Biochemistry

This section presents the requirements for programs in:

- Biochemistry B.Sc. Honours
- Biochemistry and Biotechnology B.Sc. Honours
- Computational Biochemistry B.Sc. Honours
- Biochemistry B.Sc. Major

Requirements for the program Biochemistry and Biotechnology are presented in the Biotechnology program section of this Calendar.

Program Requirements

Course Categories for Biochemistry

The program descriptions below make use of the following course categories that are defined in the Regulations for the B.Sc.

- Approved Courses Outside the Faculties of Science and Engineering and Design
- Free Electives

Biochemistry B.Sc. Honours (20.0 credits)

A. Credits included in the Major CGPA (13.5 credits)

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<td>BIOL 4318 Adaptations to Extreme Environments</td>
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<td>CHEM 2303 Analytical Chemistry II</td>
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<td>CHEM 2501 Introduction to Inorganic and Bioinorganic Chemistry</td>
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<td>BIOL 3202 Biophysical Techniques and Applications</td>
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<td>BIOL 4005 Biochemical Regulation</td>
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<td>BIOL 4007 Membrane Biochemistry</td>
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<td>BIOL 4009 Biochemistry of Disease</td>
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<td>BIOL 4200 Immunology</td>
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<td>BIOL 4201 Advanced Cell Culture and Tissue Engineering</td>
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<td>BIOL 4708 Principles of Toxicology</td>
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8. 0.5 credit from:

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<td>BIOL 4906 Interdisciplinary Research Project</td>
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BIOC 4907 [1.0] Honours Essay and Research Proposal
BIOC 4908 [1.0] Research Project

B. Credits Not Included in the Major CGPA (6.5 credits)

10. 1.0 credits from:
PHYS 1007 [0.5] Elementary University Physics I
& PHYS 1008 [0.5] Elementary University Physics II
or
PHYS 1003 [0.5] Introductory Mechanics and Thermodynamics
PHYS 1004 [0.5] Introductory Electromagnetism and Wave Motion

11. 1.5 credits in:
MATH 1007 [0.5] Elementary Calculus I
MATH 1107 [0.5] Linear Algebra I
STAT 2507 [0.5] Introduction to Statistical Modeling I

12. 2.0 credits in Approved Courses Outside the Faculties of Science and Engineering and Design (may include NSCI 1000)

13. 1.5 credits from:

BIOL courses listed in but not used to fulfill Item 8 above, one of:
BIOL 2400 [0.5] Independent Research I
BIOL 3400 [0.5] Independent Research II

CHEM courses listed in but not used to fulfill Item 6 above:
CHEM 3100 [0.5] Physical Chemistry II
CHEM 3101 [0.5] Quantum Chemistry
CHEM 3102 [0.5] Methods of Computational Chemistry
CHEM 3106 [0.5] Computational Chemistry Methods Laboratory
CHEM 3107 [0.5] Experimental Methods in Nanoscience
CHEM 3504 [0.5] Inorganic Chemistry II
CHEM 3600 [0.5] Introduction to Nanotechnology
CHEM 3700 [0.5] Industrial Applications of Chemistry
CHEM 3800 [0.5] The Chemistry of Environmental Pollutants
CHEM 4201 [0.5] Macromolecular Nanotechnology
CHEM 4202 [0.5] Advanced Topics in Organic Chemistry I
CHEM 4203 [0.5] Synthetic Organic Chemistry
CHEM 4206 [0.5] Natural Products Chemistry
CHEM 4406 [0.5] Pharmaceutical Drug Design
PHYS 2202 [0.5] Wave Motion and Optics
PHYS 2604 [0.5] Modern Physics I
MATH 2007 [0.5] Elementary Calculus II
MATH 2008 [0.5] Intermediate Calculus
MATH 2107 [0.5] Linear Algebra II
COMP 1005 [0.5] Introduction to Computer Science I

Biochemistry and Biotechnology
B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (15.0 credits)

1. 4.0 credits in:
BIOL 1103 [0.5] Foundations of Biology I
BIOL 1104 [0.5] Foundations of Biology II
BIOL 2104 [0.5] Introductory Genetics
BIOL 2301 [0.5] Biotechnology I
BIOL 2303 [0.5] Microbiology
BIOL 3104 [0.5] Molecular Genetics
BIOL 3301 [0.5] Biotechnology II
BIOL 4301 [0.5] Current Topics in Biotechnology

2. 0.5 credits in:

BIOL 2001 [0.5] Animals: Form and Function
BIOL 2002 [0.5] Plants: Form and Function

3. 0.5 credits from:

BIOL 3201 [0.5] Cell Biology
BIOL 3303 [0.5] Experimental Microbiology

4. 0.5 credits from:

BIOL 3201 [0.5] Cell Biology

5. 3.0 credits in:

BIOL 2200 [0.5] Cellular Biochemistry
BIOL 3101 [0.5] General Biochemistry I
BIOL 3102 [0.5] General Biochemistry II
BIOL 3103 [0.5] Practical Biochemistry I
BIOL 3104 [0.5] Practical Biochemistry II
BIOL 3202 [0.5] Biophysical Techniques and Applications

6. 1.0 credit from:

BIOC 4907 [1.0] Honours Essay and Research Proposal
BIOC 4908 [1.0] Research Project

7. 1.0 credit from:

BIOC 3008 [0.5] Bioinformatics
or BIOC 3203 [0.5] Biochemical Pharmacology
BIOC 4004 [0.5] Industrial Biochemistry
BIOC 4005 [0.5] Biochemical Regulation
BIOC 4007 [0.5] Membrane Biochemistry
BIOC 4008 [0.5] Computational Systems Biology
### 8. 4.0 credits in:

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<td>General Chemistry II</td>
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<td>CHEM 2103</td>
<td>Physical Chemistry I</td>
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<tr>
<td>or CHEM 2300</td>
<td>Physical Biochemistry</td>
</tr>
<tr>
<td>CHEM 2203</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>CHEM 2204</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>CHEM 2303</td>
<td>Analytical Chemistry II</td>
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<tr>
<td>CHEM 2501</td>
<td>Introduction to Inorganic and Bioinorganic Chemistry</td>
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<td>Advanced Organic Chemistry I</td>
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### 9. 0.5 credit from:

