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# BENCHMARKING AUSTRALIAN SCIENCE PERFORMANCE

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Continuing to strengthen Australian science requires objective assessment of our performance relative to our key partners. This paper presents a comparison between Australia and 23 other countries in Europe, Asia and North America, in volume and citation rate of scientific publications.

## Overview

- ▶ Citation rate is a measure of research quality. Australian science has an overall citation rate above the world average, but performs below a European average and the levels of many of our research partners.
- ▶ Australia outperforms a European average in some fields and sub-fields.
- ▶ In this context, it is important to maintain a strong overall investment in science, and to invest selectively in priority areas of recognised strength. The Australian Research Committee (ARCom) is currently developing a framework to set research priorities for Australia.

## Background

Australia is a participant in the global collaboration that underpins much of modern science. Almost half our research publications have an international connection through co-authorship<sup>i</sup>. We collaborate with scientific powerhouses in Europe and North America, and with the rapidly rising countries in Asia.

To remain an attractive partner, Australia must produce high quality science. Achieving performance above world average may not be sufficient if our partners also outperform the world average, by a greater margin. Figure 1 shows that Australian science performs at a lower level, as measured by citation rate per papers, than nearly all the North American and European countries we partner and compete with.

### Box 1: Comparison countries

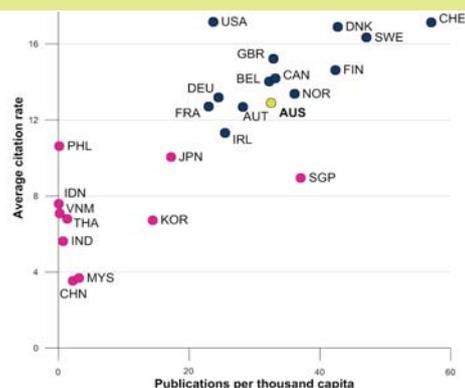
**Europe:** Austria (AUT), Belgium (BEL), Denmark (DNK), France (FRA), Finland (FIN), Germany (DEU), Ireland (IRL), Norway (NOR), Sweden (SWE), Switzerland (CHE), United Kingdom (GBR).

**Americas:** Canada (CAN), United States (USA)

**Asia:** China (CHN), India (IND), Indonesia (IDN), Japan (JPN), Malaysia (MYS), Philippines (PHL), South Korea (KOR), Singapore (SGP), Thailand (THA), Viet Nam (VNM).

Selected during analysis for the Prime Minister's Science, Engineering and Innovation Council.

Figure 1: Australia in context



## International comparisons

Different world regions achieve very different average levels of citation, as Figure 2 shows. The world and Asian averages are significantly below the European average (see *Sources of data* for descriptions of these averages). Australia lies just below the European average. It is also apparent that volume and citation rate of publications are not closely connected: there are examples of high and low citation rate both at large volume (e.g. United States, China) and small volume (e.g. Finland, Thailand).

A more detailed picture of the international situation can be provided by disaggregating each country's overall performance into its performance across a number of fields. This indicates whether a country has broad-based strengths, or has success concentrated in just a few areas.

Figure 3 shows the number of science fields where each country has a citation rate above European average, between European and world average, or below both averages. Several country groupings are evident. There is a set of high-performing northern European countries that invest heavily in R&D for their size, such as Finland, Sweden, Denmark, and Switzerland. There is a set of countries that achieve excellence at large scale, such as the United States, United Kingdom, and Canada. Asian countries achieve lower citation rates, even those that spend heavily on R&D such as Japan and South Korea, partly because of a focus on industrial research and publication in non-English journals.

## Fields of science

Figure 3 shows that Australia's average performance in five broad science fields is above the European average: these are Veterinary Science, Energy, Engineering, Earth and Planetary Sciences, and Medicine. Australia has two fields with average citation rate below world average: Neuroscience and Psychology (although in Psychology, the world average is very close to the European average). Australia's performance in the remaining seven broad fields lies between the world and European averages.

