Biotechnology

This section presents the requirements for programs in:

- **Master of Biotechnology**

Program Requirements

Master of Biotechnology (4.0 credits)

1.	**3.0 credits in:**		3.0
	BIOL 5001 [0.5]	Topics in Biotechnology	
	BIOL 5900 [1.0]	Problems and Opportunities in Biotechnology	
	BIOL 5901 [1.0]	Development of a Novel Biotechnology Product	
	BIOL 6500 [0.5]	Advanced Science Communication	
2.	**0.5 credit from:**		0.5
	TIMG 5001 [0.5]	Principles of Technology Innovation Management	
	TIMG 5002 [0.5]	Technology Entrepreneurship	
	TIMG 5003 [0.5]	Issues in Technology Innovation Management	
3.	**0.5 credit from:**		0.5
	BIOL 5004 [0.5]	Advances in Applied Biochemistry	
	BIOL 5515 [0.5]	Bioinformatics	
	BIOL 5516 [0.5]	Applied Bioinformatics	
	BIOL 6402 [0.5]	Principles of Toxicology	
	CHEM 5109 [0.5]	Advanced Applications in Mass Spectrometry	
	FOOD 5102 [0.5]	Food Biotechnology	
	HLTH 5350 [0.5]	New Health Technologies	
Total Credits			**4.0**

Admission

M. Biotechnology

Bachelor of Science (or equivalent) in a life sciences field, with B+ or higher in major subjects and B- or higher overall.

Regulations

See the General Regulations section of this Calendar.

Biology (BIOL) Courses

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.
Includes: Experiential Learning Activity
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 5002 [0.5 credit]
Seminar in Biochemistry I
A graduate seminar on current topics in the field of Biochemistry. This course introduces the seminar format and involves student, faculty and invited seminar speakers. The student will present a seminar and submit a report on a current topic in Biochemistry.
Includes: Experiential Learning Activity
Also listed as CHEM 5800.

BIOL 5004 [0.5 credit] (BIO 5104)
Advances in Applied Biochemistry
A practical hands-on course in the field of Biochemistry. This course is run in a laboratory and will train students in highly specialized technique(s) in Biochemistry. The students will run experiments, gather data, assess and analyze the results and present the findings as a seminar.
Includes: Experiential Learning Activity
Also listed as CHEM 5806.

BIOL 5104 [0.5 credit] (BNF 5104)
Bioinformatics Laboratory
Principles of organization, retrieval, manipulation, and analysis of molecular data in genomics, proteomics and transcriptomics. Hands-on analysis of these data to solve biological questions using quantitative and computational methods.
Includes: Experiential Learning Activity

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.
Includes: Experiential Learning Activity
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 5128 [0.5 credit] (BIO 5128)
Molecular Methods
An intensive two-week laboratory course where students are introduced to methods such as CRISPR-Cas9 genome editing, in situ hybridization, immunohistochemistry, qRT-PCR and digital droplet PCR.
Includes: Experiential Learning Activity

BIOL 5144 [0.5 credit] (BIO 5144)
Plant Molecular Biology
Introduction to plant gene structure and function, cloning into plants and the manipulation of plant genes. Elements of plant biochemistry, physiology and molecular biology combined with an emphasis on practical research.

BIOL 5158 [0.5 credit] (BIO 5158)
Applied Biostatistics
Applied biostatistics to real problems. Experimental design and data collection. Consequences of violating assumptions of different tests. Monte Carlo and Bootstrap analysis. Case studies and exercises in using statistical analysis packages.
Includes: Experiential Learning Activity

BIOL 5201 [0.5 credit] (BNF 8301)
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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 5313 [0.5 credit] (BIO 5313)
Topics in Evolutionary and Comparative Biology
Workshop and hands-on training to develop broad basis and familiarity with the research toolkit of modern biology. Topics include the use of statistical programs, 3D data acquisition and analysis, cladistic analysis and phylogenetic comparative method, microscopy and histology, basic bioinformatics, , and scientific illustration.