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<td>Independent Research I</td>
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<td>Methods in Biochemistry</td>
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<td>BIOC 4901</td>
<td>Selected Topics in Biochemistry</td>
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<td>BIOL 2001</td>
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<td>BIOL 2002</td>
<td>Plants: Form and Function</td>
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<td>BIOL 3102</td>
<td>Mycology</td>
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<td>BIOL 3202</td>
<td>Principles of Developmental Biology</td>
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<td>Human Anatomy and Physiology</td>
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<td>Advanced Human Anatomy and Physiology</td>
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<td>BIOL 3501</td>
<td>Biomechanics</td>
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<td>BIOL 4104</td>
<td>Evolutionary Genetics</td>
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<td>BIOL 4206</td>
<td>Human Genetics</td>
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<tr>
<td>BIOL 4207</td>
<td>Advanced Embryology &amp; Developmental Biology</td>
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<tr>
<td>BIOL 4303</td>
<td>Advanced Plant Physiology</td>
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<td>BIOL 4304</td>
<td>Forensic Biology</td>
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<td>BIOL 4309</td>
<td>Studies in Human Performance</td>
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<td>BIOL 4317</td>
<td>Neuroethology: The Neural Basis of Animal Behaviour</td>
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<tr>
<td>BIOL 4319</td>
<td>Studies in Exercise Physiology</td>
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### B. Credits Not Included in the Major (5.0 credits)

#### 1. 1.0 credit from:

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<td>Elementary University Physics II</td>
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<tr>
<td>PHYS 1003</td>
<td>Introductory Mechanics and Thermodynamics</td>
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<tr>
<td>&amp; PHYS 1004</td>
<td>Introductory Electromagnetism and Wave Motion</td>
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**GPA (5.0 credits)**

#### 11. 1.5 credits in:

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<td>MATH 1107</td>
<td>Linear Algebra I</td>
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<tr>
<td>STAT 2507</td>
<td>Introduction to Statistical Modeling I</td>
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#### 12. 2.0 credits in Approved Courses Outside the Faculties of Science and Engineering and Design (may include NSCI 1000)

**0.5 credit in free elective.**

**Total Credits**

### Computational Biochemistry

#### B.Sc. Honours (20.0 credits)

**A. Credits Included in the Major (13.5 credits)**

#### 1. 2.0 credits in:

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<td>Foundations of Biology II</td>
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#### 2. 3.0 credits in:

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<td>General Chemistry II</td>
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<td>CHEM 2103</td>
<td>Physical Chemistry I</td>
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<td>Physical Biochemistry</td>
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<td>CHEM 2203</td>
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<td>CHEM 2303</td>
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<td>Introduction to Inorganic and Bioinorganic Chemistry</td>
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#### 3. 0.5 credit in:

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<td>BIOC 3101</td>
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<td>BIOC 3202</td>
<td>Biophysical Techniques and Applications</td>
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<td>BIOC 3008</td>
<td>Bioinformatics</td>
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<td>Computational Systems Biology</td>
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<td>COMP 2401</td>
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#### 6. 1.5 credits from:

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<td>MATH 2107</td>
<td>Linear Algebra II</td>
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<td>STAT 2509</td>
<td>Introduction to Statistical Modeling II</td>
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<tr>
<td>MATH 2800</td>
<td>Discrete Mathematics and Algorithms</td>
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BIOCHEMISTRY

1.0 credit from:
BIOC 4906 [1.0] Interdisciplinary Research Project
or BIOC 4908 [1]. Research Project

B. Credits Not Included in the Major (6.5 credits)

1.0 credit from:
PHYS 1007 [0.5] Elementary University Physics I
& PHYS 1008 [0.5] Elementary University Physics II
PHYS 1003 [0.5] Introductory Mechanics and
& PHYS 1004 [0.5] Thermodynamics
Introductory Electromagnetism and
Wave Motion

2.0 credits in:
MATH 1007 [0.5] Elementary Calculus I
MATH 1107 [0.5] Linear Algebra I
MATH 2007 [0.5] Elementary Calculus II
STAT 2507 [0.5] Introduction to Statistical Modeling I

2.0 credits in approved Courses Outside the
Faculties of Science and Engineering and Design (may
include NSCI 1000)

1.0 credit in:
COMP 2402 [0.5] Abstract Data Types and Algorithms
COMP at the 2000-level or above

0.5 credit in free electives.

Total Credits 20.0

Biochemistry

B.Sc. Major (20.0 credits)

A. Credits included in the Major CGPA (12.0 credits)

2.0 credits in:
Biol 1103 [0.5] Foundations of Biology I
Biol 1104 [0.5] Foundations of Biology II
Biol 2104 [0.5] Introductory Genetics
Biol 3104 [0.5] Molecular Genetics

0.5 credit from:
Biol 2001 [0.5] Animals: Form and Function
Biol 2002 [0.5] Plants: Form and Function

0.5 credit from:
Biol 3201 [0.5] Cell Biology
Biol 3205 [0.5] Plant Biochemistry and Physiology
Biol 3303 [0.5] Experimental Microbiology
Biol 3305 [0.5] Human and Comparative Physiology
Biol 3306 [0.5] Human Anatomy and Physiology
Biol 3307 [0.5] Advanced Human Anatomy and Physiology

