

Biology

- **M.Sc. Biology**
- **M.Sc. Biology with Specialization in Bioinformatics**
- **M.Sc. Biology with Specialization in Chemical and Environmental Toxicology**
- **M.Sc. Biology with Specialization in Data Science**
- **Ph.D. Biology**
- **Ph.D. Biology with Specialization in Chemical and Environmental Toxicology**

M.Sc. Biology

Academic Regulations

See the General Regulations section of this Calendar.

Admission Requirements

An Honours B.Sc. or equivalent degree at a standard acceptable to the two universities is required for admission to the M.Sc. program.

Applicants with acceptable standing in a non-honours degree may be admitted to a qualifying-year program which will be determined in each case by the admissions committee.

Applicants must demonstrate a fluent knowledge of English (Carleton), or either English or French (Ottawa).

Program Requirements

M.Sc. Biology (5.0 credits)

1. 1.0 credit in approved coursework	1.0
2. 4.0 credits in:	
BIOL 5909 [4.0] M.Sc. Thesis (including successful oral defence)	4.0
Total Credits	5.0

M.Sc. Biology with Specialization in Bioinformatics (5.0 credits)

1. 1.0 credit in:	1.0
BIOL 5515 [0.5] Bioinformatics	
BIOL 5517 [0.5] Bioinformatics Seminar	
2. 4.0 credits in:	4.0
BIOL 5909 [4.0] M.Sc. Thesis	
Total Credits	5.0

Bioinformatics Related Courses

BIOL 5105 (BIO 5302)	Methods in Molecular Genetics
BIOL 5201 (BIO 8301)	Evolutionary Bioinformatics
BIOL 5409 (BIO 5306)	Modelling for Biologists
BIOL 5501 (BIO 8100)	Directed Studies in Biology
BIOL 5502 (BIO 8102)	Selected Topics in Biology
BIOL 5516 (BNF 5107)	Applied Bioinformatics
COMP 5306 (CSI 5100)	Data Integration

COMP 5307 (CSI 5101)	Knowledge Representation
COMP 5704 (CSI 5131)	Parallel Algorithms and Applications in Data Science
COMP 5703 (CSI 5163)	Algorithm Analysis and Design
COMP 5108 (CSI 5126)	Algorithms in Bioinformatics
STAT 5708 (MAT 5170)	Probability Theory I
STAT 5709 (MAT 5171)	Probability Theory II
STAT 5703 (MAT 5181)	Data Mining
STAT 5702 (MAT 5182)	Modern Applied and Computational Statistics
STAT 5600 (MAT 5190)	Mathematical Statistics I
STAT 5501 (MAT 5191)	Mathematical Statistics II
MATH 6508 (MAT 5314)	Topics in Probability and Stats
MATH 6507 (MAT 5319)	Topics in Probability and Stats
SYSC 5104 (ELG 6114)	Methodologies For Discrete-Event Modeling And Simulation

M.Sc. Biology with Specialization in Chemical and Environmental Toxicology (5.0 credits)

1. 1.5 credits in:	1.5
BIOL 6405/ CHEM 5805 [1.0]	Seminar in Toxicology
BIOL 6402/ CHEM 5705 [0.5] or BIOL 6403/ CHEM 5708 [0.5] [0]	Principles of Toxicology Ecotoxicology
	and 0.5 credit in additional approved coursework
2. 3.5 credits in:	3.5
BIOL 5909 [4.0]	M.Sc. Thesis (including successful oral defence)
Total Credits	5.0

M.Sc. Biology with Specialization in Data Science (5.0 credits)

1. 0.5 credit in approved coursework	0.5
2. 0.5 credit in:	0.5
DATA 5000 [0.5]	Data Science Seminar
3. 4.0 credits in:	4.0
BIOL 5909 [4.0]	M.Sc. Thesis
Total Credits	5.0

Notes

- Completion of the graduate courses specified by the student's advisory committee and the director or associate director of the OCIB; these are normally two one-term courses, but additional courses may be required, depending on the background and research program of the student.
- The passing grade for all required courses is 70% or the equivalent, and the student is not allowed a supplemental examination.

- The admissions committee or the student's advisory committee may also direct the student to take or to audit additional courses. Knowledge of a second language may be specified as a requirement.
- Completion of at least two terms as a full-time student resident at one of the two universities is normally required. Programs for part-time students may be arranged.
- Presentation of one public seminar on the candidate's thesis research.
- Completion of a thesis incorporating the results of original research carried out under the direct supervision of an approved faculty member.
- Successful oral defence of the thesis before an examination board of at least four faculty members, normally drawn from both universities.

