Appendix 1: Degree-level objectives and learning outcomes (from the 2017 Biology graduate program review document)

Goals and Objectives of the program in relation to the Graduate Degree Level Expectations

<u>MSc Program</u>

The objective of the MSc in Biology is to train students to perform research in biology. This degree prepares students to perform research under direction (e.g. as technicians, consultants, or PhD students), to teach at high school level or administer policy at any level of government, or for further academic or professional study. Reflecting this, the MSc thesis in Biology is usually a completed project of the scale and scope consistent with a single peer-reviewed publication (or in some sub-disciplines, a substantial portion of a peer-reviewed publication)

Because it is a thesis-based program, the MSc program rolls skill-development, knowledge acquisition, and professional development into an integrated program comprised of 1) supervisor-student and within-lab training; 2) program milestones, committee meetings and stream seminars; and 3) the production and defense of a thesis. Specifically, students meet all of the Graduate Degree Level expectations in the following way (see also the MSc Learning Outcomes tables below):

1) Depth and Breadth of Knowledge
   - By being able to discuss the background and context of their work, which we support through a range of in-course opportunities, such as Department seminars, scholarship applications, graduate courses, and interactions with their supervisors, and which we evaluate via the graduate courses, the proposal assessment and the thesis examination (especially the parts that pertain to the thesis introduction and discussion).
2) Research and Scholarship
   - In the MSc program, students are developing the basic tools to perform research. This development ranges from effective use of the literature and interactions with peers in the lab, through directed problem solving, to the analysis, description, and interpretation of data. Most of these aspects are supported throughout the student's progression, with most of the milestones implicitly or explicitly focused on the development of these skills, and the proposal and final thesis provide a means of evaluating its success.
3) Level of Application of Knowledge
   - In the MSc program, the focus is on giving the students the tools to do guided research more independently in future. Thus, our emphasis is on the planning and at-the-bench execution of research. This skillset is supported both within labs via lab meetings and interactions with supervisors, and via the expectations of the advisory committee meetings and Proposal and Thesis examinations.
4) Professional Capacity / Autonomy
   - In the MSc program, the focus here is on i) interpersonal communication skills (both via teaching and interactions with peers and advisors), ii) meeting the ethical, legal, and safety expectations of their sub-discipline (supported by in-lab and in-department expectations and protocols and assessed via mandatory safety training, and in the methods sections of the proposal and thesis

documents), and iii) an understanding of the outcomes of research – i.e. communication beyond the lab, which we support via interactions with supervisors, graduate courses and the co-authorship statement of the thesis (within Biology it is the custom for students and supervisors – and sometimes other collaborators – to co-author any publication(s) arising from a student's thesis).

5) Level of Communication Skills
   - The MSc program places a high premium on developing the basic skills to communicate both biological concepts and data, in the relatively narrow confines of the student's thesis work, and in both oral and written formats. We support written communication skill development via drafts of formal written requirements (e.g. proposal, thesis, and graduate courses) and also optional activities such as scholarship applications and abstracts for conferences. Usually, these drafts are developed and refined with input from peers and supervisors, and they are assessed through the proposal assessment and thesis examination.

6) Awareness of Limits of Knowledge
   - Successful MSc students will be able to contextualise their work within the sub-discipline, appreciate (and to some extent, articulate) its limitations, and positively respond to constructive criticism. We model these qualities through Department seminars and other research presentation events, and allow students to develop those skills in informal and formal discussions with peers and faculty (e.g. through Biocafé and Advisory Committee meetings), and we formally assess it in the stream seminars, the committee meetings, and the proposal assessment and thesis defense.

PhD Program

The objective of the PhD in Biology is to produce graduates who are prepared to direct research in their sub-discipline, and with the autonomy and capacity to broaden their knowledge and skill set as required. PhD graduates will be well-prepared for careers in academia; government, NGO, and industrial research; consulting; and science-related management, including in policy advisory and implementation capacities in the private, non-profit, and government sectors. Reflecting this, the PhD thesis in Biology is usually a substantial body of research, comprised of several publishable (and often published) units, with robust and critical contextualization in the General Introduction and Discussion sections; for this reason, a majority of PhD theses in Biology take the 'Integrated Article' format, although it is certainly possible to achieve this objective using the monograph format.