1.0 credit from:
Biol 3102 [0.5] Mycology
Biol 3201 [0.5] Cell Biology
Biol 3202 [0.5] Principles of Developmental Biology
Biol 3205 [0.5] Plant Biochemistry and Physiology
Biol 3301 [0.5] Biotechnology II
Biol 3303 [0.5] Experimental Microbiology
Biol 3305 [0.5] Human and Comparative Physiology
Biol 3306 [0.5] Human Anatomy and Physiology
Biol 3307 [0.5] Advanced Human Anatomy and Physiology
Biol 3501 [0.5] Biomechanics
Biol 4008 [0.5] Molecular Plant Development
Biol 4103 [0.5] Population Genetics
Biol 4106 [0.5] Advances in Molecular Biology
Biol 4109 [0.5] Laboratory Techniques in Molecular Genetics
Biol 4200 [0.5] Immunology
Biol 4201 [0.5] Advanced Cell Culture and Tissue Engineering
Biol 4202 [0.5] Mutagenesis and DNA Repair
Biol 4206 [0.5] Human Genetics
Biol 4207 [0.5] Advanced Embryology & Developmental Biology
Biol 4209 [0.5] Advanced Plant Physiology
Biol 4300 [0.5] Applied Microbiology
Biol 4301 [0.5] Current Topics in Biotechnology
Biol 4306 [0.5] Animal Neurophysiology
Biol 4309 [0.5] Studies in Human Performance
Biol 4317 [0.5] Neuroethology: The Neural Basis of Animal Behaviour
Biol 4318 [0.5] Adaptations to Extreme Environments
Biol 4319 [0.5] Studies in Exercise Physiology

2.5 credits in:
Biol 2200 [0.5] Cellular Biochemistry
Biol 3101 [0.5] General Biochemistry I
Biol 3102 [0.5] General Biochemistry II
Biol 3103 [0.5] Practical Biochemistry I
Biol 3104 [0.5] Practical Biochemistry II

1.0 credit from:
Biol 3008 [0.5] Bioinformatics
Biol 3202 [0.5] Biophysical Techniques and Applications
Biol 3203 [0.5] Biochemical Pharmacology
Biol at the 4000-level

4.0 credits from:
Chem 1001 [0.5] General Chemistry I
& Chem 1002 [0.5] General Chemistry II
Chem 2103 [0.5] Physical Chemistry I
or Biol 2300 [0.5] Physical Biochemistry
Chem 2203 [0.5] Organic Chemistry I
Chem 2204 [0.5] Organic Chemistry II
Chem 2303 [0.5] Analytical Chemistry II
Chem 2501 [0.5] Introduction to Inorganic and Bioinorganic Chemistry
Chem 3201 [0.5] Advanced Organic Chemistry I

0.5 credit from:
Chem 3202 [0.5] Advanced Organic Chemistry II
Chem 3205 [0.5] Experimental Organic Chemistry

B. Credits Not Included in the Major CGPA (8.0 credits)

1.0 credit from:
Phys 1007 [0.5] Elementary University Physics I
& Phys 1008 [0.5] Elementary University Physics II
Students including the process of Academic Performance

University regulations common to all undergraduate requirements presented here, students must satisfy the all Bachelor of Science programs. In addition to the regulations presented in this section apply to B.Sc. Regulations

Total Credits

12. 3.0 credits from:

   Biochemistry courses listed in but not used to fulfill Item 6 above
   BIOC 4901 [0.5] Selected Topics in Biochemistry

   Biology courses listed in, but not used to fulfill, Item 4 above
   BIOL 2001 [0.5] Animals: Form and Function
   BIOL 2002 [0.5] Plants: Form and Function
   BIOL 2301 [0.5] Biotechnology I
   BIOL 2303 [0.5] Microbiology
   CHEM 3100 [0.5] Physical Chemistry II
   CHEM 3101 [0.5] Quantum Chemistry
   CHEM 3102 [0.5] Methods of Computational Chemistry
   CHEM 3106 [0.5] Computational Chemistry Methods Laboratory
   CHEM 3107 [0.5] Experimental Methods in Nanoscience
   CHEM 3202 [0.5] Advanced Organic Chemistry II
   CHEM 3205 [0.5] Experimental Organic Chemistry
   CHEM 3504 [0.5] Inorganic Chemistry II
   CHEM 3600 [0.5] Introduction to Nanotechnology
   CHEM 3700 [0.5] Industrial Applications of Chemistry
   CHEM 3800 [0.5] The Chemistry of Environmental Pollutants
   CHEM 4201 [0.5] Macromolecular Nanotechnology
   CHEM 4202 [0.5] Advanced Topics in Organic Chemistry
   CHEM 4203 [0.5] Synthetic Organic Chemistry
   CHEM 4206 [0.5] Natural Products Chemistry
   PHYS 2202 [0.5] Wave Motion and Optics
   PHYS 2604 [0.5] Modern Physics I
   MATH 2007 [0.5] Elementary Calculus II
   MATH 2008 [0.5] Intermediate Calculus
   MATH 2107 [0.5] Linear Algebra II
   COMP 1005 [0.5] Introduction to Computer Science I
   COMP 1006 [0.5] Introduction to Computer Science II
   COMP 2401 [0.5] Introduction to Systems Programming

13. 0.5 credit in free electives.

Total Credits 20.0

B.Sc. Regulations

The regulations presented in this section apply to all Bachelor of Science programs. In addition to the requirements presented here, students must satisfy the University regulations common to all undergraduate students including the process of Academic Performance Evaluation (see the Academic Regulations of the University section of this Calendar).

Breadth Requirement for the B.Sc.

Students in a Bachelor of Science program must present the following credits at graduation:

1. 2.0 credits in Science Continuation courses not in the major discipline: students completing a double major are considered to have completed this requirement providing they have 2.0 credits in science continuation courses in each of the two majors

2. 2.0 credits in courses outside of the faculties of Science and Engineering and Design (but may include NSCI 1000)

In most cases, the requirements for individual B.Sc. programs, as stated in this Calendar, contain these requirements, explicitly or implicitly.

Students admitted to B.Sc. programs by transfer from another institution must present at graduation (whether taken at Carleton or elsewhere):

1. 2.0 credits in courses outside of the faculties of Science and Engineering and Design (but may include NSCI 1000) if, on transfer, the student received credit for fewer than 10.0 credits.

2. 1.0 credit in courses outside of the faculties of Science and Engineering and Design (but may include NSCI 1000) if, on transfer, the student received credit for 10.0 or more credits.

Declared and Undeclared Students

Students who are registered in a program within the degree are called Declared students. Most students designate a program of study when they first apply for admission and so begin their studies as Declared students. Students may also choose to begin their studies within the B.Sc. degree without being registered in a program. These students are referred to as Undeclared students. The recommended course pattern for Undeclared students is provided in the Undeclared entry of the Programs section of this Calendar. Undeclared students normally must apply to enter a program before beginning their second year of study. The Science Student Success Centre (SSSC) provides Undeclared students guidance to the appropriate support services in making this decision.

