



Undergraduate Programs  
in  
**BIOCHEMISTRY & MOLECULAR  
BIOLOGY**

Dalhousie University  
9B1 - 5850 College Street  
Sir Charles Tupper Medical Building  
P.O. Box 15000  
Halifax, NS B3H 4R2

*<http://www.biochem.dal.ca>*

February 17, 2022

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## Introduction

Biochemistry and Molecular Biology is the study of the molecular basis of life. This science investigates primarily the relationships of structure and function of biological compounds, and the adaptation of structure and function to environmental change. To achieve these goals, biochemistry uses a specific approach that combines basic principles of chemistry, biology, physics, and mathematics to dissect complex biological processes. Molecular biology is concerned more with the regulation and expression of genetic information. Knowledge acquired from investigating simple life forms has helped us to understand similar processes in complex organisms, and has resulted in the emergence of common themes in metabolism and in the structure and function of macromolecules. This knowledge allows biochemists and biomedical scientists to develop or improve pharmaceutical, industrial, biotechnological and food products and to monitor deleterious biological processes. It assists biomedical scientists and physicians to define the normal state, to describe the biochemical and molecular basis of disease and to improve diagnosis and therapy.

Many students first become aware of biochemistry and molecular biology while still in high school. In university, first-year biology courses show how biochemical facts and concepts are woven into modern biology, from genetics to ecology. Thus, most science students have a good idea of what biochemistry is all about by the time they choose their second-year courses, and many take some biochemistry as part of their degree programs. But have you thought of making biochemistry your major subject? This booklet shows you how to go about it.

### ***1. Biochemistry Degree Programs***

The Department of Biochemistry and Molecular Biology offers traditional 4-year programs and 4½-year Co-op programs leading to either a **MAJOR** degree or an **HONOURS** degree. Inclusion of three work terms, one of which must be during an academic term, extends the time required for co-op programs, see page 6. The academic requirements are the same for the co-op and traditional degree programs. The first year of all Biochemistry degree programs is mostly concerned with acquiring basic knowledge in related fields such as biology, chemistry, physics and mathematics. During this time students are advised to acquire experience with computers. In subsequent years, specialized courses in biochemistry and related subjects are taken. The Department of Biochemistry places special emphasis on teaching and research in molecular cell biology & molecular genetics, comparative genomics, proteomics & molecular evolution, and structure, function & metabolism of biomolecules. In addition, relevant courses in related subjects are available in the Departments of Medical Neuroscience, Pathology, Pharmacology, Physiology & Biophysics, and Microbiology & Immunology. The Honours program is a concentrated course of study requiring greater focus on biochemistry, a research Project and thesis in the form of a research paper arranged during 3<sup>rd</sup> year and undertaken in 4<sup>th</sup> year, an Honours Qualifying Component, and high academic standards. It is the usual preparation for graduate studies in biochemistry. The Major degree does not require a research project, a qualifying component, as many biochemistry courses, or as high an academic standard. This greater flexibility allows students to broaden their exposure to related subjects and increase their attractiveness to potential employers. The Major program can also be a good preparation for advanced study in related or interdisciplinary subjects if high grades are obtained.

Degree(s) Obtained	WORKPLACE				
	School*	University	Government Laboratory or Research Institute**	Hospital †	Industry ††
<b>B.Sc.</b>	(Private) Science teacher	Technician, Research Assistant	Technician, Research Assistant	Medical Technologist	Technician
<b>+ B.Ed.</b>	(Public) Science teacher T.C. 5/6	Laboratory Instructor, Technician, Research Assistant	as B.Sc.	as B.Sc. (perhaps with instructional duties)	as B.Sc.
<b>+ M.Sc.</b>	+ B.Ed. T.C. 7	Laboratory Instructor, Research Assistant	as B.Sc. (higher grade)	Higher grade Technologist especially with M.Sc. in Pathology	as B.Sc.
<b>+ Ph.D.</b>	+ B.Ed. T.C. 8	Research Associate, Professor	Research Scientist ‡	Supervisory Technologist (perhaps with university duties)	Research Scientist

**Table 1. EMPLOYMENT OPPORTUNITIES FOR BIOCHEMISTS**

- \* Administrative posts in schools and government education departments generally require a graduate degree: this is usually a M.A. or M.Ed. rather than an M.Sc.
- \*\* National Research Council, Departments of Agriculture, National Health and Welfare, Environment, Fisheries and Oceans, National Defense and Atomic Energy of Canada.
- † Information is for large teaching hospitals; smaller hospitals usually prefer a R.T. or A.R.T. Diploma, which certifies training as a medical laboratory worker.
- †† Brewing, Pharmaceuticals, Food, or Cosmetics: Graduates often enter marketing or management, especially if combined with training in commerce. The Biotechnology Industry is seeing almost explosive growth currently, and will continue to maintain a high level of demand for qualified Biochemists.
- ‡ Many will eventually become administrators.

## ***2. Degrees with a Minor***

A minor in any subject within the Faculty of Arts and Science will now be available to BSc students. Minors can be added to major or honours degree programs. For most subjects, a minor will require a minimum of 18.0 credit hours beyond the 1000-level in the minor subject in addition to the normal requirements for the major or honours program (no double counting of credit hours). Existing minors available in subjects outside the Faculty of Arts and Science remain unchanged.

### **Minor in Biochemistry & Molecular Biology**

You must complete 18.0 credit hours in advanced level BIOC courses.

Some non-BIOC courses such as BIOL 2020, BIOL 2030, CHEM 2401 and CHEM 2402 are required for Biochemistry & Molecular Biology degree programs. These non-BIOC courses cannot be counted as part of the eighteen BIOC credit hours required for the minor.

If you are considering a minor in biology or chemistry, courses used to complete program requirements in biochemistry cannot be counted toward the eighteen credit hours of the minor.

### ***3. Where Does A Biochemistry Degree Lead?***

You may hesitate to start an honours program, because standards are higher than for a major degree. If biochemistry really interests you, apply for honours; the switch from honours to major is less complicated than the alternative. We can also plan a course of study for you that stresses biochemistry, but from which you could still graduate after only three years with a 90.0 credit hour degree in Biology or Chemistry should you wish to do so.

These degrees open the door to a variety of careers (Table 1). Many biochemistry graduates find employment in government and industrial laboratories. Government laboratories are concerned with monitoring policies and research in agriculture, fisheries, forestry and public health. The RCMP employs biochemists in forensic science laboratories. There are also opportunities in clinical diagnostic medicine in hospitals and in the numerous companies now providing diagnostic procedures. The pharmaceutical, brewing and food processing industries employ biochemists. Monitoring and control of pollution are also expanding fields for biochemists. Recent advances in molecular biology and genetics have given biochemistry a major role in the biotechnology industry. The creation of many jobs at the B.Sc. level has occurred as the biotechnology industry has moved from a research base to a manufacturing base. Biochemistry will continue to be a very good preparation for the professions of medicine, dentistry and pharmacy. In addition, a biochemistry degree is increasingly used as a preparation for a more diverse range of careers, such as Law, Journalism or Business. Opportunities exist in Universities and Research Institutes for biochemists with postgraduate degrees.

### ***4. Policy for Students repeating a BIOC course with an integral lab component***

Students who have previously taken BIOC 3300, BIOC 3400, or BIOC 3700 and passed the laboratory component will not be allowed to retake the lab component if they redo the course. The previous lab marks will be used to assign the grade for the lab component based on the weight given to this component in the prospectus for the course in the year it is retaken.

