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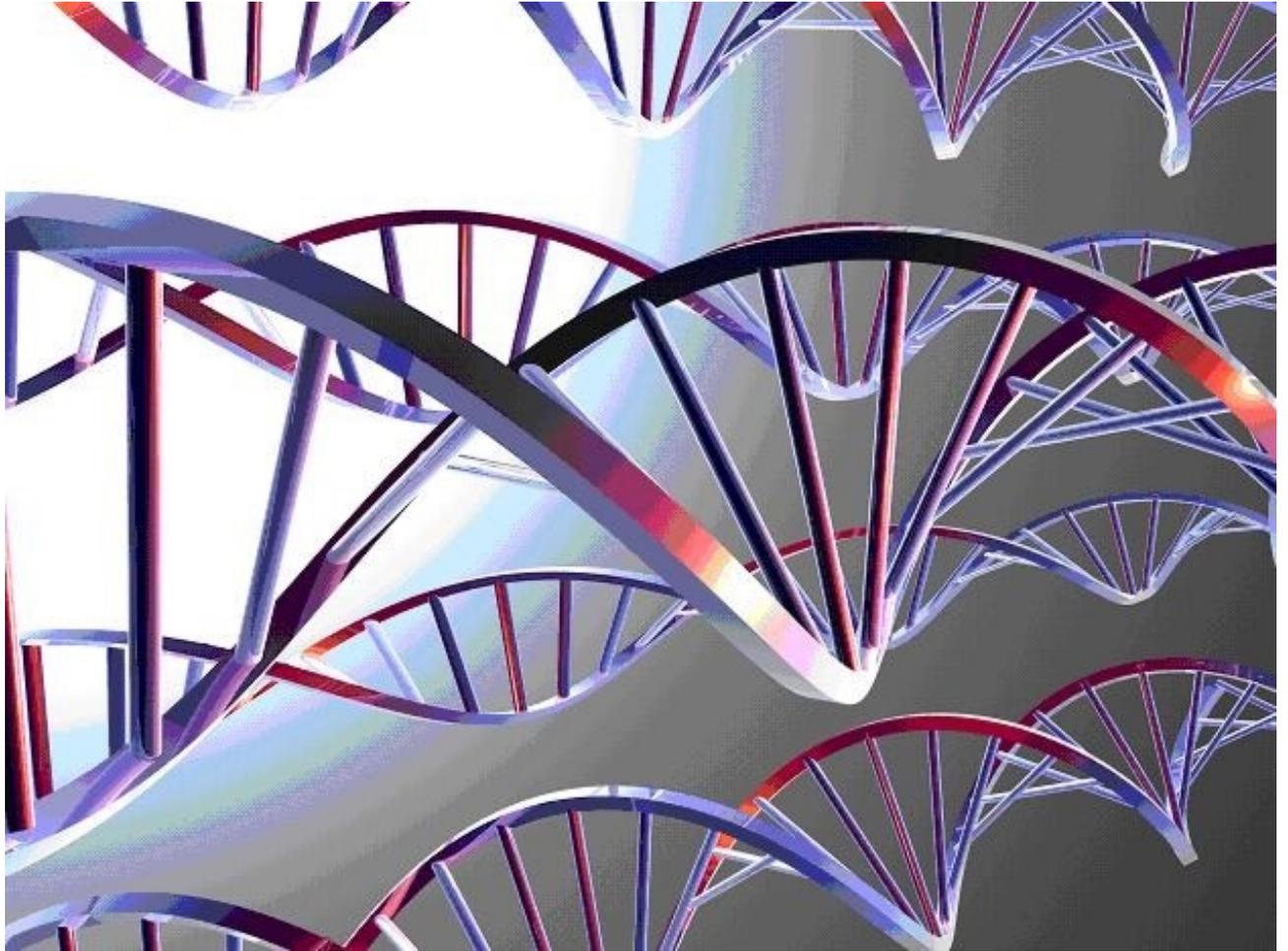
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QUEENSLAND BIOTECHNOLOGY REPORT 2006



INNOVATION DYNAMICS
Advancing Technology Businesses

Data sources

Data for the report were gathered largely from public sources, a survey of biotech organisations (public sector and industry) in Queensland and the authors' databases. Details of the survey are provided in Section 8 of this report. 86 out of a 152 organisations responded to the survey (48 companies – a response rate of 55% and 38 R&D organisations – a response rate of 55%). Of these, 58 organisations (32 companies and 26 research institutes) returned completed surveys, while the rest of the organisations declined to fill out the survey. The relative error for the companies surveyed was 6.8% and for the R&D institutions 8.1%.

Throughout the report, the term “life sciences” is used to indicate a broader group of companies/organisations than “biotech”. Life sciences include medical devices, biotech and other healthcare and is generally used when the source data are not specific to the biotech sector.

All figures for Australian firms and activities are in Australian dollars. Where data were in other currencies, currency figures have been converted to equivalent Australian Dollars using the exchange rates outlined in the appendix.

Authorship

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CONTENTS

1. Key Findings.....	4
2. Introduction	5
3. Economic Performance	6
3.1. Company Overview.....	6
3.2. Listed biotech companies in Queensland	7
3.2.1. Total revenue.....	9
3.2.2. Exports	10
3.3. Biosciences workforce.....	10
3.3.1. Wages.....	11
3.4. Biotechnology Users	11
4. Commercialisation performance.....	13
4.1. Patents granted	13
4.2. Angel VC investment secured.....	14
4.3. Commercialisation by R&D institutions	14
4.3.1. Spin-off Companies formed in Queensland.....	14
4.4. Clinical trials	15
4.5. Alliances established	18
4.6. Licences issued.....	20
5. R&D performance.....	21
5.1. Citations/publications	21
5.2. University/research organisations' bioscience investments	22
5.3. Industry/bioscience firms' R&D investment	23
6. Education/Skilling Performance	24
6.1. Science Graduates	24
6.2. Bioscience/higher education degrees awarded	24
7. Conclusions	26
8. Methodology.....	27
8.1. Data sources	27
8.2. Conversion Factors.....	28
9. References	29

1. Key Findings

As at December 2005 there were 88 core biotech companies in Queensland and 68 R&D centres and institutes which have some involvement in biotechnology.

In the last five years, up to one third of the new biotech companies formed each year have been headquartered in Queensland.

Queensland is particularly strong in agbiotech, with 25% of the State's firms targeting markets in this sector.

Queensland-based Alchemia Ltd is now one of the top ten biotech stocks on the Australian Stock Exchange, by market capitalisation.

We estimate the total income of biotech companies across Queensland was \$292 million in 2004/05, and that of biotech-related R&D institutions was \$404 million.

Company respondents to the survey reported over \$36 million in exports in 2004/05.

Queensland R&D institutions received a share of US\$9.884 million in 2005 from US philanthropic groups.

Total employment of the 88 biotech companies in Queensland in 2004/05 was estimated at 1,933 and in biotech-related R&D institutions was estimated at 3,282. We estimate the wages of employees at these organisations to have totalled over \$318 million in 2004/05.

There are over 330 products sold by biotech companies in Queensland.

Queensland inventors' share of US biotech patents awarded to Australian inventors rose from 11.6% in 2002 to 13.7% in 2005.

Queensland companies have received a total of \$40.18 million in investment from venture capital managers in the last two financial years.

Queensland R&D institutions have been particularly strong in producing spin-off companies. Of the 36 spin-off companies started by R&D institutes in Australia in 2002/03, 9 of them were started by R&D institutes based in Queensland. This proportion increased to almost 50% in 2004/05, where 6 of the 13 spin-off companies started by R&D institutes were based in Queensland.

The State's investment in biotech infrastructure since 2003 has led to the launch of Tetra-Q (preclinical services), the Queensland Clinical Trials Network (marketing clinical trials expertise) Q-Pharm (conducting Phase I clinical trials), Q-GEN (a GMP facility providing contract cell culture and other services) and BioPharmaceuticals Australia (contract manufacturing facilities for preclinical and clinical trials). As at June 2005 there were 549 clinical trials underway in R&D institutes & hospitals in the State.

Biopharmaceutical companies in Queensland were trialling 23 of their own human therapeutic products in Phase I – Phase III trials around Australia and internationally in 2004 and 2005.

Queensland-based biotech organisations announced 19% fewer alliances in 2005 than in 2004.

Queensland-based researchers have lifted their publication of biotech-related papers from 837 in 1997 to 1,364 in 2005.

When compared on a per capita basis to R&D institutions elsewhere in Australia, Queensland's R&D institutions are relatively strong in the disciplines of biochemistry and cell biology; crop and pasture production; environmental engineering; genetics; industrial biotechnology and food science; other medical and health research; and pharmacology and pharmaceutical science.

2. Introduction

This report provides an overview and update of the state of play in the Queensland biotech industry. The report is based on publicly available data plus the results of a survey that was sent to 84 core biotech companies¹ and 68 R&D institutions (including R&D centres) in the State. The survey was conducted in December 2005.

Since 2003, when the 2003 Queensland Biotechnology Report² was published, the Queensland government has committed further funding under the Queensland Biotechnology Strategy.³ In an industry where time-to-market can be many years, it is difficult to measure concrete progress in just two years. Nevertheless, there are clear signs of progress in many areas and the industry in the State is holding its own against larger States.

In addition to tracking progress within the State, the report has benchmarked Queensland internationally in areas where international data were available and were directly comparable. Where this was achieved, it shows that Queensland, along with the rest of Australia, is in its infancy in relation to commercial biotechnology developments when compared to major markets in the US, Canada and Europe. However, both Queensland and Australia have much more substantial activity than many other countries. Further, the size and strength of the biotechnology industry other countries demonstrate the potential of biotechnology to contribute to the State's, and the country's, economy.