Change of Program within the B.Sc. Degree

Students may transfer to a program within the B.Sc. degree if upon entry to the new program they would be in good academic standing.

Other applications for change of program will be considered on their merits; students may be accepted in the new program in Good Standing or on Academic Warning.

Applications to declare or change their program within the B.Sc. Degree must be made online through Carleton Central by completing a Change of Program Elements (COPE) application form within the published deadlines. Acceptance into a program or into a program element
or option is subject to any enrolment, and/or specific program, program element or option requirements as published in the relevant Calendar entry.

Minors, Concentrations and Specializations
Students may add a minor, concentration or specialization by completing a Change of Program Elements (COPE) application form online through Carleton Central. Acceptance into a minor, concentration or specialization requires that the student be in Good Standing and is subject to any specific requirements of the intended Minor, Concentration or Specialization as published in the relevant Calendar entry.

Experimental Science Requirement
Students in a B.Sc. degree program must present at graduation at least two full credits of experimental science chosen from two different departments or institutes from the list below:

Approved Experimental Science Courses

<table>
<thead>
<tr>
<th>Biochemistry</th>
<th>Biology</th>
<th>Chemistry</th>
<th>Earth Sciences</th>
<th>Food Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOC 2200 [0.5]</td>
<td>BIOL 1103 [0.5]</td>
<td>CHEM 1001 [0.5]</td>
<td>ERTH 1006 [0.5]</td>
<td>FOOD 3001 [0.5]</td>
</tr>
<tr>
<td>BIOC 4001 [0.5]</td>
<td>BIOL 1104 [0.5]</td>
<td>CHEM 1002 [0.5]</td>
<td>ERTH 1009 [0.5]</td>
<td>FOOD 3002 [0.5]</td>
</tr>
<tr>
<td>BIOC 4201 [0.5]</td>
<td>BIOL 2001 [0.5]</td>
<td>CHEM 1005 [0.5]</td>
<td>ERTH 2102 [0.5]</td>
<td>FOOD 3005 [0.5]</td>
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<tr>
<td></td>
<td>BIOL 2002 [0.5]</td>
<td>CHEM 1006 [0.5]</td>
<td>ERTH 2404 [0.5]</td>
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<tr>
<td></td>
<td>BIOL 2104 [0.5]</td>
<td>CHEM 2103 [0.5]</td>
<td>ERTH 2802 [0.5]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIOL 2200 [0.5]</td>
<td>CHEM 2203 [0.5]</td>
<td>ERTH 3111 [0.5]</td>
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<tr>
<td></td>
<td>BIOL 2600 [0.5]</td>
<td>CHEM 2204 [0.5]</td>
<td>ERTH 3112 [0.5]</td>
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<td></td>
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<td>CHEM 2302 [0.5]</td>
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<td>CHEM 2303 [0.5]</td>
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<td>CHEM 2800 [0.5]</td>
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<table>
<thead>
<tr>
<th>Course Categories for B.Sc. Programs</th>
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</thead>
<tbody>
<tr>
<td>Science Geography Courses</td>
</tr>
<tr>
<td>GEOG 1010 [0.5] Global Environmental Systems</td>
</tr>
<tr>
<td>GEOG 2006 [0.5] Introduction to Quantitative Research</td>
</tr>
<tr>
<td>GEOG 2013 [0.5] Weather and Water</td>
</tr>
<tr>
<td>GEOG 2014 [0.5] The Earth's Surface</td>
</tr>
<tr>
<td>GEOG 3003 [0.5] Quantitative Geography</td>
</tr>
<tr>
<td>GEOG 3010 [0.5] Field Methods in Physical Geography</td>
</tr>
<tr>
<td>GEOG 3102 [0.5] Geomorphology</td>
</tr>
<tr>
<td>GEOG 3103 [0.5] Watershed Hydrology</td>
</tr>
<tr>
<td>GEOG 3104 [0.5] Principles of Biogeography</td>
</tr>
<tr>
<td>GEOG 3105 [0.5] Climate and Atmospheric Change</td>
</tr>
<tr>
<td>GEOG 3106 [0.5] Aquatic Science and Management</td>
</tr>
<tr>
<td>GEOG 3108 [0.5] Soil Properties</td>
</tr>
<tr>
<td>GEOG 4000 [0.5] Field Studies</td>
</tr>
<tr>
<td>GEOG 4005 [0.5] Directed Studies in Geography</td>
</tr>
<tr>
<td>GEOG 4013 [0.5] Cold Region Hydrology</td>
</tr>
<tr>
<td>GEOG 4017 [0.5] Global Biogeochemical Cycles</td>
</tr>
<tr>
<td>GEOG 4101 [0.5] Two Million Years of Environmental Change</td>
</tr>
<tr>
<td>GEOG 4103 [0.5] Water Resources Engineering</td>
</tr>
<tr>
<td>GEOG 4104 [0.5] Microclimatology</td>
</tr>
<tr>
<td>GEOG 4108 [0.5] Permafrost</td>
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</table>

<table>
<thead>
<tr>
<th>Science Psychology Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2001 [0.5] Introduction to Research Methods in Psychology</td>
</tr>
<tr>
<td>PSYC 2002 [0.5] Introduction to Statistics in Psychology</td>
</tr>
</tbody>
</table>
### Science Faculty Electives
Science Faculty Electives are courses at the 1000-4000 level chosen from:

