# The T &T Foresight Project

# NIHERST

## Sector Foresight Project:

## BIOTECHNOLOGY

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## CONTENTS

# 1 EXECUTIVE SUMMARY

## *1.1 Introduction*

This report is the NEXT contribution to Chapter 1 of a 5 Chapter sector project that has the aim of providing a briefing paper that enables policymakers, researchers, entrepreneurs and investors to understand the potential to commercialise and grow key areas of the biotechnology sector in Trinidad and Tobago.

Chapter 1 provides an overview of how the global biotechnology sector is evolving and what the key focuses might be some 10 – 20 years from now in order to provide a context for examining potential niche opportunities that TT might seek to pursue. Chapters 2 – 5 focus on the current and potential capabilities that T&T has, identifying specific niches in the future global economy that T&T could realistically aim towards based upon the capability base, and then developing the associated business cases necessary for commercialisation to ensue.

Biotechnology is a global business in which ventures typically require to succeed in global not just domestic markets in order to be commercially viable. It is characterised by high investment requirements over long timeframes with good returns for successful comercialisation but steep losses for those ventures that fail to find a market.

## *1.2 Definition of Biotechnology*

The OECD definition of biotechnology is:

*'The application of Science and Technology to living organisms as well as parts, products and models thereof, to alter living and non-living materials for the production of knowledge, goods, and services' (1).*

# 2 WHAT IS HAPPENING GLOBALLY?

## *2.1 Key Trends Shaping the Future of the Biotechnology Sector*

The key trends that are shaping the sector include the following:

- The global biotechnology sector is maturing and total revenue is on a steady upward growth path.
- The US is the dominant player in the global sector, but the Asia-Pacific region is growing rapidly – especially in India, China, Singapore and South Korea. Europe's share is declining.
- Governments are investing vast amounts of R&D into biotechnology research and infrastructure development and this is stimulating the return of qualified expatriates, recruitment of offshore scientists and an inflow of private capital, both domestic and onshore, into the sector in those countries which take a proactive stance.
- The primary focus of global efforts is currently the health biotechnology sector but both agro-biotechnology and industrial biotechnology are likely to be rapid growth areas in the next 10 years or so.
- Industrial biotechnology is viewed as being the 'next big thing' and investment is currently being driven by concerns around energy security and climate change impact mitigation.

- Research funding trends show a shift towards funding interdisciplinary research teams and research at the convergence of disciplines to drive discovery and innovation.
- Societal reactions and concerns remain an important barometer of the acceptability of existing and emerging biotechnologies.

## *2.2 Biotechnology Sector Economics*

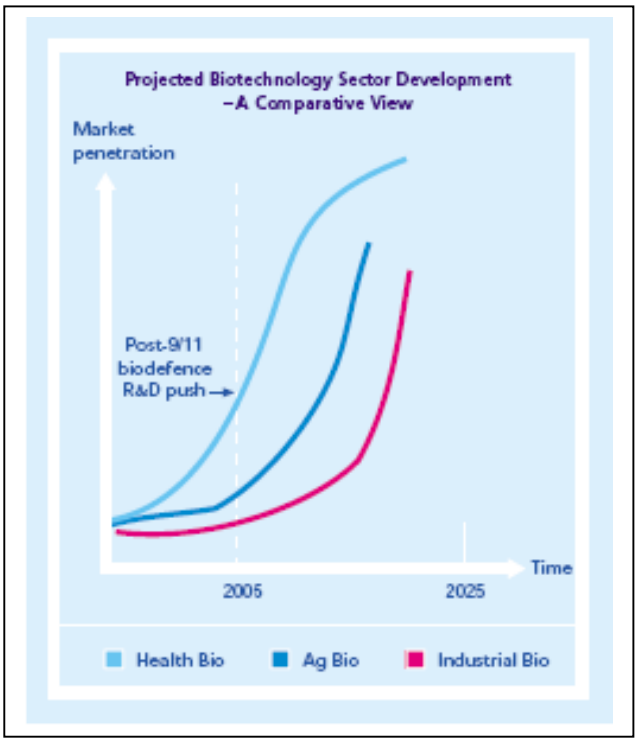
In this section we look at big picture trends in sector value growth and the major divergence between commodities and high value niche products produced using biotechnology.

Biotechnology is essentially a sector which exploits the 1970's – 1990's scientific breakthroughs in genome and DNA research by applying them to established sectors such as pharmaceuticals, medicine, agriculture, and industrial manufacturing to create new products offering new or more powerful functionalities. The very high investment required and the existing market power of the pharmaceutical companies has skewed growth into human medicine, which currently represents around 90% of the global biotechnology investment.

Like any new sector there is a tipping point followed by a rapid investment and growth curve pattern. There were high hopes for rapid growth in the sector. In 1983, global biotechnology sector revenues were projected to rise from $25 million to $65 million by the year 2000. In reality revenues had not only grown to $25 billion in 2000 but had more than doubled again in 2004 to almost US$55 billion. This growth was exacerbated by a stockmarket bubble boom, followed by a bust as investors started to realise how long the investment /return cycles were going to be.

The long-term development of the sector (see Figure 1) is likely to see a catch up with the health and wellness sub-sector by both the agricultural and industrial biotechnology sub-sectors over the next 20 years (2).

**Figure 1: Projected biotechnology sector development**



According to research group, Visiongain, the total global biopharma market was valued at US$64.3 billion in 2005, up 15.3% on 2004 (3). They expect double-digit growth to continue through to 2010 when it might reach US$118.6 billion. But this only relates to the biopharma segment of the whole biotechnology market. To add to that picture here are a few examples of what is happening in other biotechnology sub-sectors:

- US civilian bio-defence funding rose from US$ 414 million in 2001 to US$ 4,873.3 million in 2003 (up 11.8x), and further to US$ 7,642.2 million in 2005 (up 1.6x).
- The growth in Gene Silencing (RNAi) market is projected to grow from US$48 million in 2003 to US$328 million in 2010 (up 6.8x).
- Just six countries currently account for 99% of commercially grown GM crops in the world. The area grown increased from 1.7 million hectares in 1996 to 90 million hectares in 2005 (4).

### *2.3 How Profitable is it?*

The first point to make is that profits can arise from biotechnology-derived commodities as well as from high value niches. As the figures in Table 1 demonstrate, the sector offers opportunities throughout the value spectrum (2).

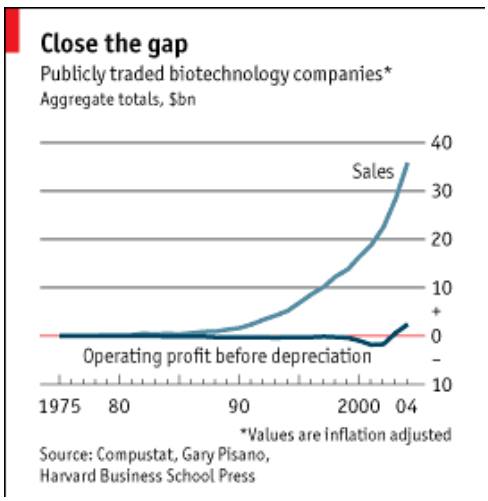
**Table 1: Production / value relationships for industrial biotechnology products**

| PRODUCT | World production (t/yr) | World market price ($/Kg) |
|---|---|---|
| Bioethanol | 26,000,000 | 0.40 |
| Citric acid | 1,000,000 | 1.50 |
| Vitamin C | 80,000 | 8.00 |
| Antibiotics (bulk products) | 30,000 | 150.00 |
| Antibiotics (specialties) | 5,000 | 1500.00 |
| Vitamin B12 | 10 | 25,000.00 |

For example, bio-ethanol is a very low margin commodity product - so is citric acid. On the other hand Vitamin B12 is an extremely high value niche product.

