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# A review of bioinformatics degrees in Australia

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## Abstract

Bioinformatics has been a hot topic in Australia's biotechnology circles for the past five years. As with biotechnology in the 1990s, there has been a sudden increase in the number of Bioinformatics undergraduate degrees. For students in the 2005 intake there are six undergraduate Bioinformatics degrees to choose from and another five Bioinformatics streams within a Bachelor of Science degree. The courses vary from three to four years of full-time study. This report aims at dissecting each of these degrees to determine where the differences lie, to give the prospective students an idea as to which degree suits their career goals and to give an overview of the pedagogy of Australian bioinformatics education.

## INTRODUCTION

A student wishing to study bioinformatics at the undergraduate level has the choice of enrolling in a specialised bioinformatics degree or choosing a major in bioinformatics within a more general science degree. The subject content between and within these choices is not uniform. While each of the courses surveyed contains a number of biological and computer subjects, the number and variety of mathematical, statistical and bioinformatic subjects vary significantly and are even absent in some instances.

The universities that provide a bioinformatic education are listed in Table 1. At present only two of the degrees (USyd and La Trobe) have had graduates and so we are yet to see the full impact such specialised graduates will have on the biotechnology job market.

In the Australian institutions not mentioned in detail here it is possible to choose a combination of computer science, mathematics, statistics and biology to create your own bioinformatics degree but as this is not an official mode of study it was not considered here.

## BACHELOR OF BIOINFORMATIC COURSE COMPARISON

The curricula of the 11 degrees were examined from the websites listed in

Table 2, and six areas were chosen as markers for course content. These areas were: biological sciences, computer sciences, statistics, mathematics, bioinformatics and other. Biological sciences included all biology and chemistry subjects. Computer sciences included programming, computer studies and other subjects taught by the Department of Computer Science. Statistics includes all statistic and probability subjects. Mathematics includes mathematical subjects not covered in the area of statistics. Subjects that included a combination of biology and computer science (eg phylogenetics, microarray analysis or bioinformatic project) and/or were titled bioinformatics were grouped into the area of bioinformatics. The final category included subjects that ranged from ethics, experimental design and language comprehension through general electives outside the Faculty of Science.

Each of the courses has some subjects that fall in the biological sciences and computer science areas. Statistics is a compulsory subject in the degree from USQ, UWA, UOW, UNSW and La Trobe. Mathematical subjects are also compulsory in USQ, UWA, UOW, UNSW and La Trobe. Dedicated bioinformatics courses are present in only USyd, UNSW, UWA and UOW. A comparison of the distribution of

**Table 1:** Undergraduate and postgraduate bioinformatics degrees in Australia

University	Degree	Length	Started
<b>Undergraduate degree</b>			
University of Sydney (USyd)	Bachelor of Science (Bioinformatics)	3 years	1998
La Trobe University	Bachelor of Science (Bioinformatics)	4 years	1999
University of NSW (UNSW)	Bachelor of Engineering (Bioinformatics)	4 years	2001
University of Southern Queensland (USQ)	Bachelor of Bioinformatics	4 years	2003
University of Wollongong (UOW)	Bachelor of Computer Bioinformatics	4 years	2003
University of Western Australia (UWA)	Bachelor of Science (Informatics)	3 years	2003
<b>Postgraduate coursework degree</b>			
University of Sydney	Graduate Certificate in Applied Science (Bioinformatics)		2003
University of Sydney	Graduate Diploma in Applied Science (Bioinformatics)		2003
University of Sydney	Masters in Applied Science (Bioinformatics)		2003
<b>Undergraduate degree – bioinformatics stream within existing degree</b>			
Australian National University (ANU)	(i) Bachelor of Computational Science		
	(ii) Bachelor of Biotechnology		
University of Queensland (UQ)	Bachelor of Biotechnology		
Queensland University of Technology (QUT)	Bachelor of Science Innovation		
University of Melbourne (UMelb)	Bachelor of Computer Science		

**Distribution of study in bioinformatics**

The list gives the location, name of degree, length of degree and year instigated. The university year begins in February/March and ends in November. List current as of October 2003.