- **BIOC (Biochemistry)**
- **BIOL (Biology)**
- **CHEM (Chemistry)** except **CHEM 1003, CHEM 1004, and CHEM 1007**
- **COMP (Computer Science)** except **COMP 1001**
- **ERTH (Earth Sciences)** except **ERTH 1010, ERTOS 1011, and ERTOS 2415**. Earth Sciences students may use ERTOS 2401, ERTOS 2402, and ERTOS 2403 only as free electives.
- **HUMAN (Human Services)**
- **ISCI (Interdisciplinary Science)**
- **ISAP (Interdisciplinary Science Practice)**
- **MATH (Mathematics)**
- **NEUR (Neuroscience)**
- **PHYS (Physics)** except **PHYS 1901, PHYS 1902, PHYS 1905, PHYS 2903**
- **PSYC (Psychology)** except **PSYC 3700**
- **STAT (Statistics)**
- **TSES (Technology, Society, Environment)**
- **NSCI 1000** Introduction to Cognitive Psychology
- **PSYC 2307** [0.5] Human Neuropsychology I
- **PSYC 3307** [0.5] Human Neuropsychology II

### Science Continuation Courses
A course at the 2000 level or above may be used as a Science Continuation credit in a B.Sc. program if it is not in the student's major discipline, and is chosen from the following:

- **BIOL (Biology)**
- **CHEM (Chemistry)**
- **COMP (Computer Science)** A maximum of two half-credits at the 1000-level in COMP, excluding COMP 1001 may be used as Science Continuation credits.
- **ERTH (Earth Sciences)**, except **ERTH 2415** which may be used only as a free elective for any B.Sc. program. Students in Earth Sciences programs may use ERTOS 2401, ERTOS 2402, and ERTOS 2403 only as free electives.

### Free Electives
Any course is allowable as a Free Elective providing it is not prohibited (see below). Students are expected to comply with prerequisite requirements and enrolment restrictions for all courses as published in this Calendar.

### Courses Allowable Only as Free Electives in any B.Sc. Program

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4810 [0.5]</td>
<td>Education Research in Biology</td>
</tr>
<tr>
<td>CHEM 1003 [0.5]</td>
<td>The Chemistry of Food, Health and Drugs</td>
</tr>
<tr>
<td>CHEM 1004 [0.5]</td>
<td>Drugs and the Human Body</td>
</tr>
<tr>
<td>CHEM 1007 [0.5]</td>
<td>Chemistry of Art and Artifacts</td>
</tr>
<tr>
<td>ERTOS 1010 [0.5]</td>
<td>Our Dynamic Planet Earth</td>
</tr>
<tr>
<td>ERTOS 1011 [0.5]</td>
<td>Evolution of the Earth</td>
</tr>
<tr>
<td>ERTOS 2415 [0.5]</td>
<td>Natural Disasters</td>
</tr>
<tr>
<td>ISCI 1001 [0.5]</td>
<td>Introduction to the Environment</td>
</tr>
<tr>
<td>ISCI 2000 [0.5]</td>
<td>Natural Laws</td>
</tr>
<tr>
<td>ISCI 2002 [0.5]</td>
<td>Human Impacts on the Environment</td>
</tr>
<tr>
<td>MATH 0107 [0.5]</td>
<td>Algebra and Geometry</td>
</tr>
<tr>
<td>PHYS 1901 [0.5]</td>
<td>Planetary Astronomy</td>
</tr>
<tr>
<td>PHYS 1902 [0.5]</td>
<td>From Our Star to the Cosmos</td>
</tr>
<tr>
<td>PHYS 1905 [0.5]</td>
<td>Physics Behind Everyday Life</td>
</tr>
<tr>
<td>PHYS 2903 [0.5]</td>
<td>Physics Towards the Future</td>
</tr>
</tbody>
</table>

### Prohibited Courses
The following courses are not acceptable for credit in any B.Sc. program:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 1001 [0.5]</td>
<td>Introduction to Computational Thinking for Arts and Social Science Students</td>
</tr>
</tbody>
</table>
Co-operative Education
For more information about how to apply for the Co-op program and how the Co-op program works please visit the Co-op website.

All students participating in the Co-op program are governed by the Undergraduate Co-operative Education Policy.

Undergraduate Co-operative Education Policy

Admission Requirements
Students can apply to co-op in one of two ways; directly from high school or after beginning a degree program at Carleton.

If a student is admitted to co-op from high school, their grades will be reviewed two terms to one year prior to their first work term to ensure they continue to meet the academic requirements after their 1st or 2nd year of study. The time at which evaluation takes place depends on the program of study. Students will automatically be notified via their Carleton email account if they are permitted to continue.

Students not admitted to Carleton University with the co-op option on their degree can apply for admission via the co-operative education program website. To view application deadlines, visit carleton.ca/co-op.

Admission to the co-op option is based on the completion of 5.0 or more credits at Carleton University, the CGPA requirement for the students’ academic program as well as any course prerequisites. The articulated CGPA for each program is the normal standard for assessment. Please see the specific degree program sections for the unique admission and continuation requirements for each academic program.

Participation Requirements

COOP 1000
Once a student has been given admission or continuation confirmation to the co-op option s/he must complete and pass COOP 1000 (a mandatory online 0.0 credit course). Students will have access to this course a minimum of two terms prior to their first work term and will be notified when to register.

Communication with the Co-op Office
Students must maintain contact with the co-op office during their job search and while on a work term. All email communication will be conducted via the students’ Carleton email account.

Employment
Although every effort is made to ensure a sufficient number of job postings for all students enrolled in the co-op option of their degree program, no guarantee of employment can be made. Carleton’s co-op program operates a competitive job search process and is dependent upon current market conditions. Academic performance, skills, motivation, maturity, attitude and potential will determine whether a student is offered a job. It is the student’s responsibility to actively conduct a job search in addition to participation in the job search process operated by the co-op office. Once a student accepts a co-op job offer (verbally or written), his/her job search will end and access to co-op jobs will be removed for that term. Students that do not successfully obtain a co-op work term are expected to continue with their academic studies. The summer term is the exception to this rule. Students should also note that hiring priority is given to Canadian citizens for co-op positions in the Federal Government of Canada.

Registering in Co-op Courses
Students will be registered in a Co-op Work Term course while at work. The number of Co-op Work Term courses that a student is registered in is dependent upon the number of four-month work terms that a student accepts.

While on a co-op work term students may take a maximum of 0.5 credit throughout each four-month co-op work term. Courses must be scheduled outside of regular working hours.

Students must be registered as full-time before they begin their co-op job search (2.0 credits). All co-op work terms must be completed before the beginning of the final academic term. Students may not finish their degree on a co-op work term.

