Carleton University
Faculty of Science | Department of Chemistry
CHEM 4207A, BIOC 4207A and CHEM 5010A
Bio-Organic Chemistry
Fall 2025
Syllabus

I. General Information

1. Instructor: David Sabatino, Ph.D.
Office: Steacie Building, Room 207F
Lab: Steacie Building, Room 329
e-mail: david.sabatino@carleton.ca
phone: 613-520-2600 ext. 4229
Office Hours: T, R: 10:00 AM – 11:30 AM, and by appointment

II. Course Meetings:

- Tuesdays and Thursdays 8:35 am – 9:55 am, in-person location: Please check Carleton Central for class location

III. Course Objectives/Credits and Requisites:

- The course covers chemical and biosynthetic methods applied to the major classes of biomolecules and their derivatives, including: carbohydrates, amino acids, peptides, proteins, nucleic acids, lipids, terpenes, heterocycles and natural products. Content will focus on reactions and mechanisms that contribute to their biological activities.
- Pre-requisites: CHEM 3201 or permission of the department
- 0.5 credit lecture only
- Also offered at the graduate level, with different requirements, as CHEM 5010, for which additional credit is precluded.

IV. Course Materials: Students are not required to purchase textbooks or other learning materials for this course. The following resources are suggestions for learning materials related to the course content.

1. John McMurry and Tadhg Begley, The Organic Chemistry of Biological Pathways, 2nd edition, 2016, Roberts and Company Publishers, ISBN-10: 193622156X | ISBN-13: 978-1936221561

2. John McMurry, Organic Chemistry with Biological Applications, 3rd edition, 2015, Cengage Learning, ISBN-10: 128584291X | ISBN-13: 9781285842912

3. Selected journal articles including but not limited to the Journal of Organic Chemistry, Accounts of Chemical Research, Journal of Medicinal Chemistry, Journal of Natural Products, Organic and Biomolecular Chemistry, ChemComm, Organic Letters and

Bioconjugate Chemistry. Selected journal articles are accessible via our University library on-line electronic journals and periodicals (MacOdrum Library | Carleton University).

4. Additional literature information may be found at (www.pubs.acs.org) and search engines such as Scifinder, PubMed Online, Science Direct, Web of Science and Google Scholar.

V. Approach to study

1. Attend lectures, take class notes and ask questions. Review lectures notes before the next class. Keep pace with the lecture material on a weekly basis—avoid falling behind!

2. Do assigned problem set. Review answers and ensure responses are well understood.

3. If additional explanation is required, ask in class, during office hours or email questions.

4. Review and study your lecture notes and assigned problems prior to exams.

VI. Course Learning Outcomes

1. Develop a fundamental, molecular understanding of the structure-function relationships that govern the biological activities of biomolecules

2. Gain a deep understanding of the chemical reactions and mechanisms that drive the synthesis, functionalization and degradation/breakdown of biomolecules found in nature

3. Compare and contrast chemical synthesis *vs* biosynthesis methods of biomacromolecules

4. Survey the importance of biomolecules in medicinal chemistry, chemical biology and biotechnology applications

VII. Grading:

1. **Assignments (20%), Tuesday October 28 and Tuesday December 2nd, 2025**

   Description: there will be two (2) homework assignments, one prior to the mid-term and another before the final exam. Each will be worth 10% for a total of 20% of the final grade. The assignments will contain problem solving questions like those on the exams.

2. **Group Presentation (25%), Thursday December 4th, 2025**

   Description: Students will be assembled into small groups (3-4 students) and will select a presentation topic in bio-organic chemistry based on a recent research communication or letter (2-5p article) approved by the course instructor. Students will be required to formulate a short 15 min PowerPoint presentation followed by a brief 5 min question/answer period.

3. **Mid-term exam (25%), Tuesday November 4th, 2025**

   Description: in-class mid-term exam will cover lecture topics on Carbohydrates, Nucleic Acids, Amino Acids, Peptides and Proteins

4. **Final exam (25 %), December 8th-20th, location: TBD**

   Description: final exam will cover lecture topics on Lipids, Terpenes, and Heterocycles

5. **In class participation (5%)**

VIII. Class Schedule *(tentative)*

Week 1: ***September 4th***

Topics: ***Welcome to Bio-Organic Chemistry***

- Course introduction
- Syllabus review

Week 2: ***September 9th and 11th***

Topics: ***Introduction to Bio-Organic Chemistry***

- Organic Chemistry of Biomolecules
- Molecular Structure and Stereochemistry of Biomolecules
- Reactions and Mechanisms in Biological Chemistry

Week 3: ***September 16th and 18th***

Topics: ***Carbohydrates***

- Classifications, Structure and Stereochemistry
- Monosaccharides, Oligosaccharide and Polysaccharides: acetal chemistry and the formation of glycosidic bonds
- Solid-phase oligosaccharide synthesis
- Biosynthesis of oligosaccharides
- Carbohydrate derivatives and bio-conjugation: applications in glycobiology

Week 4: ***September 23rd and 25th***

Topics: ***Nucleic Acids***

- Structure and chemical properties of nucleic acids
- Vorbruggen *N*-glycosylation: preparation of nucleosides and analogs
- Synthesis of biologically active nucleosides and nucleotide derivatives
- Template synthesis: enzymatic *vs* chemical ligation and polymerization methods
- Solid-phase synthesis of (modified) oligonucleotides
- Oligonucleotide bioconjugation: application to therapeutic oligonucleotides
- Semi-synthesis and biosynthesis (epigenetic modifications) of nucleic acids