This report is divided into 9 sections, all of which cover both companies and R&D institutions. The first section covers general economic performance. The second section covers commercialisation performance. This is followed by sections on R&D performance, education/skilling and conclusions. The methodology, comments on data sources and references are at the end of the report.

¹ A further 4 companies have since been identified – the total number currently is therefore 88, and this number has been used to derive the State-level estimates elsewhere in the report.

² Ernst & Young (2003): *2003 Queensland Biotechnology Report*

³ Queensland Biotechnology Strategic Plan 2005-2015: Biotechnology – Setting New Horizons

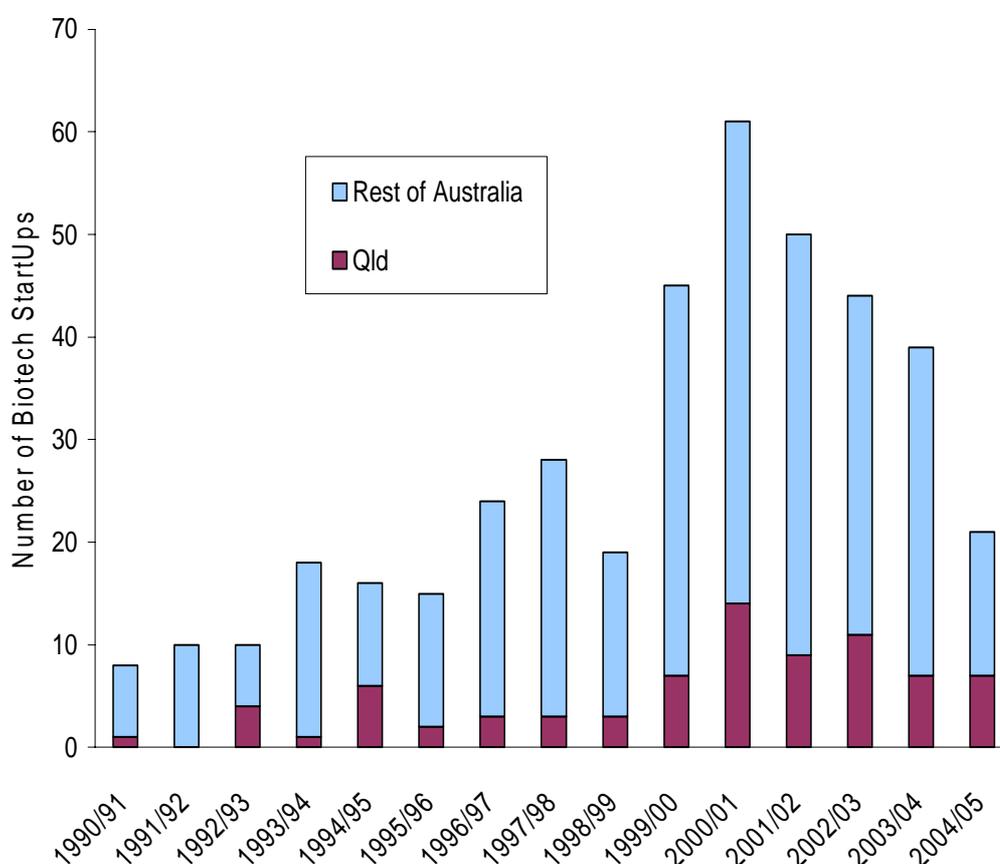
3. Economic Performance

3.1. Company Overview

The Queensland biotech industry continues to increase in size. New firm formation in the State since the mid-1980s has closely followed trends nationally. Since 2000, new companies in Queensland have comprised between 12.5% and 33% of new core biotech firms each financial year. The strongest year was 2004/05, when 7 of the 21 new biotech companies formed were in Queensland.

Figure 1 shows trends in new biotech company formation since 1990/91. The main reason for the increase in Queensland-based biotech firms since 1999/2000 has been the numbers of research spin-off companies from State R&D institutions (see page 14). New biotech formation varied from a low of 8 in 1990/91 to a high of 61 in 2000/01 and averaging 31 per year over the 5 years from 2000/01 to 2004/05.

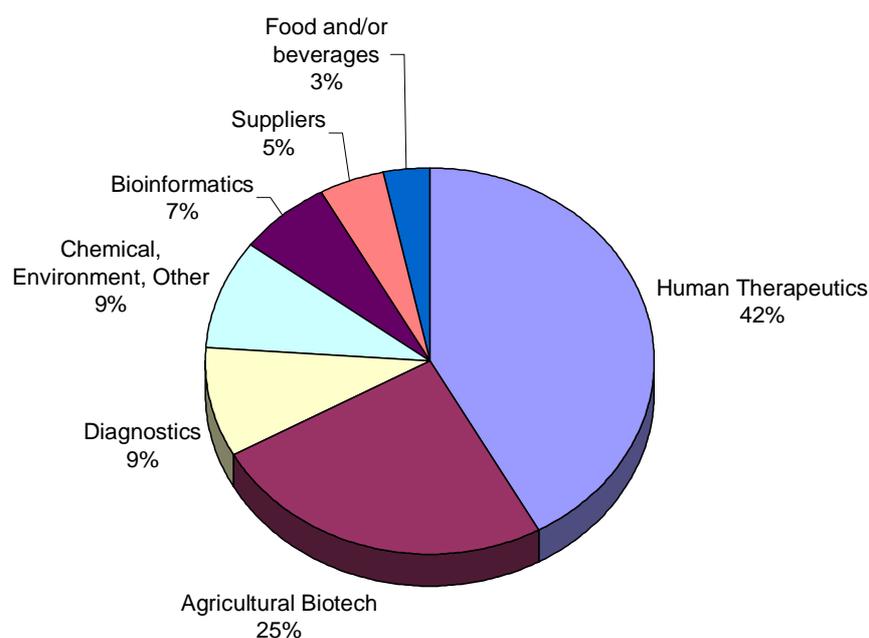
Figure 1: Core biotech start-up formation Queensland vs rest of Australia



Source: Innovation Dynamics' database

Biotech companies target a range of markets, including human therapeutics, agriculture, human diagnostics and other markets (Figure 2). Of the core biotech companies in the State, 45 companies are targeting human health (37 developing human therapeutics and 8 diagnostic products and services). Queensland is particularly strong in agbiotech, with 22 companies in this sector.

Figure 2: Target markets for Queensland core biotech firms, end 2005



Source: Innovation Dynamics, n=88

Box 1: Genetic Solutions

Genetic Solutions Pty Ltd combines biotechnology and IT expertise to provide testing services for the Australian and international livestock and aquaculture industries. Genetic Solutions launched the world's first DNA tests for tender beef, its innovativeness recognised in mid 2005 by the granting of \$1.3 million under the federal government's Commercial Ready program to accelerate its work on genetic markers. Genetic Solutions has a number of trademarked products including SureTRAK®, a DNA traceability system for the food production chain which is used for approximately 20% of the beef carcasses processed in Australia; GeneSTAR®, a suite of DNA tests used as a genetic selection tools by cattle producers; and SireTRACE®, which uses DNA profiling to verify or assign parentage (sire &/or dam) in cattle, sheep, horses and aquaculture species. Customers of Genetic Solutions include companies in the breeding, feeding and processing sectors of the livestock and aquaculture industries.

3.2. Listed biotech companies in Queensland

As at 2005, there were eight ASX-listed biotech companies in Queensland - Agenix, Analytica, Alchemia, Biopropect, Panbio, Peplin Biotech, Progen Industries and Tissue Therapies. Two of these, Tissue Therapies and Alchemia, have listed since 2003. Alchemia has been particularly successful and is now one of the top ten listed Australian biotech firms. Alchemia's history and current activities are summarised in the box over the page.

Box 2: Alchemia

Alchemia Ltd is a biotech company that listed on the Australian Stock Exchange in December 2003. The company's first product, a generic synthetic heparin, was based on an in-house capability in carbohydrate synthesis, and is planned for market launch in North America in 2008. Synthetic heparin is being manufactured by Dow Chemical and will be marketed by American Pharmaceutical Partners. Alchemia is also using its carbohydrate expertise to develop therapeutic products, its first being an anti-angiogenic anti-cancer candidate, ACL 16907. Alchemia is currently completing pre-clinical studies on this molecule.

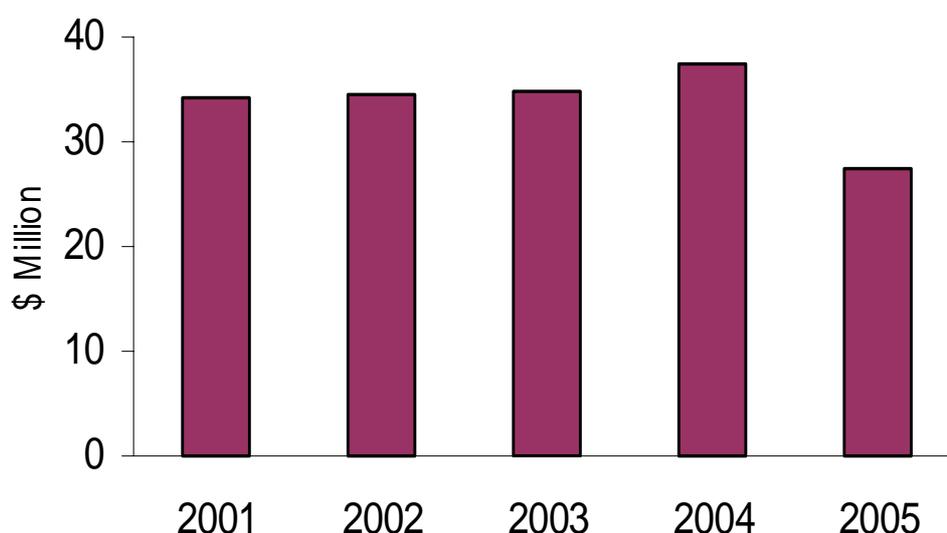
Alchemia was successful in attracting venture capital investment totaling AU\$26 million prior to listing, as well as AU\$11.7 million in federal government R&D grants and a grant of AU\$7.8 million under the federal government P3 program. The company raised AU\$21 million on listing and has since raised AU\$21 million in additional share placements. Alchemia is participating in a Level 1 American Depository Receipts program on the NASDAQ exchange.

