COUNTY
Investment Management

THE BIOTECHNOLOGY REVOLUTION:

A UNIQUE OPPORTUNITY FOR AUSTRALIA*

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*This paper results from research undertaken as part of County's investment process in which we assess the impact on markets of major structural changes in society and the economy.

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Prologue

Put yourself forward in time 100 years. You are a 130 year-old athlete, and have just run your best time in the annual over-120s marathon. Last week you visited your local DNA Bank to replace a couple of limbs that were beginning to feel worn out, after some annoying compatibility problems you experienced after your second artificial heart transplant three years ago. Your diet for today includes the latest cloned cholesterol-free beef and genetically-engineered tomatoes, which were developed in the laboratory of locally-based conglomerate FlexiVeg Incorporated. Fortunately you have sufficient financial resources to pay for this indulgent lifestyle because you live in Australia, the centre of the world's biotechnology industry for the past century.

Does this all sound fanciful to you?

It is the contention of this paper that, on the contrary, the scenario described above is not only plausible, but is likely to be quite commonplace in the world to be inherited by our children - or perhaps (if we are very fortunate) to be achievable within our own lifetimes. The catalyst for this brave new world - and for the immense social changes, economic impacts and moral dilemmas it will bring - is the impending revolution in biotechnology research, a revolution which has the potential to unleash structural changes more profound than any technological advance in human history.

While the biotechnology revolution will pose many challenges, both practical and ethical, to all nations, Australia has the opportunity not only to rise to these challenges, but also to prosper from them. With some vision from Government, providing a suitable policy environment, and from business, in grasping the opportunity, Australia has the opportunity to be at the centre of "Genome Valley", the 21st century equivalent of today's icon of successful technological development, Silicon Valley.

Achieving such an outcome is the topic of this paper.

1 The biotechnology revolution

Much has been written on the biotechnology revolution, with interest being particularly heightened last year with the announcement of the cloning of the sheep named Dolly[1].

As with most scientific revolutions, the biotechnology revolution has evolved from many small steps interspersed with some giant leaps. The historical timeframe of developments in biotechnology can be set by the date of three significant leaps.

1. The first is the discovery of the three-dimensional, double helix structure of DNA by Watson and Crick in 1953. The structure of DNA encodes all of the genetic information of life. In a sense, Watson and Crick started the process of decoding the equivalent of the computer program that determines the nature of each life form.

2. A further major leap forward occurred in 1973 when Cohen and Boyer performed the first successful recombinant DNA experiment. Recombinant DNA technology allows pieces of DNA from one source to be recombined with DNA from another source. This technology is not only used for developments such as the cloning of Dolly but also for the development of genetically engineered drugs and as a tool in the ongoing search for the understanding of the genetic structure of life.

3. It was with this latter intent in mind that a further major step forward was initiated in 1988, with the launch of the human genome project[2]. The aim of this 15-year project, funded by the United States Department of Energy and National Institute of Health, is to determine the complete chemical structure of human DNA and to locate the estimated 50,000-100,000 genes within the human genetic structure. In effect, the project is aiming to complete the decoding of the program of life.

Already, the human genome project is helping to identify genes associated with diseases, thus allowing research into therapies[1]. In the early part of the next century, the flow-on effects of the project and associated technology will snowball, with profound implications for societies and economies.

Rather than speculate on specific applications and implications, we attempt to highlight the magnitude of the structural change that will be wrought by the biotechnology revolution by drawing on an analysis used to elucidate the impact on the US economy of the information technology revolution.

[1] See "The Biotech Century", *Business Week*, March 10, 1997, Page 36.
[2] For an overview see the World Wide Web link of the National Human Genome Research Institute: www.nhgri.nih.gov/HGP/

The paper[3] reproduced in Appendix A sets out to resolve the following paradox:

The United States has maintained a fairly constant productivity lead over Japan and Germany despite having a savings/investment rate which was not only the lowest for three decades, but which declined sharply throughout most of the period as well.

The paper explains this paradox by arguing that the United States' mastery of information technology so increased its "innovation quotient" as to compensate for the impact of declining savings. The reason that information technology was able to have this effect is that it is a so-called General Purpose Technology (GPT)[4]. The concept of a GPT is discussed on page 10 of Appendix A. It is recommended that the reader should read that discussion or, ideally, all of Appendix A before proceeding.

The paper in Appendix A argues that binary logic and electronic circuits (the heart of information technology) are today's GPT. The general-purpose nature of the technology is what has led to information technology having such a profound economic structural effect.

The structural logic of DNA and recombinant DNA technology (the heart of biotechnology) are likely to be the GPT of the 21st century. The special characteristic of this GPT is that it is the technology of life. As a consequence, the impact of this GPT is likely to be more profound than any before[5].

Mastery by a country of the GPT of biotechnology is bound to result in an accelerating innovation quotient, just as in the case of information technology. The domination of aspects of information technology, such as Microsoft's dominance of PC operating systems with its Windows product, is to some disturbing[6]. Domination by countries or companies of the GPT of biotechnology will bestow power that will make the information technology domination issues seem insignificant.

The granting of patents over biotechnological discoveries is facilitating the potential for domination. The logic for awarding patents in biotechnology is exactly as for other areas of innovation. The difference, that has caused controversy, is that patents are being awarded over fundamental elements of life.

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[3] This analysis is inspired by an August 1995 report from Strategic Economic Decisions Inc., reproduced as Appendix A, with their kind permission.