Guidelines for Completion of Master's Degree

The maximum time limits for the completion of the requirements of the master's program are listed in the General Regulations, Section 13 of this Calendar. Full-time candidates in the master's program are expected to complete their degree requirements within six terms of first registration for full-time study. Part-time candidates in the master's program, and candidates who elect to complete their program by a combination of full-time and part-time study, are expected to complete their degree requirements within four calendar years or twelve terms from the initial registration in the master's program.

Ph.D. Biology

Academic Regulations

See the General Regulations section of this Calendar.

Admission Requirements

An M.Sc. from a recognized university is required for entry to the Ph.D. program.

A student already registered for the M.Sc. may be permitted to transfer to the Ph.D. program following a recommendation by the departmental graduate committee and successful completion of the Qualifying Examination required of Ph.D. candidates.

All applicants must demonstrate a fluent knowledge of English (Carleton), or either English or French (Ottawa).

Program Requirements

Ph.D. Biology (10.0 credits)

1. 1.0 credit in approved coursework	1.0
2. 9.0 credits in:	9.0
BIOL 6909 [9.0] Ph.D. Thesis	
Total Credits	10.0

Ph.D. Biology with Specialization in Chemical and Environmental Toxicology (10.0 credits)

1. 1.5 credits in:	1.5
BIOL 6405/ Seminar in Toxicology CHEM 5805 [1.0]	
BIOL 6402/ Principles of Toxicology CHEM 5706 [0.5]	

or BIOL 6403/ Ecotoxicology CHEM 5708 [0.5] [0]	
and 0.5 credit in additional coursework	
2. 8.5 credits in:	8.5
BIOL 6909 [9.0] Ph.D. Thesis	
Total Credits	10.0

Notes

- Completion of the graduate courses specified by the student's advisory committee and the director or associate director of the OCIB; these will normally be two one-term courses (four one-term courses if transferred to the Ph.D. program without completing the M.Sc.).
- Only graduate courses may form part of the candidate's course requirements.
- The passing grade for all required courses is 70%, and the student is not allowed a supplemental examination.
- The admissions committee or the student's advisory committee may also direct the student to take or to audit additional courses. Knowledge of a second language may be specified as a requirement.
- Scheduling of an oral Qualifying Examination within approximately 12 months of entry into the program and completion normally within 18 months; this examination will cover the candidate's area of research, and related topics. The format of the examination will be established by the departmental graduate committee. The examination committee generally will be composed of faculty members of both universities.
- Presentation of at least one public seminar on the candidate's thesis research.
- A thesis incorporating the results of original research carried out under the direct supervision of an approved faculty member.
- Completion of at least four terms as a full-time student resident at one of the two universities (or six terms if transferred from an M.Sc.) is required. Under exceptional conditions programs may be arranged for part-time students.
- Successful oral defence of the thesis before an examination board of at least five faculty members, with representation from both universities, and including an external examiner from outside the two universities who is an authority on the thesis research area.

Guidelines for Completion of the Doctoral Degree

The maximum time limits for the completion of the program requirements of the doctoral program are listed in the General Regulations, Section 13 of this Calendar. Full-time candidates in the doctoral program are expected to schedule their oral Qualifying Examination within approximately 12 months of entry into the program, and to complete it within 18 months of entry into the program. Part-time candidates in the doctoral program are expected to schedule their oral Qualifying Examination within approximately 18 months after entry into the program. Full-time candidates are expected to complete their degree requirements within 4 calendar years or 12 terms of

registered full-time study. Doctoral candidates who have transferred from the master's to the doctoral program without completing the master's program are expected to complete their degree requirements within 4 calendar years or 12 terms of registered full-time study from initial registration in the master's program. Part-time candidates in the doctoral program, and candidates who elect to complete their program by a combination of full- and part-time study, are expected to complete their degree requirements within 6 calendar years or 18 terms after the date of initial registration.

BIOL 5001 [0.5 credit] (BIO 5101)
Topics in Biotechnology

A course concerned with the use of biological substances and activities of cells, genes, and enzymes in manufacturing, agricultural, and service industries. A different topic will be selected each year.
Prerequisite(s): a course in cell physiology or biochemistry, or permission of the instructor and permission of the director or associate director of OCIB.