The Economist recently reported that investment into biotechnology companies in the USA has been huge – US$350 billion – and nearly half of that has occurred in the past 5 years (5). The share market value of biotechnology companies has risen 1,000% over the past decade – up to US$500 billion. But the sector has yet to show an aggregate net profit, as shown in Figure 2.

**Figure 2: Operating profits as opposed to sales figures for publicly traded biotechnology companies**



There is also a high business failure rate risk. Sector specialists see perhaps half of today's 1,500 biotech companies in the US disappearing – some through mergers, others by failing to come up with a winning product. The main incentive for being in the biotechnology business is that when a win is made, the potential value associated with that win can be huge. However, that is generally after a 10 – 15 year lead-time which has to be funded through investor channels.

There is no doubt individual companies can make huge wins – a good example is the recent buy-out of biotechnology company Chiron (a specialist in cancer drugs and blood-testing expertise) by Novartis for US$5.4 billion.

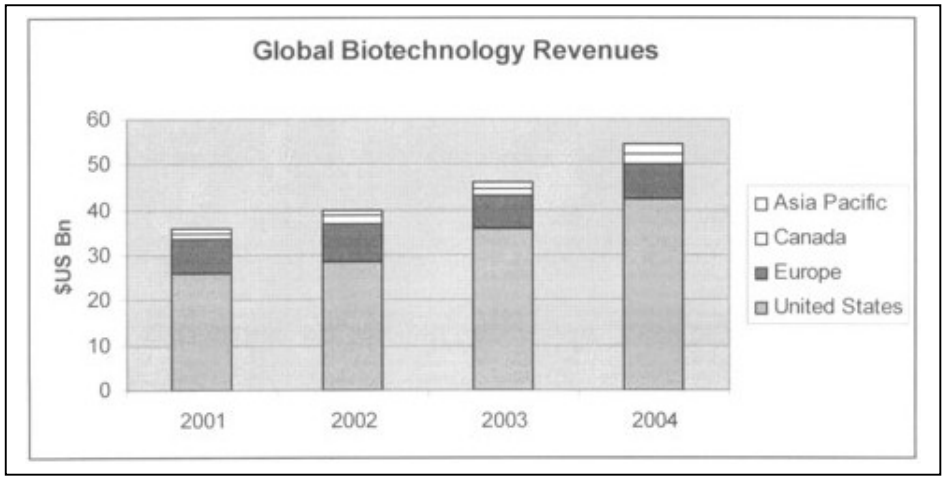
There will be growth over the coming decade through convergence between the biotechnology and the pharmaceutical sector, because the latter sector is weak with regard to options for the future as patents run out. Alliances between companies in these two sectors are expected to account for a third of the US$35 billion of fresh investment going into the biotechnology sector in 2006.

# 3 WHAT INVESTMENT APPROACH IS BEING TAKEN?

## *3.1 Who are the Big Players?*

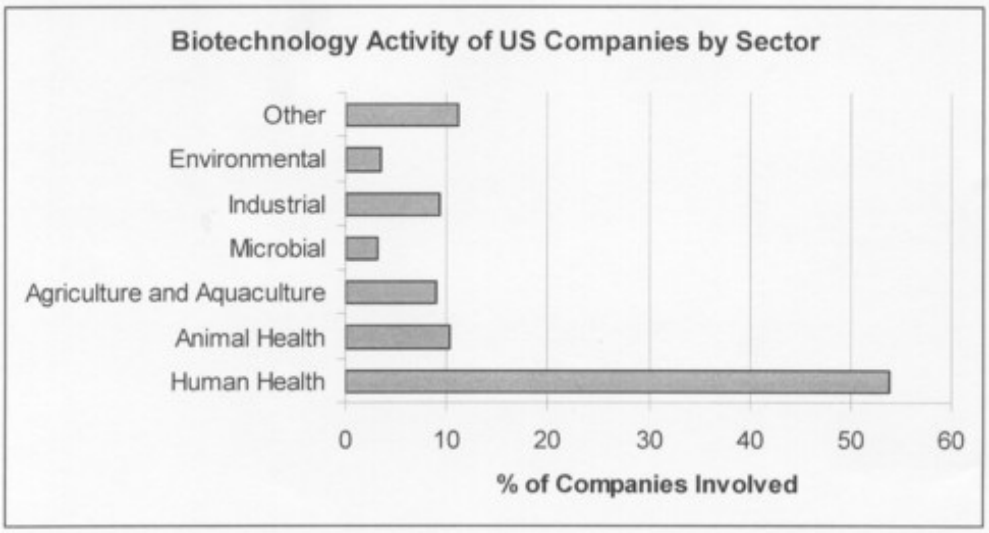
The USA is by far the biggest player in the global biotechnology sector (see Figure 3). Europe has failed to improve its position over recent years. There are many factors holding back developments in European countries, not the least being public attitudes. The revenues generated in the Asia-Pacific region are still small in relative terms, but are expected to grow rapidly over the next several decades because of the large public and private investments being made in countries such as China, India, Korea, Australia, Singapore and New Zealand (4).

**Figure 3: Global biotechnology revenues and key players – 2001 to 2004**




In the USA, by far the main biotechnology focus is the human health area. Other areas with potential have a much lesser focus by companies in the sector. This is illustrated by the breakdown of how US companies are positioned within the sector - see Figure 4.

**Figure 4: Biotechnology activity of USA companies by sector**




As a benchmark, we have to remember that the USA is a world heavyweight in the biotechnology sector and it is built upon its very high investment in universities and science institutes, its large venture capital market, and its skills in commercialising research.

### *3.2 New Zealand as a Small Country Example*

The approach to the biotechnology sector in New Zealand is more relevant to T&T. This is because it is also a small country and its economy has been built on the back of agriculture with strong research and innovation traditions.

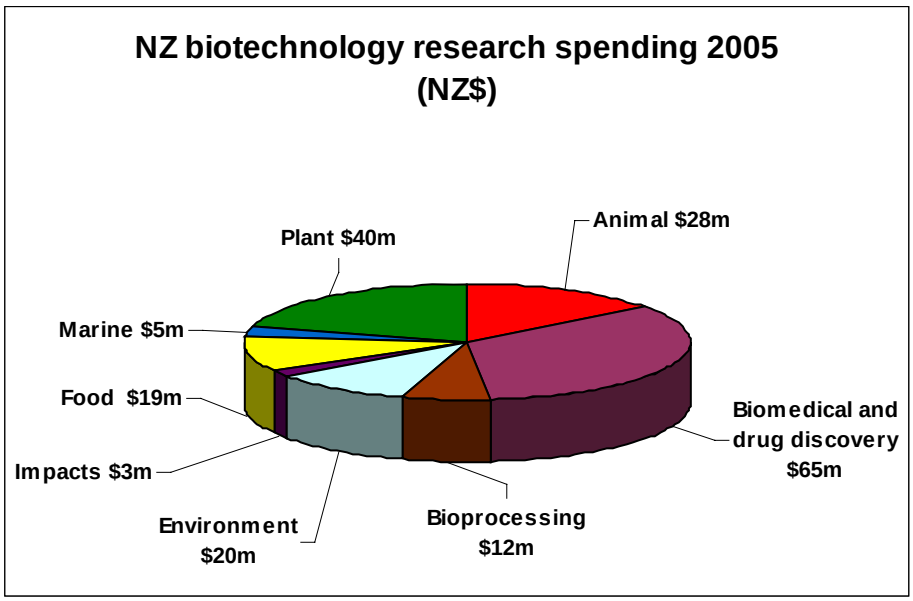
Up to 2015 the framework within which biotechnology research will focus has been defined by Ministry of Science, Research and Technology (MORST) in New Zealand as follows:

- The country's primary sector will need to have transformed certain aspects of its business to maintain and enhance global competitive advantage through greater productivity, but without increasing the environmental footprint:
- Biotechnology products and services developed offshore will be widely available – to industry, to health practitioners, to consumers – and there will be a need for skilled scientists to help adopt, adapt and manage these appropriately.
- The country's natural and built environment will still be adjusting to a changing climate and a greater reliance on sustainable energy sources. Biotechnology will be part of the country's response and will need to be integrated with decision-making.