## Co-op Programs

The Department of Biochemistry and Molecular Biology offers a Co-operative Education program to a limited number of highly qualified students. This program supplements the honours, combined honours or major degree with organized work terms. When you combine Biochemistry with a subject where there is no Co-op option, the majority of advanced credit hours must be in Biochemistry. You may take the work terms in industry, in government, university or research institutes. Conclude each with a mandatory written report. Three work terms are included in the program. Work terms may begin in the summer following the 2<sup>nd</sup> year or 3<sup>rd</sup> year of study. At least one work term must be in the fall or winter term and the program must end with an academic term.

Students in co-op programs fulfill all the academic course requirements of the regular B.Sc. programs. At the price of an extra term, co-op students gain some definite advantages. They acquire valuable experience in day-to-day laboratory work, exposure to problem solving and involvement with developing technologies. These experiences widen the horizons of students and give them practical biochemistry knowledge. They obtain direct exposure to potential careers and they also benefit from day-to-day contact with working professionals. Thus, co-op students are better prepared to compete for employment opportunities after graduation. Students receive a salary from the employer during the work term.

### ***Application and Entry to the Co-op program:***

Students wishing to enroll in this program must first consult with the department's co-op advisor. Applications can be submitted after the 1<sup>st</sup> academic year or after the 2<sup>nd</sup> academic year by August 1<sup>st</sup>. Acceptance into the co-op program requires a grade point average of 3.0 or better. Successful applicants must include a Professional Development course (SCIE 2800, a non-credit seminar class) to prepare them for the first work term experience. In subsequent years co-op honours students must maintain a minimum 3.0 GPA in the relevant science subjects normally required for the degree as well as in the work terms. This level of achievement is the same as required for the honours degree. The minimum GPA for co-op major students is 3.0, which is well above the usual minimum required for the major degree. The University regards work terms as part of the total academic program. A comprehensive report is required for each work term. Although not included in the GPA calculation, the department grades your reports and marks are recorded on the student's transcript. The university charges an additional fee for each work term. The usual sequence of academic and work terms is shown below.

**CO-OP PROGRAM WORK TERM SCHEDULE**

<i>Year</i>	<i>Fall</i>	<i>Winter</i>	<i>Summer</i>
I	Acad	Acad	—
II	Acad	Acad	Work 1
III	Acad	Acad	Work 2
IV	Work 3	Acad	—
V	Acad	—	—

Department Co-op Advisor: Dr. H-S. Ro, 902-494-2367, [hyo-sung.ro@dal.ca](mailto:hyo-sung.ro@dal.ca)  
 Additional information from the Faculty of Science Co-operative Education Office  
 1390 LeMarchant Street. Phone: (902) 494-2044, [scicoop@dal.ca](mailto:scicoop@dal.ca),  
<http://www.dal.ca/scicoop/>

## Major Programs

Satisfying and rewarding careers are open to biochemistry graduates who do not have an honours degree. The major degree gives you a chance to study all aspects of biochemistry (Table 2) with more choice than is possible in an honours program (Table 4). Select many of your courses to coincide your own special interests, or to broaden your scientific or general education. For example, a program consisting of the required and recommended courses, together with twelve credit hours in each of physics and geology, would be an excellent preparation for a career as a science teacher. Inclusion of a significant number of Commerce courses will help prepare for a career in science and technology based industry.

### 1. General Requirements

- (a) **Major** – 120.0 credit hours are required with at least 72.0 beyond the 1000 level. These must include 6.0 credit hours each in (1) mathematics, (2) in language/humanities and (3) in social science. An approved writing course is mandatory. In the major area of study, at least 30.0 and not more than 60.0 credit hours beyond the 1000 level are required with at least 18.0 of these credit hours beyond the 2000 level. Students should consult an advisor in the Biochemistry Department for acceptance into this program.
- (b) In addition to the Biochemistry credit hours discussed below, our program includes 6.0 credit hours each of the required Chemistry and Biology courses.
- (c) **Major with Minor in Business** - In addition to the general requirements for the Major, 33.0 credit hours in Business are required. Of these, 27.0 should be beyond the 1000 level and at least 6.0 credit hours should be at the 3000 or 4000 level. ECON 1101 & 1102 and COMM 1010, 1501, 2101, 2202, 2303, 2401 and 3511 must be included in the 33.0 credit hours. Students must consult advisors in both departments.
- (d) **Double Major programs** - A total of at least 60.0 and not more than 84.0 credit hours (beyond the 1000 level) are required in two subject areas, which are usually but not necessarily, related. No more than 48.0 and no less than 30.0 credit hours may be in either subject. At least 12.0 credit hours in each subject must be beyond the 2000 level. Other requirements are as described for the Major program. When combining a science subject with a non-science subject, the larger number of advanced credit hours must be in the science subject to qualify for a B.Sc. Students must consult advisors in both departments.

### 2. The First Year of Study

Biochemists use the concepts and techniques of both biology and chemistry, so that introductory courses in these subjects are prerequisites for all biochemistry courses. All students must complete 6.0 credit hours in each of chemistry (CHEM 1011 + 1012 or equivalent) and in biology (BIOL 1010 + 1011 or 1020 + 1021). These courses must be passed with at least a B- grade. Students must also complete 6.0 credit hours in mathematics: MATH 1000 or 1215 and MATH 1010 or 1060. Please note that if you wish to take CHEM (2301 + 2304) or some higher-level Biochemistry courses (such as BIOC 4702), you must take MATH 1000 and MATH 1010.

During your first two years you must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science (see Undergraduate Calendar). We suggest that you complete one of these requirements in first year and that it should also satisfy the Writing Course requirement. Although the Writing Courses are chosen with the intent of exercising English Grammar and Composition, they are not so focused. If you would prefer to polish your writing skills, we recommend SCIE 1111, Elements of Writing; these 3.0 credit hours entirely satisfy the

Writing Requirement. For the Minor in Business it is probably wise to take COMM 1000 and 1501 in the first year.

Physics, while not required, is highly recommended.

Alternatively, Dalhousie Integrated Science Program (DISP) options that provide the equivalent of the first-year requirements to enter second year biochemistry courses can be taken provided you obtain a B<sup>-</sup> grade or better. In most cases, adding PHIL 1050 in conjunction with SCIE 15XX completes the 30.0 credit hour course load in year one. You must take an additional 3.0 credit hours in language/humanities in the years to follow to meet Bachelor of Science requirements.

### **3. Studies Beyond The First Year**

- (a) **Required Courses** - The second- and third-year biochemistry (BIOC 2300, 2610, 3300, 3400, 3700) are designed to give you a broad biochemical background; they must be included in your program. Cell Biology (BIOL 2020), Genetics & Molecular Biology (BIOL 2030) and Organic Chemistry (CHEM 2401 + 2402) are prerequisites for third-year biochemistry; these must be taken in your second year. Analytical chemistry (CHEM 2201) can be taken in second year, but does not timetable in year three. You are normally expected to complete the language/humanities and social science requirements by the end of the second year.  
At least 15.0 credit hours in biochemistry at the 4000 level are required and a good choice is available. These courses are normally taken in fourth year. BIOC 4604 and 4605 (Research Project I and II) are not required, but may be taken by Major students who obtain a 3.0 grade point average in 3000 level Biochemistry.‡
- (b) **Major with Minor in Business** - COMM 2101, 2202, 2303, 2401, 3511 plus 12.0 credit hours (at least one beyond the 2000 level) are required. The order in which they are taken is determined by the prerequisites for the more advanced courses.
- (c) **Recommended Courses** – see **Table 2**
- (d) **Electives** - Any course for which you have the prerequisites and which can fit into your timetable can form part of your program, including extra biochemistry credit hours. Keep in mind that you need at least 72.0 of the total of 120.0 credit hours beyond the 1000-level.
- (e) **Experiential Learning** (BIOC 3620) The purpose is to provide relevant non-academic learning opportunities outside of regular class-room teaching. It is distinguished from the co-op work term by the amount of work required. It is distinguished from special topics courses and laboratory research project courses in being less focused on academic learning, or in addressing a particular experimental hypothesis. Instead, it is more focused on the application of accumulated skills in a practical context, or learning skills not provided in the regular curriculum, or acquiring relevant experience outside of the university context.