**Table 2:** Bioinformatics degrees and streams

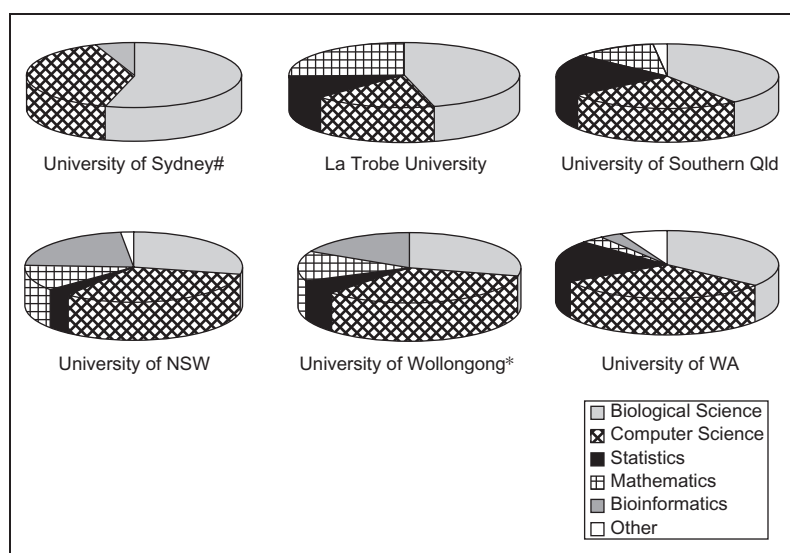
Australian National University	<a href="http://www.maths.anu.edu.au/study/bcomptlsci/programs">http://www.maths.anu.edu.au/study/bcomptlsci/programs</a>
La Trobe University	<a href="http://www.latrobe.edu.au/handbook/scitech/stbsbb.htm">http://www.latrobe.edu.au/handbook/scitech/stbsbb.htm</a>
Queensland University of Technology	<a href="http://www.studyfinder.qut.edu.au/cgi-bin/WebObjects/StudyFinder">http://www.studyfinder.qut.edu.au/cgi-bin/WebObjects/StudyFinder</a> (use search term Bioinformatics)
University of Melbourne	<a href="http://www.cs.mu.oz.au">http://www.cs.mu.oz.au</a>
University of New South Wales	<a href="http://www.eng.unsw.edu.au/prospect/ug/be/bio.htm">http://www.eng.unsw.edu.au/prospect/ug/be/bio.htm</a>
University of Queensland	<a href="http://www.uq.edu.au/study/plan.html?acad_plan=BIOINX2055">http://www.uq.edu.au/study/plan.html?acad_plan=BIOINX2055</a>
University of Southern Queensland	<a href="http://www.usq.edu.au/handbook/2003/BBIN.html">http://www.usq.edu.au/handbook/2003/BBIN.html</a>
University of Sydney	<a href="http://www.science.usyd.edu.au/future/ug/bsc-bio.html">http://www.science.usyd.edu.au/future/ug/bsc-bio.html</a>
	<a href="http://www.scifac.usyd.edu.au/future/pg/pgc_bioinform.html">http://www.scifac.usyd.edu.au/future/pg/pgc_bioinform.html</a>
University of Western Australia	<a href="http://www.publishing.uwa.edu.au/handbooks/2003/sciences/BScInformatics.html">http://www.publishing.uwa.edu.au/handbooks/2003/sciences/BScInformatics.html</a>
University of Wollongong	<a href="http://www.uow.edu.au/discover/courses/yr2002/bcompbioinf.html">http://www.uow.edu.au/discover/courses/yr2002/bcompbioinf.html</a>

**Choice of electives can vastly influence the degree outlook**

compulsory subjects from the six named bioinformatics degrees is shown in Figure 1.

Most of the degrees included a number of compulsory subjects (usually all of first year and part of second/third year) and a number of elective subjects that students could choose to personalise their degree (Table 3). The choice of electives can affect the subject composition within a degree. For example, in choosing all electives from the biological sciences in the La Trobe degree, it becomes almost

75 per cent biased towards the biological sciences. In choosing all non-biological electives there can be a more equal distribution of biological sciences, statistics, computer sciences and mathematics. Two students can therefore graduate with the same degree from the same institution but will have a far different background. The effect that this has on the degree content is illustrated in Figure 2, where subject bias within three of the listed degrees is shown. It is hard to see how a degree that has a large



**Figure 1:** Distribution of subject areas covered in undergraduate degrees. The compulsory subjects required for each degree were separated into six categories based on course content (see text). \*The distribution for the honours programme. #The distribution with a computer science bias

**Table 3:** Ratio of compulsory to elective subjects in undergraduate bioinformatics degrees

University	Compulsory (%)	Elective (%)
USyd	79	21
UNSW	78	22
La Trobe	33	67
USQ	75	25
UWA	100	0
UOW	72	28
UMelb	100	0
ANU	100	0
UQ	76	24
QUT	100	0

Elective component indicates the portion of subjects that can be taken from different subject areas. An option of two biological subjects is listed in the compulsory component as both choices are in the area of biology.

percentage of electives differs from a general science degree where a student chooses their own combination of biology, computer and mathematics subjects. A specialised bioinformatics degree should distinguish itself from the self-made bioinformatics degree by being more structured and inclusive of the types of subjects that makes a study in bioinformatics so desirable (computer science, statistics and mathematics).