As a thesis-based program, a successful PhD thesis and defense is the benchmark for completion, and reflects the cumulative and integrative development of research, communication, and leadership skills, as well as the acquisition and contextualization of knowledge. Specifically, Biology PhD students and candidates meet all of the Degree Level Expectations as follows (see also the PhD Learning Outcomes tables below):

1) Depth and Breadth of Knowledge
   - This is a key component of the PhD program, reflected in learning outcomes associated with acquiring, explaining, contextualizing, and discussing the broad body of knowledge in the sub-discipline. We support this outcome via the stream seminars, meetings with visiting scientists, formal and informal discussions with faculty (e.g. in Biocafé and advisory committee meetings), and in interactions with supervisors and labmates. We assess this outcome throughout the program, as it is a key component of graduate courses, stream seminars, proposal assessments and the thesis defense (especially the parts associated with the Introduction and Discussion). Most notably, achievement of this outcome is formally assessed in the Comprehensive Examination.
2) Research and Scholarship
   - Graduates of the PhD program are expected to have developed the skills to plan, execute, and disseminate research. Almost every component of the program supports the development of these skills, which we formally assess through our health and safety training requirements, advisory committee meetings, the proposal assessment and (as an outcome of this ability) a PhD thesis and successful defense.
3) Level of Application of Knowledge
   - PhD graduates are expected to be able to apply their knowledge to novel problems and to be able to modify and pass on their knowledge where necessary. This includes teaching and training – both via Teaching Assistantships and through mentoring in the laboratory (note that the latter is not formally assessed in the program), and also the design and execution of a project that may involve developing novel protocols based on the student's broader knowledge or experience.
4) Professional Capacity / Autonomy
   - As well as the professional skills and autonomy implied by the previous two learning outcomes, graduates of the PhD program are expected to be able to initiate, implement, and appropriately disseminate research – this includes an understanding of the ethical and legal aspects of research, and an understanding of the publication process. These are supported throughout the program, and assessed in the thesis, including the components which have already been published, or for which publication is planned. Successful PhD graduates will also be able to initiate and lead collaborations – although this is not directly assessed in the program (except, perhaps, in the acknowledgements and thesis co-authorship statements), we support the development of this skill set via group work in graduate courses, an active encouragement of cross-lab and inter-departmental collaboration, and the student's experience working on team projects within their lab. Students who choose to be involved in departmental committees, or SOBGS will also have the opportunity to fine-tune these skills.
5) Level of Communication Skills
   - Successful PhD graduates are expected to be able to coherently discuss and present their work to a variety of audiences (both specialist and lay), in both written and oral formats. We support this through supervisor feedback on drafts of written documents for proposals, applications, and instructor feedback in graduate courses, and students have opportunities to communicate orally in stream seminars, graduate courses, advisory committee meetings, and at conferences. We assess communication skills in the Proposal assessment and thesis defense (both of which include both written and oral components) and in the Comprehensive exam (oral only).
6) Awareness of Limits of Knowledge
   - Successful Biology PhD graduates can critically evaluate research (both their own and others') at both a micro-scale (e.g. an individual study) and over a sub-discipline, and clearly identify and

articulate the strengths and weaknesses of research activities and reports. They are able to suggest and design future research. Further, as well as developing superior problem-solving skills, successful PhD graduates will also be able to clearly identify when collaboration will facilitate problem solving, and initiate appropriate collaborations to this effect. We support these learning outcomes throughout the program, and assess them particularly in the Comprehensive Examination and in the Thesis and its defense.