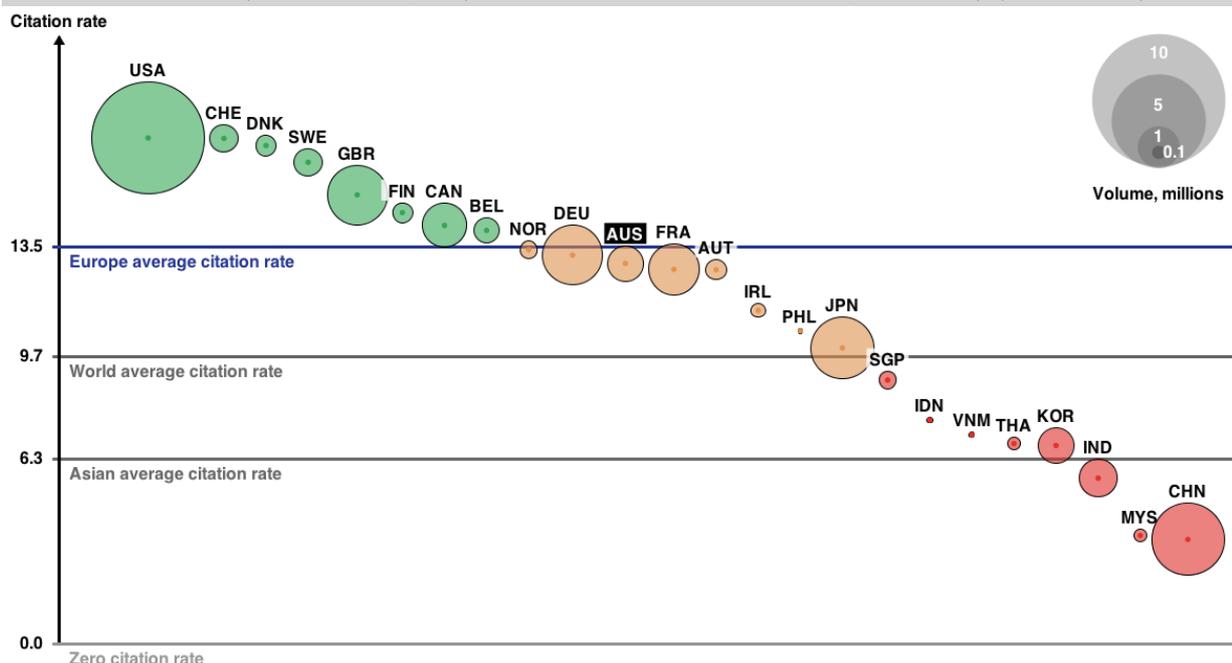
These are coarse averages across broad fields; within each field, there is some outstanding research that performs above the European average. Examining Australia's performance across specific sub-fields is also useful. Figure 4 shows how each field is composed of a number of sub-fields. In Veterinary Science, Engineering, Earth and Planetary Sciences, and Medicine, more than half of sub-fields perform above the European average.

There is high performing Australian science in specific disciplines across a wide range of fields. Of the 192 sub-fields examined, 78 had a citation rate above the European average, falling across all but one of the broad fields. Of the rest, 82 sub-fields performed between the European and world averages, and 32 were below both averages. Many areas of strength produce small volumes of publications: 20 of the 78 top sub-fields averaged less than 100 publications per year over the period.

Investing in strong areas, such as through the framework being developed by the Australian Research Committee, is one means to maintain Australia's scientific standing and reap the benefits of international collaboration.