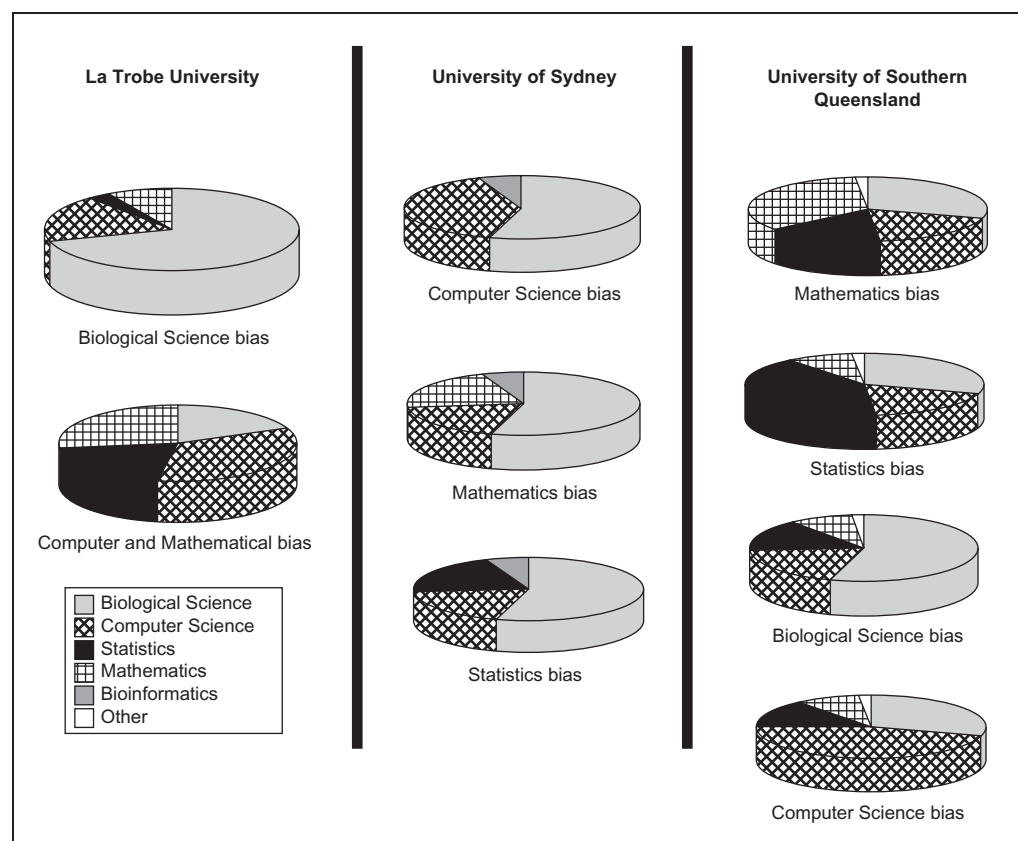
An additional comparison can be made between the specific subject matter that is taught within each subject areas. For instance, in the biological science area some degrees involve a large amount of basic chemistry and biochemistry knowledge, while others concentrate only on the biology and genetics side of the issue. Similarly within the computer science area some degrees offer only an introduction to computer science and information technology while others include programming, artificial intelligence, networks, database construction, computer studies and software development (eg La Trobe, UNSW). This variation is also seen to a smaller extent in the mathematics and statistics division. This divergence in subject matter means that some degrees are more adept at producing bioinformatics engineers (eg UNSW) and others, bioinformatics technicians.

### BIOINFORMATIC STREAMS WITHIN DEGREES

Of the remaining 27 Australian universities that have a biological or medical science degree, 4 have bioinformatics streams within an existing degree. These include a Bachelor of Science Innovation (QUT), Bachelor of Biotechnology (UQ and ANU), Bachelor of Computer Science (UMelb) and Bachelor of Computational Science (ANU). Given that the bioinformatics major is itself a stream within a degree, there is little room for specialisation, ie few electives are available. The biotechnology degrees are biologically centred whereas the Science Innovation and Computer Science degrees concentrate on computer studies.

