincoln University Auckland University of Technology (AUT) Institute of Environmental Science and Research (ESR) Manaaki Whenua -Landcare Research Plant and Food Research AgResearch Scion (Forest Research Institute) The National Institute of Water and Atmospheric Research (NIWA) Centres of Research Excellence (CoREs) • Bio-Protection Research Centre, hosted by Lincoln University • Riddet Institute, hosted by Massey University The Pastoral Greenhouse Gas Research Consortium (PGgRc)) Pastoral Genomics Consortium New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)

Source: BioTechNZ, 2020.

TABLE 12: RECENT ACHIEVEMENTS

ORGANISATION	ACHIEVEMENT
A2 Milk Company	Fonterra Brands New Zealand partnering with a2 Milk Company (A2MC).
Engender	Engender has been acquired by CRV International, a co-operative of 27,000 dairy and beef farmers and an international leader in the livestock industry.
South Pacific Sera	Working with Avalia Immunotherapies, Malaghan Institute of Medical Research, University of Otago, Victoria University of Wellington, AgResearch.
LIC + CRV	A pilot trial funded by Agricultural Greenhouse Gas Research Centre (NZAGRC) to identify a possible link between the methane cows produce and their genetics is underway in the Waikato.
AgResearch	Developed a genetically modified (GM) ryegrass known as the High Metabolisable Energy (HME) Ryegrass, which aims to strike a balance among reductions in greenhouse gas emissions, better drought tolerance and farm productivity.
Ecolibrium Biologicals	Signed a licence agreement with Beijing company CoBio to make and sell their product, "Lateral", exclusively in China.

Source: BioTechNZ, 2020.

Environmental and Industrial Biotechnology

Environmental and industrial, (white and grey biotechnology), applies microbes and enzymes, to traditional manufacturing and chemical processes to produce bio based or cleaner, more sustainable products and materials. The following tables list many of the key participants within the sector and recent major milestones.

TABLE 13: KEY PARTICIPANTS

PRIVATE SECTOR	PUBLIC SECTOR
Cawthron CH4 Global Aduro Biopolymers Lactonol. (Fonterra) BioFab Compostme Extrutec Futurity Lanaco Ligar Lignotech Development Ltd Mint Innovation Revolution Fibres Sanfords BPN Glycosyn Technologies LanzaTech	ESR (Institute of Environmental Science and Research) Manaaki Whenua - Landcare Research Plant and Food Research AgResearch NIWA (The National Institute of Water and Atmospheric Research) Scion The University of Auckland The University of Otago The University of Waikato Victoria University of Wellington Massey University of New Zealand Lincoln University Auckland University of Technology The Pastoral Greenhouse Gas Research Consortium (PGgRc) Pastoral Genomics Consortium New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)

Source: BioTechNZ, 2020.

TABLE 14: RECENT ACHIEVEMENTS

ORGANISATION	ACHIEVEMENT
Mint Innovation	Wins Most Innovative Deep Tech Solution at NZ Hi-Tech Awards 2020.
Lanzatech	Next generation fuels producer LanzaTech announced the launch of LanzaJet Inc, a company that will make sustainable aviation fuel (SAF), with the help of investors from Canada and Japan.
Futurity	Submitted funding proposal to implement New Zealand's first, proven Bio Refinery in the Tairāwhiti region.

Source: BioTechNZ, 2020.

Marine Biotechnology

Marine or blue biotechnology, occurs where the biological materials originate from the aquatic environment, freshwater and marine. The following tables list many of the key participants within the sector and recent major milestones.

TABLE 15: KEY PARTICIPANTS

PRIVATE SECTOR	PUBLIC SECTOR
Cawthron Institute	The University of Auckland
CH4 Global	The University of Otago
AgriSea	The University of Waikato
Biobrew	Victoria University of Wellington
Sanfords	Massey University of New Zealand
Seadragon	Lincoln University
Alaron Products	
Seperex	ESR (Institute of Environmental Science and Research)
New Zealand Coastal Seafoods	Manaaki Whenua - Landcare Research
NXT Fuels	Plant and Food Research
	AgResearch
	NIWA (The National Institute of Water and Atmospheric Research)
	Scion

Source: BioTechNZ, 2020.

TABLE 16: RECENT ACHIEVEMENTS

ORGANISATION	ACHIEVEMENT
CH4 Global	Secured seed funding of US$3 million (NZ$4.45 million).
Sanfords	Announced $20 million Investment into Innovative Marine Extracts Centre in Blenheim, focusing on high value nutrition products from New Zealand seafood.
Agrisea	Supreme Winner at the NZI Rural Women NZ Business Awards.
New Zealand Coastal Seafoods	Secured a deal to acquire 100 percent of Kiwi Dreams International, which develops nutraceutical products and offers services including ingredient supply, quality and validation, and formulation development.