As at the end of 2005, Alchemia was ranked 8 out of the top ten biotech companies listed on the ASX, by market capitalisation. In late March 2006, Alchemia lodged a bidder statement for Meditech Research, which has a product in Phase II trials and two programs that have completed Phase I.

Market capitalisation of listed biotech firms fluctuates from year to year. While Queensland has fluctuated significantly in the last five years (Figure 3), the value of Queensland-based listed firms has fluctuated less than firms in the rest of Australia.

Listed firms in Queensland are, on average, slightly smaller than those elsewhere in Australia.⁴ This may be due, in part, to the young age of some listed Queensland firms - Alchemia, for example, was formed in 1995 and Tissue Therapies in 2002. The average revenue of Queensland-based listed biotech companies was \$6.15 million per firm in 2003, rising to \$6.55 million in 2005.

Figure 3: Average Market Capitalisation of Listed Biotech Companies in Queensland 2001-2005



Source: ASX data and authors' analysis, excludes CSL, market cap data taken in July each year

⁴ Excluding CSL

Listed biotech companies in Queensland and elsewhere in Australia are small when compared to listed biotech companies in major markets. In the US, for example, the total market capitalisation of listed biotech companies in the US has risen from the equivalent of AU\$398 billion to AU\$514 billion between 2002 and 2004. The size and strength of the US industry is an indication of the potential for biotech to be a major force in a nation's economy.

While activity in Australia may look insignificant in relation to that in the US, Australia as a whole is much stronger than many other nations in biotech. Other major countries such as the UK and Canada are much closer in scale to Australia – market capitalisation of UK listed biotech sector totalled AU\$16 billion in 2003 and that of Canada totalled AU\$12 billion in the same year. Australian firms, including CSL, had a market cap of AU\$4.5 billion in 2003, rising to AU\$10.9 billion in 2005. Market cap of the biotech sectors in other countries is generally much lower.

The box below provides a summary of Panbio, a long-established Queensland-based diagnostics company.

Box 3: Panbio

Panbio was established in 1988 and was listed on the Australian Stock Exchange in 2001. The company develops and markets innovative diagnostic tests to aid in the diagnosis of infectious disease. Panbio is recognised as a world leader in tests used in the diagnosis of flavivirus and other arthropod-borne viruses. Panbio developed the first commercial diagnostic assays for Ross River Fever, Dengue Fever and West Nile virus and recently released a sensitive and specific assay for Japanese encephalitis virus infection.

While having a reputation in the area of arthropod-borne viruses, Panbio's product portfolio covers over 30 infectious diseases including EBV, Q-fever and Leptospirosis. Its technical platforms include enzyme-linked immunosorbent assay (ELISA), indirect fluorescent antibody test (IFA) and rapid lateral flow devices. Panbio is also investing in the development of new state of the art diagnostic platforms, including innovative Homogeneous Assay technology.

The company reported a net sales revenue of \$14.5 million in 2004/05. In early 2006 Panbio's Maryland-based US subsidiary, Panbio Inc, was awarded a Small Business Innovation Research grant of US\$100,000 by the US Department of Defence to further develop the company's Oligo Rapid lateral flow technology, which is to be used to develop a multiplexed point of care assay system.

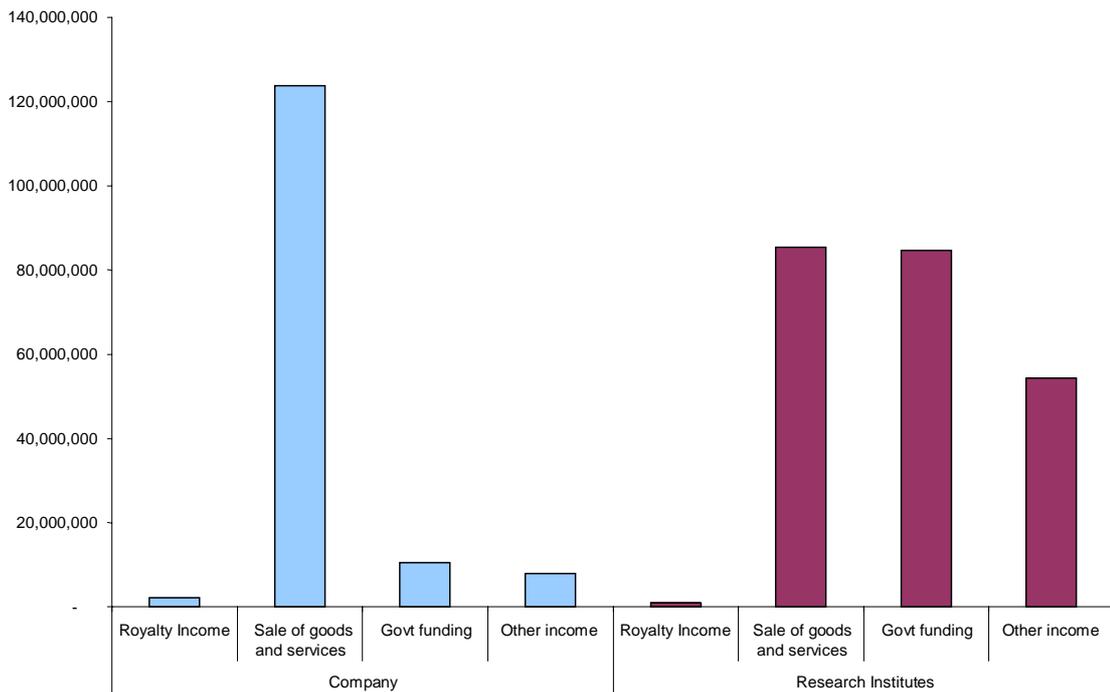
3.2.1. Total revenue

Companies and R&D institutions which responded to the survey have a strong commercial focus (Figure 4). Company survey respondents reported that they generated \$144.37 million in revenue during the 2004/05 financial year, of which 86% was derived from sale of goods and services and only 7% is derived from government grants. State-wide, we estimate that the total income of the 88 biotech companies was \$292 million in 2004/05.

Respondent R&D institutions generated nearly \$225.27 million in total income from bioscience related activity. Of the total, 38% of income was derived from sale of goods and services and 38% from government funding. We estimate the total income of 68 biotech-related R&D institutions across the State to be \$404 million.

Income split for both company and R&D institution respondents is summarised in Figure 4.

Figure 4: Income split for companies and R&D institutions, Queensland



Source: survey, Q11 – Q15 (n=32 companies and n=26 R&D institutions). "Other" includes income from sale of assets, dividends and philanthropic donations.

3.2.2. Exports

Fourteen of the 32 company survey respondents (53%) reported exports worth \$36.28 million in 2004/05. This is an average of \$1.13 million per respondent and \$2.59 million per exporting company.

Nine of the 26 R&D institutes responding to the survey reported export income. This income would include fee-for-service contract R&D, overseas grants, overseas licensing income and income for collaborative R&D. In 2004/05, this export income totalled \$4.64 million. This is an average of \$178,516 per institute over the whole sample of R&D institute respondents and \$515,714 per exporting institute.

Export income for Queensland R&D institutions includes international grants. In 2005 these included:

- AU\$12 million (approximately) from the Bill and Melinda Gates Foundation to the University of Queensland to lead an international team to develop a malaria biocontrol method which affects mosquito population age structure and causes mosquitoes to die before they can transmit the disease; and
- AU\$1.5 million (approximately) from the Bill and Melinda Gates Foundation over four years to the Queensland University of Technology, with an international team from Uganda and the US, to develop bananas with increased micronutrient content.

3.3. Biosciences workforce

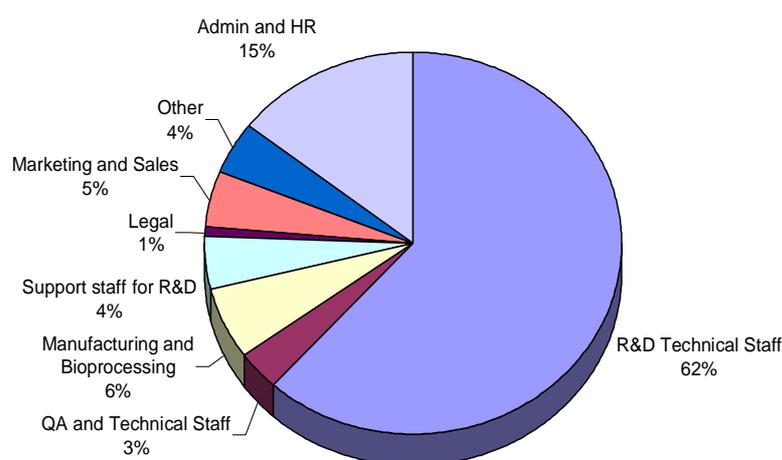
As might be expected, Queensland biotech firms vary greatly in size. As is the pattern elsewhere in Australia, there are many small companies and only a small number of larger firms. All the firms which responded to the survey would be classed as small to medium enterprises, with less than 200 staff. The company survey respondents reported a total of 759 staff. Scaling this up to the 88 biotech

companies across the State, we estimated that there were 1,933 people employed in these firms in Queensland as at June 2005.

