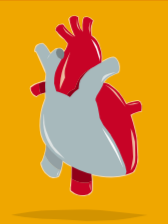


BIOTECHNOLOGIES TO 2025?

- KEY**
- Technical Bottlenecks** Technical areas which require solutions and if a breakthrough occurs could result in a flood of new developments.
 - Legislative Readiness?** Future technological areas that our legislative system may not yet be equipped to handle.
 - Possibility Space?** The convergence of technology forecasts, or the dual use of technologies which could result in completely novel outcomes.
 - Decision Point?** A fork in the road: if two technologies converge to produce the same result, which one will be taken up by different markets?
 - Interdependencies** Technology forecasts which are dependent on other technological areas or other systems or infrastructures to eventuate.
 - Convergence** The merging or coming together of different technologies or market sectors.
 - Trend Drivers** Trends occurring in other realms which are emerging as a result of, or drive or limit the advance of, biotechnologies.

2005 | 2010 | 2015 | 2025

REGENERATIVE MEDICINE



Tissue Engineering - First Wave Structural tissues like skin, bone and cartilage. Biomolecular growth factors forecast to be integrated into bioengineered skin

TECHNICAL BOTTLENECK

- A complete understanding of how stem cells differentiate into various types of tissue
- The ability to replicate the vascular system

Legislative Readiness? Is our legislative system prepared for neuroprosthesis?

Xeno-Cell Therapies Therapeutic use of GM pig cells to treat liver and pancreatic illnesses

Neuroprostheses Mind-controlled prosthetics and devices, such as artificial limbs

Bioartificial Organs Hybrid devices designed to tide over and/or cure organ transplant patients

Whole organ regeneration?

Whole organ xenotransplantation?

ENHANCEMENT

"Better than well"



Consumer Trend Continued growth of lifestyle drug market and "off-label" use of drugs like ritalin®

Social Trend The populations of developed nations are living longer; coupled with this, perceptions about aging are changing from it being something "natural" to something that can be "treated"

Neuro-enhancement? Will advances in our understanding of brain function result in enhancing as well as therapeutic applications?

2014 First true anti-aging product forecast to emerge in the marketplace

POSSIBILITY SPACE? If a gene therapy application emerges for muscle-wasting diseases, will it be abused by professional sports people or used for cosmetic purposes to enhance "healthy" muscles?

POSSIBILITY SPACE? "Designer babies"? Will the convergence of gene therapy technologies, embryo screening and selection and a growing understanding of the interaction of genetics and environmental factors lead to genetically enhanced babies?

REPRODUCTIVE TECHNOLOGIES



Ability to screen, select and store healthy embryos will continue to grow at a rapid pace

Social Trend Women waiting until later in life to have children = increasing difficulty in conceiving naturally

2005-2010 - "Sperm sorting" technique emerges, enabling the accurate selection of the gender of an embryo through sperm testing and separation techniques prior to implantation

Industry Trend The growth of a "drug delivery" industry sub-sector

TECHNICAL BOTTLENECK Effectively delivering biological drugs to target sites

By 2007, 50% of clinical trials are forecast to incorporate genetic testing of participants

Legislative Readiness? Is our legislative system prepared to deal with the privacy issues that may emerge through genetic testing?

Potential availability of "artificial wombs" to house premature babies to full term

Gene therapy emerges: RNA interference seen as the technology "most likely" to enable it

Bio-nanotechnology-based diagnostics available

Legislative Readiness? Is our legislative system prepared for bio-nanotechnologies?

First meaningful data from large-scale, population-based longitudinal genetic projects (like UK Biobank) which may begin to give us a better understanding of the complex interplay between genetic and environmental factors

GENOMIC MEDICINE



1997 - First gene-based targeted therapeutic Herceptin® for breast cancer enters the marketplace

1997 - 16% of new drugs based on biotechnology

2003 - Map of the human genome completed

TECHNICAL BOTTLENECK Data overload and the challenge of interpreting genomic and proteomic data

Diagnostic technologies make up the first wave of genomic medicine

Proteomics will build understanding of protein markers for disease, enabling early diagnosis

Market Trend Market fragmentation based on sub-populations of patients and consumers

2015 - 40% of new drugs based on biotechnology

Legislative Readiness? Is our legislative system prepared for bio-nanotechnologies?