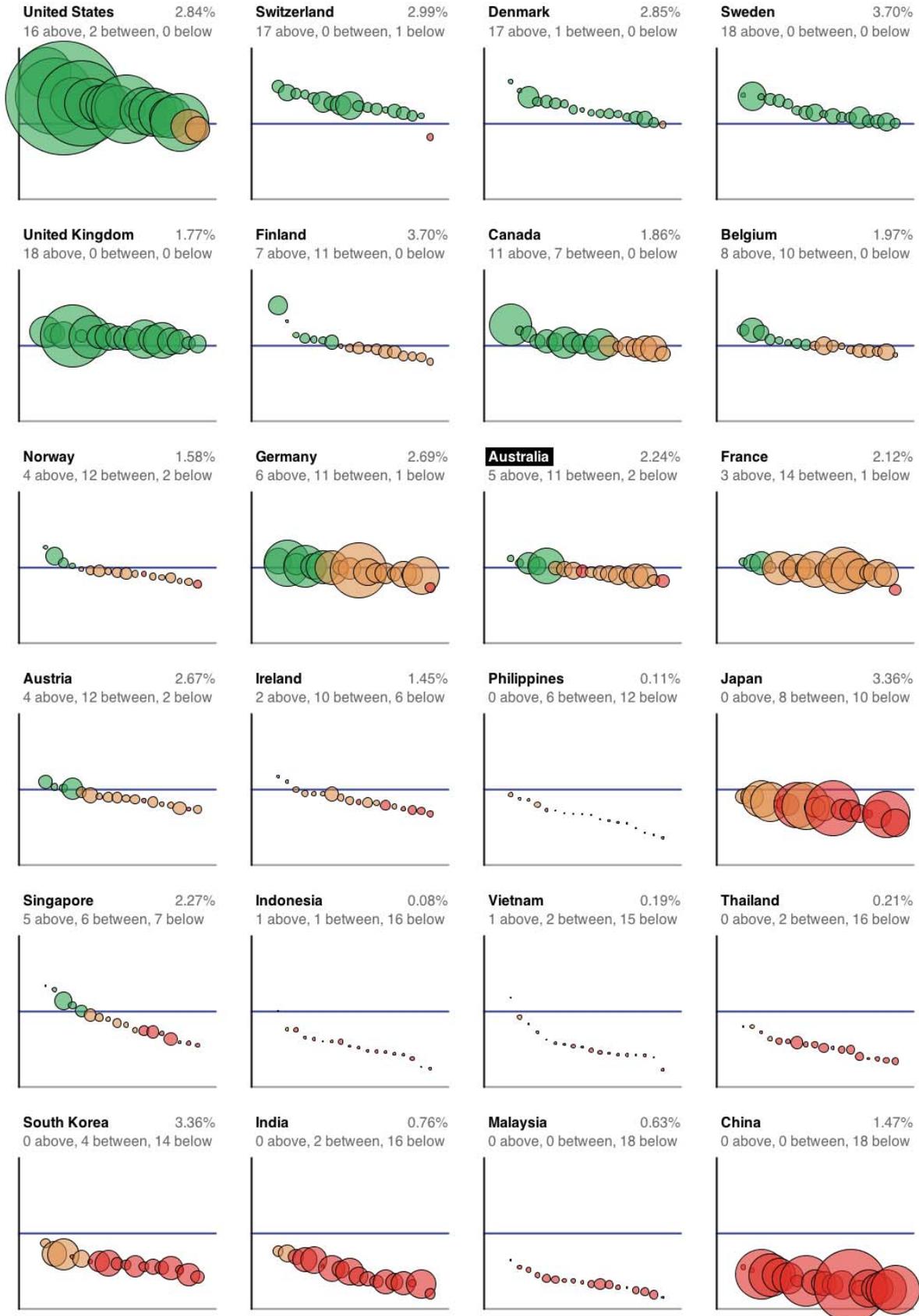
**Figure 2: Aggregate national performance**

Circles are placed vertically and coloured by average citations per paper over the period: green above European average; amber between European and world averages; and red below both. Countries are ordered horizontally by decreasing citation rate; horizontal placement is only to spread out countries. Circles are sized by volume of papers over the period.