R&D institutions were larger, with the 26 respondent R&D institutes reporting that they employed 1,727 staff. Based on these figures we estimate, therefore, that the total employment in Queensland biotech-related R&D institutions was 3,282 as at June 2005.

Survey respondents employed mostly R&D staff, with a range of support, marketing and administrative staff making up the balance (Figure 5).

Figure 5: Employees by classifications in survey respondents



Source: Survey, n = 58 (Company=32, Research Institute=26)

3.3.1. Wages

Based on the survey, the average wage of a bioscience employee in Queensland is \$62,315 as at June 2005. Bioscience workers employed by R&D institutes earned on an average \$60,341 in the last financial year. These salaries are much higher than the average wage across the whole workforce in Queensland. In August 2005, this was \$38,714.⁵

Based on the total employment estimate of 5,215 across both companies and R&D institutions, the total wages earned in 2004/05 by employees of biotechnology companies was \$120.3 million and by employees of R&D institutions was \$198 million.

3.4. Biotechnology Users

Users of biotechnology are under-recognised in Australia. Several Queensland biotech companies are selling products and services into sectors other than the healthcare/therapeutics market which is the focus of most analysis (and which has the longest and most difficult path to market).

⁵ ABS Cat. 1388.3 (2006): *Queensland Key Statistics March 2006*; Table 5, Average Weekly Earnings, all persons, August 2005

Biotech companies in Queensland have over 330 products on the market nationally and internationally.⁶ A recent report which provided a method of measuring the impact of biotechnology on the economy recommended that users of biotechnology be surveyed in order to identify the real impact of biotechnology on productivity, input costs, labour costs and other economic indicators.⁷ While this was beyond scope of the current report, it is possible to provide examples of how Queensland biotech firms are contributing to sound environmental practices and reduction in the use of harmful chemicals (see boxes below).

Box 4: Bioglobal

Bioglobal Limited is a Queensland company which manufactures environmentally friendly chemical products. The company is planning to expand into Asia, the US, Europe and South America, a strategy aimed at increasing its export earnings from \$2.5 million in 2006 to \$50 million in 2009. The Brisbane-based company was formed in 2000 to make clean green agricultural, animal health and environmental insecticides. Bioglobal's product portfolio includes a chemical pheromone which controls bugs in horticulture, a pesticide which kills moths in cotton, legumes and vegetables and the Lucilure blowfly trap and lure for sheep and landfill markets which sells in Australia and South Africa. Another product Bioglobal has developed through its clean technology is Bioattract CRW, which is a pesticide designed to eliminate the corn-root worm. Bioglobal's innovative approach to product development was recognised by the Queensland Government in November 2005 when the company received a Smart State grant of \$37,500 from the Department of State Development, Trade and Innovation.

Box 5: Biopropect

Brisbane-based Biopropect Ltd, a listed public company, collects biological material under license from various sovereign states, under sustainable conditions and strict protocols, and in full accordance with the Convention on Biological Diversity. It has facilities and expertise which enable it to extract purified compounds from plants with development of bioassay-guided fractionation. It offers bioactive screening services and is developing a discovery made in 2001 from the leaves of a North Queensland Eucalypt. The product, Qcide, is active against a range of pests. Biopropect's termite-control product, also originally derived from an Australian tree, is being evaluated by international partners. The Company is also researching a number of compounds active against the Hepatitis C Virus, that were identified from its natural library of biological material. The users of Biopropect's products include the agrochemical and human health industries.

⁶ Innovation Dynamics' Australian biotech product development survey, 2005

⁷ ACIL Tasman and Innovation Dynamics (2006): Proposed Methodology to Measure the Contribution of Biotechnology to the Economy, report for the Department of Industry, Tourism and Resources.

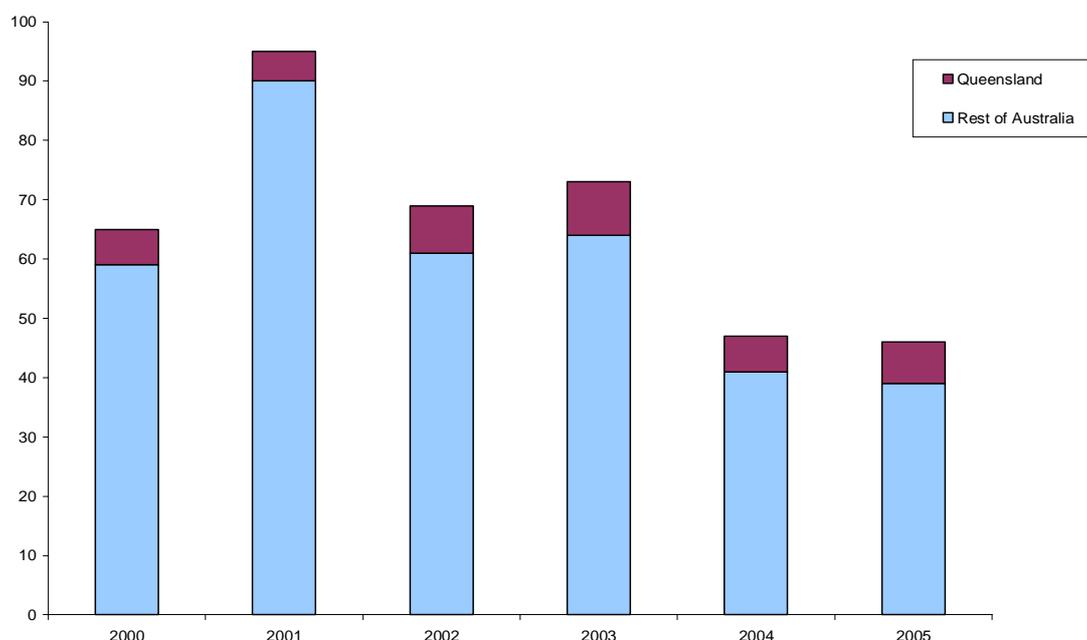
4. Commercialisation performance

4.1. Patents granted

Data on patents were collected from two sources – the survey, which tracked Australian patents, and a review of published granted patents issued by the US Patent Office. Of the 32 company survey respondents, 6 had been granted a total of 27 Australian patents in 2004/05. Of the 26 R&D institution survey respondents, 12 had been granted a total of 26 Australian patents in 2004/05.

The number of US biotech patents granted to Australian inventors has not followed a simple trend, but appears to have peaked in 2001 and to have been falling gradually since then. This pattern applies in both R&D institutions and companies. The decline has also been evident in other major biotech countries, including the US. Queensland's proportion of these patents was lowest in 2001, when the number of US biotech patents granted to Australians was at its peak. However, Queensland-based inventors have since increased their share of these patents (11.6% in 2002 and 13.7% in 2005) (Figure 6).

Figure 6: US biotech Patents Granted to Australian Inventors 2000-2005, Queensland vs rest of Australia



Source: United States Patent and Trademark Office, US Patent Class 435, authors' analysis

Queensland-based researchers are working in a range of biotech-related areas and have been granted patents in areas of direct application – for example treatments for infectious diseases – and basic research – for example genetic transcription (see Box 6).

Box 6: Significant patents awarded to Queensland researchers

University of Queensland, 2005 – US Patent 6,846,671 – Method and polynucleotides for determining translational efficiency of a codon
University of Queensland, 2005 – US Patent 6,867,033 – Treatment of papillomavirus infection
Alchemia, 2005 – US Patent 6,953,850 – Protecting groups for carbohydrate synthesis
Council of the Queensland Institute of Medical Research, CSIRO, The University of Melbourne, Walter and Eliza Hall Institute, CSL Ltd, 2004 – US Patent 6,723,695 – Cytotoxic T-cell Epitopes from Epstein Barr Virus
Fungi Gulp, 2004 – US Patent 6,824,683 – Anaerobic treatment of wastes containing insoluble components

4.2. Angel VC investment secured

Venture and angel venture capital investment is difficult to track as not all investments by venture capital managers are announced publicly. However, it appears that the average venture capital investment in Queensland life sciences companies rose from \$676,000 per investee in 2002/03 to \$810,590 per investee in 2003/04. However, over this period the amount of total funds invested in State life sciences firms decreased (Table 1).⁸ Over the same period, the percentage of investment in early expansion also rose, indicating further expansion of Queensland companies.

Table 1: Life science venture capital funding by Stage 2002/03 and 2003/04, Queensland

	2002/03 (\$m)	2003/04 (\$m)
Seed	15.355	4.97
Start-up	9.89	5.76
Early Expansion		3.05
Expansion	1.2	
Total	26.445	13.78
Percent seed/startup	95.4	77.9

Source: Australian Venture Capital Journal, authors' analysis

4.3. Commercialisation by R&D institutions

Commercialisation of biotech research from Australian R&D institutions usually takes the form of licensing of patented technologies or creation of spin-off companies. The choice from technology to technology will depend on the potential market, the availability of suitable licensees, institution policies in relation to spin-offs (as these require particular expertise, may be higher risk, and may require more patience in terms of generating financial returns to the institution).