### **4. Minimum Standards for Major Degree**

First year chemistry and biology must be passed with at least a grade of B<sup>-</sup>. Completion of BIOC 2300, BIOC 2610, BIOL 2020, and BIOL 2030 must meet pre-requisite standards for BIOC 3300, BIOC 3400, and BIOC 3700. You must also achieve a cumulative grade point average of at least 2.0 to graduate.



**Table 2. MAJOR DEGREE IN BIOCHEMISTRY**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Class</b> <b>Electives</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 6.0 approved credit hours (Requirement I.B in Calendar) 6.0 credit hours <sup>a</sup>
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2201</b> <b>CHEM 2401 &amp; 2402</b> <b>Electives</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Analytical Chemistry Introductory Organic Chemistry 9.0 credit hours <sup>b</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>Electives</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 21.0 credit hours <sup>a</sup>
<b>IV</b>	<b>BIOC 3XXX/4XXX</b> <b>Electives</b>	15.0 credit hours <sup>b</sup> 15.0 credit hours <sup>a</sup>

<sup>a</sup> **Recommended Electives** – Almost any course in biology or chemistry will help to give you a wider biochemical perspective. We recommend MICI 2100, 3114, 3115, and 3119 as especially helpful.

PHYC 1300 is recommended for inclusion in any Biochemistry degree program and can be scheduled as one of the electives in either year one or year three, but will not timetable in year two.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

<sup>b</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03

CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Please note that for an Honours degree in Biochemistry & Molecular Biology, a single three credit hour BIOC 3XXX-level course other than BIOC 3300, BIOC 3400, and BIOC 3700 can be counted toward the total number of advanced level BIOC credit hours required (maximum of twelve credit hours in BIOC 3XXX).

**Table 3. DOUBLE MAJOR DEGREE IN BIOCHEM AND MICRO**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Class</b> <b>Electives</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 6.0 approved credit hours (Requirement I.B in Calendar) 6.0 credit hours <sup>a</sup>
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>MICI 2100</b> <b>MICI 2400</b> <b>CHEM 2401 &amp; 2402</b> <b>Electives</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Microbiology & Immunology Lab Methods in Microbiology & Immunology Introductory Organic Chemistry <sup>b</sup> 6.0 credit hours <sup>a</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>MICI 3114</b> <b>MICI 3115</b> <b>MICI 3119</b> <b>Electives</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry Virology Immunology Physiology of the Prokaryotic Cell 12.0 credit hours any subject <sup>a</sup>
<b>IV</b>	<b>BIOC 4XXX</b> <b>MICI 4XXX</b> <b>BIOC or MICI</b> <b>Electives</b>	6.0 credit hours <sup>c</sup> 3.0 credit hours 9.0 credit hours <sup>c</sup> 9.0 credit hours <sup>a</sup>

<sup>a</sup> **Recommended Electives** – Almost any course in biology or chemistry will help to give you a wider biochemical perspective. We recommend CHEM 2201 for developing good analytical/lab skills. CHEM3601 is a prerequisite for some BIOC 47XX courses.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

<sup>b</sup> CHEM 2441 is not an option for a double major in BIOC and MICI.

<sup>c</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03

CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 4. DOUBLE MAJOR DEGREE IN BIOCHEM AND NESC**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Class</b> <b>PSYO 1XXX</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 6.0 approved credit hours (Requirement I.B in Calendar) PSYO 1011/1012 or PSYO 1021/1022
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>PSYO 2000</b> <b>NESC 2470</b> <b>NESC 2570</b> <b>PSYO 2501</b> <b>CHEM 2401 &amp; 2402</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Methods in Experimental Psychology Introduction to Neuroscience I. Brain Systems Introduction to Neuroscience II. Cellular Neurobiology Statistical Methods I Introductory Organic Chemistry
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>NESC 2XXX</b> <b>NESC 3XXX</b> <b>L/H Elective</b> <b>Elective</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 3.0 credit hours 6.0 credit hours chosen from approved NESC lab courses 6.0 credit hours in language/humanities (see Calendar). 6.0 credit hours
<b>IV</b>	<b>BIOC 4XXX</b> <b>NESC 3XXX/4XXX</b> <b>Elective</b>	6.0 credit hours 6.0 credit hours 18.0 credit hours

MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03

CHEM 3601 will be considered equivalent to BIOC 3XXX.03

Students are strongly recommended to take PHYC 1300 prior to finishing their degree.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 5. DOUBLE MAJOR DEGREE IN BIOCHEM AND ESS**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>SUST 1000 &amp; 1001</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 12.0 credit hours
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2401 &amp; 2402</b> <b>SUST 2000 or 2001</b> <b>Electives</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Organic Chemistry 6.0 credit hours 6.0 credit hours <sup>a</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>SUST Selective</b> <b>SUST Selective 3XXX/4XXX</b> <b>Electives</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 6.0 credit hours, cannot be BIOC XXXX 6.0 credit hours, cannot be BIOC 3XXX/4XXX 9.0 credit hours <sup>a</sup>
<b>IV</b>	<b>BIOC 4XXX</b> <b>BIOC XXXX or SUST Selective</b> <b>SUST Selective 3XXX/4XXX</b> <b>Elective</b>	6.0 credit hours <sup>b</sup> 3.0 credit hours 6.0 credit hours 15.0 credit hours <sup>a</sup>

<sup>a</sup> We recommend students take CHEM 2201 as an elective in year two to optionally switch to a concentrated honours or major Biochemistry degree at the end of year two.

PHYC 1300 is recommended for all Biochemistry degree programs and could be included in year three.

ESS students meet the BSc writing component on completion of SUST 1000.06. Either SUST 1000.06 or SUST 1001.06 satisfies the BSc social science component. 6.0 credit hours in language/humanities must be completed for BSc graduation requirements.

SUST Selectives are chosen from list of courses approved by College of Sustainability. See Calendar, or <http://www.dal.ca/faculty/sustainability/programs/ess/approved-electives.html>

<sup>b</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03  
CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 6. DOUBLE MAJOR DEGREE IN BIOCHEM AND ARTS<sup>a</sup>**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>ARTS 1XXX</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 12.0 credit hours <sup>b</sup>
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2401 &amp; 2402</b> <b>ARTS 2XXX</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Organic Chemistry 12.0 credit hours
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>ARTS 3XXX</b> <b>Social Science Elective</b> <b>Elective</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 9.0 credit hours 6.0 credit hours in social science (see Calendar) 6.0 credit hours
<b>IV</b>	<b>BIOC 4XXX</b> <b>ARTS 4XXX</b> <b>Elective</b>	6.0 credit hours <sup>c</sup> 6.0 credit hours 18.0 credit hours

<sup>a</sup> ARTS designates any subject granting major and double major degrees. Consult the ARTS department for specific advanced level (2XXX and above) courses you need to consider. The advanced credit hours in ARTS in this table somewhat mirror the increasing complexity of BIOC courses required at each level based on year of study.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science. Students are strongly recommended to take PHYC 1300 prior to finishing their degree.

<sup>b</sup> The writing requirement (Degree Requirements I.B) will likely be met in one of the Arts Major first year courses.