In 2005 revenue generated from biotechnology in New Zealand was US$510 million – from both internal and export sales. Biotechnology exports currently go to 60 countries and export earnings are projected to reach US$620 million by 2014 (6).

The current allocation of NZ government biotechnology research funding is shown in Figure 5.

**Figure 5: Allocation of funding for biotechnology research in New Zealand 2005**



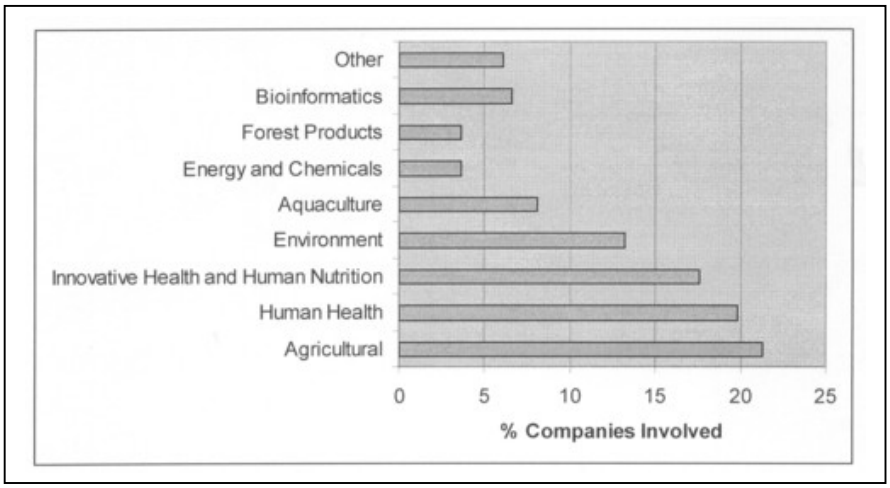

## 4 BUSINESS MODELS AND PLAYER POSITION

We have briefly discussed the New Zealand model. In this section we look at how New Zealand players in the sector are positioning themselves.

### *4.1 Where Are Players Positioning Themselves?*

The positioning of New Zealand biotechnology players can be summed up as shown in Figure 6.

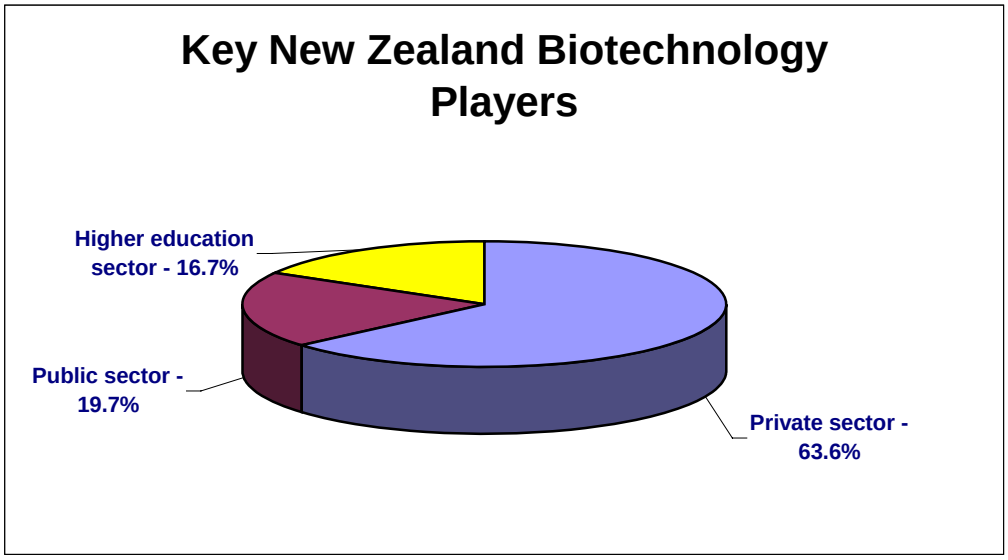
**Figure 6: Biotechnology sub-sector positioning of New Zealand players**



### *4.2 Who are the Key Players?*

Figure 7 illustrates where the key players in the New Zealand biotechnology sector come from. The market shares are based upon sub-sector revenues generated in 2005. The private sector is the major player, but both state (including government owned corporations) and educational players are very significant and account for 36.4% of the total revenue generated by the sector.

**Figure 7: Market share of key player groups in New Zealand, 2005**

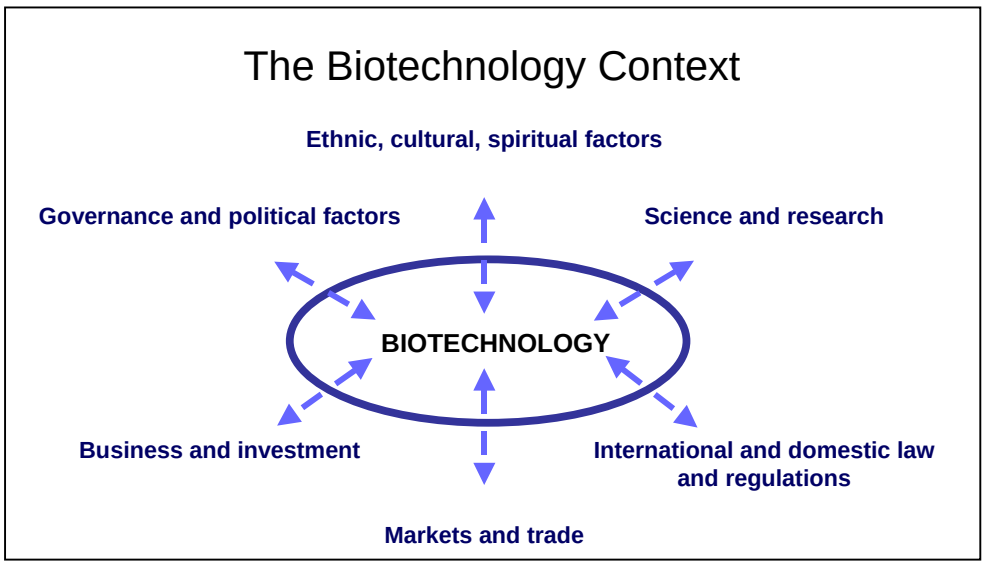



## 5 HOW THE GLOBAL BIOTECHNOLOGY SECTOR IS EVOLVING

### *5.1 The Biotechnology Sector Context*

Figure 8 provides an overview of the factors which are shaping the future of biotechnology and which, in turn, biotechnology is shaping (2).

**Figure 8: The key parameters shaping biotechnology**



### 5.1.1 Key Sector Roadmap Issues

How the biotechnology sector evolves depends on being able to monitor and adapt to the following:

**Intersections –'forks in the road':** Where one path becomes favoured over another, e.g. GM versus non-GM.

**Interdependencies – synergy or clash?** Where an opportunity e.g. bioenergy, is dependent upon a biotechnological advance e.g. GM plants – and the possible conflict with environmental outcomes.

**Regulatory readiness – are we future-proofed?** Does the country's legislative system help or hinder emerging biotechnologies (e.g. provide confidence to customers regarding biotechnology related safety and security issues)?

**The emergence of a possibility space:** Where a convergence of technologies emerging from different market sectors can enable totally novel solutions e.g. production of novel nanoparticles from living cells.