4.3.1. Spin-off Companies formed in Queensland

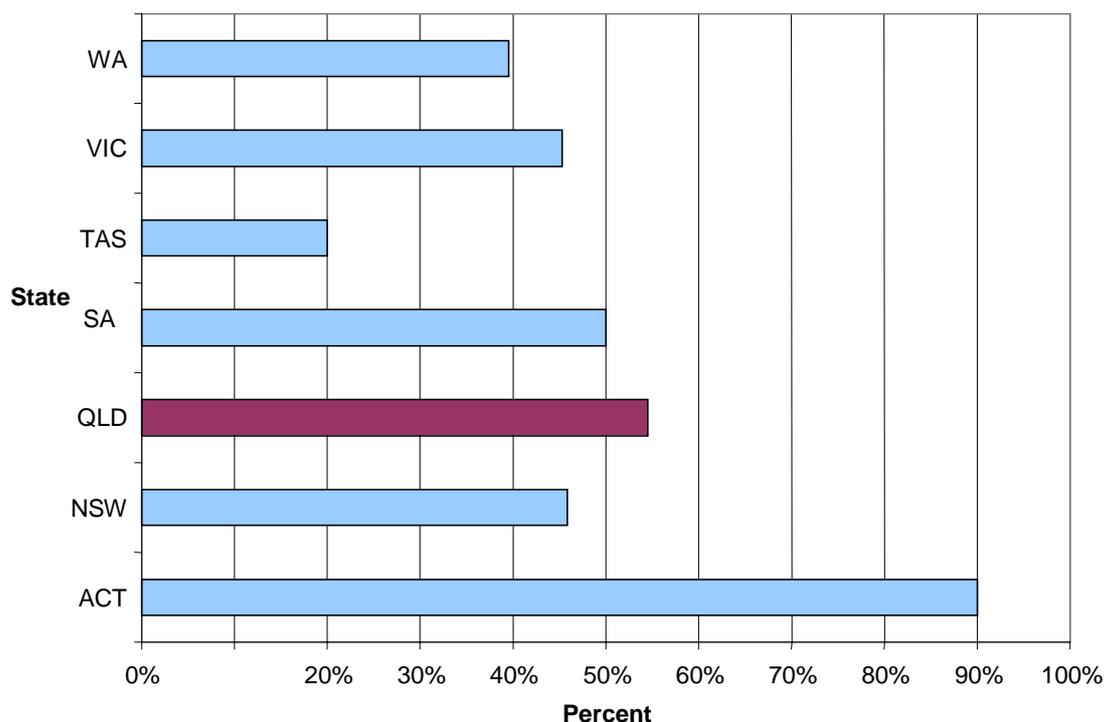
In the last five years Queensland has been particularly strong in producing spin-off companies and the University of Queensland is one of the more active R&D institutions in Australia in this regard. Of the 11 biotechnology companies that were formed in Queensland in 2002/03, 9 were spun out from a R&D institute. The same is true for 6 of the 7 biotechnology companies formed in Queensland in 2004/05.

Of the 36 spin-off companies started by R&D institutes in Australia in 2002/03, 9 of them were started by R&D institutes based in Queensland. This proportion increases

⁸ 39 companies in 2002/03 and 17 companies in 2003/04

to almost 50% in 2004/05 where 6 of the 13 spin-off companies started by R&D institutes were based in Queensland. In fact, in the last 20 years, Queensland is second only to the ACT (which has a much smaller base of companies) in the proportion of new biotech companies which are spin-offs from R&D institutions (Figure 7).

Figure 7: Percent of biotech companies which are research spin-offs, by State



Source: Innovation Dynamics' databases.

Internationally, there is some comparative information on spin-off companies from the US and Canada. Survey years have varied and are reflected in Table 2. Spin-offs per AU\$100 million range from a low of 0.73 (the US, 2002/03) to a high of 4.55 (Queensland, 2003/04). However, it can be seen from the figures that numbers fluctuate from year to year, reflecting changes in economic conditions (mainly funding) and institutional policies conducive to spin-off formation.

Table 2: Spin-off companies reported by R&D institutions, various years

Year	Country	Research Spin-offs reported	Spin-off company per US\$100m R&D expenditure
2002/03	US	374	0.73
	Canada	58	2.22
	Queensland	9	4.55
	Rest of Australia (excl Qld)	27	3.74
2003/04	US	462	0.87
	Canada	45	1.35

Source: US and Canada - Assoc. Of University Technology Managers' Licensing Survey 2003 and 2004; Queensland and Australia - Innovation Dynamics database, authors' analysis. Figures standardised to US\$

4.4. Clinical trials

The number of clinical trials being conducted in Queensland is an indicator of the expertise in the State, as well as the contributions of the State to commercialisation of biotechnology-based therapeutic products.

Infrastructure for clinical trials in Queensland has expanded significantly since 2003, with significant government support leading to the launch of Q-GEN at the Queensland Institute of Medical Research, Q-Pharm, Tetra-Q, the Queensland Clinical Trials Network and funding announced for the Queensland Preclinical Scale-up Manufacturing Facility, Biopharmaceuticals Australia. These are all summarised in the box below.

Box 7: Key biotech-related research and service infrastructure in Queensland

Q-GEN has eight class-350 clean rooms and tissue culture rooms which are all certified to PC2 containment. The facility provides contract cell culture, fermentation, monoclonal antibody production, purification, formulation and packaging for preclinical, clinical or diagnostic purposes. As at January 2006, Q-GEN was currently manufacturing for 11 separate clinical trials from Phase I – Phase III.

Q-Pharm, launched in 2002, is a joint facility between the University of Queensland and the Queensland Institute of Medical Research. Q-Pharm conducts Phase I and Phase II clinical trials and pharmacokinetic studies, bioequivalence studies and drug analysis. It has a PC-3 containment area and can be involved in short term and long term trials. It has alliances with a number of other Queensland-based organisations, including The Wesley Research Institute, Clinical Network Services and Affiliated Clinical Trials Services.

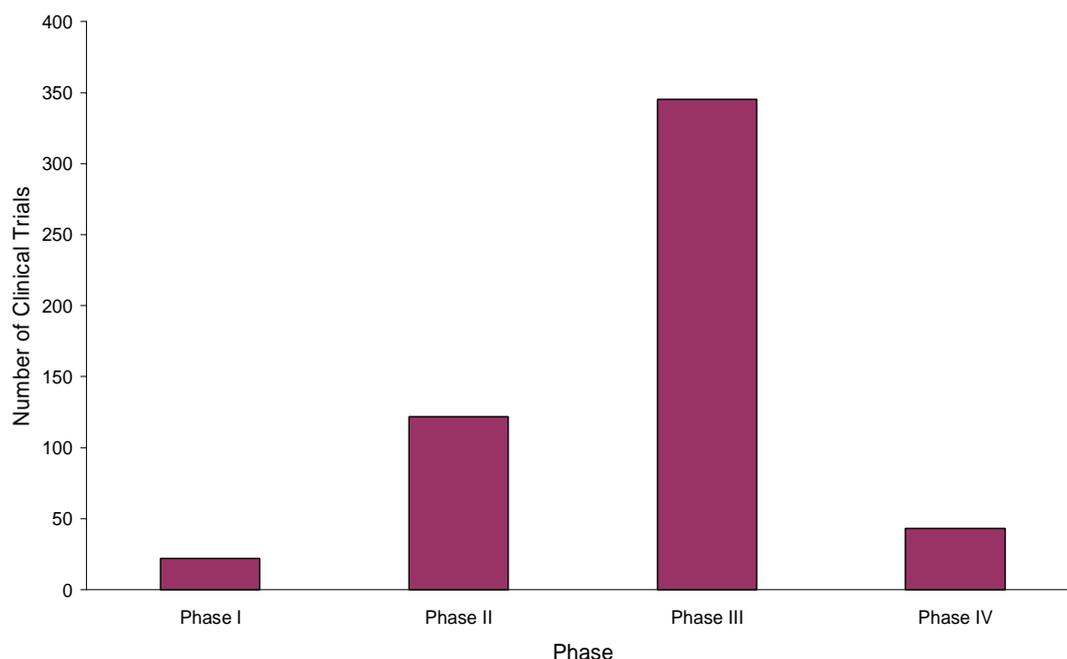
Tetra-Q, launched in 2005, offers a broad range of preclinical services to biotech and pharmaceutical companies. Tetra-Q is currently building a new facility at the University of Queensland, funded by a grant of \$8.1 million from the Queensland Smart State Research Facilities Fund.

Queensland Clinical Trials Network was funded with \$5 million to promote and market Queensland clinical trials service providers nationally and internationally and to provide a visible point of contact for overseas, interstate and local organisations wanting to conduct clinical trials in Queensland.

In November 2005, the Queensland government announced the formation of Biopharmaceuticals Australia, which has been funded through a \$7 million State government investment. BioPharmaceuticals Australia will be the nation's first dedicated contract manufacturing organisation to make drugs and therapeutics to international standards for the purpose of preclinical and clinical trials.

This infrastructure has enhanced the attractiveness of Queensland as a place to undertake clinical trials. In August 2005, the government launched the Queensland Clinical Trials Directory which provided information on 549 trials being undertaken in Queensland in 2004/05 (Figure 8). These trials include both biotech-based and other products, and methods of treatment. These trials are being undertaken on behalf of companies Australia-wide, as well as international drug developers such as AstraZeneca, Bristol-Myers Squibb, GlaxoSmithKline, Pfizer, Boehringer-Ingelheim and Abbott.

Figure 8: Clinical trials by phase, Queensland, 1 Jan 2000 – 31 Dec 2004



Source: The Queensland Directory of Clinical Trials & Related Services 2005-2006. The number of drugs under trial was not reported.