<sup>c</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03  
CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

## Honours Programs

### **1. General Honours Requirements**

There are three honours degrees offered at Dalhousie University: **CONCENTRATED**, **COMBINED**, and **MULTIDISCIPLINARY**. All honours degrees require 120.0 credit hours and are normally completed in four years of study. Students normally submit a completed Honours Application Form to the Registrar's Office in the third year of study. *However, students should always consult with an Advisor to choose appropriate courses; do this before registering for courses in the third year.* The Undergraduate Calendar details the Faculty of Science requirements for this degree; consult the general requirements for a major in this booklet.

### **2. The First Year Of Study**

To enter an honours program you will need to have taken first-year biology and chemistry (passing both with a grade of B- or better) and mathematics. Physics, while not required, is highly recommended. In case you missed chemistry or biology you would have to take courses in the summer sessions because they are prerequisites for obligatory second year courses.

Alternatively, Dalhousie Integrated Science Program (DISP) options meet the first-year requirements to enter second year biochemistry courses when you obtain a B- grade or better. In most cases, adding PHIL 1050 in conjunction with SCIE 15XX completes the five-credit course load in year one. You must take an additional 3.0 credit hours in language/humanities in the years to follow to meet Bachelor of Science requirements.

### **3. Study Beyond First Year**

At least 72.0 of the 90.0 credit hours obtained in the last three years must be beyond the 1000 level. A concentrated honours degree program must include at least 54.0 credit hours and no more than 66.0 credit hours in the honours subject. A combined honours program must include at least 66.0 and no more than 84.0 credit hours in two allied subjects, with at least 48.0 credit hours in each of the two subjects. For a multidisciplinary honours, 72.0 credit hours in three or more subjects are required; a minimum of 18.0 credit hours in each. You **must** obtain an average grade of **B** or better in the three core third year Biochemistry & Molecular Biology courses (BIOC 3300, BIOC 3400, and BIOC 3700) and you must obtain a grade of C or better in all courses in the honours subject(s).

You are also required to take sufficient **electives** to bring your total credit hours up to 120.0. These may be at any level, provided no more than 48.0 credit hours in total are at the first year level, and let you follow up other interests such as commerce, music, philosophy, statistics or computer science. Within limits, you may also use electives to gain extra credit hours in the honours subjects (you must pass them with a grade of C or better).

Faculty Regulations also require an extra grade for all honours graduates. In what follows, we consider each kind of program in turn to show how you will make up the 120.0 credit hours, and how to determine the honours qualifying component in each case.

### **4. Minimum Standards for the Honours Degree**

The overall standard for an honours degree is higher than for the Major degree. A grade of C- or lower in any of your courses in the honours subject(s) is not acceptable and cannot be counted toward the requirements. Completion of BIOC 2300, BIOC 2610, BIOL 2020, and BIOL 2030 must meet pre-requisite standards for BIOC 3300, BIOC 3400, and BIOC 3700. You must obtain a cumulative grade point average (GPA) of at least **3.0** in your courses in the honours subject(s). For a degree with first-class honours you need a cumulative GPA of at least **3.7** in your courses in the honours subject(s).

### **5. Honours Certificates**

If you have a three-year, 90.0 credit hour degree from this University, it may be possible to convert it into an honours degree by a suitable course of study, often lasting only one year. At the end of the program you must have satisfied all the requirements for an honours degree, and will be awarded a certificate to that effect. Interested students should consult the Department.

## ***6. Concentrated Honours Degree in Biochemistry***

Students who wish to get the best grasp of biochemistry in the time available will choose this program. The Biochemistry concentrated honours program has requirements beyond those of other honours programs. Of the 90.0 credit hours beyond the first year, at least 72.0 must be 2000 level or higher:

<b>Biochemistry:</b>	36.0 or 39.0 credit hours, depending on whether CHEM 3601 is chosen, some choice in 4 <sup>th</sup> year.
<b>Biology:</b>	6.0 credit hours
<b>Chemistry:</b>	9.0 or 12.0 credit hours, depending on whether CHEM 3601 chosen.
<b>Electives:</b>	36.0 credit hours, depending on choices above, very wide selection.

This program is shown in Table 7. Some of the questions that students ask are answered in the following section.

- \* Students should be aware that where there is choice in program requirements, not all choices satisfy prerequisite requirements for more advanced courses, e.g. MATH 1010 is required for BIOC 4702 and for CHEM 2304. Students are therefore warned to carefully check the requirements for advanced courses that may interest them before choosing a less demanding option.

**Table 7. HONOURS DEGREE IN BIOCHEMISTRY**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Course</b> <b>Elective</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) <sup>b</sup> 6.0 approved credit hours (Requirement I.B in Calendar) 6.0 credit hours <sup>a</sup>
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2201</b> <b>CHEM 2401 &amp; 2402</b> <b>Elective</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Analytical Chemistry Introductory Organic Chemistry 9.0 credit hours <sup>a, c</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>CHEM 3601<sup>b</sup></b> <b>or BIOC XXXX</b> <b>Elective</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry Chemistry of Living Systems or an additional 3.0 credit hours in another BIOC class 18.0 credit hours <sup>a, c</sup>
<b>IV</b>	<b>BIOC 4604 &amp; 4605</b> <b>BIOC 4XXX<sup>d</sup></b> <b>Elective</b>	Research Project I & II. Includes an oral defense of the research project. 15.0 credit hours, 9.0 credit hours of which must be chosen from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 9.0 credit hours

<sup>a</sup> **Recommended Electives** – Almost any course in biology or chemistry will help to give you a wider biochemical perspective, but some are particularly relevant. We recommend MICI 2100, 3114, 3115, and 3119 as especially helpful.

PHYC 1300 is recommended for inclusion in any Biochemistry degree program and can be scheduled as one of the electives in either year one or year three, but will not timetable in year two.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

<sup>b</sup> Students are **warned** to carefully check the requirements for advanced courses that may interest them before choosing a less demanding option.

<sup>c</sup> After three years you have an option to graduate with a 90.0 credit hour B.Sc. with concentration in Chemistry by taking CHEM 2101 (Introductory Inorganic Chemistry), CHEM 2301 + 2304 (Physical Chemistry) **and** 3.0 credit hours in CHEM 3XXX if you elect CHEM 3601 or 6.0 credit hours in CHEM 3XXX.

You could also graduate with a 90.0 credit hour B.Sc. with concentration in Biology by completing 6.0 credit hours from BIOL 2003, 2004, 2040 or 2060 **and** 3.0 credit hours in BIOL 3XXX.

<sup>d</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03

CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Please note that for an Honours degree in Biochemistry & Molecular Biology, a single three credit hour BIOC 3XXX-level course other than BIOC 3300, BIOC 3400, and BIOC 3700 can be counted toward the total number of advanced level BIOC credit hours required (maximum of twelve credit hours in BIOC 3XXX).



## **(b) *Frequently Asked Questions***

### **Why include advanced chemistry?**

Biochemists use the words, ideas, and tools of chemistry. Biochemists in different specialties have different needs, but a general education in biochemistry requires a general education in chemistry. The advanced courses in chemistry fulfill that requirement.

### **How do I choose electives?**

Keep open as many degree options as possible and use electives to explore other interests. Like any field of study, biochemistry has links to many other subjects. Some of these are biology, chemistry, mathematics, microbiology, physics, and psychology.