BIOL 5003 [0.5 credit] (BIO 5103)
Advanced Biochemistry

Advanced topics in biochemistry: the chemical structure and function of biological macromolecules, biochemical thermodynamics, metabolism, photosynthesis, lipids and membranes.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5004 [0.5 credit] (BIO 5104)
Advances in Applied Biochemistry

Contemporary methods in recombinant DNA technology and protein characterization, including advanced techniques in proteomics.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5105 [0.5 credit] (BIO 5302)
Methods in Molecular Genetics

Theory and associated applications of emerging methods in molecular genetics, including information gathered from large-scale genome-wide analysis and protein-protein interaction data, and how this information can advance understanding of cell biology.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5106 [0.5 credit] (BIO 5308)
Laboratory Techniques in Molecular Genetics

Laboratory course designed to give students practical experience in recent important techniques in molecular genetics.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5111 [0.5 credit] (BIO 5111)
Biophysical Techniques

Theory and application of current biochemical/biophysical instrumentation and techniques including X-ray crystallography, nuclear magnetic resonance spectrometry, infrared, circular dichroism and fluorescence spectroscopy, and isothermal titration and differential scanning calorimetry.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5121 [0.5 credit] (BIO 5121)
Advances in Protein Engineering

An advanced lecture, discussion and seminar course covering the theory, development and current techniques of protein and enzyme engineering. Topics to be discussed may also include applications in biotechnology, nanotechnology and new frontiers in basic and applied research.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5201 [0.5 credit]
Evolutionary Bioinformatics

Basic concepts in molecular evolution and hands-on experience with the computer analysis of DNA sequences. Topics may include molecular sequence databases, multiple alignments and phylogenetic trees.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5202 [0.5 credit] (BIO 8302)
Topics in Evolutionary Genetics

A lecture/seminar course on the genetic mechanisms and forces responsible for variation and evolutionary change in natural populations. Topics to include protein and genome evolution, molecular phylogenies, DNA sequences in population biology, and the evolution of multigene families.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5203 [0.5 credit] (BIO 8303)
Advanced Microscopy

Development of the practical skills of microscopy through original research and supporting theory lectures.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5304 [1.0 credit]
Fundamentals in Neuroscience

A comprehensive neuroscience course from cellular levels to neural systems and behaviour. Topics covered include aspects of neuroanatomy, neurophysiology, neuropharmacology and behavioural and cognitive neuroscience.
Also listed as NEUR 5100.
Precludes additional credit for PSYC 5200.

BIOL 5307 [0.5 credit] (BIO 8122)**Advanced Insect Biology**

Overview of the biological processes that allow insects to function in their environments and to overcome the constraints and limitations that the environment places on them.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5402 [0.5 credit] (BIO 8162)**Advanced Endocrinology**

Major topics in comparative endocrinology: understanding the structure, function and evolution of vertebrate endocrine systems, including endocrine disruption.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5407 [0.5 credit] (BIO 5305)**Biostatistics I**

Application of statistical analyses to biological data. Topics include ANOVA, regression, GLMs, and may include loglinear models, logistic regression, general additive models, mixed models, bootstrap and permutation tests.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5409 [0.5 credit] (BIO 5306)**Modelling for Biologists**

Use and limitations of mathematical and simulation modelling approaches for the study of biological phenomena.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5501 [0.5 credit] (BIO 8900)**Directed Studies in Biology**

One-to-one instruction in selected aspects of specialized biological subjects not covered by other graduate courses. Students may not take this course from their thesis supervisor(s), and are limited to one directed studies course per program.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5502 [0.5 credit] (BIO 8120)**Selected Topics in Biology**

Lecture and seminar courses in selected aspects of specialized biological subjects not covered by other graduate courses.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5503 [0.5 credit] (BIO 5901)**Biological Science in Practice**

Introduction to cross-cutting skills and issues in common to all biological disciplines. Key perspectives on philosophy of science, practical approaches to scientific publication and peer-review, data analysis and presentation, scientific inference, and technical writing will be provided through discipline-specific examples and associated practical work.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5506 [0.5 credit] (BIO 5213)**Principles and Methods of Biological Systematics**

Biological systematics with reference to morphological and molecular character evolution and phylogeny reconstruction.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5508 [0.5 credit] (BIO 8306)**Advanced Topics in Ecology**

Recent developments in population, community and/or ecosystem ecology.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5510 [0.5 credit] (BIO 5310)**Advanced Evolutionary Biology**