Note: Number of clinical trials, per phase, conducted at Queensland centres. As some centres did not identify the trial phase for their completed trials, the total number of trials based on the per phase data (n=509) does not equate to the total number of trials conducted overall (n=549).

Therapeutics developers in Queensland are also active in conducting clinical trials. These trials may be undertaken within the State or elsewhere in Australia or overseas, depending on the phase and the location of key clinicians.

Twelve biotherapeutics companies in Queensland had 23 drugs in Phase I to Phase III clinical trials in both 2004 and 2005. This compares to a total of 415 drugs under development in the rest of Australia as at the end of 2005. Key Queensland companies with compounds in clinical trials include:

- Alchemia Ltd, which announced in March 2005 that it was proceeding into human clinical trials with its compound ACL6907, an anti-cancer compound discovered using its novel drug discovery technology.⁹
- Peplin Ltd, which at the end of 2005 announced positive Phase IIa trial results for its anti-cancer compound PEP005 Topical for actinic keratosis, a skin condition which can develop into skin cancer.¹⁰
- Progen Industries, which in early 2005 announced the initiation of a new Phase II trial for its lead compound, PI-88. The new trial will test PI-88 combined with chemotherapy agent, DTIC (dacarbazine) and will assess PI-88's use as first line treatment for metastatic melanoma.¹¹

Internationally, the US is the leading player in drug development with a reported 1,779 drugs in various phases of clinical trials in 2002, rising to 1,877 in 2003. UK had 312 drugs in clinical trials in 2002 and showed a slight decline the following year with 300 drugs in development. Sweden's drugs in trials also fell, from 47 in 2002 to 35 in 2003. The only data available for Canada was for 2001 and it had 299 drugs under clinical trials in that year.

⁹ Company announcement, 23 March 2005

¹⁰ Company announcement, 28 November 2005

¹¹ Company announcement, 23 May 2005

Table 3 summarises these data and converts it to trials per million population in order to provide a basis for comparison. Canadian data, available only for 2001, show a high incidence of clinical trials per million population. Among the US, UK and Sweden, the US was the leading drug developer in both 2002 and 2003 with 6.2 and 6.5 trials per million population respectively.

Using 2005 data for Queensland, the State was placed second with 5.8 trials per million population, however the overseas data are for 2001 – 2003 and the situation in the other countries may well have advanced since these surveys were completed. The UK and Sweden each had 5.3 trials per million population in 2002. While the trials per million for both the countries fell in 2003, the UK had a higher incidence with 5.3 trials per million population, while Sweden had only 3.9 trials per million population.

Table 3: Clinical Trials of Drugs, Selected Countries vs Queensland

Country	Year	Clinical Trial Phase				Total	Trials/Million Population
		Preclinical	Phase I	Phase II	Phase III		
USA	2002	673	458	465	183	1779	6.2
	2003	805	468	405	199	1877	6.5
Canada	2001	133	62	69	35	299	9.6
UK	2002	112	72	96	32	312	5.3
	2003	100	83	82	35	300	5.0
Sweden	2002	20	15	11	1	47	5.3
	2003	16	10	9	0	35	3.9
Queensland	2005	13	5	3	2	23	5.8

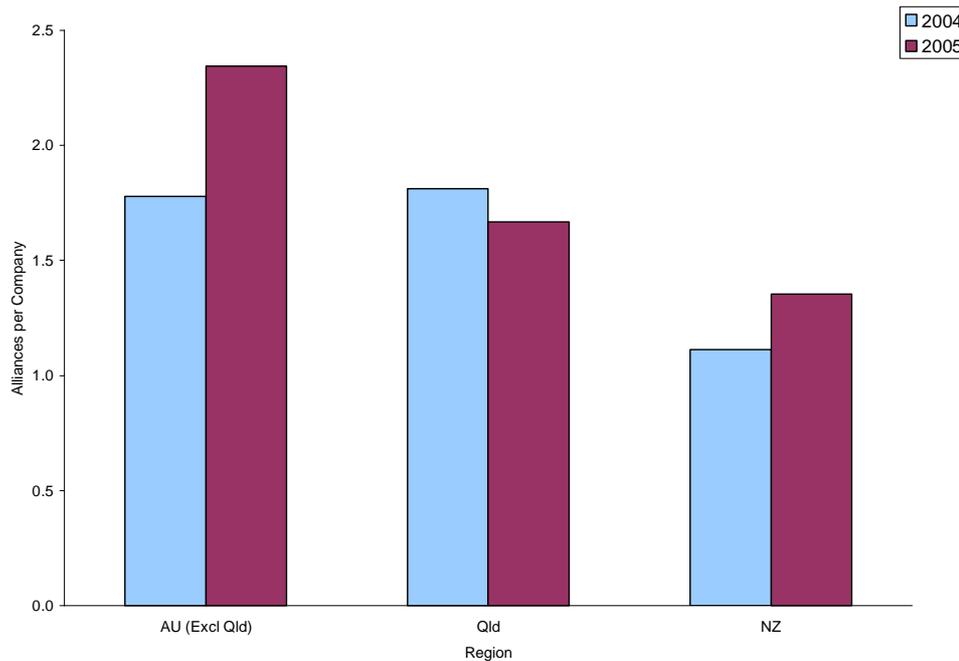
Source: Published sources

4.5. Alliances established

Alliances are commonly entered into by biotech organisations in order to reduce risk, to provide access to a greater range of intellectual property and to conduct collaborative R&D. In biotech, the number of alliances can be an indicator of the organisation's awareness of global issues and skill in external interactions. Queensland biotech organisations announced 37 alliances in 2004 (29 by companies and 8 by R&D institutions). In 2005, a total of 31 alliances were announced (20 by companies and 11 by R&D institutions).

As seen in Figure 9, the average alliances formed per Queensland R&D institute have risen between 2004 and 2005, while the average number of alliances per R&D institute in the rest of Australia decreased in the same period. In New Zealand, alliances per R&D institute remained steady at 1.5 per institute over the two years.

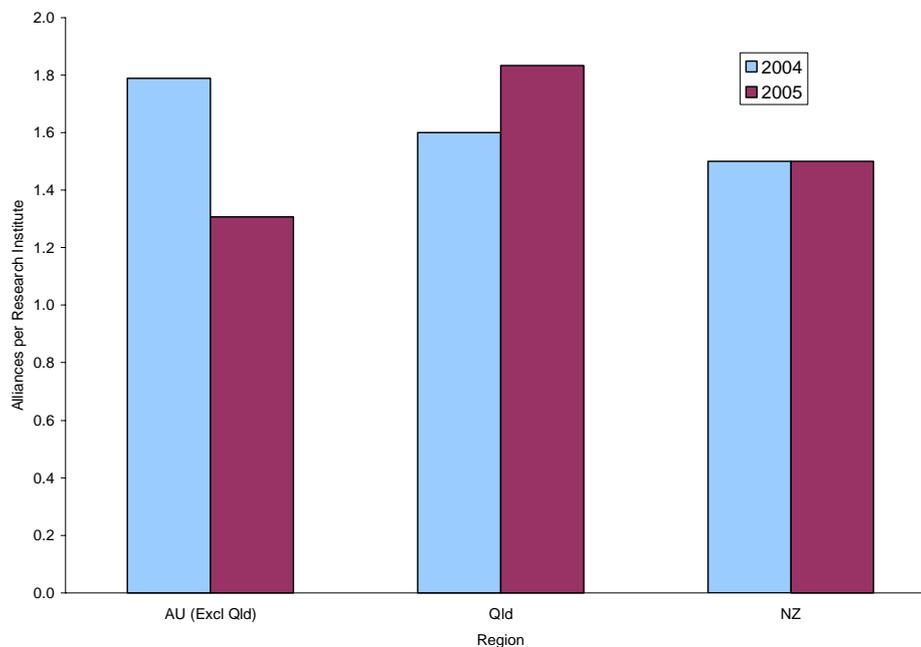
Figure 9: Average biotech-related alliances by R&D institutes, 2004 and 2005, Queensland, rest of Australia and New Zealand



Source: Innovation Dynamics Database, Authors' Analysis

During the same period, companies in all three regions have also shown mixed trends in alliance formation. The average alliance formation by companies in Queensland decreased from 1.8 to 1.7 in 2004 and 2005 respectively, while that of Australia (excluding Queensland) increased from 1.8 to 2.3 during the same period. New Zealand companies formed 1.1 alliances on an average in 2004. This increased to 1.4 in 2005 (Figure 10).

Figure 10: Average biotech-related alliances by companies, 2004 and 2005, Queensland, rest of Australia and New Zealand



Source: Innovation Dynamics Database, Authors' Analysis

4.6. Licences issued

Licences are a specific category of alliance and are a major means of commercialisation of intellectual property. The analysis here concentrates on out-licensing agreements (from the IP owner to another organisation) as an indicator of commercialisation activity. At an individual company or institutional level, it is to be expected that licensing deals will vary greatly from year to year, and they are usually the culmination of many years of research. Propensity to license will also depend on business models (i.e. whether income is to be generated from royalties) and, for institutions, whether spin-off or licence is preferred for commercialisation.

Of the 32 company respondents, two had finalised four licensing agreements in 2002/03, and three companies had finalised 11 out-licensing agreements in 2004/05.