Table A: MSc learning outcomes

Degree Level Expectations	Program-level Learning Outcomes
1. Depth & Breadth of Knowledge	a) Explain the biological concepts, experiments, key study systems and techniques in their immediate sub-discipline b) Describe the societal and environmental context of their work
2. Research & Scholarship	a) Teach a peer a laboratory/field or analytical method following a protocol. b) Prepare a draft manuscript in which data are interpreted and presented, in preparation for submission to a peer-reviewed journal. c) Approach and analyze biological data and process into a final form using discipline-appropriate tools and approaches and present the data and the results in a meaningful descriptive manner in written, tabular or graphical form. d) Identify and solve problems that prevent progress with biological data collection and/or analysis with the help of a supervisor or collaborator. e) Evaluate the results of a biological study and articulate its soundness and limitations at the level of the data and the conclusions derived. f) Locate, acquire, read, organize, maintain, and interpret and cite the primary literature relevant to a biological question.
3. Level of Application of Knowledge	a) Design a project that addresses a defined biological question, using approaches and methods appropriate to the discipline using the scientific method, and modifying existing protocols where necessary b) Plan and perform the research activities required to answer a defined biological question within a circumscribed timeframe
4. Professional Capacity / Autonomy	a) Teach undergraduate students in a lab/field/lecture context. b) Conduct research that meets the ethical standards in biology and the student's sub-discipline, including proper attribution, data integrity, and respectful treatment of colleagues and ethical treatment of animals and the environment. c) Participate collegially in a collaboration or working relationship with one or more other researchers

		d)	Explain the culture and expectations of publication and authorship, and participate in authorship and publication in their biological sub-discipline
5.	Level of Communication Skills	a)	Produce coherent written documents in a variety of formats that communicate biological concepts and/or accurately describe biological experiments, procedures, and analyses, and meet specific format requirements.
		b)	Clearly present biological data, concepts, and conclusions to both a specialist and lay audience, in a manner that is appropriate to the audience and venue, both verbally and with appropriate audiovisual support

Table B: PhD learning outcomes

Degree Level Expectations	Program-level Learning Outcomes
1. Depth & Breadth of Knowledge	a) Describe the societal and environmental context of their sub-discipline, and justify their work in this context. b) Explain and discuss biological research in general with other biologists, and respond productively to constructive criticism. c) Explain the biological concepts, experiments, key study systems, innovations, and techniques in their sub-discipline, and outline the relationship of this knowledge to other sub-disciplines in biology. d) Locate, acquire, read, organize, maintain, and interpret and cite the primary literature relevant to a biological question, and synthesise this information to identify knowledge gaps, overarching concepts and/or novel hypotheses.
2. Research & Scholarship	a) Bring together a complete set of data, its interpretation ad conceptualization, into the form of a peer-reviewed scientific paper and respond productively to criticism on that work. Navigate the submission, review, and revision process, leading to published peer-reviewed articles. b) Collect biological data using methods and techniques appropriate to the sub-discipline in a safe, ethical, legal, and effective manner; these methods and techniques may be self-taught (e.g. from review of the literature), and/or developed or expanded as the study requires. c) Plan and perform the research activities required to answer two or more defined biological questions within a circumscribed timeframe, multitasking and prioritizing where necessary, and articulating the short-and long-term goals in advance. d) Approach and analyze biological data and process it into a final form using discipline-appropriate tools and approaches and present the data and the results in a meaningful descriptive manner in written, tabular or graphical form.
3. Level of Application of Knowledge	a) Teach undergraduate students in a lab/field/lecture context. b) Mentor or supervise less-experienced colleagues by assisting in development of ideas and technical and communication skills.

		c) Conceive of and design an original project that addresses an open-ended biological question, using approaches and methods appropriate to the discipline using the scientific method, modifying existing protocols or developing novel ones where necessary.
4.	Professional Capacity / Autonomy	a) Conduct research that meets the ethical standards in biology and the student's sub-discipline, including proper attribution, data integrity, and respectful treatment of colleagues and ethical treatment of animals and the environment, and be able to meaningfully discuss these standards and the consequences of not meeting them. b) Initiate and lead a collaboration with one or more other researchers. c) Explain the culture and expectations of publication and authorship, and lead in authorship, peer-review, and publication in their biological sub-discipline.
5.	Level of Communication Skills	a) Clearly present biological data, concepts, and conclusions to both a specialist and lay audience, in a manner that is appropriate to the audience and venue, both verbally and with appropriate audiovisual support. b) Produce coherent written documents in a variety of formats that communicate biological concepts and/or accurately describe biological experiments, procedures, and analyses, and meet specific format requirements.
6.	Awareness of Limits of Knowledge	a) Evaluate the results of a biological study and articulate its soundness and limitations at the level of the data and the conclusions derived, propose alternative interpretations and suggest future research directions. b) Independently and pre-emptively identify and solve problems that prevent progress with biological data collection and/or analysis; identify when collaboration will expedite this progress.