### **Can I specialize?**

Most students will wait until fourth year before choosing a specific area in which to specialize. However, you may already have a clear idea of what sort of biochemistry most interests you. Table 8 illustrates the various options available within the concentrated honours framework, while combined honours programs can be designed to allow you to specialize in an area that spans two disciplines. You could work towards becoming a molecular geneticist (biochemistry plus microbiology/immunology), a neurochemist (biochemistry plus chemistry or neuroscience), or some other kind of specialist. Within limits, we can draw up a course of study to suit you. For example, you may want to pursue a research career in pharmacology, because of the interesting employment opportunities in the pharmaceutical industry or medicine. You could incorporate a substantial pharmacology and physiology component in a biochemistry honours degree by including courses such as BIOC 4804 & 4806, and BIOL 3078 & 3079. A co-op Biochemistry honours degree is an ideal preparation for those who might have an interest in applying their science in a company or research lab setting after finishing their degree program.

### **What if I don't wish to specialize?**

If you have not yet defined your interests and are not sure what you would like to pursue, use your electives to try out other subjects. Table 5 lists courses in a range of topics that you might find interesting. All are potentially useful to biochemists. In any case, discuss your plans with a Faculty Advisor to make sure that you meet all Faculty requirements.

### **What are the Research Project I and II?**

University students in any honours program should learn what it is like to actually practice their craft. BIOC 4604/4605 lets you do this by working in a research laboratory during your final year. You will be given your own problem – usually a small, but not trivial part of your supervisor's research program – and you will try to solve it by experimental work. You will be expected to work the equivalent of at least one full day per week on your project throughout the fall and winter terms. Library study is also needed, because you are also expected to understand both the history of the problem that you are studying and the way in which its solution contributes to the advance of biochemical knowledge.

It is up to you to choose the general area in which to work. Near the beginning of your third year you should talk with the Honours Coordinator. Many of the topics you will have learned about in years two and three are researched in the department. Table 9 tells you what is going on in the Department and in the laboratories of adjunct and cross-appointed professors. A limited number of students may be able to start their research work as a summer job after their third year. Some

students may continue a successor project in the same laboratory during the academic year, but for fairness' sake they will be marked only for the latter part of their work. You must choose a topic and obtain the agreement of a faculty member to act as your supervisor before you will be granted approval to register for this course. With special permission from the Honours Coordinator, your project may be in a laboratory outside the Department, providing the topic is mainly biochemistry or molecular biology; this must be justified by a comprehensive project outline submitted prior to the end of third year. The Honours Coordinator will communicate the due dates of (1) a written report describing your project plus preliminary results submitted at the end of the first semester and (2) a final comprehensive report written in the style of a research paper submitted at the end of the second semester.

### **Honours Qualifying Component**

Scientists must learn to tell others of their work, both in writing and in oral presentations. As well as preparing a written report of your research in BIOC 4604/4605, you must give an oral presentation and defense of your work to the department at a special seminar. In addition, you are required to attend the weekly departmental seminar series (Thursday afternoons at 4:00 p.m.). Assessment of your oral presentation and seminar attendance will be graded on a Pass/Fail basis.

### **Experiential Learning (BIOC 3620)**

Honours students may exercise the option to take this course in year three, but not year four of their program. The purpose of this course is to provide relevant non-academic learning opportunities outside of regular classroom teaching. It is distinguished from the co-op work term by the amount of work required. It is distinguished from special topics courses and laboratory research project courses in being less focused on academic learning, or in addressing a particular experimental hypothesis. Instead, it is more focused on the application of accumulated skills in a practical context or learning skills not provided in the regular curriculum.

**Table 8. SECOND YEAR COURSES COMPLEMENTARY TO BIOCHEMISTRY**

<b>Subject</b>	<b>Number</b>	<b>Course Title</b>
Biology (BIOL)	2003	Diversity I
	2004	Diversity II
	2060	Introductory Ecology
Chemistry (CHEM)	2101	Inorganic Chemistry
Computing (CSCI)	1100	Computer Science I
	1101	Computer Science II
	1200	Microcomputer Applications
Mathematics (MATH)	1060	Introductory Statistics
	2001	Intermediate Calculus I
	2002	Intermediate Calculus II
	2030	Matrix Theory and Linear Algebra I
	2040	Matrix Theory and Linear Algebra II
Microbiology (MICI)	2100	Introductory Microbiology and Immunology
	2400	Lab Methods in Microbiology & Immunology
Physics (PHYC)	2500	Oscillations and Waves
	2505	Mechanics & Relativity
	2510	Electricity and Magnetism
	2515	Modern Physics
	2240	Biophysics
	2250	Physics of Biological and Medical Technology
	2451	Astronomy I
	2452	Astronomy II
Psychology (PSYO)	2000	Methods in Experimental Psychology
	2170	Hormones and Behavior
	2270	Introduction to Neuropsychology
	2470	Introduction to Neuroscience I
	2570	Introduction to Neuroscience II
Statistics (STAT)	2050	Exploratory Data Analysis
	2060	Probability and Statistics
	2080	Statistical Methods for Data Analysis
Science (SCIE)	1111	Elements of Writing (fulfills writing requirement for BSc)

Other courses may also be suitable: if in doubt, ask us.

**Table 9. RESEARCH ACTIVITIES IN BIOCHEMISTRY**

<b>TOPIC</b>	<b>PROFESSOR</b>
<b>Molecular Cell Biology &amp; Molecular Genetics</b>	
Nuclear structure and cancer biology	Dellaire, Tupper 11G
Chromosome function, yeast cell biology	Dobson, Tupper 10J
Membrane protein structure-function and cell-cell fusion	Duncan, Tupper 7S
Lipid metabolism and signaling in cardiac health and disease	Kienesberger, DMNB <sup>b</sup>
Proteomics, signal transduction by kinases	Marignani, Tupper 9F
Molecular genetics of phospholipid acylation	McMaster, Tupper 6B2
Control of gene expression	Ro, Tupper 10M
Regulation of programmed cell death in cancer	Rosen, ARC <sup>a</sup>
Protein secretion/transcriptional regulation	Singer, Tupper 10H
Hormone action in cancer	Too, Tupper 9D
Molecular mechanisms of metastasis and angiogenesis	Waisman, Tupper 11N2
<b>Comparative Genomics, Proteomics &amp; Molecular Evolution</b>	
Evolution, endosymbiosis, molecular phylogeny	Archibald, Tupper 8H
Protein evolution and folding	Blouin, Computer Science Bldg.
Genomics, molecular phylogeny, gene transfer	Doolittle, Tupper 8C
Organelle genome evolution and expression	Gray, Tupper 8F
Inteins and protein splicing	Liu, Tupper 9M
Genome, organelle and protein evolution	Roger, Tupper 8D
Molecular biology and evolution of eukaryotes	Slamovits, Tupper 8B
<b>Structure, Function &amp; Metabolism of Biomolecules</b>	
Enzyme catalysis and mechanisms	Bearne, Tupper 9J
Cholesterol metabolism in the brain	Karten, Tupper 9G
Structural biology and protein engineering	Langelan, Tupper 8F
Lipoprotein assembly and secretion	McLeod, Tupper 9C
Amino acid and signaling in cardiac metabolism	Pulinilkunnil, DMNB <sup>a</sup>
Protein structure and function	Rainey, Tupper 10N
Cholesterol and sphingolipid metabolism	Ridgway, ARC <sup>a</sup>
Metabolism and cell biology of glycosphingolipids	van der Spoel, ARC <sup>a</sup>

<sup>a</sup>ARC – Atlantic Research Centre, 3<sup>rd</sup> Floor Clinical Research Centre, University Avenue

<sup>b</sup>DMNB – Dalhousie Medical School, Saint John Campus, University of New Brunswick

### **3. Combined Honours Programs**

While there is choice within an honours program, some students would like to take more credit hours in other subjects than the rules allow. For example, Table 7 shows that concentrated honours Biochemistry students cannot do much chemistry at the fourth-year level. Some students might prefer to take fewer fourth-year biochemistry courses and so have room for advanced courses in, say, analytical and organic chemistry. That sort of choice is available in a combined honours program. Examples of popular combined honours programs are shown in the tables that follow.

