

Welcome to the Yellow Brick Road  
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Innovation for Australia

Tom Quirk

15 October 2015

# Innovation : How it works?

*“Advanced scientific knowledge is discovered by research scientists, who are often motivated by their own curiosity. It is translated into ‘useful’ knowledge and then applied to economic inputs. This is done by research scientists and science-trained professionals, who are responding to signals from business. Business managers then use the economic inputs to produce output, in response to signals from consumers.”*

Report from the Chief Scientist and the Australian Academy of Sciences

# The Facts

- Sources of ideas
- Patent activity
- Research and development funding by and from business and government
- Australina business performance

# Sources of ideas for innovation

Source of ideas	Europe and USA 1980's	UK survey 2001	Australia ABS 2013*
Business - general trade	80%	79%	94%
Competitors	6%	5%	
Customers	8%	12%	
Higher education	4%	2%	3%
Government laboratories	2%	2%	3%
Total	100%	100%	100%

\* ABS has multiple sources

# USA Patent Activity in 2014

2014 Position	Organisation	Patents granted
1	International Business Machines	7481
2	Samsung Electronics Co., Ltd	4936
3	Canon K.K.	4172
4	Sony Corp.	3124
5	Microsoft Corp.	2983
6	Google, Inc.	2881
7	Toshiba Corp	2850
8	Qualcomm, Inc.	2706
9	Panasonic Corp.	2394
10	General Electric Co.	2293

# USA Patent Activity in 2014

2014 Position	Organisation	Patents granted
33	Johnson & Johnson	1115
84	Roche Holdings, Inc	484
91	Regents of the University of California	453
92	Abbott Laboratories	437
109	United States of America, Navy	364
124	Sanofi	295
125	Merck Sharp & Dohme Corp	293
135	Massachusetts Institute of Technology	275
147	Novartis	243

# Australia Patent Activity

<b>Patents granted</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
Total	17,873	17,724	17,112
Non-resident	16,611	16,413	16,002
Resident	1,262	1,311	1,110

## Australian Higher Education Patent Activity for 2006 to 2012

- 4,056 patents published in years 2006 to 2012 of which
- 1,256 were pharmaceutical and
- 438 medical technology
- 1,300 patent publications came from one university

**647 patents published from all universities in 2011 and an average of about 600 per year for January 2006 to June 2012**

# Patent Activity - Conclusions

- Patent filing activity from industry confirms the results of the source of ideas surveys
- Not all inventions turn out to be innovations but not all innovations are patented

University of California report on Technology Licensing

## **Guiding Tenets of Technology Transfer**

- Revenue from licensing is dominated by small fraction of disclosures with less than 0.2 percent make up 80 percent of UC's revenues
- One cannot predict which inventions will result in significant revenue
- It generally takes ten or more years for successful inventions to begin generating revenue

# Research and Development 2010-11

<b>R &amp; D % GDP</b>	<b>Total</b>	<b>Business</b>	<b>Government</b>	<b>Higher Education</b>
Australia	2.13	1.24	0.26	0.63
Canada	1.74	0.88	0.21	0.65
Finland	3.64	2.56	0.35	0.73
USA	2.79	1.95	0.45	0.39
OECD average	2.33			

# Research and Development 2010-11

- Australia spent some \$4 billion on mineral exploration. This is the mining business equivalent of industrial expenditure on R & D.

This is 0.27% of GDP so total R & D would be 2.40% of GDP if it were included

- For Finland some 40% of business R & D is from Nokia
- US Government expenditure is roughly 50% on defence and 50% on higher education.

# Business Research and Development

	% Business R & D (2001)			
	High-tech	Medium high-tech	Low-tech	Service
Sweden	49.1	29.1	7.1	12.8
United States	39.4	19.4	6.1	34.4
Australia	21.4	15.4	13.7	39.9

Australia has a quite different mix of businesses when compared to Sweden and the United States.

Australia has a small manufacturing base. This a function of market size and distance from other markets.