Advances in micro- and macroevolution including the mechanisms both driving and constraining evolutionary change, phylogenetic relationships, patterns of evolutionary change at the molecular or phenotypic level, and evolutionary theory and techniques as applied to these areas.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5511 [0.5 credit] (BIO 5311)**Advanced Evolutionary Ecology**

The ecological causes and consequences of evolutionary change, focussing on how the ecological interactions among organisms and their biotic and abiotic environments shape the evolution of phenotypic and species diversity.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5512 [0.5 credit] (BIO 8105)**Advances in Applied Ecology**

The application of ecological and evolutionary principles in addressing resource management challenges and environmental problems.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5514 [0.5 credit] (BIO 5314)**Advances in Aquatic Sciences**

Advanced theoretical and applied aquatic sciences including current topics in limnology and oceanography (e.g. impacts of climate change, invasive species, atmospheric pollution) with implications for lake, river, coastal and wetland management.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5515 [0.5 credit] (BNF 5106)**Bioinformatics**

Major concepts and methods of bioinformatics. Topics may include genetics, statistics and probability theory, alignments, phylogenetics, genomics, data mining, protein structure, cell simulation and computing.

BIOL 5516 [0.5 credit] (BNF 5107)**Applied Bioinformatics**

Computational knowledge discovery in and the dynamic nature of cellular networks. Includes, but is not limited to, knowledge representation, large scale data integration, data mining and computational systems biology.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5517 [0.5 credit] (BNF 6100)**Bioinformatics Seminar**

Current topics in bioinformatics. Students must successfully complete a presentation and written report.

BIOL 5518 [0.5 credit] (BNF 5318)**Biostatistics II**

Application of multivariate methods to biological data, including methods such as discriminant functions analysis, cluster analysis, MANOVA, principle components analysis.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5520 [0.5 credit] (BIO 5320)**Advances in Conservation Biology**

Interdisciplinary exploration of the science of scarcity and diversity in a human dominated world.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5521 [0.5 credit] (BIO 5321)**Evolutionary Genetics**

Genetic mechanisms and processes responsible for variation and evolutionary change in natural populations. Topics may include population and quantitative genetics as applied to protein and genome evolution, molecular phylogenies, DNA sequences in population biology, and the evolution of multigene families.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5605 [0.5 credit] (BIO 5102)**Advanced Field Ecology**

Field experience in a new environment (e.g., local, national, international) to learn about ecological processes (note - extra fees associated with course).

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5709 [0.5 credit] (BIO 8113)**Chemical Toxicology**

An introduction to modeling chemical hazards and exposures at the cellular level. The properties of toxic substances are compared to the responses of enzymatic systems. These interactions are defined as Quantitative Structure-Activity Relationships and used to interpret hazardous materials under regulations such as WHMIS. Also listed as CHEM 5709/CHM 8157.

Prerequisite(s): BIOL 6402/CHEM 5708 (BIO 9101/CHM 8156), and permission of the director or associate director of OCIB.

BIOL 5801 [0.5 credit] (BIO 5105)**Advanced Neuroethology**

A comparative and evolutionary approach to studying neural mechanisms underlying animal behaviour, including genetic, neural and hormonal influences on behaviour.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5802 [0.5 credit] (BIO 8365)**Advanced Behavioural Ecology**

Recent advances in behavioural ecology including topics such as the evolution of tactics and strategies of group living, foraging, anti-predation, resource use and defence, cooperation, reproduction, and parental care.

Prerequisite(s): Either BIOL 3802 or BIOL 3804 or equivalent AND permission of the director or associate director of OCIB.

BIOL 5909 [4.0 credits]**M.Sc. Thesis****BIOL 6001 [0.5 credit] (BIO 8109)****Advanced Molecular Biology**

In-depth coverage of the structure, function, and synthesis of DNA, RNA, and proteins.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6002 [0.5 credit] (BIO 8116)**Advances in Plant Molecular Biology**

Use of molecular genetics in general plant biology and the contribution of plant genomics to our understanding of plant metabolism, plant development, and plant interactions with the environment at the molecular, genome, and cellular levels.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6201 [0.5 credit] (BIO 8117)**Advanced Cell Biology**

Recent advances in cell biology, including such topics as membranes, signalling, the cytoskeleton and control of the cell cycle.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6202 [0.5 credit] (BIO 8118)**Advanced Cell Biology II**

Topics for discussion may include: the structure, composition and three-dimensional organization of the nucleus, mechanisms and regulation of genome replication, structure organization of transcription. Nuclear reorganization during gamete development, fertilization, viral infection and the mitotic cell cycle. Normally offered in alternate years.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6203 [0.5 credit] (BIO 6103)**Special Topics in Neuroscience**

In-depth study of current topics in neuroscience. Course content varies yearly and has recently included cognitive neuroscience, neuropharmacology, neurodegeneration, and behavioural medicine.