**Requirements:** A combined honours student must take at least **66.0** advanced credit hours (passing grade, C or better) in two allied subjects. The number of advanced credit hours may be up to 84.0 if both departments agree. Whatever the total, you may not take fewer than 30.0 credit hours in the other subject.

**Required Courses:** Each department usually specifies core courses that must be taken as part of any combined honours program in that department. You should consult each department for their requirements. All combined honours programs in Biochemistry must include the following courses:

- BIOL 2020 & 2030: grades of B- or better
- CHEM 2401 & 2402: grades of C or better, even if chemistry is not one of your combined honours subjects
- CHEM 2301 & 2304: required for combined honours with Chemistry and recommended for other biochemistry honours programs
- BIOC 2300, 2610, 3300, 3400, and 3700 plus 6.0 credit hours, which must be chosen from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX. (BIOC 2300 must be passed with a grade of B- or better).
- CHEM 3601 is not mandatory for Biochemistry & Molecular Biology degree programs. It deals with chemical principles that are crucial if you are to understand metabolism and enzyme reaction mechanisms.

**Where can I do my Research Project?** Combined honours students usually do their project in the department where they take most of their advanced credit hours. If that were the Biochemistry department, they would take BIOC 4604/4605 and Biochemistry & Molecular Biology would be the first named subject in their combined degree.

Sometimes a joint project can be worked out. For example, you might synthesize a radioactive compound in the Chemistry department and study its metabolism in the Biochemistry department. Agreement is negotiated with the two departments about registering for the most suitable honours course number.

**Honours Qualifying Component** You will likely follow the practice of the primary department of the two departments concerned or special arrangements may be made. Practices vary among departments. In Chemistry, the Honours Project is completed in addition to the standard 30.0 credit hours of courses in the fourth year. In Biochemistry and most other departments, the Honours Project is the Research Project and is included in the 30.0 credit hours. The oral presentation and defense of the work done for the Research Project constitutes the Honours Qualifying Component.

**Experiential Learning (BIOC 3620)** Honours students may exercise the option to take this course in year three, but not year four of their program. The purpose is to provide relevant non-academic learning opportunities outside of regular classroom teaching. It is distinguished from the co-op work term by the amount of work required. It is distinguished from special topics courses and laboratory research project courses in being less focused on academic learning, or in addressing a particular experimental hypothesis. Instead, it is more focused on the application of accumulated skills in a practical context or learning skills not provided in the regular curriculum.

**Table 10. COMBINED HONOURS DEGREE IN BIOCHEM AND CHEM**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH 1000 &amp; 1010</b> <b>Writing Course</b> <b>Elective</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) Differential and Integral Calculus 6.0 approved credit hours (Requirement I.B in Calendar) 6.0 credit hours <sup>a</sup>
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2201</b> <b>CHEM 2301 &amp; 2304</b> <b>CHEM 2401 &amp; 2402</b> <b>Electives</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Analytical Chemistry <sup>b</sup> Thermodynamics <sup>b</sup> and Kinetics and Dynamics <sup>b</sup> Introductory Organic Chemistry 3.0 credit hours (not BIOC or CHEM) <sup>a</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>CHEM 2XXX/3XXX</b> <b>Electives</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 9.0 credit hours <sup>c</sup> 12.0 credit hours <sup>a</sup>
<b>IV</b>	<b>BIOC 4604 &amp; 4605</b> <b>BIOC 4XXX</b> <b>CHEM 3XXX/4XXX</b> <b>or BIOC 4XXX</b> <b>Electives</b>	Research Project I & II. Includes an oral defense of the research project. 6.0 credit hours chosen from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 9.0 credit hours <sup>c</sup> 9.0 credit hours <sup>a</sup>

<sup>a</sup> **Recommended Electives** – PHYC 1300 is recommended for inclusion in any Biochemistry degree program and historically can be scheduled as one of the electives in either year one or year three.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

<sup>b</sup> We specifically identify these courses as they constitute pre-requisites for later study

<sup>c</sup> CHEM 3601 is highly recommended for a Biochemistry honours program when combined with Chemistry.

MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03

CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 11. COMBINED HONOURS DEGREE IN BIOCHEM AND MICRO**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Class</b> <b>Electives<sup>a</sup></b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 and 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 6.0 approved credit hours (Requirement I.B in Calendar) 6.0 credit hours in language/humanities or social science (see Calendar).
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>MICI 2100</b> <b>MICI 2400</b> <b>CHEM 2401 &amp; 2402</b> <b>Elective<sup>a</sup></b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Microbiology & Immunology Lab Methods in Microbiology & Immunology Introductory Organic Chemistry 9.0 credit hours
<b>III<sup>a</sup></b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>MICI 3114</b> <b>MICI 3115</b> <b>MICI 3119</b> <b>Electives<sup>a</sup></b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry Virology Immunology Physiology of the Prokaryotic Cell 12.0 credit hours
<b>IV</b>	<b>BIOC 4604 &amp; 4605</b> <b>or MICI 4900.06</b> <b>BIOC 4XXX</b> <b>MICI 4XXX</b> <b>BIOC and/or MICI<sup>b</sup></b> <b>Electives</b>	Research Project I & II. Includes an oral defense of the research project. 6.0 credit hours chosen from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 3.0 credit hours 9.0 credit hours 3.0 credit hours

<sup>a</sup> CHEM 2201 is a very useful course for developing good analytical and lab skills.

CHEM 3601 is a prerequisite for some BIOC 47XX courses.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

<sup>b</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03

CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 12. COMBINED HONOURS DEGREE IN BIOCHEM AND BIOL**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Class</b> <b>Elective</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 & 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 6.0 approved credit hours (Requirement I.B in Calendar) 6.0 credit hours in language/humanities or social science (see Calendar).
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>BIOL 2060</b> <b>BIOL 2003</b> <b>BIOL 2004</b> <b>CHEM 2401 &amp; 2402</b> <b>Electives</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Ecology Diversity I Diversity II Introductory Organic Chemistry 3.0 credit hours <sup>a</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>BIOL 2040</b> <b>BIOL 3078 &amp; 3079</b> <b>or Phyl 2030.06</b> <b>or BIOL 3050</b> <b>Electives</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry Evolution Principles of Animal Physiology Human Physiology Developmental Biology + 3.0 credit hours in Biology 12.0 credit hours <sup>a</sup>
<b>IV</b>	<b>BIOC 4604 &amp; 4605 or</b> <b>BIOL 4900</b> <b>BIOC 4XXX</b> <b>BIOL 3XXX/4XXX</b> <b>or BIOC 4XXX</b> <b>Electives</b>	Research Project I & II. Includes an oral defense of the research project. 6.0 credit hours chosen from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 9.0 credit hours <sup>b</sup> 9.0 credit hours <sup>a</sup>

<sup>a</sup> CHEM 2201 is a very useful course for developing good analytical and lab skills. You could also graduate with a 90.0 credit hour B.Sc. in Biology after three years of study if you take BIOL 3078 & 3079 or BIOL 3050; otherwise you would need an additional 3.0 credit hours in BIOL 3/4XXX.

All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.

<sup>b</sup> MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03  
CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.