# Australian industries - a comparison

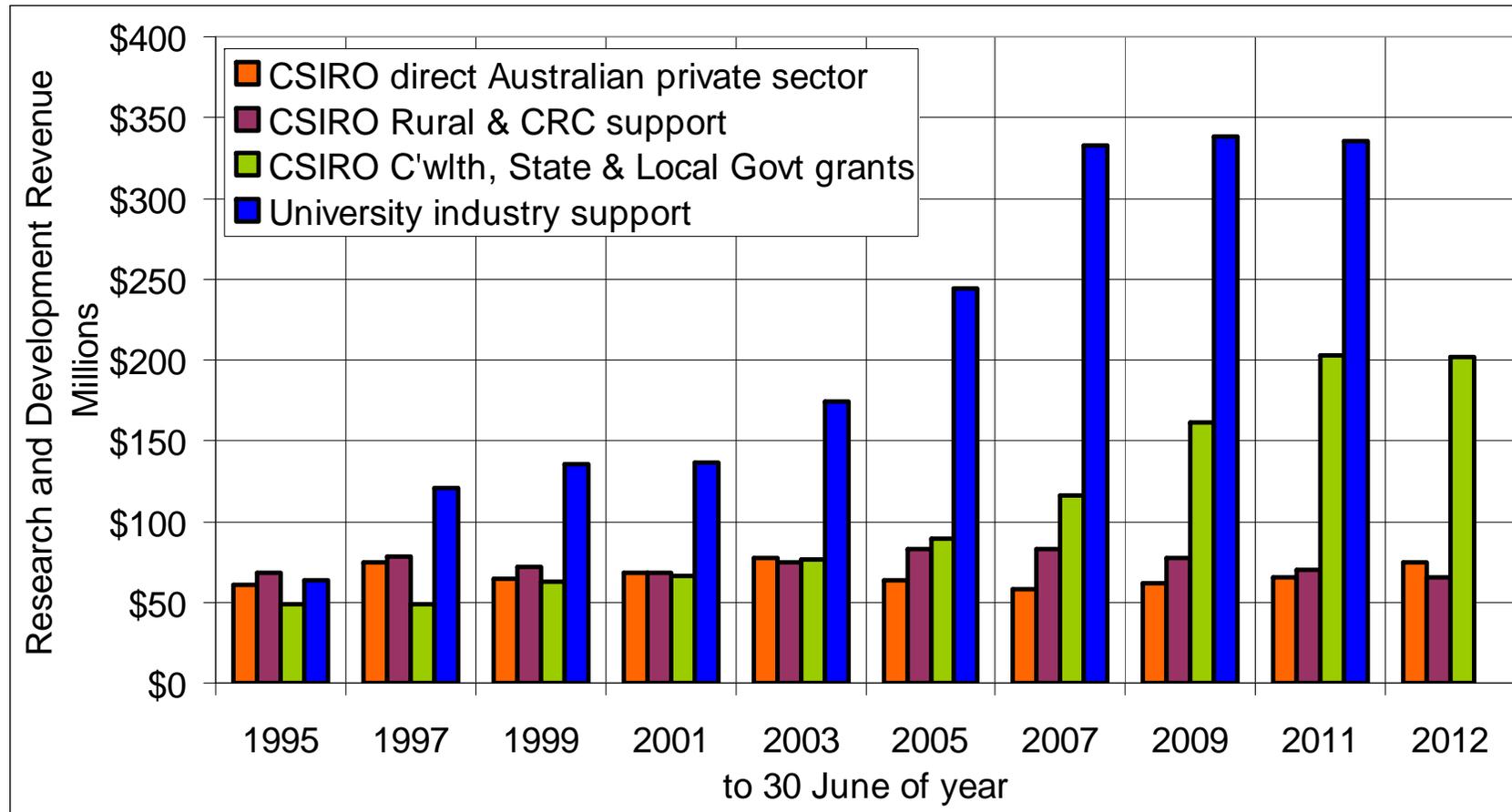
Company		Revenue \$ millions	R & D \$ millions	R & D as % of revenue
Merck & Co Inc	2012	47,267	8,168	17
CSL Limited	2013	4,950	427	9
ResMed Inc	2015	1,679	115	7
Cochlear Limited	2014	805	128	16
Microsoft	2014	86,833	11,381	13
Computershare	2014	2,015	74	3.7
BHP Billiton	2014	64,227	43	0.1
include exploration			926	1.4
Rio Tinto	2014	47,664	112	0.2
include exploration			895	1.9

# Business R & D - Conclusions

- Australia, with a resource based economy has a respectable R & D performance.
- The small population and remote large markets makes product development and marketing difficult
- However, successful Australian businesses that do market and sell high-tech products internationally have R & D spends of the same order as that of their peers elsewhere.
- Mineral exploration should not be overlooked in performance comparisons with other countries,

# Government and Higher Education R & D

For Australia, industry has moved to support universities rather than the CSIRO



# Government and Higher Education R & D

## - Conclusions

- There are no rules for how much governments spend on R & D.
- Higher education spending is vital for the supply of graduates but not just in science and engineering
- Higher education is a major "export" earner and attracts students from the region because of our excellent universities. University reputations are built on leading edge research.
- Government research institutions are a problem. The CSIRO seems to have lost industry support. It may be unmanageable given the range of its activities.