**Uncertainties – the need for flexibility:** Certainty is only one side of the equation. There are areas of uncertainty that can change the playing field – such as a serious bio-related incident. The sector needs to be use foresight to be aware of potential uncertainties, develop processes to manage risk, be flexible so it can adapt, and take advantage of any opportunities that arise.

### 5.1.2 Sector Convergences

The advances in biotechnology are closely related to developments in other sectors. ICT and nanotechnology are two examples. Material science is another example, e.g. the ability to transmit nerve impulses from a living neuron to a silicon chip and back. 'Smart' prosthetics made of carbon fibre that are becoming almost as effective as the 'real thing'.

As well as the increasing synergies between different technologies driving innovation, there are also growing convergences between different biotechnology industry sub-sectors. A good example is the potential for personalising treatments through genomic medicine being mirrored by developments in the food and nutrition sector due to nutrigenomic advances.

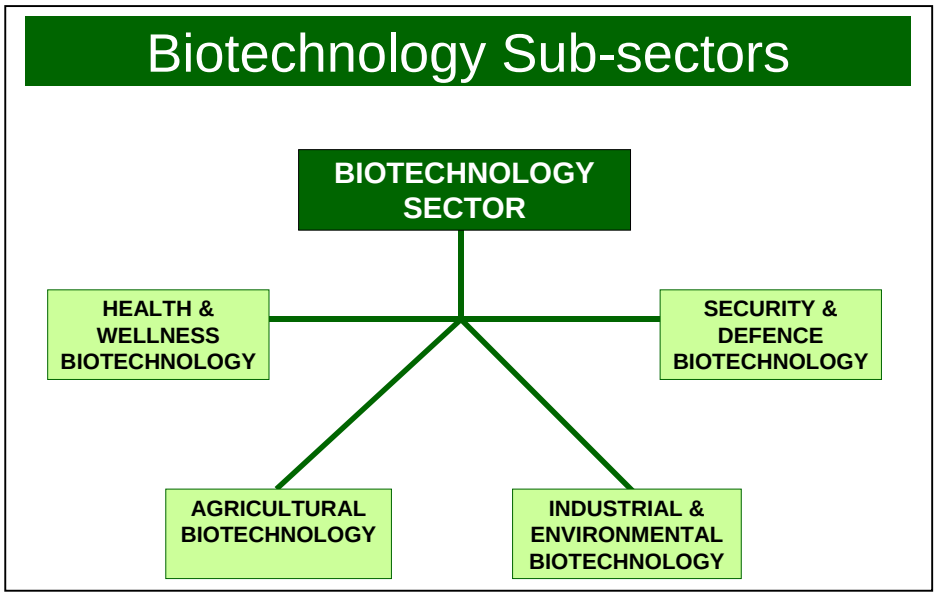
A US National Science Foundation priority research area is 'Biocomplexity of the Environment' and funds multi-disciplinary projects that embrace biological, environmental and physical sciences.

## *5.2 Key Biotechnology Sub-Sectors*

### 5.2.1 Overview

The main current international focus is on biotechnology as it relates to the health and pharmaceutical sectors. But there are a number of other important sub-sectors that cover a much broader field as shown in Figure 9.

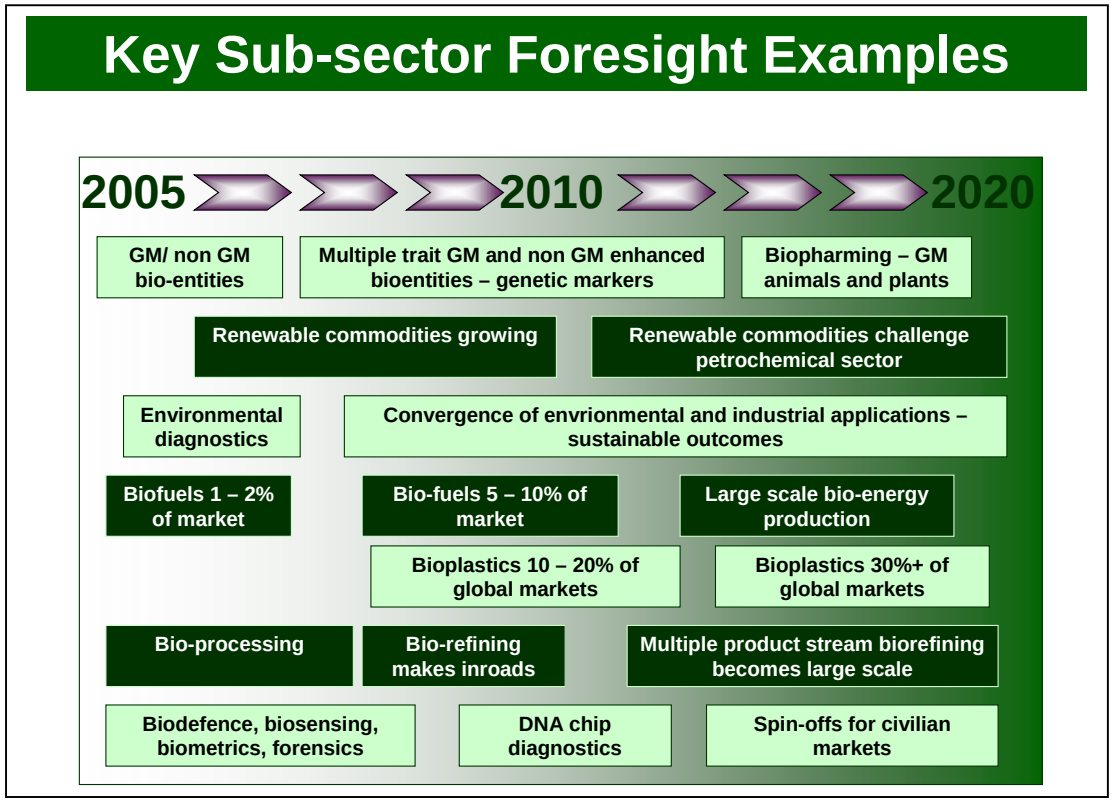
**Figure 9: An overview of major biotechnology sub-sectors**




### 5.2.2 The Agricultural, Industrial & Environmental, and Security & Defence sub-sectors

Figure 10 illustrates a number of foresight examples of product and concept development pathways for the agricultural, industrial, environmental, and security and defence biotechnology sub-sectors.

**Figure 10: Foresight-based development pathways in the agriculture, industry, environment and security and defence sub-sectors**



In the following sections we look at the key overarching drivers, technology trends, paradigm shifts, and uncertainties associated with the various sub-sectors (2).

