

# Threshold learning outcomes for a microbiology major

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The concept of National Guidelines for Microbiology Curricula was workshopped at the inaugural meeting of EduCon (the ASM Microbiology Educators' Conference) in 2014. Subsequently, an *ad hoc* special working group was formed at the 2015 EduCon to formulate National Guidelines for the threshold learning outcomes of Australian undergraduate microbiology curricula. The group, through discussion and several iterations, developed draft threshold learning outcomes for microbiology majors based on the Science Learning and Teaching Academic Standards Statement<sup>1</sup> and informed by the curricular guidelines of the American Society for Microbiology<sup>2</sup>.

In this context, microbiology is taken to mean study of any or all microorganisms. Collectively, the group agreed that a major in microbiology should demonstrate significant learning of the key concepts of microbiology (see Merkel *et al.*<sup>2</sup>) at an advanced undergraduate level and recognised that there are diverse course structures that could enable this outcome. Commonly, the course structure would require completion of four units of microbiology at years 3 (single degree) or 3 and 4 (double degree) depending on the degree undertaken; however, one of these units could be replaced with a complementary science unit. A capstone unit of microbiology in which students demonstrate critical evaluation and synthesis of a microbiological topic should be included. These standards would necessitate that assessment tasks be linked to each of the learning outcomes and should show progressive development throughout the major. To help Australian academics validate that their students have reached these threshold learning outcomes, each subcategory will be progressively linked to curriculum learning resources that will be available with these guidelines at an EdSIG website hosted by the ASM. Additionally, a list of some current microbiology majors at Australian universities will provide examples of what subjects might be included in a microbiology major (Table 1).

The draft threshold learning outcomes were discussed and supported by the National Examinations and Qualifications Board of the ASM at their December, 2015 meeting and subsequently by National Council in February 2016. The draft threshold learning outcomes

were then circulated to the state branches and to all members of EdSIG for comment. The threshold learning outcomes for a microbiology major presented here are the outcomes from these discussions. It is not the intent of EdSIG that ASM would accredit microbiology majors nor to exactly define curricula, but rather to give guidance to Australian academics on what ASM considers that a microbiology graduate should be able to do whilst working professionally as a microbiologist.

## Introduction to microbiology major threshold learning outcomes

A major in microbiology should demonstrate significant learning of the key concepts of microbiology (see Merkel *et al.*<sup>2</sup>) at an advanced undergraduate level. In this context, microbiology is taken to mean study of any or all microorganisms, including bacteria, viruses, fungi, and parasites. There are diverse student pathways that can enable this outcome, but commonly, the course structure includes four units of microbiology at year 3 (single degree) or years 3 and 4 (double degree) depending on the degree undertaken. One of these advanced units may be replaced with a complementary science unit. A capstone unit in which students demonstrate critical evaluation and synthesis of a microbiological topic addressing the course learning outcomes should be included. These standards necessitate that assessment tasks be linked to each of the learning outcomes and should show progressive development throughout the major. The threshold learning outcomes for microbiology majors are based on the Science Learning and Teaching Academic Standards Statement<sup>1</sup> and informed by the curricular guidelines of the American Society for Microbiology<sup>2</sup>.

## Threshold Learning Outcomes for Majors in Microbiology

### Understanding microbiology

1. Demonstrate a coherent understanding of microbiology and its applications by:

- 1.1. Demonstrating a broad knowledge of, and applying the principles and concepts of microbiology.
- 1.2. Articulating and applying the scientific method of hypothesis testing to the field of microbiology.
- 1.3. Articulating and competently applying analytical methods to advance their understanding of microbiology.
- 1.4. Recognising and explaining the manifold roles and relevance of microbiology to society.

**Knowledge of and practical skills to study microbes, their interactions and their applications**

2. Exhibit depth and breadth of knowledge by:
  - 2.1. Demonstrating well-developed knowledge of microbiology.
  - 2.2. Demonstrating competency in core microbiological skills and techniques.
  - 2.3. Articulating the interactions of microbes with their environment and applications.

**Inquiry and problem solving**

3. Critically analyse and solve specific microbiological problems both individually and in teams by:
  - 3.1. Gathering, analysing and synthesising both quantitative and qualitative data /information from a range of sources relevant to the issue at hand.
  - 3.2. Designing and planning a safe and efficient investigation or experiment.
  - 3.3. Selecting and correctly applying relevant and appropriate practical and/or theoretical techniques or tools in order to carry out an experiment or investigation.

- 3.4. Collecting, accurately recording, interpreting and drawing conclusions from scientific data.

**Communication**

4. Be effective communicators by:
  - 4.1. Using appropriate written and oral forms to communicate understanding of microbiology to a broad range of stakeholders.
  - 4.2. Working collaboratively in teams.
  - 4.3. Effectively advocating for a rational understanding of microbiological issues.