Work Term Assessment and Evaluation
To obtain a Satisfactory grade for the co-op work term students must have:

1. A satisfactory work term evaluation by the co-op employer;
2. A satisfactory grade on the work term report.

Students must submit a work term report at the completion of each four-month work term. Reports are due on the 16th of April, August, and December and students are notified of due dates through their Carleton email account.

Workplace performance will be assessed by the workplace supervisor. Should a student receive an unsatisfactory rating from their co-op employer, an investigation by the co-op program manager will be undertaken. An unsatisfactory employer evaluation does not preclude a student from achieving an overall satisfactory rating for the work term.

Graduation with the Co-op Designation
In order to graduate with the co-op designation, students must satisfy all requirements for their degree program in addition to the requirements according to each co-op program (i.e. successful completion of three or four work terms).
Voluntary Withdrawal from the Co-op Option
Students may withdraw from the co-op option of their degree program during a study term ONLY. Students at work may not withdraw from the work term or the co-op option until s/he has completed the requirements of the work term.

Involuntary or Required Withdrawal from the Co-op Option
Students may be required to withdraw from the co-op option of their degree program for one or any of the following reasons:
1. Failure to achieve a grade of SAT in COOP 1000
2. Failure to pay all co-op related fees
3. Failure to actively participate in the job search process
4. Failure to attend all interviews for positions to which the student has applied
5. Declining more than one job offer during the job search process
6. Continuing a job search after accepting a co-op position
7. Dismissal from a work term by the co-op employer
8. Leaving a work term without approval by the Co-op manager
9. Receipt of an unsatisfactory work term evaluation
10. Submission of an unsatisfactory work term report

Standing and Appeals
The Co-op and Career Services office administers the regulations and procedures that are applicable to all co-op program options. All instances of a student’s failure during a work term or other issues directly related to their participation in the co-op option will be reported to the academic department.

Any decision made by the Co-op and Career Services office can be appealed via the normal appeal process within the University.

International Students
All International Students are required to possess a Co-op Work Permit issued by Immigration, Refugees and Citizenship Canada before they can begin working. It is illegal to work in Canada without the proper authorization. Students will be provided with a letter of support to accompany their application. Students must submit their application for their permit before being permitted to view and apply for jobs on the Co-op Services database. Confirmation of a position will not be approved until a student can confirm they have received their permit. Students are advised to discuss the application process and requirements with the International Student Services Office.
Degrees
• B.Sc. (Honours)
• B.Sc. (Major)
• B.Sc.

Admission Requirements

B. Sc. Honours Program

First Year
The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. For most programs including Biochemistry, Bioinformatics, Biotechnology, Chemistry, Combined Honours in Biology and Physics, Chemistry and Physics, Computational Biochemistry, Food Science, Nanoscience, Neuroscience, Neuroscience and Mental Health, and Psychology, the six 4U or M courses must include Advanced Functions and two of Biology, Chemistry, Earth and Space Sciences or Physics. (Calculus and Vectors is strongly recommended).

Specific Honours Admission Requirements
For the Honours programs in Earth Sciences, Environmental Science, Geomatics, Interdisciplinary Science and Practice, and Physical Geography, Calculus and Vectors may be substituted for Advanced Functions.

For the Honours programs in Physics and Applied Physics and for double Honours in Mathematics and Physics, Calculus and Vectors is required in addition to Advanced Functions and one of 4U Physics Chemistry, Biology, or Earth and Space Sciences. For all programs in Physics, 4U Physics is strongly recommended.

For the Combined Honours program in Chemistry and Computer Science, 4U Chemistry and Calculus and Vectors are strongly recommended.

For Honours in Psychology, a 4U course in English is recommended.

For Honours in Environmental Science, a 4U course in Biology and Chemistry is recommended.

Advanced Standing
For entry to an Honours program after the completion of 5.0 included credits, a student must have a major CGPA of 5.00 or higher, an overall CGPA of 4.50 or higher and the recommendation of the Honours department or committee. A student beginning the final 10.0 credits towards an Honours degree must present a major CGPA of 6.00 or higher, an overall CGPA of 5.00 or higher and the recommendation of the Honours department or committee. A student beginning the final 5.0 credits towards an Honours degree must present a major CGPA of 6.50 or higher and an overall CGPA of 5.00 or higher, as calculated for graduation. Advanced standing will be granted for studies undertaken elsewhere when these are recognized as the equivalent of subjects offered at Carleton University.

B.Sc. Major Program

B.Sc. Program

First Year
The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. The six 4U or M courses must include Advanced Functions and two of Calculus and Vectors, Biology, Chemistry, Earth and Space Science or Physics (Calculus and Vectors is strongly recommended). For the B.Sc. Major in Physics. 4U Physics is strongly recommended. Equivalent courses may be substituted between the old and new Ontario mathematics curriculum.

Advanced Standing
For entry to a B.Sc. or B.Sc. Major program after the completion of 5.0 included credits, a student must have a major and core CGPA of 3.50 or higher and an overall CGPA of 3.50 or higher. A student beginning the final 5.0 credits towards a B.Sc. or B.Sc. Major degree must present a major and core CGPA of 4.00 or higher and an overall CGPA of 4.00 or higher, as calculated for graduation. Advanced standing will be granted for studies undertaken elsewhere when these are recognized as the equivalent of subjects offered at Carleton University.

Co-op Option

Direct Admission to the First Year of the Co-op Option
Applicants must:
1. meet the required overall admission cut-off average and prerequisite course average. These averages may be higher than the stated minimum requirements;
2. be registered as a full-time student in the Bachelor of Science Honours program;
3. be eligible to work in Canada (for off-campus work placements).

Note that meeting the above requirements only establishes eligibility for admission to the program. The prevailing job market may limit enrolment in the co-op option.

Note: continuation requirements for students previously admitted to the co-op option and admission requirements for the co-op option after beginning the program are described in the Co-operative Education Regulations section of this Calendar.
Biochemistry (BIOC) Courses

BIOC 2200 [0.5 credit]
Cellular Biochemistry
Cellular functions and their interrelationships. Introduction to thermodynamics, membrane structure and function, transport mechanisms, basic metabolic pathways, energy production and utilization, communications between cells. It is strongly recommended that Biology Majors and Honours students take this course in their second year of study.