Source: BioTechNZ, 2020.

Biotechnology Definitions

Bacteria	Single celled organisms without a distinct nucleus.
Bioeconomy	Comprises those parts of the economy that use renewable biological resources from land and sea (including crops, forests, fish, animals and microorganisms) to produce food, materials and energy.
Bioinformatics	The electronic data management of biological information, for example, the archiving of gene sequencing information.
Biomass	Plant or animal material used for energy production (electricity or heat), or in various industrial processes as raw substance for a range of products.
Biomanufacturing	The process of using living systems, particularly microorganisms and cell cultures, to produce biological molecules and materials on a commercial scale.
Bioprocessing	Manufacture of fermented products like cheeses, yoghurt, breads, brewing, pharmaceutical and vaccine manufacture, provided that genetic manipulation has occurred.
Bioprospecting	The search for plant and animal species from which medicinal drugs, biochemicals, and other commercially valuable material can be obtained.
Bioreactor	An apparatus in which a biological reaction or process is carried out, especially on an industrial scale.
Bioremedial	Employs the use of living organisms, like microbes and bacteria, in the removal of contaminants, pollutants, and toxins from soil, water, and other environments.
Biotechnology (biotech)	Traditional Biotechnology – refers to ancient ways of using living organisms to make new products or modify existing ones. Modern biotechnology – term adopted by international convention to refer to biotechnological techniques for the manipulation of genetic material and the fusion of cells beyond normal breeding barriers. It also refers to the intentional modification and manipulations living organisms and organic matter.
Cas9	Cas9 (CRISPR associated protein 9) is an RNA guided DNA endonuclease enzyme associated with the CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) adaptive immunity system in some bacteria.
Cell	The basic structural, functional, biological unit of all living organisms. Cells are often called the 'building blocks of life'.
Chromosome	A threadlike structure in our cells, made of a long DNA molecule, wrapped around a protein scaffold. Humans have 23 pairs of chromosomes.
Clone	A cell, cell product or organism that is an exact copy of cells, genetically identical to the unit from which it was derived.
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) is a genetic engineering tool that uses a sequence of DNA and its associated protein to edit the base pairs of a gene.
DNA	Deoxyribonucleic acid (DNA) is a long molecule that contains our unique genetic code. It holds the instructions for making all the proteins in our bodies.
Enzyme	Biological molecules, usually proteins, that are responsible for thousands of metabolic processes essential to life.
Eukaryotes	Organisms whose cells have a nucleus enclosed within a membrane, unlike prokaryotes (Bacteria and Archaea). Animals, plants, fungi and insects are eukaryotes.

Gene	Section of DNA that contains the instructions for our individual characteristics, for example eye and hair colour.
Gene Drive	Type of genetic engineering technique that modifies genes so they don't follow the typical rules of heredity.
Gene expression	The result of the activity of a gene or genes, which influences the biochemistry and physiology of an organism, and may change its outward appearance.
Genetics	The study of the patterns of inheritance of specific traits.
Gene Therapy	The treatment of a disease by introducing modified DNA into the cells of the patient.
Genetic disease	A disease that is caused by a change in an individual's DNA (also known as a genetic disorder).
Gene editing	Techniques that can be used in both plants and animals to make changes at specific targeted locations in the genome.
Genetic engineering	The manipulation of genes to alter an individual's characteristics.
Genetically modified organism (GMO)	An organism that has had its genome changed in a way that does not happen normally in nature.
Genome	An organism's complete set of genetic instructions.
Genome Sequencing	The process of determining the complete DNA sequence of an organism's genome.
Genotype	The genotype is the part of the genetic makeup of a cell that determines one of its characteristics.
Nucleus	A structure at the centre of all eukaryotic cells that contains the genome and acts as the 'control room' for the cell.
Phenotype	The physical traits and characteristics of an organism resulting from their genetic makeup.
Polymerase chain reaction (PCR)	A technique to make large quantities of a specific fragment of DNA.
Protein	Large molecules made up of chains of amino acids.
RNA	A nucleic acid similar in structure and properties to DNA, but it only has a single strand of bases.
Stem cells	Cells that have the potential to develop into many different cell types in the body.
Synthetic biology	Synthetic Biology combines elements of engineering, chemistry, computer science, and molecular biology.
Transgenic	An organism that contains additional, artificially introduced genetic material in every cell.
Vector	Large molecules made up of chains of amino acids.

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