In addition, all universities that teach biological science (with the exception of University of Tasmania and University of the Sunshine Coast) teach individual subjects that include the analysis of data using bioinformatics tools and techniques. These subjects do not include any computer/programming components but are designed to expose students to the

**Figure 2:** Variation of subject distribution possible within a bioinformatics degree. It is assumed that all elective subjects will be in one particular area. It is possible for the student to select a range of subjects, hence producing a broader, less specialised degree



### Postgraduate study is limited in Australia

software currently available for analysis of data.

### POSTGRADUATE COURSEWORK DEGREES

There are currently three postgraduate coursework degrees in bioinformatics in Australian universities. These postgraduate degrees include some biological subjects, one or two computer subjects (generally an introduction to computer science subject), a bioinformatics project or subject and a statistical subject. Most of these subjects are modified undergraduate subjects and are not created solely for the purpose of the postgraduate degree.

Many graduates interested in bioinformatics come from a biological background and are choosing to study for a dedicated Computer Science Certificate or Diploma or undertake training in a particular programming language rather than study for one of the degrees listed. Owing to time/work restraints, many people who wish to retrain themselves are

unable to attend regular classes and so look towards degrees that are taught by distance education or short courses that can be completed one night a week or on the weekend. Computer subjects are readily taught in this manner.

### FUTURE DIRECTIONS AND CONCLUSIONS

The role that bioinformatics degrees play is in the production of programmers who can create and modify programs for use in particular projects, ie the type of student produced from a computer/mathematics/statistics-centred degree rather than a biologically centred degree. With most biology/genetics students exposed to bioinformatics applications during their undergraduate training, producing bioinformatics technicians should not be an aim of the specialist bioinformatics degree.

Since 2003, three additional bioinformatics degrees have closed or are in the process of closing. In 2003, University of Western Sydney instigated a

**Closure of degrees indicates declining student interest**

Bachelor of Science (Bioinformatics). The course did not take enrolments after this first year. Flinders University (Bachelor of Science (Bioinformatics)) and Macquarie University (Bachelor of Bioinformatics) will also not be taking new enrolments in 2005. Two postgraduate coursework degrees have also ceased taking in new enrolments (Curtin University, Graduate Certificate in Bioinformatics and Royal Melbourne Institute of Technology, Graduate diploma in eScience (which had a bioinformatics stream)). In all cases there were insufficient student enrolments to justify keeping the degree running.

With the exception of UNSW, there has been a decrease in the number of enrolments in 2004 compared with previous years. The number of students currently enrolled in first year range from 3 (UWA) to 20 (UNSW), with most being around 7–12. Around half of the students enrolled in the UNSW degree are completing a double degree. Discussions with the UNSW course coordinator suggest that the ‘double-degree’ option and the degree being in Engineering and not Science may have contributed to the healthy enrolment numbers.

**Aiming degrees to specific markets will ensure their survival**

It is important that degrees are created to fill a need or niche in the academic community and not to join in with everyone else, or we may see additional degrees disappear. These newer degrees need to be seen to create a specific niche or produce a particular kind of graduate in order to guarantee themselves a long life. For instance, UNSW is a computer engineering degree designed towards producing computer programmers; USQ

is on the way to fill the niche of a distance education degree, UWA fits in the geographical need for bioinformatics on the west coast. The future may lie in bioinformatics streams within existing degree instead of creating multiple specialised degrees that cater for only a handful of students.

It is interesting to note that only one of the above universities offers a bioinformatics degree externally. A number of Australian universities are committed to teaching undergraduate courses by distance, yet only USQ offers subjects towards the Bachelor of Bioinformatics in this way. USQ is a leader in distance education, with 75 per cent of its students studying via this mode. It should be mentioned that apart from USQ none of the universities mentioned here teaches a Bachelor of Science degree (of any kind) via distance mode.<sup>1</sup> It appears that the universities that have good distance education networks are not the ones that are venturing into science.

It must be remembered that a number of these degrees are in their infancy (some only in their second year) and it is expected that the content will be modified in the coming years to reflect the final direction each of the universities will take. Progress has been made in the number and types of course made available at the undergraduate level. Australian universities must now look now to what can be offered in the postgraduate level.

**Reference**

1. <http://www.thegoodguides.com.au>