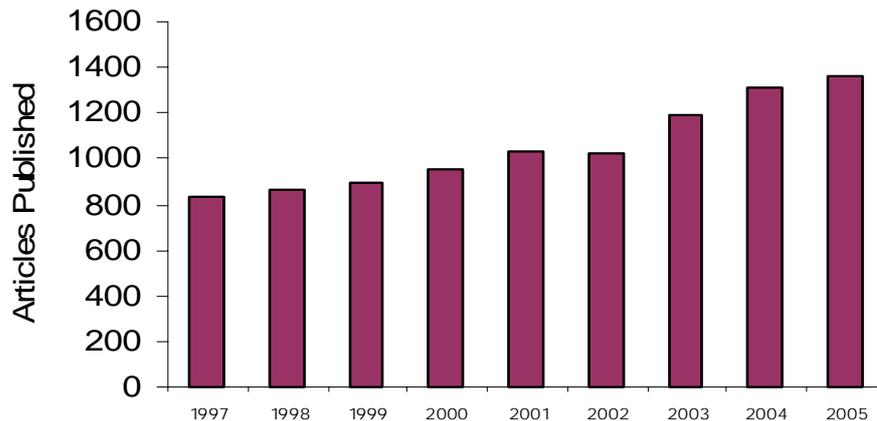
In 2002/03, of the 26 R&D institute respondents, 5 had finalised 20 out-licence agreements (an average of 1.3 per institution) with a total value of \$13.335 million. In 2004/05, again 5 R&D institutions completed 6 out-licensing agreements (an average of 0.33 per institution) valued at AU\$5.1 million. The value of these deals will be realised over the longer term and will depend on whether milestones (such as granting of patents and successful completion of clinical trials) are met in the future.

5. R&D performance

5.1. Citations/publications

The ISI Citation Index records publications of scientific articles in international journals. For this study, a search was conducted for the number of biotechnology-related articles by researchers affiliated with Queensland-based organisations. The number of bioscience articles authored by Queensland-affiliated researchers has risen from 837 in 1997 to 1,364 in 2005 (Figure 11).

Figure 11: Biotechnology-related articles published by Queensland researchers, 1997-2005

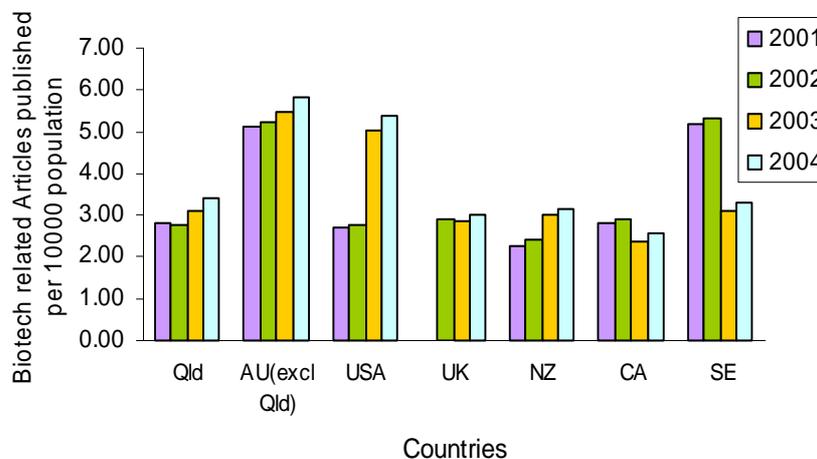


Source: ISI Citations Index

Queensland-affiliated authors accounted for 12.5% of the total 7,513 articles published by Australian authors in 2003. In 2005, this proportion had risen slightly to 12.8% of the total of 10,625 articles with Australian authors.

On a per capita basis, Australia and Queensland both do well in relation to articles published, leading the US (but not Sweden) in the early years surveyed. However, while the rest of Australia continues to do well against the US, Queensland authors have not increased as much as authors in other locations. However, they are still ahead of authors in the UK, New Zealand and Canada on the same basis (Figure 12).

Figure 12: Articles by biotech researchers per 10,000 population, 2001-2004, Queensland vs selected countries

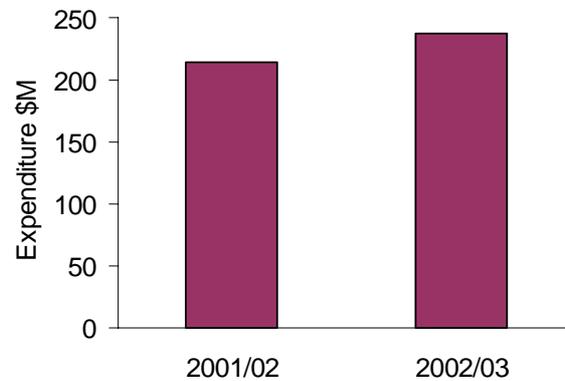


Source: ISI Citations Index, authors' search and analysis

5.2. University/research organisations' bioscience investments

According to an analysis of unpublished data from the Australian Bureau of Statistics (ABS) a total of \$215 million was spent by government organisations¹² in biotechnology-related R&D in Queensland in 2001/02, rising to \$237 million in 2002/03 (Figure 13).

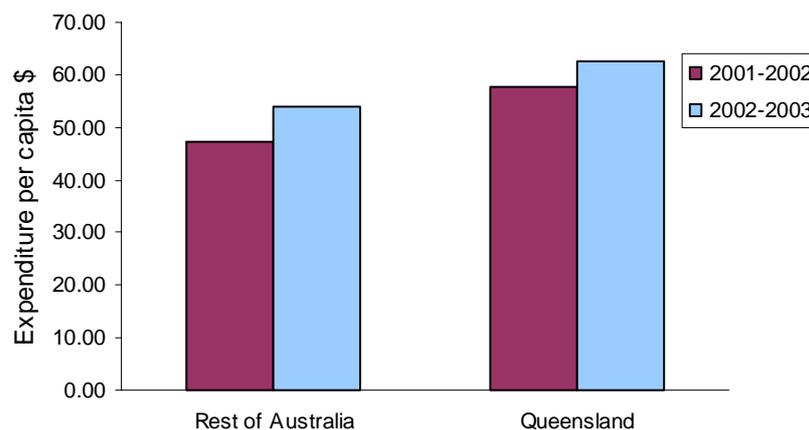
Figure 13: Government Research and Experimental Development Expenditure, 2001/02 and 2002/03, Queensland



Source: Unpublished ABS Government Expenditure on R&D data.

On a per capita basis, government expenditure on biotechnology-related R&D exceeds that of the rest of Australia, with \$58 per capita in 2001/02 (compared to \$47 nationally) and \$63 per capita in 2002/03 (compared to \$54 nationally) (Figure 14).

Figure 14: Government Research and Experimental Development expenditure per capita, 2001/02 and 2002/03, Queensland vs rest of Australia



Source: Authors' analysis based on ABS data for 2001/02 and 2002/03:
Note: Population data taken on June 2002 and June 2003¹³

¹² Includes expenditure in Queensland by universities, medical R&D institutes, federal government laboratories (CSIRO, AIMS) and state departmental research groups. R&D deemed to be "biotech-related" was defined by the authors and analysed across all States. Some data are collected on a calendar year basis and have been assigned to the following financial year.

¹³ Some data are collected on a calendar year basis and have been assigned to the following financial year.

Queensland has considerable strengths in some areas of biotechnology-related R&D. An analysis of unpublished ABS data based on science disciplines, on a per capita basis government funded institutions in the State have relative strengths in:

- biochemistry and cell biology;
- crop and pasture production;
- environmental engineering;
- genetics;
- industrial biotechnology and food science;
- other medical and health research; and
- pharmacology and pharmaceutical science.

Research fields which have shown considerable increases in investment since 2001/02 include:

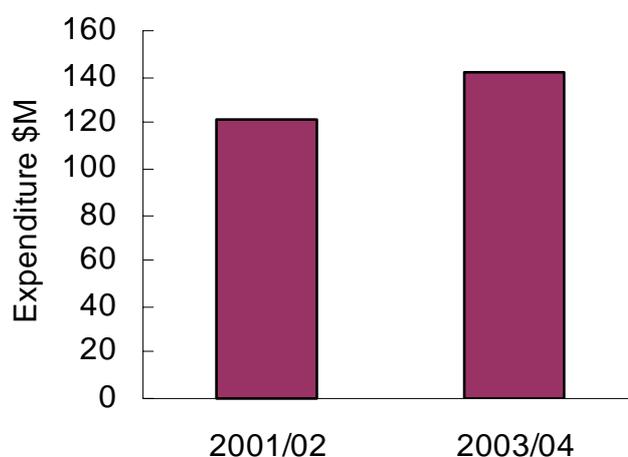
- animal production;
- biochemistry;
- cell biology;
- industrial biotech and food science; and
- medical biochemistry and clinical chemistry.

The impact of recent state government investments in clinical trials and testing will not be apparent until the next ABS survey.

5.3. Industry/bioscience firms' R&D investment

In 2001/02, a total of \$121 million was spent by Queensland businesses on R&D in the sectors relevant to biotechnology (Figure 15). This increased to \$142 million in 2003/04. This equates to a per capita expenditure of \$33 in 2001/02 and \$37 in 2002/03.