## Figure 3: National performance across fields of science

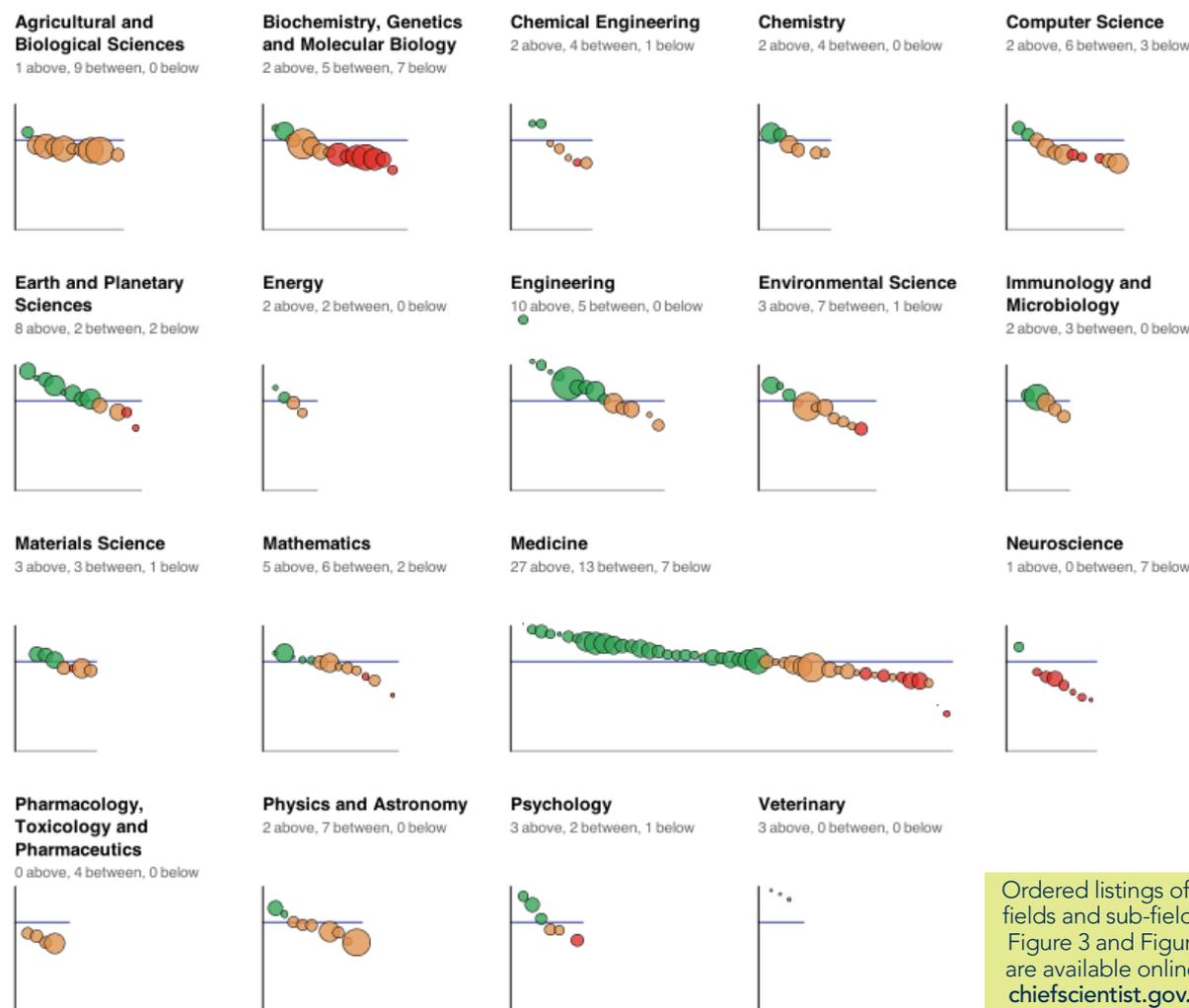
Each circle shows one field for one country. Circles are placed vertically by citation rate relative to the European average in each field, and placed horizontally for spreading only. Circles are sized by publication volume. Axes and colours are as for Fig 2; only the European average and zero lines are shown here. Countries are arranged on the page by average citation rate across all fields, from Fig 1. Percentages show recent R&D spending as a proportion of GDP.



## Figure 4: Australian performance across fields and sub-fields of science

Each chart shows one field (equivalent to one circle from Fig 3); each circle shows one sub-field. As in Fig 3, circles are placed vertically by citation rate relative to the European average in the sub-field, and sized by volume. Colours and axes are as for Fig 3, with green above European average; amber between European and world averages; and red below both.

A larger number of green bubbles in a field chart indicates a larger amount of sub-fields where Australia performs strongly. The European and world average citation rates are different for every sub-field; sub-fields with the lowest citation rate compared to European average (at the right of each graph) are not all red, as colour also depends on the world average.



Ordered listings of the fields and sub-fields in Figure 3 and Figure 4 are available online at [chiefscientist.gov.au](http://chiefscientist.gov.au).

### Sources of data

All figures are based on data from the Scopus database, for 1996-2010. Figs 2-4 use the fields and sub-fields from Fig 4, which are from the Scopus All Science Journal Classification. European and Asian averages cover all nations from those regions in the paper. World average covers all nations, including nations not addressed in the paper. These averages are de-duplicated so that multi-author papers are only counted once. Gross Expenditure on R&D in Fig 3 is for 2008 or nearest available year, from OECD and UNESCO. Population is for 2008, from OECD and UNESCO.

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### Reference

(i): Office of the Chief Scientist (2012), *Health of Australian Science*, Chapter 6. Australian Government, Canberra.

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