**Table 13. COMBINED HONOURS DEGREE IN BIOCHEM AND NESC**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>Writing Class</b> <b>PSYO 1XXX</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 and 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 6.0 approved credit hours (Requirement I.B in Calendar) PSYO 1011/1012 or PSYO 1021/1022 (social science requirement)
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>PSYO 2000</b> <b>NESC 2470</b> <b>NESC 2570</b> <b>CHEM 2401 &amp; 2402</b> <b>PSYO 2501</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Methods in Experimental Psychology Systems Neuroscience Cellular Neuroscience Introductory Organic Chemistry Statistical Methods I
<b>III<sup>a</sup></b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>NESC 2XXX</b> <b>NESC 3XXX</b> <b>L/H Elective</b> <b>Elective</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 3.0 credit hours in Neuroscience 6.0 credit hours chosen from approved NESC lab courses 6.0 credit hours in language/humanities (see Calendar). 6.0 credit hours
<b>IV</b>	<b>BIOC 4604 &amp; 4605</b> <b>BIOC 4XXX</b> <b>NESC 3XXX/4XXX</b> <b>Elective</b>	Research Project I & II. Includes an oral defense of the research project. 6.0 credit hours from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 6.0 credit hours 12.0 credit hours

<sup>a</sup> Note if Neuroscience is the first named subject in the combined degree, Statistical Methods II (PSYO 3502) would need to be included, NESC 4500.06 would replace BIOC 4604 & 4605.  
Students are strongly recommended to take PHYC 1300 prior to finishing their degree.  
All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science.  
CHEM 3601 is a prerequisite for some BIOC 47XX courses.  
MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03  
CHEM 3601 will be considered equivalent to BIOC 3XXX.03

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 14. COMBINED HONOURS DEGREE IN BIOCHEM AND ESS**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>SUST 1000 &amp; 1001</b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 and 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 12.0 credit hours
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2401 &amp; 2402</b> <b>SUST 2000 or 2001</b> <b>Electives</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Organic Chemistry 6.0 credit hours 6.0 credit hours <sup>a</sup>
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>SUST Selective</b> <b>SUST Selective 3XXX/4XXX</b> <b>Electives</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 6.0 credit hours, cannot be BIOC XXXX 6.0 credit hours, cannot be BIOC 3XXX/4XXX 9.0 credit hours <sup>a</sup>
<b>IV</b>	<b>BIOC 4604 &amp; 4605</b> <b>BIOC 4XXX</b> <b>BIOC or SUST selective</b> <b>SUST Selective 3XXX/4XXX</b> <b>Electives</b>	Research Project I & II. Includes an oral defense of the research project. 6.0 credit hours from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 3.0 credit hours 6.0 credit hours, cannot be BIOC 3XXX/4XXX 9.0 credit hours <sup>a</sup>

- <sup>a</sup> We recommend students take CHEM 2201 as an elective in year two to optionally switch to a concentrated honours or Major Biochemistry degree at the end of year two.
- ESS students meet the BSc writing component on completion of SUST 1000.06. Either SUST 1000.06 or SUST 1001.06 satisfies the BSc social science component. 6.0 credit hours in language/humanities must be completed for BSc graduation requirements.
- SUST Selectives are chosen from list of courses approved by College of Sustainability. See Calendar or <http://www.dal.ca/faculty/sustainability/programs/ess/approved-electives.html>
- CHEM 3601 is a prerequisite for some BIOC 47XX courses.
- MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03
- CHEM 3601 will be considered equivalent to BIOC 3XXX.03
- PHYC 1300 is recommended for all Biochemistry degree programs and could be included in year three.

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

**Table 15. COMBINED HONOURS DEGREE IN BIOCHEM AND ARTS<sup>a</sup>**

<b>Year</b>	<b>Courses</b>	<b>Description</b>
<b>I</b>	<b>CHEM 1011 &amp; 1012</b> <b>BIOL 1010 &amp; 1011</b> <b>MATH</b> <b>ARTS 1000<sup>b</sup></b>	Concepts in Chemistry (or equivalent) Principles of Biology (or BIOL 1020 and 1021) 6.0 credit hours (MATH 1000 or 1215 and MATH 1010 or 1060) 12.0 credit hours
<b>II</b>	<b>BIOC 2300</b> <b>BIOC 2610</b> <b>BIOL 2020</b> <b>BIOL 2030</b> <b>CHEM 2401 &amp; 2402</b> <b>ARTS 2XXX</b>	Introduction to Biochemistry Introductory Biochemistry Lab Cell Biology Genetics and Molecular Biology Introductory Organic Chemistry 12.0 credit hours
<b>III</b>	<b>BIOC 3300</b> <b>BIOC 3400</b> <b>BIOC 3700</b> <b>ARTS 3XXX</b> <b>Social Science Elective</b> <b>Elective</b>	Intermediary Metabolism Nucleic Acid Biochemistry & Molecular Biology Biomolecular Chemistry 9.0 credit hours 6.0 credit hours social science (see Calendar) 6.0 credit hours
<b>IV</b>	<b>BIOC 4604 &amp; 4605</b> <b>BIOC 4XXX</b> <b>ARTS 4XXX</b> <b>Elective</b>	Research Project I & II. Includes an oral defense of the research project. 6.0 credit hours from BIOC 40XX, 43XX, 44XX, 45XX, and 47XX 6.0 credit hours 12.0 credit hours

<sup>a</sup> ARTS designates any subject granting major and double major degrees. Consult the ARTS department for specific advanced level (2XXX and above) courses you need to consider. The advanced credit hours in ARTS in this table somewhat mirror the increasing complexity of BIOC courses required at each level based on year of study.

<sup>b</sup> The writing requirement (Degree Requirements I.B) will likely be met in one of the Arts Major first year courses. All BSc students must complete 6.0 credit hours in language/humanities and 6.0 credit hours in social science. CHEM 3601 is a prerequisite for some BIOC 47XX courses. MICI 4033 and PHAC 4403 will each be considered equivalent to BIOC 4XXX.03. CHEM 3601 will be considered equivalent to BIOC 3XXX.03. Students are strongly recommended to take PHYC 1300 prior to finishing their degree.

BIOC 3620 may be taken in year three or four. Students can take one experiential learning course in a BSc program.

Double major and combined honours degrees students will complete a maximum of 48.0 credit hours in the first subject and a minimum of 30.0 in the second. The total number of advanced-level credit hours in the two major subjects is 60.0 - 84.0.

#### ***4. Multidisciplinary Honours Programs***

Occasionally a student wants to follow a course of study that cannot fit into either a concentrated or a combined honours framework. This student can apply for admission to a multidisciplinary honours program, which includes **72.0** advanced credit hours in **three** or more subject areas, for details see the Undergraduate Calendar (Degree Requirements). For instance a student in such a program may choose 30.0 credit hours in Biochemistry, 24.0 in Chemistry, and 18.0 (including the Honours Research Project) in Psychology. The actual research for the project may be carried out in the Pharmacology department, and the Honours Qualifying Component can be obtained in Psychology.

Graduates from a multidisciplinary honours program almost always have to do extra course work if they wish to pursue graduate studies in any one of their three honours subjects. On the other hand, a suitable multidisciplinary honours degree can be an excellent preparation for graduate work in departments that do not have an undergraduate degree program. At Dalhousie, both physiology and pharmacology are in this category.

## Medical Biotechnology

For students who are interested in Medical Biotechnology as a career, the following courses are suggested either to fulfill program requirements or as electives.