***Agricultural biotechnology***

**Table 2: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of agricultural biotechnology**

| Parameter | Agricultural Biotechnology Sub-sector |
|---|---|
| ***Overarching drivers of growth*** | • S & T - data collection and analysis, convergence<br>• Economic – value add, productivity, convergence with health |
| ***Technology trends*** | • GM - from input to output<br>• Smart breeding<br>• Genetic diagnostics<br>• Cloning<br>• GM animals as bioreactors |
| ***Paradigm shifts*** | • From low value / high volume to high value / low volume |
| ***Uncertainties*** | • Ethical concerns – playing God<br>• Environmental impacts<br>• Consumer preference<br>• Complexity – the more we know the less we know |

***Industrial & Environmental Biotechnology***

**Table 3: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of agricultural biotechnology**

| Parameter | Industrial & Environmental Biotechnology Sub-sector |
|---|---|
| ***Overarching drivers of growth*** | • S & T-data collection and analysis, convergence<br>• Economic – productivity and energy<br>• Environment – sustainable industries<br>• Governmental – intervention and investment |
| ***Technology trends*** | • Biomass<br>• GM based bio-commodities<br>• Super-enzymes<br>• Metabolically engineered micro-organisms<br>• Bio-prospecting<br>• Biosensors and DNA diagnostics |
| ***Paradigm shifts*** | • Move towards using renewable products and materials – away from petrochemicals<br>• Closed loop manufacturing |
| ***Uncertainties*** | • Systemic readiness – at all levels<br>• Consumer resistance – especially to GM crops |

***Security & Defence Biotechnology***

**Table 4: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of agricultural biotechnology**

| Parameter | Security & Defence Biotechnology Sub-sector |
|---|---|
| ***Overarching drivers of growth*** | • S & T-data collection and analysis, convergence<br>• National security - biosecurity |
| ***Technology trends*** | • Dual use technologies<br>• Diagnostics in real time<br>• Biometrics for personal ID<br>• Biological threat detection |
| ***Paradigm shifts*** | • From documents and X-rays to data-base driven real time biological recognition and detection systems |
| ***Uncertainties*** | • Bioterrorism<br>• Consumer concerns about privacy<br>• Whether options are used for 'good' and / or 'bad' purposes |

### 5.2.3 Health & Wellness Biotechnology

Health and wellness is a huge sub-sector and covers a wide range of fields – not just the medical field but also areas related to lifestyle and 'personal enhancement' needs (appearance modification, mind altering substances, supplements, etc). Within this sub-sector the niches shown in Figure 11 have been identified as having strong growth potential.

**Figure 11: Growth niches within the health and wellness sub-sector**

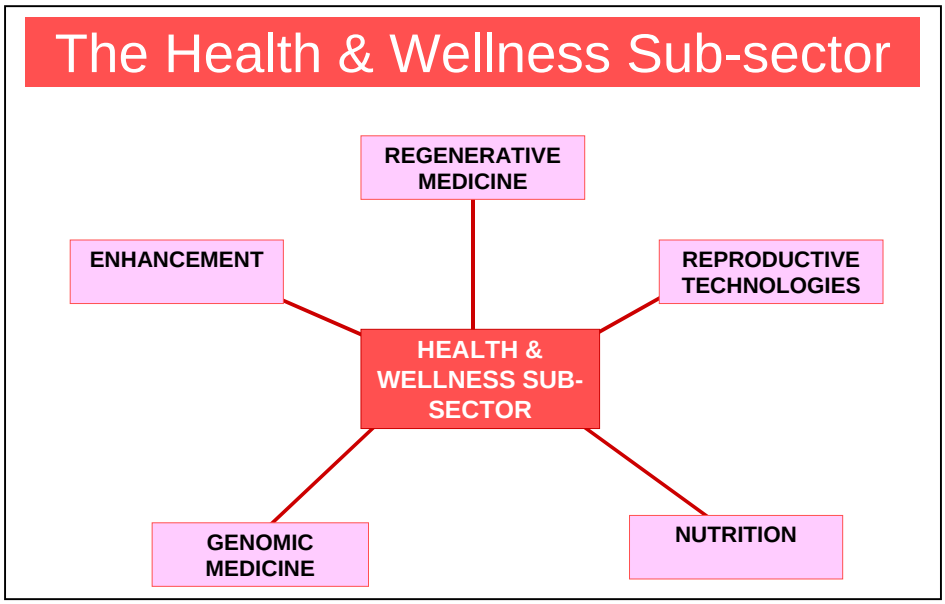
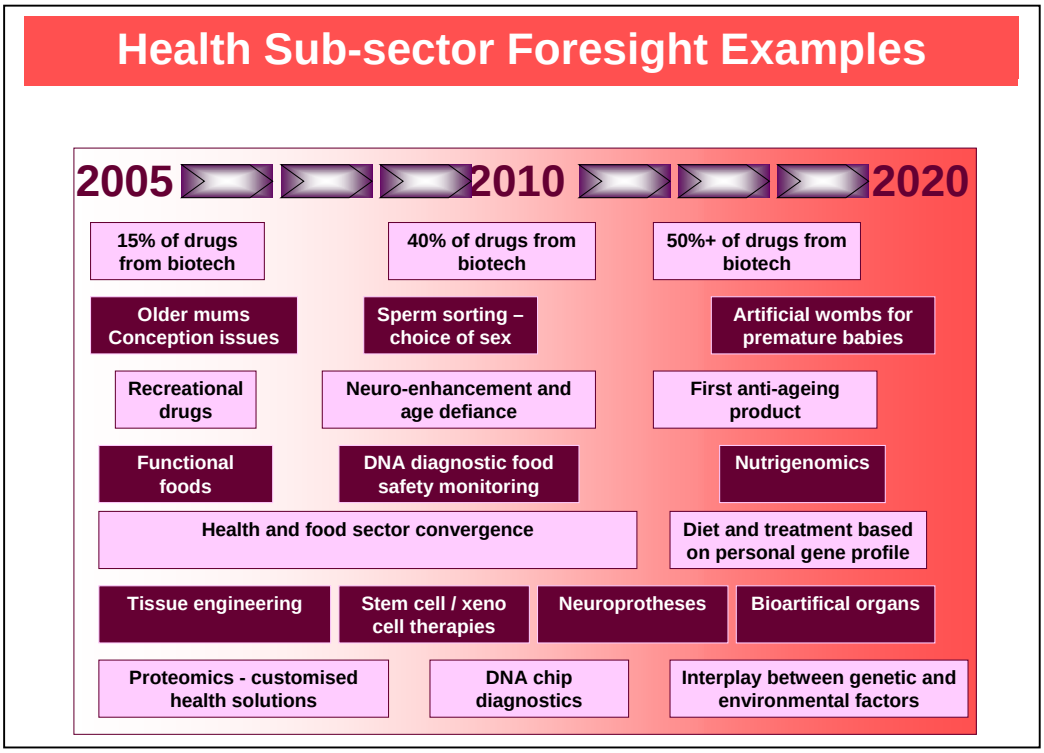


Figure 12 provides an overview of foresight examples that may impact on the future of the health and wellness biotechnology sub-sector.

**Figure 12: Key health and wellness sub-sector product and concept development pathways**




The key overarching drivers, technology trends, paradigm shifts, and uncertainties associated with the health and wellness sub-sector are summarised in Table 5.

**Table 5: Health and wellness drivers, technology trends, paradigm shifts and uncertainties**

| Parameter | Health and Wellbeing Sub-sector |
|---|---|
| Overarching drivers of growth | ●Demographic – longevity, ageing, decreased fertility, delayed reproduction<br>●S & T – data collection and analysis, convergence<br>● Improving health outcomes – chronic and inherited diseases, ageing associated diseases, infectious diseases, lifestyle diseases<br>●Consumer trends – self diagnosis, self care, lifestyle drugs<br>●Economic drivers – large profits if a target drug is commercialised |
| Meta trends | ● The 3 Ps – predictive diagnostics, preventive interventions, personalised healthcare<br>●Convergence – biotechnology with ICT and nanotechnology at cellular and molecular levels |
| Paradigm shifts | ●From replacement of tissues to repair and regeneration<br>●From chemical based to biotechnology based drug development<br>●Dual use – from therapy to enhancement (lifestyle drugs) |
| Incremental growth trends | ●Diagnostics leading the way – especially molecular and DNA diagnostics<br>●Drug delivery becomes and industry segment - technically complex solutions<br>●Embryo screening and selection – multi-genic |
| Uncertainties | ●Ethical, moral and religious – especially regarding foetal and genetic therapeutics<br>●Complexity – the more we know the less we know<br>●Systemic unreadiness – at the governance, market and healthcare system levels |

### *5.3 Factors Shaping the Future of S & T in the Biotechnology Sector*

From a science and technology perspective, there are a number of other key factors shaping the future biotechnology sector. A summary of the more important ones is shown in Table 6.