NUTRITION



Continued rapid growth of the functional foods sector

DNA diagnostic technologies enable more effective food safety monitoring

Consumer Trend Move among consumers in developing nations towards self care and self diagnosis

Nutrigenomics - diet based on individual genetic make-up

CONVERGENCE of health and food sectors. Personalisation of treatment and diet based on an individual's genetic profile

AG-BIO

1996 - First commercial planting of GM Crops. First generation of GM Crops exhibits production, or "input", traits, like insect and herbicide resistance

2002 - First livestock cloned for commercial purposes



Stacked Traits Genetic modification of multiple traits in plants forecast to become common

Consumer Trend Strengthening consumer resistance to GM crops entering the food chain and the environment

Decision Point? To GM or not GM? If marker-assisted breeding techniques can deliver similar and cost-effective outcomes to GM techniques, will different markets decide to go down different paths?

2009 → 2013 marker-assisted breeding techniques forecast to be capable of producing controlled, complex traits without the need for genetic modification

2010 Rapid DNA diagnostics for animal health forecast to be common

Biopharming - 2008 Forecast emergence of GM livestock as "factories" to produce therapeutic proteins for use in biopharmaceuticals

CONVERGENCE between industrial and ag-bio sectors via the use of plants and animals as factories

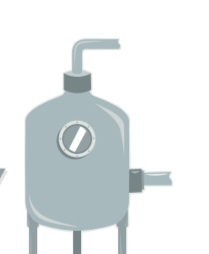
Second Generation of GM Crops forecast to emerge. These crops have enhanced "output" traits, for example modified starch, fatty acid, lignin and protein content

Third Generation of GM Crops Therapeutic food and crops which are resistant to environmental stresses like drought and salt

2015 - Apomictic or "self cloning" crop technology forecast to enter the market

Biopharming GM plants forecast to be used to produce therapeutic proteins for the production of drugs

INDUSTRIAL BIOTECHNOLOGY



5-10% of transport fuels based on bioethanol and biodiesel blends

Rapid improvements in enzyme and microorganism engineering set to lead to market penetration in non-traditional areas where cost-benefits evident

Achieving Scale Prototype biorefineries emerging

Achieving Scale Biorefineries becoming established and diversifying into the production of multiple product streams

Achieving Scale - 2020 Larger-scale bioenergy production capability

2004 → Bioplastics make up 5% of total global plastics market

2010 → Bioplastics make up 10-20% of global plastics market

2015 → Bioplastics make up 30% of global plastics market

INTERDEPENDENCIES The ability of industries to adapt to uptake commodity renewables will depend on their infrastructure. For example, in transport the uptake of biofuels will be dependent on the development of the fuel distribution infrastructure and internal combustion engine technology design

INTERDEPENDENCIES Forecasts of widespread uptake of commodity biofuels depend strongly on the uptake of forecasted GM crop technologies to improve crop yields

CONVERGENCE of environmental and industrial applications via the development of sustainable industrial processes and renewable products

Hydrogen fuel cells?

ENVIRONMENTAL BIOTECHNOLOGY



Diagnostic biotechnologies (DNA chips and biosensing devices) start to play an increasingly important role in environmental management

Legislative Readiness? Are we adequately prepared to protect or derive benefits from bioprospecting our own native flora and fauna in NZ?

Decision Point? Advances in animal cloning technologies make safe cloning of endangered species feasible

SECURITY AND DEFENCE



The emergence of new viral diseases like SARS and Asian flu coupled with biodefence measures is resulting in greater efforts being put into national pandemic planning strategies

2005-2010 Forensic science applications are more portable, able to process smaller DNA samples in real time

Possibility Space? Advances in synthetic biology are making it possible to create novel viruses and bacteria from scratch. There is potential for these advances to be misused - so-called "dual use" technologies

Biodefence R&D spending, particularly in the US, targeted at vaccine and anti-viral drug development and biosensing technologies, with resulting spin-offs for civilian markets, for example environmental monitoring, food safety and drug manufacturing