BIOC	4010	Bioinformatics
BIOC	4403	Genes and Genomes
BIOC	4404	Gene Expression
BIOC	4501	Medical Biotechnology I
BIOC	4700	Proteins
BIOC	4701	Enzymes
BIOC	4813	Biochemistry of Clinical Disorders
BIOC	4835	Human Genetics
MICI	2115	Human Organs and Tissues
MICI	3024	Microscopy
MICI	3119	Physiology of the Prokaryotic Cell
MICI	4027	Molecular Mechanisms of Cancer
MICI	4118	Molecular Bacterial Pathogenesis
MICI	4302	Molecular Immunology (requires MICI 3115)
BIOL	3102	Microbial Eukaryotes: Biodiversity and evolution
BIOL	3036	Transgenic Organisms
BIOL	4020	Advanced Cell Biology
PHAC	4403	Systems Pharmacology I
PHYL	2030.06	Human Physiology
PHYL	4322	Core Concepts in Medical Physiology (requires PHYL 2030)
STAT	1060	Introductory Statistics for Science and Health Sciences
STAT	2060	Introduction to Probability and Statistics I

### Other Useful Electives

BIOL	2060	Introductory Ecology
BIOL	3060	Environmental Ecology (requires BIOL 2060)
CSCI	1204	Computer Techniques for Health and Life Sciences
CHEM	3203	Advanced Analytical Laboratory
PHIL	2480	Environmental Ethics
PHIL	2485	Technology and the Environment
PHIL	2805	Ethics and Health Care: Patient Care
PHIL	2810	Ethics and Health Care: Social Policy

## Certificate in Genetics

This certificate provides students with an opportunity to take, within Honours or Major BA or BSc degree program, a set of courses and a research project that will accord them recognition of specialization in genetics. Enroll in the Certificate in Genetics program in your third year of study when seeking approval of the research component by the Genetics Certificate Coordinator for their department. Completion of the certificate will be shown on a student's transcript.

It is the responsibility of students in the Certificate in Genetics to complete the required courses, and to provide the departmental certificate coordinator with confirmation that the necessary courses have been taken by the end of the examination period in their final year of study. The certificate will only be awarded to students upon graduation from their undergraduate degree program.

Genetics Certificate requirements:

1. A minimum grade of a B- is required in four mandatory courses:
  - BIOL 2020: Cell Biology
  - BIOL 2030: Genetics and Molecular Biology
  - BIOC 2300: Introduction to Biochemistry
  - BIOC 3400: Nucleic Acid Biochemistry and Molecular Biology
2. A minimum grade of B- in 12 credit hours of elective courses chosen from the following list (at least 6 credit hours must be at the 4000 level):
  - 2000 level
    - BIOL 2040: Evolution
  - 3000 level
    - BIOL 3036: Transgenic Organisms
    - BIOL/MARI 3042: Molecular Ecology
    - BIOL 3044: Ecological Genetics
    - BIOL 3046: Molecular Evolution
    - BIOL 3102: Microbial Eukaryotes: Biodiversity and Evolution
    - MICI 3114: Virology
    - MICI 3119: Physiology of the Prokaryotic Cell
    - NESC 3670/PSYO 3670: Genes, Brain and Behaviour
  - 4000 level
    - BIOC 4010: Bioinformatics
    - BIOC/MICI 4027.03: Molecular Mechanisms of Cancer
    - BIOC 4403: Genes and Genomes
    - BIOC 4404: Gene Expression
    - BIOC 4501: Medical Biotechnology
    - BIOC 4835/BIOL 4035: Human Genetics
    - MICI 4114: Advanced Topics in Molecular and Medical Virology
    - MICI 4033: Advanced Microbial Genetics
3. Other required courses (either of these are prerequisites for BIOC 3400)
  - CHEM 2441 or CHEM 2401 & 2402
4. A minimum grade of B- in 3.0 credit hours or more of independent research on a topic involving molecular genetics, transmission genetics or population genetics. Options are:
 

BIOL 4001	BIOL/MARI 4901 & 4902 (formerly 4900.06)
BIOL 4604 & 4605	MICI 4701 & 4702 (formerly 4700.06)
BIOL/MARI 4806	MICI 4901 & 4902 (formerly 4900.06)
BIOL/MARI 4807	NESC/PSYO 4501 & 4502 (formerly 4500.06)
BIOL/MARI 4809	SCIE 4101 & 4102 (formerly 4100.06)
BIOL/MARI 4811	SCIE 4901 & 4902 (formerly 4900.06)

The research topic must be pre-approved by the department's Certificate Coordinator.

## Minor In Bioinformatics

Much of the current research in the biological sciences today requires the handling of “Big Data”. Nowhere is this need more apparent than in the area of genomics, where next generation sequencing techniques are capable of producing, at a relatively low cost, hundreds of gigabytes and even terabytes of DNA sequence data. There is increasing need for people who have an understanding of molecular and evolutionary genomics (the structure and function of genes and genomes) and the skill set needed to analyze the data. A **Minor in Bioinformatics** provides students with an introduction to molecular genomics and to some of the informatics tools currently available.

### PATH for Biochemistry & Molecular Biology students

**Coordinator:** Dr. Claudio Slamovits (claudio.slamovits@dal.ca)

**Students must take all required courses and enough selective courses to total 18 credit hours.** Courses (required or selective) cannot be used toward the Minor if the course is being counted toward a Major or Honours degree.

### Required prerequisite courses (don't count toward minor)

- **CSCI 1105.03** Introduction to computer programming (or **CSCI 2202.03** Computer Modelling for Scientists)
- **CSCI 1110.03\*** Introduction to Computer Science
  - \*Students with prior programming experience may register in **CSCI 1110.03** without taking **CSCI 1105.03** or **2202.03**
- **BIOL 1010.03** Principles of Biology Part I or **BIOL 1020.03** Introductory Biology I
- **MATH 1000.03** Differential and Integral Calculus I or **MATH 1215.03** Life Sciences Calculus

### Required course

- **STAT/MATH 2060.03** Introduction to Probability and Statistics

### Selectives

- **STAT/MATH 2080.03** Statistical Methods for Data Analysis and Inference
- **CSCI 2110.03** Data structures and algorithms **OR CSCI 2141:** Introduction to Databases (**Highly recommended**)
- **CSCI 4180.03** Intro to Computational Biology and Bioinformatics
- **CSCI 4181.03** Bioinformatics Algorithms
- **BIOL 3046.03** Molecular Evolution
- **\*BIOC 4010.03** Bioinformatics (offered on odd-numbered years only)
- **\*BIOC 4403.03** Genes and Genomes (**Highly recommended**)

\* Cannot be used toward the Minor if the course is being counted toward a Major or Honours degree

## **Faculty Advisors**

This booklet has been prepared to help you make up your mind about doing a degree in Biochemistry at Dalhousie. Talking can often be a useful addition to reading, so feel free to come and see any of the Faculty Advisors listed below. It is best to contact the Department Office first to determine which advisors are available (particularly in the summer when advisors are available on a rotation schedule).

**For this and other information contact the Biochemistry Office,  
Tupper 9-B1, Telephone (902) 494-6436, FAX (902) 494-1355**

**or post a request:**

**<https://medicine.dal.ca/departments/department-sites/biochemistry-molecular-biology/about/contact-form.html>**

**More information here:**

**<https://medicine.dal.ca/departments/department-sites/biochemistry-molecular-biology/programs/undergraduate.html>**

**List of advisors:**

**Dr. C. K. L. Too, Tupper 9D-1  
Chair of Undergraduate Committee**

**B. Bigelow, Tupper 9B-1**

**Dr. V. Ewart, Tupper 9S-1**

**D. Langelaan, Tupper 8F-1**

**J. Rainey, Tupper 10N-1**

**D. C. Slamovits, Tupper 8B-2**

**Dr. S. Xiong, Tupper 8J-2**