Includes: Experiential Learning Activity
Also listed as BIOL 2200.
Precludes additional credit for BIOC 2300.
Prerequisite(s): (BIOL 1003 and BIOL 1004) or (BIOL 1103 and BIOL 1104), (CHEM 1006 or CHEM 1002) or permission of the Institute. It is strongly recommended that students in Biochemistry programs take this course in their second year of study.
Lectures three hours a week, laboratory or tutorial four hours a week.

BIOC 2300 [0.5 credit]
Physical Biochemistry
Energy of biological systems, molecular interactions, diffusion principles, introduction to protein folding, structure and thermodynamics, ligand binding and nucleic acid structures; experimental design and data management.
Precludes additional credit for CHEM 2103.
Prerequisite(s): BIOC 2200 (can be taken concurrently with BIOC 2300) and MATH 1007 and MATH 1107, and (PHYS 1007 and PHYS 1008) or (PHYS 1003 and PHYS 1004).
Lectures three hours a week, tutorials three hours a week.

BIOC 2400 [0.5 credit]
Independent Research I
Students carry out a laboratory research project under the supervision of a faculty member from the Institute of Biochemistry. A research report must be submitted by the last day of classes for evaluation by the Director and Faculty supervisor.
Includes: Experiential Learning Activity
Precludes additional credit for BIOC 3006 (no longer offered).
Prerequisite(s): restricted to Honours students of second-year standing in a Biochemistry program with a GPA of 10.0 or higher in first year, and approval of the Director and a Faculty supervisor.
Laboratory research for at least three hours a week over two terms.

BIOC 3008 [0.5 credit]
Bioinformatics
A practical exploration in the application of information technology to biochemistry and molecular biology. Insight into biological knowledge discovery via molecular structure and function prediction, comparative genomics and biological information management.
Includes: Experiential Learning Activity
Also listed as BIOL 3008 and COMP 3308.
Prerequisite(s): BIOC 2200 or BIOL 2200; or permission of the Institute.
Lecture two hours a week, computer workshop three hours a week.

BIOC 3101 [0.5 credit]
General Biochemistry I
Chemistry, structure and function of proteins, lipids, carbohydrates and nucleic acids. Monomers, linkages and types of biochemical polymers that are formed. Mechanism of action of enzymes, regulatory control mechanisms of proteins and integration of biochemical pathways.
Precludes additional credit for CHEM 3401.
Prerequisite(s): (BIOC 2200 or BIOL 2200), and (CHEM 2203 and CHEM 2204) or (CHEM 2207 and CHEM 2208) or permission of the Institute.
Lectures three hours a week.

BIOC 3102 [0.5 credit]
General Biochemistry II
Prerequisite(s): BIOC 3101 and BIOL 2104.
Lectures three hours a week.

BIOC 3103 [0.5 credit]
Practical Biochemistry I
Introduction to experimental biochemistry and the theory and concepts dealt with in BIOC 3101, and BIOC 3202. Includes: Experiential Learning Activity
Precludes additional credit for BIOC 3006 (no longer offered).
Prerequisite(s): (BIOC 2200 or BIOL 2200) and CHEM 2203 or permission of the Institute. CHEM 2204 and (BIOC 2300 or CHEM 2103) are also recommended.
It is highly recommended that BIOC 3101 and BIOC 3202 be taken concurrently.
Laboratory four hours a week, tutorial one hour per week.
BIOC 3104 [0.5 credit]
Practical Biochemistry II
Introduction to experimental biochemistry and the theory and concepts dealt with in BIOC 3101, BIOC 3102, and BIOC 3202.
Includes: Experiential Learning Activity
Precludes additional credit for BIOC 3006 (no longer offered).
Prerequisite(s): BIOC 3103. It is highly recommended that BIOC 3102 be taken concurrently.
Laboratory four hours a week, tutorial one hour a week.

BIOC 3202 [0.5 credit]
Biophysical Techniques and Applications
Theory and applications of current biochemical/biophysical instrumentation and techniques including biophysical spectroscopy, molecular structure determination, calorimetry, and mass spectrometry.
Precludes additional credit for BIOC 4002.
Prerequisite(s): BIOC 2200 or permission of the Institute.
Lectures three hours a week.

BIOC 3203 [0.5 credit]
Biochemical Pharmacology
Biochemical principles of pharmacology, including receptor mechanisms, signal transduction, pharmacokinetics, and pharmacodynamics. Genome-wide association studies, pharmacogenomics, and personalized medicine will also be included.
Prerequisite(s): BIOC 2200 or BIOL 2200, or permission of the Institute.
Lectures three hours a week.

BIOC 3400 [0.5 credit]
Independent Research II
Students carry out a laboratory research project under the supervision of a faculty member from the Institute of Biochemistry. A research report must be submitted by the last day of classes for evaluation by the Director and Faculty supervisor.
Includes: Experiential Learning Activity
Prerequisite(s): restricted to Honours students of third-year standing in a Biochemistry program with a GPA of 10.0 or higher in second year, and approval of the Director and Faculty supervisor.
Laboratory research for at least three hours a week over two terms.

BIOC 3999 [0.0 credit]
Co-operative Work Term
Practical experience for students enrolled in the co-operative option. Students must receive a satisfactory evaluation from their work term employer; and present a written report describing their work term project. Graded Sat or Uns.
Includes: Experiential Learning Activity
Prerequisite(s): registration in the Biochemistry co-operative option and permission of the Institute.

BIOC 4001 [0.5 credit]
Methods in Biochemistry
Principles and applications of modern biochemical methodology, including ultracentrifugation, electrophoresis, ELISA, EMSA, experimental planning, ligand binding kinetics, fluorescence spectroscopy, affinity purification, and in vitro translation.
Includes: Experiential Learning Activity
Prerequisite(s): BIOC 3103 and BIOC 3104 or permission of the Institute.
Lectures and discussion two hours, laboratory four hours a week.