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.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5404 [0.5 credit]
Biological Data Science in R
Develops the practical skills needed to work with large and complex datasets, as a complement to statistical methods. Topics include programming, quality control, tidy data, visualization, project organization, reproducibility, how to troubleshoot code, and how to translate research goals into a project pipeline.
Includes: Experiential Learning Activity
Prerequisite(s): a course in statistics at the undergraduate level, or 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 5408 [0.5 credit] (BIO 5108)
Bayesian Statistics for Biologists
Introduction to the philosophy of Bayesian inference; practical experience applying to biological data. Model formulation, identification of appropriate priors and resulting posteriors given priors and data, and the practice of drawing inferences from these posteriors.
Includes: Experiential Learning Activity
Prerequisite(s): An advanced course in applied biostatistics (e.g. BIOL 5407) or permission of the Department and good standing in a Carleton University Biology or Biochemistry Graduate Program.

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 8120)
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.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5502 [0.5 credit] (BIO 8102)
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 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 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity

BIOL 5516 [0.5 credit] (BNF 5107)
Applied Bioinformatics
Introduction to programming for students in the life sciences. Through lectures, assignments, and independent projects, students will learn about basic concepts and techniques in programming, including variables, control structures, subroutines, and input/output. No previous knowledge of bioinformatics or programming is required.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of Ottawa-Carleton Institute for Biology.

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.

Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5520 [0.5 credit] (BIO 5320)
Advances in Conservation Science
Interdisciplinary exploration of the science of scarcity and diversity in a human dominated world.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5526 [0.5 credit] (BIO 5126)
Analysis of Next-generation Sequence Data
Assembly and analysis of next-generation sequence (NGS) data. Through hands-on exercises and independent projects, students will learn to use tools for quality control, assembly, mutation calling, and other NGS applications. No previous knowledge of bioinformatics or programming is required.
Includes: Experiential Learning Activity
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).
Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 5709 [0.5 credit] (TOX 8157)
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 (TOX 9156/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.
Includes: Experiential Learning Activity
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 5900 [1.0 credit]
Problems and Opportunities in Biotechnology
Identification of problems, solutions and opportunities in regional biotechnology industries. Lectures and workshops explore challenges of regional startup and established biotechnology companies.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the Department and good standing in a Carleton University biology or biochemistry graduate program.

BIOL 5901 [1.0 credit]
Development of a Novel Biotechnology Product
Capstone course. Under faculty supervision, students will either design and develop a start-up venture in their area of interest, or carry out an internship with a regional biotechnology company. Theory of business and entrepreneurship will be reinforced throughout.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the Department and good standing in a Carleton University biology or biochemistry graduate program.

BIOL 5909 [4.0 credits]
M.Sc. Thesis
Includes: Experiential Learning Activity

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 6040 [0.5 credit] (BIO 8940)
Advanced Statistics and Open Science
The course aims to provide an understanding of advanced statistical models (including generalized linear mixed models), to develop good coding practices (using R and Rmarkdown), to improve data and code management (data manipulation and github) and present the principles of open science (using OSF).
Lectures

BIOL 6102 [0.5 credit]
Seminar in Biochemistry II
A graduate seminar on current topics in the field of Biochemistry. This course introduces the seminar format and involves student, faculty and invited seminar speakers. The student will present a seminar and submit a report on a current topic in Biochemistry.
Includes: Experiential Learning Activity
Also listed as CHEM 6800.

BIOL 6115 [0.5 credit] (BIO 8115)
Genomics in Graduate Studies
Applying tools of genomics in the current research environment. Students will build an original research proposal that includes genomics analyses distinct from those they currently use. The goal is to investigate how genomics (broadly defined) can help students tackle and/or uncover new questions in research.

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.
Includes: Experiential Learning Activity
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.
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.
Prerequisite(s): BIOL 6305.

BIOL 6402 [0.5 credit] (CHM 8156, TOX 8156)
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.
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6403 [0.5 credit] (CHM 9109, TOX 9104)
Ecotoxicology
Selected topics and advances in ecotoxicology with emphasis on the biological effects of contaminants. The potential for biotic perturbance resulting from chronic and acute exposure of ecosystems to selected toxicants will be covered along with methods of pesticide, herbicide and pollutant residue analysis.
Also listed as CHEM 5705.

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 [0.5 credit] (TOX 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.
Includes: Experiential Learning Activity
Also listed as CHEM 5805.
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.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the director or associate director of OCIB.

BIOL 6500 [0.5 credit]
Advanced Science Communication
The theory and practice of effective science communication. Topics may include: writing for, presenting to, and engaging with diverse audiences, as well as graphic design and data visualization, social and digital media, and knowledge mobilization.
Includes: Experiential Learning Activity

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 [0.0 credit]
Ph.D. Thesis
Includes: Experiential Learning Activity