**Personal and professional responsibility**

5. Be accountable for their own learning and work by:
  - 5.1. Working effectively, responsibly and safely with microorganisms.
  - 5.2. Being independent and self-directed learners.
  - 5.3. Demonstrating knowledge of the legal and regulatory frameworks relevant to microbiology.
  - 5.4. Practicing ethical conduct in science.

**References**

1. Jones, S. *et al.* (2011) Learning and Teaching Academic Standards Project SCIENCE. Learning and Teaching Academic Standards Statement September 2011. Australian Learning and Teaching Council Report, 36 pp.
2. Merkel, S. and ASM Taskforce on Curriculum Guidelines for Undergraduate Microbiology. (2012) The development of curricular guidelines for introductory microbiology that focus on understanding. *J. Microbiol. Biol. Educ.* **13**, 32–38. doi:10.1128/jmbe.v13i1.363

Table 1. Example course structures of microbiology majors in Australia. The list includes examples of microbiology majors taught at some Australian Universities. The information is current as of January 2016. The listed majors show minimum requirements and only a single version. Some universities allow different prerequisites for example.

Code	Unit name	Weight	Level
<b>Sydney</b>	<b>Microbiology major</b>		
BIOL1001	Concepts in Biology	12.5	Introductory
MBLG1001	Molecular Biology and Genetics (Intro)	12.5	Introductory
CHEM1001	Fundamentals of Chemistry 1A	12.5	Introductory
The major is the 6 units below, but the introductory units (or similar) are prerequisites			
MICR2021	Microbial Life	12.5	Intermediate
MICR2022	Microbes in Society	12.5	Intermediate
Any 4 of:			
MICR3011	Microbes in Infection	12.5	Advanced
VIRO3001	Virology	12.5	Advanced
MICR3032	Cellular and Molecular Microbiology	12.5	Advanced
VIRO3002	Medical and Applied Virology	12.5	Advanced
MICR3042	Molecular Microbiology Research Skills	12.5	Advanced
URL	<a href="http://sydney.edu.au/courses/pathways/major-microbiology">http://sydney.edu.au/courses/pathways/major-microbiology</a>		

Table 1. (continued)

Code	Unit name	Weight	Level
<b>Western Sydney</b>	<b>Microbiology</b>		
300802.1	Biodiversity	12.5	Introductory
300816.1	Cell biology	12.5	Introductory
300803.1	Essential Chemistry 2	12.5	Introductory
300936.1	Functional Proteins and Genes	12.5	Introductory
The major is the 8 units below, but the introductory units (or similar) are prerequisites			
300936.1	Functional Proteins and Genes	12.5	Intermediate
300833.1	Microbiology 1	12.5	Intermediate
300896.1	Microbiology 2	12.5	Intermediate
300817.1	Molecular Biology	12.5	Intermediate
Any 4 of:			
300866.1	Analytical Microbiology	12.5	Advanced
300826.1	Medical Microbiology	12.5	Advanced
300905.1	Advanced Immunology	12.5	Advanced
300883.1	Laboratory Quality Management	12.5	Advanced
300924.1	Science Research Project	12.5	Advanced
URL	<a href="http://handbook.westernsydney.edu.au/hbook/specialisation.aspx?unitset=M3099.1">http://handbook.westernsydney.edu.au/hbook/specialisation.aspx?unitset=M3099.1</a>		
<b>Queensland</b>	<b>Microbiology</b>		
BIOL1020	Genes, Cells and Evolution	12.5	Introductory
BIOL1040	Cells to Organisms	12.5	Introductory
CHEM1100	Chemistry 1	12.5	Introductory
BIOC2000	Biochemistry and Molecular Biology	12.5	Intermediate
MICR2000	Microbiology and Immunology	12.5	Intermediate
Plus 1 of 7 choices:			
	e.g. from fields such as Biochemistry, Genetics, Ecology, Biostatistics, Forensic Science	12.5	Intermediate
MICR3001	Microbes and Human Health	12.5	Advanced
And any 3 of:			
BIOC3005	Molecular Systems Biology	12.5	Advanced
BIOL3003	Advanced Immunology	12.5	Advanced
BIOL3004	Genomics and Bioinformatics	12.5	Advanced
BIOL3009	Arthropods and Human Health	12.5	Advanced
MICR3002	Virology	12.5	Advanced
MICR3003	Molecular Microbiology	12.5	Advanced

Table 1. (continued)