[4] See Appendix A and "General Purpose Technologies: Engines for Growth?", T Bresnahan and M Trajtenberg, National Bureau of Economic Research, Working Paper No. 4148, 1992.

[5] Previous General Purpose Technologies, apart from electronic circuits, include printing and the steam engine.

[6] See, for example, "Court warns off 'bully' Microsoft", *The Weekend Australian*, December 13-14, 1997, Page 16 or "Justice vs. Microsoft: What's The Big Deal", *Business Week*, December 1, 1997, Page 63.

An interesting review of this controversy can be found in a paper by McNally and Wheale[7], in which the authors propose that biotechnology patents will lead to significant structural change, which they characterise as follows:

Biotechnological innovation constitutes a new "regime of accumulation" while the globalisation of intellectual property rights in genetically engineered life forms constitutes a new "mode of regulation". The combination of the two is creating a new global order dominated by the bio-industrial complex.

Much of the remainder of this paper is concerned with Australia's place in this new global order.

[7] "Biopatenting and biodiversity: comparative advantages in the new global order." *The Ecologist*, September 1996, Page 222.

2. Lessons for Australia

Cries of lack of government "vision" have become familiar in Australia in recent times, resulting in the Prime Minister's policy statement "Investing for Growth"[8]. Be they associated with high unemployment or the need for industry policy, we believe that the root cause of these pleadings is the perception that Australia is ill-prepared to deal with the massive structural change that is currently sweeping the world.

Change, generally labelled as "globalisation"[9], can be seen as exporting Australian jobs, increasing unemployment, and as intensifying the corporate competitive environment, resulting in calls for industry policy.

The massive structural change to an "information economy" in the developed world can be seen as sweeping past Australia, leading to massive opportunity in the United States and some other countries[10].

National benefit from structural change does not occur solely by chance. Planning by government and industry in anticipation of the impact of structural change can have a dramatic effect on whether a country is a winner or loser from change.

The strong position of the United States in information technology arguably stems from the hundreds of billions of dollars of U.S. Government expenditure on information technology research and development as a result of the space and arms races[11]. The United States Government foresaw the change that would result from such technology admittedly, in very narrow fields. This investment has spilled over into myriad related fields giving the United States unrivalled superiority in commercial information technology.

The Australian Government's initiatives to catch up in information technology[8] are admirable but are 40 years too late to capture the most high value advantage. This is the time that it has taken Silicon Valley to develop from its roots to the information technology powerhouse that it is today[12] [13].

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[8] The statement is available on the Internet at www.dist.gov.au/growth. See also "Going for Growth: Business Programs for Investment, Innovation and Export", D Mortimer, Commonwealth of Australia, June 1997.

[9] "Globalisation vs Tribalisation: A County Theme for the 90's", *County InHouse*, County NatWest Investment Management, August 1995.

[10] "The Global Information Economy: The Way Ahead", The Information Industries Taskforce, Professor A Goldsworthy, Chairman, Commonwealth of Australia, July 1997.

[11] United States Budget for Fiscal Year 1996, Tables 9.7 & 9.8

[12] "Silicon Valley: How it really works", *Business Week*, August 18, 1997, Page 46.

[13] "Survey: Silicon Valley", *The Economist*, March 29, 1997, Page 66.

Australians should be asking how are we going to be at the centre of the "Silicon Valley" of the next revolution. This requires looking to the structural changes that are likely to have profound global repercussions early in the next century, rather than just attempting to catch up with the structural changes of the past.

The biotechnology revolution offers many opportunities for a nation prepared to embrace the change to its advantage. Australia is fortunately well positioned to benefit from the biotechnology revolution.

3. SWOT analysis

To take a systematic approach to forming an appropriate response to such change, we undertake an analysis of Australia's Strengths, Weaknesses, Opportunities and Threats (SWOT) in relation to the biotechnology revolution.

3.1 Threats

We start with threats to get the potential bad news out of the way.

The primary focus of this paper is the economic impact of the biotechnology revolution and the social consequences that flow from the economics. We thus do not consider the potential ethical and related social consequences of the revolution, although these pose many threats that certainly require considerable attention.

The economic threat from the biotechnology revolution is primarily to our balance of trade. The structural changes described in the previous section will lead to an increasing proportion of our consumption being in goods and services that result either directly or indirectly from the GPT of biotechnology.

Australia's poor position in transitioning from the agrarian age to the post industrial revolution era[14] and from that era to the information age has left us with a structural balance of payments deficit[15] and Australian jobs being "exported" overseas. As we move to the biotechnology age the threat of this trend continuing looms large.

Two additional structural effects magnify the threat. The first is globalisation, referred to earlier in this paper. In the world of global free trade of the 21st century, Australia will not be able to hide behind the tariff barriers that it has used to protect itself in previous transitions. Such trade protection has arguably left Australia in a worse position at the end of the transition by allowing Australia's business and government leaders to push on without a clear vision of Australia's place in the changed world. This protection will not be available in dealing with the transition to the biotechnology age. Vision will be required

[14] In the 1800s, Australia had the World's highest GDP per capita according to an OECD study "Monitoring the World Economy 1820-1992", OECD 1995. By 1992, Australia had fallen to 13th in the sample of 56 countries in the OECD study. See also, "The century the earth stood still", *The Economist*, December 20, 1997, Page 65.

[15] In 1994-95 Imports of Computer Merchandise, Services and Royalties were valued at $5,97 billion compared with exports of $1.73 billion. The deficit of $4.24 billion was a 16% increase on 1993-94. ("Balance of Payments and International Investment Position. 1994-95", Australian Bureau of Statistics.)