BIOC 4004 [0.5 credit]
Industrial Biochemistry
The application of biochemistry to the production of biological compounds useful in nutrition, medicine, and the food and chemical industries. General strategies for efficient production of these compounds by controlling the activities of living cells or enzymes.
Prerequisite(s): BIOC 3101 and BIOC 3102 (BIOC 3102 may be taken concurrently), or permission of the Institute.
Lecture three hours a week.

BIOC 4005 [0.5 credit]
Biochemical Regulation
Regulation at the transcriptional, translational and metabolic level; regulation of cell and subcellular organelle function and other timely topics may be included.
Prerequisite(s): BIOC 3101 and BIOC 3102.
Lectures three hours a week.

BIOC 4007 [0.5 credit]
Membrane Biochemistry
Biochemical and biophysical aspects of biomembrane structure and function. Topics may include: membrane lipids and proteins, lipid polymorphism, model membranes, liposomes, membrane biogenesis, the membrane cytoskeleton, membrane trafficking, membrane fusion, exocytosis and signal transduction across membranes.
Prerequisite(s): BIOL 2200 or BIOC 2200, or BIOC 3101 (which may be taken concurrently with BIOC 4007), or permission of the Institute.
Lectures two hours a week and workshop two hours a week.

BIOC 4008 [0.5 credit]
Computational Systems Biology
Modeling and simulation of metabolic and regulatory networks towards understanding complex and highly dynamic cellular systems. Biotechnological applications include metabolic engineering, synthetic biology, and drug discovery.
Includes: Experiential Learning Activity
Also listed as COMP 4308.
Prerequisite(s): BIOC 3101 or permission of the Institute.
Lecture one and a half hours per week, workshop one and a half hours per week.
BIOC 4009 [0.5 credit]
Biochemistry of Disease
The biochemical basis of disease including genetic and metabolic disorders such as cancer, neurological degenerative conditions, diabetes, stroke and microbial infections.
Prerequisite(s): BIOC 3101 and BIOC 3102, or permission of the Institute.
Lectures three hours a week.

BIOC 4200 [0.5 credit]
Immunology
The organization and function of the immune system, including the anatomy of the immune system, the properties and behaviour of cells of the immune system, and the molecular and genetic bases of the immune response.
Also listed as BIOL 4200.
Prerequisite(s): BIOL 3201 or permission of the Institute.
Lectures three hours a week.

BIOC 4201 [0.5 credit]
Advanced Cell Culture and Tissue Engineering
Theory and application of current techniques and developments in cell culture as applied to research questions in the field of stem cells and tissue engineering.
Includes: Experiential Learning Activity
Also listed as BIOL 4201.
Prerequisite(s): BIOL 3201 or permission of the Institute.
Laboratory four hours per week, tutorial one hour a week.

BIOC 4202 [0.5 credit]
Mutagenesis and DNA Repair
A mechanistic study of mutagenesis and DNA repair. Topics include DNA structure perturbations, spontaneous and induced mutagenesis, the genetics and biochemistry of DNA repair and recombination, and the role of mutations in the development of genetic disease and cancer.
Also listed as BIOL 4202.
Prerequisite(s): BIOL 3104 and BIOL 2200/BIOC 2200, or permission of the Institute.
Lectures and tutorial three hours a week.

BIOC 4203 [0.5 credit]
Advanced Metabolism
Structure, biochemical derivation and function of secondary metabolites such as toxins and antibiotics. Examples from plant, fungal and animal systems.
Prerequisite(s): BIOC 3101 and BIOC 3102, or permission of the Institute.
Lectures three hours a week.

BIOC 4204 [0.5 credit]
Protein Biotechnology
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.
Precludes additional credit for BIOC 4002.
Prerequisite(s): BIOC 3101 and BIOC 3202 (may be taken concurrently), or permission of the Institute.
Lectures two hours a week, workshop two hours a week.

BIOC 4708 [0.5 credit]
Principles of Toxicology
Basic theorems of toxicology with examples of current research problems. Toxic risk is defined as the product of intensive hazard and extensive exposure. Each factor is assessed in scientific and social contexts and illustrated with many types of experimental material.
Prerequisite(s): BIOC 3101 and fourth-year standing or permission of the Institute.
Also offered at the graduate level, with different requirements, as BIOL 6402, CHEM 5708, for which additional credit is precluded.
Lectures three hours a week.

BIOC 4901 [0.5 credit]
Selected Topics in Biochemistry
Selected topics of current interest in biochemistry are offered upon approval by the Director in consultation with members of the Institute.

BIOC 4906 [1.0 credit]
Interdisciplinary Research Project
Collaborative, interdisciplinary research project approved by the Director. Requires co-supervision, with at least one faculty member from the Institute of Biochemistry. Evaluation is based on a written thesis and poster presentation.
Includes: Experiential Learning Activity
Precludes additional credit for BIOC 4907 and BIOC 4908.
Prerequisite(s): (BIOC 3103 and BIOC 3104) and (BIOC 3101 and BIOC 3102) or equivalent, eligibility to continue in Honours Biochemistry or in Biochemistry and Biotechnology, permission of the Institute.

BIOC 4907 [1.0 credit]
Honours Essay and Research Proposal
An independent research study using library or computational resources. The candidate will prepare a critical review of a topic approved by a faculty adviser. Evaluation will be based on a written report and a poster presentation of the project.
Includes: Experiential Learning Activity
Precludes additional credit for BIOC 4906 [1.0] and BIOC 4908 [1.0].
Prerequisite(s): fourth-year standing in an Honours Biochemistry program and permission of the Institute.
BIOC 4908 [1.0 credit]
Research Project
Students carry out a research project approved by the Director, under the supervision of a faculty member of the Institute, in either the Biology or Chemistry departments. Evaluation is based on a written thesis and poster presentation.
Includes: Experiential Learning Activity
Precludes additional credit for BIOC 4906 and BIOC 4907.
Prerequisite(s): (BIOC 3103 and BIOC 3104) and (BIOC 3101 and BIOC 3102) or equivalent, and eligibility to continue in Honours Biochemistry or in Biochemistry and Biotechnology.