**Table 6: Additional factors shaping the future of the biotechnology sector**

| Parameter | Future S&T Focuses in Biotechnology |
|---|---|
| ***Key drivers*** | • Scientists – the way they shape the discovery process<br>• Integration of genetic and other data – making sense of vast data streams by improving collection and analysis |
| ***Meta trends*** | • Increasing complexity of information – from single genes to gene and protein networks<br>• Convergence of disciplines - funding providers are encouraging further convergence<br>• Identification and diagnostics – development of new tools and markers to identify, detect and diagnose |
| ***Areas to watch*** | • Cell biology – more detailed understanding of how cells function, grow and divide is essential for developing biotechnology applications<br>• Epigenetics – developing understanding of non-DNA factors that influence biological development and regulatory processes<br>• Systems biology – a rapid growth field that seeks to describe molecular and cellular networks and interactions, and make sense of the wealth of molecular data being collected<br>• Transgenics – a platform technology where advances in vector constructs, vector delivery and control of gene expression will have a significant influence on types of biotechnological applications<br>• Chemical genetics – an emerging discipline that seeks to improve the rate of determining protein function |
| ***Uncertainties*** | • Complexity – the more we learn the less we know<br>• Serendipity – plays a major role in science – it is difficult to know what new discoveries or insights could radically affect how we perceive or use organisms. |

## 6 CONSUMER FORESIGHT

The future of any sector depends upon customers – whether they be patients in the medical sphere, purchasers of products and services, or enjoy a personal benefit – experiential, lifestyle compatible, or enhancement orientated. Understanding tomorrow's consumers and the things they are likely to want and demand is key to mapping the future of any sector.

### *6.1 The Global Consumer Market*

The world's population is ageing – rapidly. Latest estimates indicate it may peak as early as 2050. There is still likely to be an extra 2 billion+ people in the world by the time the peak is reached. However, the make-up of the population in individual countries is likely to vary significantly – particularly in wealthy countries.

For example, the average age of the German population is expected to be 45 years within a decade. In Japan, close to 50% of the population will be 50 years of age or older and in India almost 25% by 2025. China is also greying rapidly with 35.6% of the population expected to be 50 years+ by 2025.

This is a major shift – never seen before in the history of mankind. This will impact on markets in every country in a multitude of ways.

### *6.2 Key Consumer Groups*

In tomorrow's world we believe the following consumer groups will be of growing in importance and shape future markets:

- **Cultural Creatives** – people with knowledge and skills who contribute strongly to the new economy and who also have strong personal values – especially regarding personal health and wellness, ethics, and the environment.
- **Ethnic entrepreneurs** – in both mature and emerging economies. Self-assured, successful and ready to take risks.
- **The 60s generation in their 60s** – more independent and healthier than previous generations – many wish to leave a positive legacy to their children and grand-children before they die.
- **The Baby Boomers** – a self-indulgent generation, always a bit rebellious, determined to fight ageing for as long as possible and prepared to spend on it. The oldest are now reaching 60 years of age.
- **New age women** – self-confident, independent, delaying or not having children, increasingly suffering from 'male' as well as 'female' problems – coping with life balancing and stress.
- **Generations Y & D** – the under 28 year olds. Live 50% in a 'real' and 50% in an 'unreal' (virtual) world. The boundaries between the two are blurring. They face some real personal health and wellness challenges, require constant fascination – including the use of mind altering substances, reshape their bodies and minds without a thought, have grown up with high technology solutions that they don't question.
- **Global nomads** – high net worth individuals who move from country to country and contract to contract and need to support a highly mobile lifestyle.
- **Cyber tribes** – who interact through interfaces such as the Internet. They spread 'fact' and 'fiction' rapidly around the world through their networks.

### *6.3 Key Consumer Trends*

Associated with the emerging consumer groups, we have identified a number of significant trends that are likely to impact significantly on markets over the next decade or two:

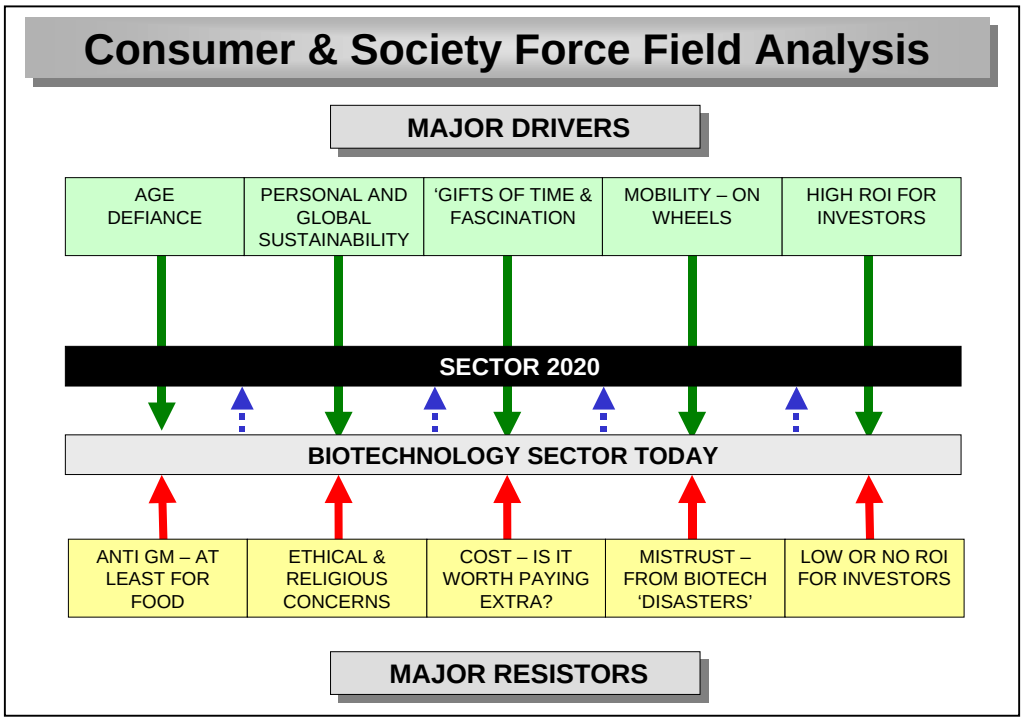
- Pursuit of pleasure, quality of life, and happiness.
- Self-enhancement -including cosmetic surgery, drug based, supplements, non-traditional therapeutic channels, and similar interventions.
- Comparative material well-being.
- 'Give me a gift of time' – so I have more time to do the things I love.
- Longevity & 'Age Defiance' – people want to defy ageing and will pay for it – particularly amongst the over 45s but also increasingly a focus of the young.
- Individualism – markets of one; more singles, the egoistic society.
- Fascination – people are looking for '5 minute fascination' – instant gratification.
- Parents with decreased parenting skills – who need help to redress growing imbalances with the health of their children – obesity, diabetes etc.
- Global living – being able to move freely around the world with the minimum of hassles and stay healthy and fit.
- Health and wellness – particularly as the over 45s begin to realize half their lives are behind them and looking after their health and wellness is essential is they want to maximize what they get out of the rest of their lives.

- Being ‘out’ is ‘in’ – the death of the mass market – an aspect of growing individualism – ‘I am unique’.

### *6.4 How Do These Relate to Future Sector Prospects?*

How consumers are likely to influence the future of the biotechnology sector can be illustrated by separating impacts into drivers (characteristics that will favour the sector) and resistors (characteristics that will hold back progress), as shown in Figure 13.