# Innovation Case Studies

- Location and navigation
- The transistor
- The integrated circuit
- The internet
- WiFi
- Cancer vaccine
- Nobel Prizes

# Location and Navigation

- Establishing longitude was vital for exploration
- The meridian line measurements at the summer solstice often measured in cathedrals - Bologna a good example
- The transit of Venus across the Sun established longitudes for distant place - Captain Cook in the South Pacific
- Harrison's clock helped with navigation in 1736 - first sea trial
- Longitude for Australia at Darwin measured using the telegraph in the 1880s when cloud prevented a transit of Venus measurement. Singapore. had a well measured longitude and with a telegraph cable connection to Darwin its longitude was measured using the "American method".
- Global positioning by satellite started in the 1970s. GPS use corrections derived from Einstein's Special and General Relativity Theories

# The Transistor

- 1947 The first transistor was created by Bardeen, Brittain and Shockley
- 1953 the first transistor radios from Texas Instruments
- As part of an Anti-Trust settlement with Bell, Bell Labs made non exclusive licences available for \$50,000. Masaro Ibuka, a co-founder of Sony, purchased a licence.
- Shockley moved to the Bay area of California and founded Shockley Semiconductor and hired some superb engineers and physicists.



# The Integrated Circuit

- Eight key staff ("The Traitorous Eight") left Shockley to found Fairchild Semiconductor.
- Of these, Bob Noyce and Gordon Moore moved on to found Intel in 1968 to manufacture integrated circuits
- The Chief Scientist of the US Department of Defence told them there was no call for such circuits.
- 1970 Intel gains a contract to design and build a chip for a Japanese company. The Japanese company would pay for the development and own the intellectual property
- The task of design was given to three Intel engineers
- Their solution was a programmable processor - the **microprocessor**
- Senior management thought there might be wider uses for this device
- In 1971 the contract with the Japanese company was quickly renegotiated with Intel retaining all rights other than the specific task set by the Japanese company

# The Internet

- In 1969 the US Department of Defence Advanced Research Projects Agency (ARPA) funded a project to enable remote computers to interact. This was the ARPANET.
- The ARPANET was used by physicists in the 1970s to gain access to large but remote computers. Even then email and games were available and hacking occurred.
- In 1989 Tim Berners-Lee at CERN in Geneva proposed the hypertext transfer protocol (http). This enabled large and dispersed scientific collaborations to swap data and analysis results
- This was the development of a tool that enabled fundamental research.
- So the World Wide Web was born
- A most disruptive invention that has allowed the creation of Google, Amazon and other online retailing and wholesaling activities.
- The internet is a threatening development for the news and entertainment industries

# WiFi

- In 1991 WLAN was developed by NCR and AT & T for use in a cashier system
- In 1992 radio astronomers at the CSIRO filed a key patent that enabled reception of a clear radio signal
- The patent was granted in 1996
- in the late 1990s two Macquarie University professors acquired a non-exclusive licence for the CSIRO invention. They established a company Radiata to make the WiFi chips.
- 2000 Cisco Systems acquired Radiata for \$567 million.
- 2002 the first patent infringement appeared
- 2006 CSIRO files infringement claims
- 2009 first settlement for \$205 million and in 2012 a second settlement for \$212 million,
- So \$417 million in royalties for an invention to assist radio astronomy

# CSL and a cancer vaccine

- Mid 1980's researchers at Queensland University, Rochester University and the National Cancer Institute started to develop a vaccine against the human papilloma virus, a cause of cervical cancer
- In 1994 Frazer and Zhou filed a patent for a virus like particle to act as a vaccine.
- CSL (privatised in 1994) had supported this work but chose to licence the clinical development to Merck & Co for a royalty of 7.5% of sales
- In 2006 the FDA approved the marketing of the vaccine under the name Gardasil
- Gardasil sales rose to \$1830 million in 2013
- Royalties to date are over \$450 million but the patent must be nearing its expiry date
- CSL presumably retains marketing rights in Australia and New Zealand

# Case Studies - Conclusions

- Expert opinions may not be well informed. This is particularly obvious with policy makers.
- Innovations arise from scientific research but often as a by-product of leading edge work.
- Innovation is frequently the result of an accumulation of experience and inventions. GPS depends on research that was completed some 100 years ago.
- Taking innovations to market depends on being able to overcome financial barriers. Sometimes, as in drug development, this is beyond the reach of a local business.

# Innovation gives rise to discovery

- The most famous and fundamental discovery coming from commercial development was made at Bell Labs
- Penzias and Wilson were trying to remove the background microwave noise from their satellite receiver.
- The lab was close to New York city but that was not the cause and the noise appeared constant despite the search for variability.
- In fact it was the cosmic microwave background radiation. An echo of the Big Bang.
- They were awarded the Nobel Prize in 1978

**Note:** The inventors of the transistor and the integrated circuit were awarded Nobel Prizes

# Conclusions

## **Innovation is a random walk along a tortuous road**

Some simple lessons are:

1. Leading edge research is a key supplier of ideas but many innovations come from enabling research but not the endpoint of the research.
2. Universities should support leading edge research and not expect an income stream from inventions.
3. The key role for universities is producing graduates who will invent, implement and deploy innovations.
4. National needs offer little guidance for direction or level of financial support.
5. There is no better incentive than to see the success of others.