Also listed as NEUR 5800.

BIOL 6204 [0.5 credit] (BIO 6304)**Techniques in Neuroscience**

Completion of a research project carried out under the supervision of a neuroscience faculty member, normally not the current supervisor. The student will learn a new neuroscience technique and apply it to a research objective. Students must obtain prior approval from the graduate committee.

Also listed as NEUR 6301, NEUR 6302.

Precludes additional credit for PSYC 6204.

BIOL 6300 [0.5 credit] (BIO 8320)**Advanced Plant Biology**

Recent developments in plant biology. Topics may include plant anatomy, systematics, evolution, genetics, ecology, ethnobotany, cell biology, and/or biotechnology.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6304 [0.5 credit] (BIO 8361)**Advanced Animal Physiology**

Recent advances in animal physiology, emphasizing comparative, evolutionary and environmental approaches.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6305 [1.0 credit] (BIO 6305)**Advanced Seminar in Neuroscience**

A comprehensive pro-seminar series, covering issues ranging from cellular and molecular processes through to neural systems and behaviours as well as psychopathology. Students will also be required to attend the neuroscience colloquia series as part of this course. Also listed as NEUR 6100.

Precludes additional credit for PSYC 6200, PSYC 6202, PSYC 6203, BIOL 6303.

Prerequisite(s): BIOL 5304 or equivalent.

BIOL 6306 [0.5 credit]**Adv Seminar in Neuroscience II**

A comprehensive pro-seminar series, covering issues ranging from cellular and molecular processes through to neural systems and behaviours as well as psychopathology.

Precludes additional credit for BIOL 6303.

Prerequisite(s): BIOL 6305.

BIOL 6402 [0.5 credit] (BIO 9101)**Principles of Toxicology**

The basic theorems of toxicology with examples of current research problems. The concepts of exposure, hazard and risk assessment will be defined and illustrated with experimental material from some of the more dynamic areas of modern research.

Also listed as CHEM 5708/CHM 8156/TOX8156.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6403 [0.5 credit] (BIO 9104)**Ecotoxicology**

Advances in ecotoxicology with emphasis on the biological effects of contaminants. The potential for biotic perturbation resulting from chronic and acute exposure of ecosystems to selected toxicants will be covered along with the methods pesticide, herbicide and pollutant residue analysis and the concept of bound residues.

Also listed as CHEM 5705/CHM 9109/TOX9104.

Prerequisite(s): BIOL 6402/CHEM 5708 (BIO 9101/CHM 8156), permission of the director or associate director of OCIB.

BIOL 6404 [0.5 credit] (BIO 8938)**Plant: Animal Interactions**

The biology of co-evolutionary relationships between plants and phytophagous animals.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6405 [1.0 credit] (BIO 9105)**Seminar in Toxicology**

A seminar course highlighting current topics in toxicology. The student will present a seminar and submit a report on the seminar topic. Student, faculty and invited seminar speakers.

Also listed as CHEM 5805/CHM 8167/TOX9105.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6406 [0.5 credit] (BIO 9106)**Genetic Toxicology**

Topics in mutagenesis and DNA repair, including spontaneous and induced mutagenesis, genetic toxicology testing, the genetics and biochemistry of replication, DNA repair and recombination, and the role of mutagens in the development of genetic disease and cancer.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6505 [0.5 credit] (BIO 8108)**Advanced Topics in Development**

Recent advances in developmental biology. Topics may include embryonic induction, regulation of morphogenesis and differentiation, mechanisms of regional specification and pattern formation, and developmental genetics.

Offered in alternate years.

Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6909 [9.0 credits]**Ph.D. Thesis**

Summer session: some of the courses listed in this Calendar are offered during the summer. Hours and scheduling for summer session courses will differ significantly from those reported in the fall/winter Calendar. To determine the scheduling and hours for summer session classes, consult the class schedule at central.carleton.ca

Not all courses listed are offered in a given year. For an up-to-date statement of course offerings for the current session and to determine the term of offering, consult the class schedule at central.carleton.ca