**Figure 13: Consumer and society force field analysis**




Consumer drivers that favour growth of the biotechnology sector include:

- Anything that will contribute to ‘Age Defiance’ – especially the Baby Boomer cohort but not only as evidenced by trends in cosmetic surgery.
- Personal and global sustainability – health and wellness of the individual and the environment within which they live.
- Anything that gives consumers a ‘gift of time’ e.g. by providing them with a means of improving health and / or diet, but without extra effort.
- Especially for generations Y and D – anything that is cool, experimental. High-tech, and helps them be different – and which also helps them deal with their own quality of life issues, which are starting to grow.
- Anything that contributes to maintaining / enhancing individual mobility – getting from ‘a’ to ‘b’ – in the face of rising energy costs.
- Biotechnology breakthroughs that add real wealth to investors – who are also consumers.

The resistors holding back biotechnology include:

- The anti-GM in food movement – it remains strong and is driven by the ageing boomers and highly educated creative class (however, the use of GM in medicine is not viewed quite so negatively).
- Ethical and religious concerns – such as those regarding the use of stem cells from embryos.

- Cost – is it worth me paying extra for higher health biotechnologically derived products e.g. cholesterol reducing spreads?
- Mistrust – through things going wrong – the Vioxx problem with Merck Sharpe and Dohme, and the disastrous Northwick Park Hospital drug trial for testing the biotechnology-derived drug TGN1412.
- The biotechnology sector continues to fail to deliver adequate returns to many investors.

# 7 SECTOR FORESIGHT – SHAPING THE BIOTECHNOLOGY OVER THE NEXT 10 – 20 YEARS

How biotechnology evolves over the next 10 – 20 years can be viewed using several different tools. These include PESTE (an analysis from the Political, Economic, Social, Technological, and Environmental perspectives), SWOT (strengths and weaknesses – as seen today; opportunities and threats – in the future), and global scenarios.

## *7.1 Sector PESTE*

A PESTE perspective of the major future influences on biotechnology is shown in Table 7.

**Table 7: Major future influences on the biotechnology sector from a PESTE perspective**

| Parameter | Influences |
|---|---|
| ***Political*** | • Legislation impacts – positive and negative<br>• Funding initiatives through state channels<br>• Incentives to the private sector<br>• Security – both biological and border |
| ***Economic*** | • Returns on investment – how the sector performs relative to other sectors |
| ***Social*** | • Consumer demands and acceptance of biotechnology solutions and products – for health the basis of acceptability is different to food<br>• Health and wellness demands |
| ***Technological*** | • Developing ways of dealing with complexity<br>• New breakthroughs<br>• Convergence of technologies |
| ***Environmental*** | • Sustainability – and a convergence between industrial and environmental sustainability focuses<br>• A need to use sustainable rather than finite resources |

## *7.2 Sector SWOT*

The SWOT tool provides a simple matrix analysis of key areas that are fundamental to scenario development. Table 8 lists some of the more important areas.

**Table 8: Biotechnology sector SWOT analysis**

| Strengths | Weaknesses |
|---|---|
| Provides 'natural' solutions<br>• Huge investor interest<br>• Offers breakthroughs in human health and wellness<br>• Mass customisation<br>• Is knowledge based rather than resource based<br>• Has application over a range of sectors | • Lack of returns for investors<br>• Opposition to GM foods<br>• Animal welfare<br>• Lack of knowledge – both in people resource terms and in understanding the complexity of biological systems<br>• Long lead times<br>• A reliance on GM in some sub-sector areas<br>• Long lead times |
| **Opportunities** | **Threats** |
| • Improved human health and wellness<br>• Sustainable and renewable energy<br>• Individual customisation of solutions to improve human health and nutrition<br>• Adding value to commodities<br>• Vastly improved diagnostics<br>• Convergence with other sectors offers new options<br>• Offers potentially large rewards | • Bioterrorism<br>• Unforeseen outcomes that have negative impacts<br>• Investors fail to gain the expected returns<br>• Competition from non-renewable resources and affects on pricing (e.g. an oil price slump) |

## *7.3 Global Scenarios*

How the biotechnology sector evolves is very dependent upon how the world evolves over the coming decades. Using scenarios can be useful for developing a picture of alternative futures and how to develop a flexible approach to future markets and opportunities. The following three scenarios developed by the Forest Research Institute in New Zealand provide a useful summary of how things could play out (2).

### 7.3.1 Globalisation and Security - A 'Biotechnology for Profit' Scenario.

In this scenario globalisation is a key driver, constrained and moderated by increased anxiety, conflict, security measures and strengthened national borders. Geopolitics retains elements of multilateralism, but it is increasingly bloc orientated and bilateral. The environment for science and technology in this scenario is most characterised by support for world-class science, strategic partnering and collaboration in blocs, yet reducing information flows.

The outcome of this scenario is that specific commercial entities around the world, predominantly within key trading blocs, make vast profits out of specialised biotechnological solutions. However, these are not necessarily beneficial to the world as a whole and the knowledge and know how tends to be in the hands of particular commercial entities along with allied S&T and political interest groups.

### 7.3.2 Conflicted World – A 'Biotechnology for Basics' Scenario

This scenario extends the 'Globalisation and security' scenario and envisages a decline and eventual breakdown of international and multilateral trust, agreements, and institutions, brought about by more intense conflicts and unilateral responses. Nationalism rises and self-sufficiency substitutes for substantial international trade, leading to severe recession. The environment for science and technology in this scenario is characterised by science for national needs, restricted collaboration and information flows, and technology duplication.

The outcome of this scenario is an introverted nationalistic biotechnology focus which aims at developing solutions on a localised rather than local scale and does not leverage the full potential of biotechnology through international cooperation.

### 7.3.3 Sustainability Emerges – A 'Biotechnology for Life' Scenario

This scenario is based upon an emergent grass roots social belief that the dominant globalisation / security economic model is not environmentally sustainable in the medium (or even short) term. In this scenario ecological values dominate, and economic activity is incentivised and regulated with environmental imperatives. Multilateral agreements shift from trade and security to sustainability. The environment for science and technology in this scenario is characterised by world-class science, open collaboration and information flows, technology sharing and world collegiality.

The outcome of this scenario is the ideal for the world where biotechnology developed through international cooperation provides global scale solutions that provide a long term sustainable future built upon fully renewable resources that are compatible with the world's social and environmental balances and needs.

## 8 FINAL COMMENT

We have developed a global view of biotechnology sector and key sub-sectors that provides a context for looking at potential niche areas in which T&T can identify 'best bet' opportunities.

The challenge is to identify areas that are going to be of the greatest relevance in markets 10 – 20 years from now rather than in today's context as the whole sector is changing rapidly.

As the three global scenarios demonstrate, how the sector evolves will depend upon how the various scenarios play out. At present parts of all three are in play and impacting differently in different parts of the world.

# 9 APPENDIX 1: KEY REFERENCES


1. Biotechnology Regulatory System Baseline Study, Ministry of Science, Research & Technology, New Zealand, October 2004 www.morst.govt.nz
2. Biotechnologies to 2025, Ministry of Science, Research & Technology, New Zealand, January, 2005 www.morst.govt.nz
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4. The Biotechnology Research Landscape, Ministry of Science, Research & Technology, New Zealand, April, 2006 www.morst.govt.nz
5. Profitless Prosperity, The Economist, April 20, 2006 www.economist.com
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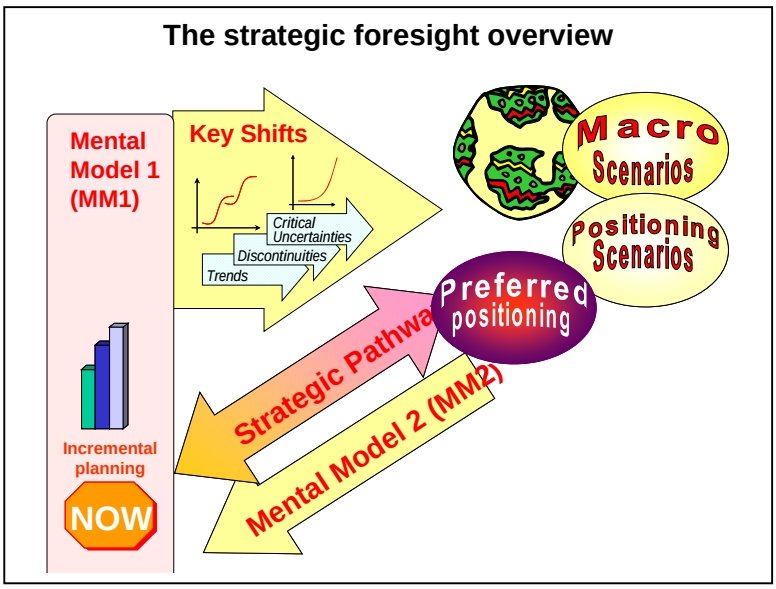
7. Current Investments by Core Research area (04/05), Ministry of Science, Research & Technology, New Zealand, 2006 www.morst.govt.nz