Figure 15: Business Research and Experimental Development expenditure, 2001/02 and 2003/04, Queensland



Source: *Research and Experimental Development - Businesses, Australia*, Australian Bureau of Statistics. Covers ANZSIC codes for food, beverages and tobacco; petroleum coal and chemicals; scientific research and others

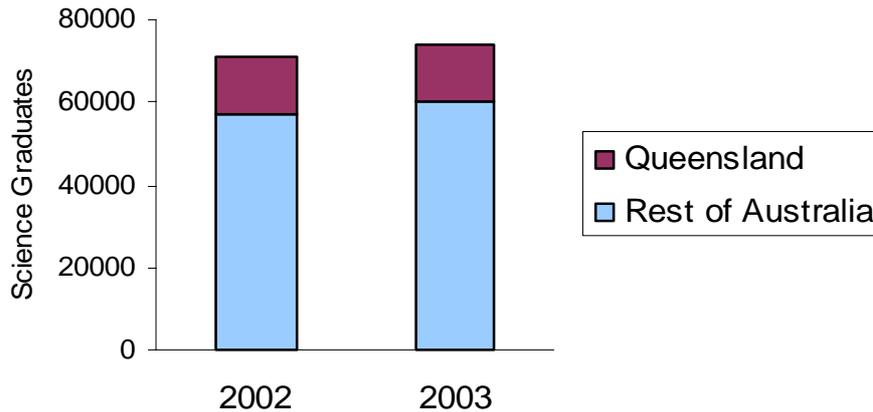
6. Education/Skilling Performance

6.1. Science Graduates

The most effective measure of the level of science skills in a region is the number of science graduates. A total of 13,362 students graduated with science degrees from Queensland institutions in 2002 and 13,840 in 2003.

Nationally, 57,324 students graduated with science degrees in other areas of Australia in 2002 and a further 60,229 in 2003. Hence, Queensland science graduates comprised 19% of those in the rest of Australia in 2002 and 18% in 2003 (Figure 16).

Figure 16: Science Graduates, 2002 and 2003, Queensland vs rest of Australia



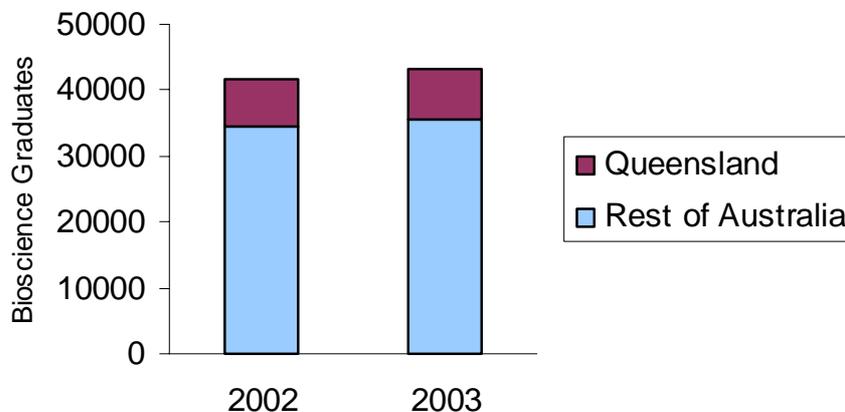
Source: Data from Department of Education, Science and Training

6.2. Bioscience/higher education degrees awarded

In 2002, 7,336 students completed bioscience degrees in Queensland institutions, and 7,404 in 2003 (Figure 17).

Nationally, a total of 41,623 students graduated with bioscience degrees in Australia in 2002, of which Queensland accounted for 17.6%. In 2003, bioscience graduates in Australia rose by 3.35% to 43,020. Of these, about 17.2% or 7,404 students had graduated from Universities based in Queensland.

Figure 17: Bioscience Graduates, 2002 and 2003, Queensland vs rest of Australia



Source: Data from Department of Education, Science and Training

The box below highlights some key achievements of Queensland-based educational institutions in developing new approaches to biotechnology education.

Box 8: Key achievements of Queensland educational institutions in biotech

Queensland is proactively addressing the challenge to meet an innovative approach to education and training in biotechnology. Initiatives include:

- Science on Saturday—‘hands on’ science and biotechnology for seven to 14 year olds encouraging today’s students to become tomorrow’s scientists;
- BioBus—an interactive and engaging travelling biotechnology exhibition for teenagers which aims to nurture a life-long interest in biotechnology by showing its contribution to everyday life;
- Smart State University Internships Program—funds Queensland universities to offer undergraduate students real, ‘hands-on’ experience with industry;
- Queensland universities’ Master and Bachelor degrees—world-class degrees that integrate the science and business of biotechnology;
- Innovation Skills Fund—a multi-million dollar fund for students and researchers undertaking ground-breaking research in Queensland. The fund has three programs: Smart State Premier’s Fellowships (for experienced researchers of national and international prominence), Smart State Fellowships (for outstanding researchers) and Smart State PhD Scholarships (for graduates of outstanding ability); and
- Science in Parliament—facilitates communication between scientists, students and members of Queensland Parliament.

7. Conclusions

The Queensland biotech sector contributes substantially to the State's economy, providing direct jobs for over 5,200 people. Companies and R&D institutions have demonstrated substantial progress since 2003, increasing the numbers of research spinoff companies, and their proportion in national terms of US biotech patents granted to Australian inventors. The State government's investment in infrastructure has built further clinical trials expertise and it is expected that this sub-sector will increase its activity substantially in the coming years.

Queensland's biotech activity, and that of Australia as a whole, is still small when compared internationally with major players such as the US, UK and Canada. However, it must be remembered that both the State and Australia as a whole are major players when compared to biotech sectors in many other countries.

8. Methodology

8.1. Data sources

Data on revenues, employment and licences/patents derived from a survey of bioscience companies and organisations in Queensland. The survey was sent to 152 organisations, of which 84 were companies and 68 were public sector R&D institutions or R&D centres within institutions.¹⁴ The original mail list was compiled from the Queensland Government's *Directory of Biotechnology in Queensland Australia 2005*. Of these, 86 organisations responded (48 companies – a response rate of 55% and 38 R&D organisations – a response rate of 55%). Of these 86, 58 organisations (32 companies and 26 R&D institutes) returned completed surveys. Table 4 summarises the sub-sectors for companies and Table 5 summarises them for R&D institutions.

Table 4: Sector Distribution of Company respondents

Sector	Number State-wide	Number that returned completed surveys
Human Therapeutics	37	14
Agbiotech	22	4
Diagnostics	8	4
Chemical, Environment	8	3
Other	6	3
Suppliers/ services firms*	4	4
Food and/or Beverages	3	0
Total	88	32

*Includes bioinformatics, reagents suppliers and services

Table 5: Type of Research Institutes

Type of R&D institution	Total in sample	Total in respondents
Medical Research Centre (stand-alone)	20	8
CRC	19	7
Non-Medical Research Centre (University Affiliated)	12	3
Non-Medical Research Centre (stand-alone)	8	2
University	8	5
CSIRO	1	1
Total	68	26

National level data were derived from Innovation Dynamics' databases (which have drawn on data from public sources), other public data plus surveys by the ABS. Innovation Dynamics' databases contain information on patents, alliances and new company formation and are classed by date (either calendar year or financial year) and State. Companies are assigned to States according to their office location registered with the Australian Securities and Investment Commission.

For all international comparisons, data were derived from public sources including studies of the biotechnology industry in the countries reviewed. Patent data were derived from the US Patent office website and citation information was derived from a search of the ISI Citations Index.

¹⁴ Since issuing the survey a further 4 biotech companies in Queensland were identified. The estimates of economic activity at the State level were thus based on 88 companies and 68 R&D institutions.

8.2. Conversion Factors

The table below provides the conversion rate information for all dollar conversions in the report.

Table 6: Exchange rate (AUD per unit currency) at 31 Dec of listed Year

Country	2002 (AUD)	2003(AUD)	2004(AUD)
US\$	1.7770342	1.328055	1.282368
UK Pound	2.8608699	2.37161	2.456875
Canada \$	1.1252313	1.027135	1.065206
Sweden SEK	0.2043815	0.184648	0.19223
New Zealand \$	0.9306276	0.870995	0.922968
Euro	1.863379	1.673473	1.735538

Source: www.xe.com/ict

Table 7 provides population statistics used to derive national comparisons.

Table 7: Population statistics for Queensland, Australia and selected overseas countries over time

Year	2001	2002	2003	2004	2005
Qld	3,668,848	3,754,154	3,840,111	3888100	3964000
Rest of Australia	15,860,426	16,003,742	16,168,566	16203400	16364600
Australia total	19,529,274	19,757,896	20,008,677	20091500	20328600
USA	285,107,923	287,984,799	290,850,005	293,656,842	296,410,404
UK	59113000	59322000	59554000	59835000	
NZ	3880500	3939100	4009200	4061400	4098200
Canada	31021300	31372600	31669200	31974400	32270500
Sweden	8909128	8940788	8975670	9011392	9 044 789
Singapore	n/a	n/a	n/a	4240300	4351400

Source:

- 1 Qld and Australia: 2001-2003: 3239.0.55.001 - Population, Australian States and Territories, (year End Estimates) Australian Bureau of Statistics, 2004: Population Projections, Australia, 2004 to 2101, POPULATION SIZE, Observed and projected at 30 June 2004, Australian Bureau of Statistics, 2005: 3101.0 Australian Demographic Statistics, Population at end June qtr 2005, Australian Bureau of Statistics
- 2 USA: 2005 Population Estimates, U.S. Census Bureau (Population Estimates are for 1 July each year except for 2000. Year 2000 data is actual population on 1 April 2000)
- 3 UK: Table 1.1, Population and vital trends International, Population trends 122, Winter 2005, National Statistics UK
- 4 New Zealand: Table 1, Estimated Resident Population and Population Change, statistics New Zealand (Population taken at 30 June each year)
- 5 Canada: CANSIM, table (for fee) 051-0001, Population as of July 1, Statistics Canada
- 6 Sweden: Swedish Population (in one-year groups) 1860-2004, Statistics Sweden (2005 population is current till Nov 2005)
- 7 Singapore: Keystats, Singapore Department of Statistics (mid year estimates)

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