Code	Unit name	Weight	Level
MICR3004	Microbial Genomics	12.5	Advanced
URL	<a href="https://www.uq.edu.au/study/plan_display.html?acad_plan=MICRBX2030">https://www.uq.edu.au/study/plan_display.html?acad_plan=MICRBX2030</a>		
<b>Tasmania</b>			
<b>Microbiology major</b>			
Choose 2 introductory units from:			
	Biology, Chemistry, Cell Biology	12.5	Introductory
KLA256	Microbes and Man	12.5	Intermediate
One of:			
KLA200	Microbiology (Marine)	12.5	Intermediate
KLA210	Microbiology	12.5	Intermediate
Choose any 4 of 8 microbiology units:			
KLA304	Foodborne Pathogens	12.5	Advanced
KLA346	Plant Pathology	12.5	Advanced
KLA392	Microbiology Research Project	12.5	Advanced
KLA394	Advanced Food Safety Management	12.5	Advanced
KLA396	Food Microbiology	12.5	Advanced
KLA398	Applied Environmental Microbiology	12.5	Advanced
CJA313	Medical Microbiology	12.5	Advanced
CJA314	Advanced Immunology	12.5	Advanced
URL	<a href="http://www.utas.edu.au/courses/set/courses/730-bachelor-of-science">http://www.utas.edu.au/courses/set/courses/730-bachelor-of-science</a>		
<b>RMIT</b>			
<b>Microbiology major</b>			
BIOL2257	Introduction to Microbiology, Immunology and Genetics	12.5	Introductory
BIOL2158	Microbiology	12.5	Intermediate
ONPS2113	Food Microbiology	12.5	Intermediate
ONPS2115	Industrial Microbiology	12.5	Intermediate
ONPS2118	Medical Microbiology 1	12.5	Advanced
ONPS2120	Medical Microbiology 2	12.5	Advanced
ONPS2388	Immunology	12.5	Advanced
ONPS2186	Science Project	12.5	Advanced
URL	<a href="http://www.rmit.edu.au/study-with-us/levels-of-study/undergraduate-study/bachelor-degrees/bp226/#pagelD=BP226P7">http://www.rmit.edu.au/study-with-us/levels-of-study/undergraduate-study/bachelor-degrees/bp226/#pagelD=BP226P7</a>		
<b>Monash</b>			
<b>Microbiology major</b>			
BI01011	Biology 1	12.5	Introductory
BI01012	Biology 2	12.5	Introductory
MIC2011	Introduction to Microbiology & Microbial Biotechnology	12.5	Intermediate
MIC2022	Microbes in Health and Disease	12.5	Intermediate

Table 1. (continued)

Code	Unit name	Weight	Level
Any four of:			
MIC3011	Molecular Microbiology	12.5	Advanced
MIC3022	Molecular Virology and Viral Pathogenesis	12.5	Advanced
MIC3032	Pathogenesis of Bacterial Infectious Diseases	12.5	Advanced
MIC3041	Medical Microbiology	12.5	Advanced
MIC3990	Action in Microbiology Research Project	12.5	Advanced
URL	<a href="https://monash.edu/pubs/2016handbooks/aos/microbiology/">https://monash.edu/pubs/2016handbooks/aos/microbiology/</a>		
<b>Melbourne</b>	<b>Microbiology and immunology major</b>		
BIOL10004	Biology of Cells and Organisms	12.5	Introductory
BIOL10005	Genetics and the Evolution of Life	12.5	Introductory
MIIM20001	Principles of Microbiology and Immunology	12.5	Intermediate
MIIM20002	Microbes, Infections and Responses	12.5	Intermediate
The major is the 4 units below, but the introductory and intermediate units (or similar) are prerequisites			
MIIM30011	Medical Microbiology: Bacteriology	12.5	Advanced
MIIM30014	Medical Microbiology: Virology	12.5	Advanced
MIIM30016	Techniques in Microbiology	12.5	Advanced
Plus one of 11 choices:			
	e.g. from fields such as Biochemistry, Genetics, Molecular biology, Pharmacy, Pathology	12.5	Advanced
URL	<a href="https://handbook.unimelb.edu.au/view/2016/%21B-SCI-MAJ%2B1041">https://handbook.unimelb.edu.au/view/2016/%21B-SCI-MAJ%2B1041</a>		
	<a href="https://handbook.unimelb.edu.au/view/2016/%21B-SCI-SPC%2B1022">https://handbook.unimelb.edu.au/view/2016/%21B-SCI-SPC%2B1022</a>		
<b>UWA</b>	<b>Microbiology and immunology major</b>		
SCIE1106	Molecular Biology of the Cell	6	Introductory
SCOM1101	Introduction to Scientific Practices	6	Introductory
One of:			
ANHB1101	Human Biology I: Becoming Human	6	Introductory
ANHB1102	Human Biology II: Being Human	6	Introductory
BIOL1130	Frontiers in Biology	6	Introductory
MICR2208	Introductory Microbiology	6	Intermediate
MICR2209	Introduction to Infectious Diseases and Immunology	6	Intermediate
MICR3310	Applied and Environmental Microbiology	6	Advanced
MICR3320	Viruses and Viral Disease	6	Advanced
MICR3330	Bacteria and Bacterial Disease	6	Advanced
MICR3340	Immunity and Infection	6	Advanced
URL	<a href="http://handbooks.uwa.edu.au/majors/majordetails?vdir=mjdmcbim">http://handbooks.uwa.edu.au/majors/majordetails?vdir=mjdmcbim</a>		