## 10 APPENDIX 2: GLOBAL FORESIGHT OVERVIEW

To develop a context for the biotechnology sector and the opportunities it may offer to T&T economically and socially, we first need to look at the global picture of the sector – the trends, players and positioning, then develop scenarios which relate to the T&T situation within that global picture, and then a way of determining the strategic positioning T&T might take to exploit opportunities the sector offers.

**Figure 14: The overarching strategic foresight framework**




A key part of developing an understanding of how the global picture is being shaped is by knowing the meta-trends that are driving change. We call these the 7 Tsunamis of Change. These global drivers are shaping the future of our lives, of markets, of business, of the world we live in. The Tsunamis are changing the landscape within we will operate – destroying some things, changing other things, causing new things to be build in their aftermath.

**Figure 15: Meta-trends – The 7 Tsunamis of Change**

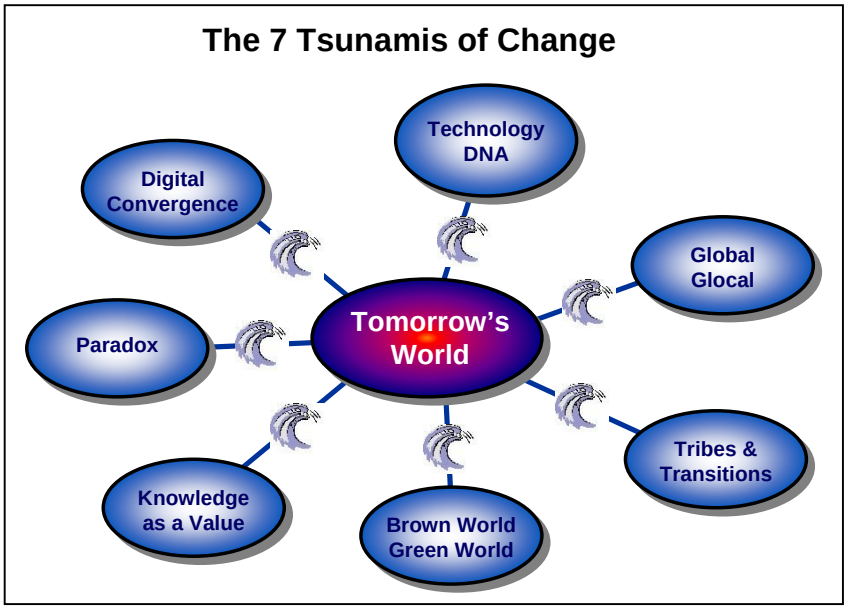


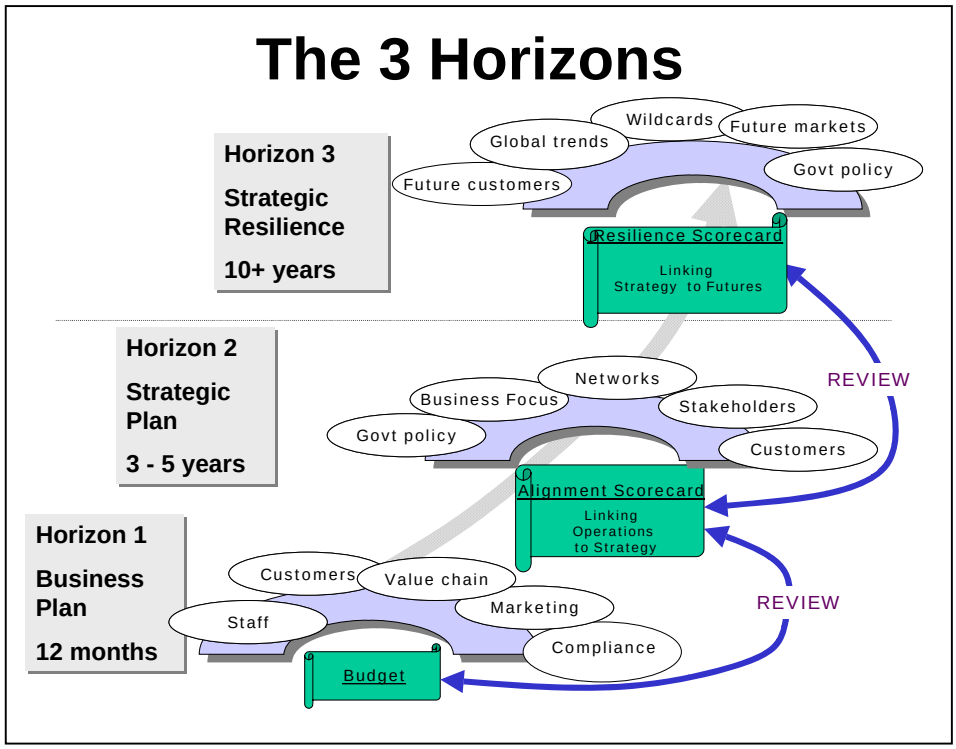
Table 9 provides a brief overview of the areas each Tsunami is driving.

**Table 9: Areas where each Tsunami of Change is impacting**

| TSUNAMI | CHARACTERISTICS |
|---|---|
| ***Digital Convergence*** | • Chips in everything<br>• Total interconnectivity<br>• Virtuality |
| ***Technology DNA*** | • Biological/technological convergence<br>• Cumulative innovations<br>Re-shaping of life itself |
| ***Global Glocal*** | • Global village<br>• Cultural convergence<br>Biggest or most unique |
| ***Tribes & Tribulations*** | • The digital divide<br>• Tribalism<br>Changing lifestyles / work styles |
| ***Brown World, Green World*** | • Climate change<br>• Resource productivity<br>Water, air, energy |
| ***Knowledge as a Value*** | • Hierarchy of knowledge and value<br>• Knowledge management<br>Consumer Power |
| ***Paradox*** | • Unexpected effects<br>• Living with degrees of grey versus black and white<br>Solutions take opposites into consideration |

The long-term views we develop by using foresight help us develop a picture of how a business Horizon 3 may look 10 – 20 years from now – which is often quite different to how it looks today. This horizon helps us understand the future destination we wish to aim for – the desired scenario. By backcasting from Horizon 3 we can then develop a 3 – 5 year strategic plan (Horizon 2) and then a short- term business or implementation plan (Horizon 1) – see Figure 16. By taking this approach, commercialisation of opportunities discovered during the research and evaluation process is made within a long-term context.

**Figure 16: The three business Horizons**




There are a number of tools and processes that can be used to help shape Horizon 3. These include foresight research, the PESTE analysis, scenario development (for the global sector), developing a view of the long-term destination for the sector and country, and then local scenarios that provide a framework for decision making.

**Figure 17: Tools and processes for developing a Horizon 3 perspective**