Week 5: ***September 30th and October 2nd***

Topics: ***Amino Acids***

- Structure, Stereochemistry and Acid-Base Properties
- Classical chemical synthesis of Amino Acids (*eg*. Gabriel, Strecker, Reductive Amination reactions)
- Modern synthetic methods: Asymmetric synthesis (solution *vs* solid-phase)
- *C* and *N*-terminal modifications: an introduction into protecting group chemistry
- Un-natural amino acid synthesis: amino acid mimicry
- Amino acid catalysis (chiral auxiliaries and organocatalysts)

Week 6: ***October 7th and 9th***

Topics: ***Peptides***

- Structure, Stereochemistry and Biology
- Protecting groups and coupling reagents in peptide synthesis
- Solution *vs* Solid-Phase Peptide Synthesis (Boc *vs* Fmoc Approach)
- Synthesis of peptidomimetics and bioconjugation of therapeutic peptides
- Peptide catalysis

Week 7: ***October 14th and October 16th***

Topics: ***Proteins***

- Protein Structure-Function Properties
- Total Chemical Synthesis of Proteins: Native Chemical Ligations, Staudinger Ligation, Oxime/Hydrazide Ligations, Click Chemistry Ligations
- Bio-orthogonal Synthesis of Protein Derivatives
- Protein Bioconjugation, Ligation and Labelling Strategies
- Application to Un-natural Protein Synthesis
- Protein Semi-Synthesis and Biosynthesis Methods

Post assignment 1.

Week 8: ***October 21st and 23rd***

No Lectures: Fall Break!

Week 9: ***October 28th and 30th***

Assignment 1 due

- Assignment Review
- Mid-Term Exam Tutorial

Week 10: ***Tuesday November 4, 2025***

- ***Tentative date for in-class mid-term exam***

Mid-term will cover topics from weeks 3-7 (inclusive) on Carbohydrates, Nucleic Acids, Amino Acids, Peptides and Proteins

November 6th: In-class mid-term exam review

Week 11: ***November 11th and 13th***

Topics: ***Lipids***

- Types of lipids
- Triacylglycerols, phospholipids and steroid chemical synthesis
- Waxes and Oils-conversion of carboxylic acids to esters and ester hydrolysis
- Lipid bioconjugation
- Asymmetric synthesis of bio-active lipids
- Chemoenzymatic synthesis of lipids
- Cationic lipids
- Steroid (bio)synthesis

Week 12: ***November 18th and 20th***

Topics: ***Terpenes***

- Types of terpenes and terpenoids
- Prostaglandins and Eicosanoids
- Chemical Synthesis (*eg.* Citral, Dipentene, Geraniol, α-Terpineol, α-Pinene, Menthol, Camphor)
- Selective functionalization
- Asymmetric synthesis and applications in catalysis (*eg*., chiral auxiliaries and organocatalysts)
- Applications in natural product synthesis

Week 13: ***November 25th and 27th***

Topics: ***Heterocycles***

- Structures, Classification and Acid-Base properties
- Purine and Pyrimidine chemical synthesis-application to nucleic acids
- Alkaloid synthesis: pyrroles, pyridines, imidazoles, lactams and indoles
- Furans and Thiophenes and the multi-functional heterocycles
- Chemical Synthesis of Heterobicycles: quinolines and benzodiazepines

Post assignment 2.

Week 14: ***December 2nd***

Assignment 2 due

- Assignment 2 review.
- Final Exam Tutorial

December 4th

Group presentations

Final Exam Period: ***December 8th – 20th***

Tentative dates for final exam

Location: TBD

Final exam will cover topics from weeks 11-13 (inclusive) on Lipids, Terpenes, and Heterocycles

VIII. Course Policies

Attendance:
All lectures will begin promptly at the scheduled time. Do not be late or you may not be admitted to that class period.

1. Absences:
   In-class lectures will provide the necessary information for successful performance on assignments and exams. Students are responsible for getting the lecture notes from their classmates and review the lecture materials in the event of an absence.
2. Makeups and Lateness:
   Are only permissible with the approval from the instructor. If approved, the student will have one additional week to complete the task. A grade of 0 will be administered if the student does not complete the make-up task within the allotted time period.

Instructor Responsibilities:

Instructor will be responsible for giving the lectures in an organized and clear manner. The instructor will also be responsible for addressing student questions during and after the lectures, including tutorials and office hours. The instructor will also prepare the course assignments and examinations. Teaching assistants (if applicable) will aid in the administration, proctoring and evaluation of assignments and exams. If anything is unclear or misunderstood, ask your instructor that is here to help! Instructor questions may be asked during lectures or email questions that will be later addressed. Participate in office hours and tutorial sessions held by the instructor. Schedule appointments by email if scheduling conflicts with office hours and tutorial sessions.

Student Responsibilities:

Students will be responsible for attending the in-class lectures, taking notes and asking questions. Students also have the responsibility for obtaining lecture notes from classmates for any missed lectures, which should be reviewed before the next class. Keep pace with the lecture content on a weekly basis. Students have the responsibility for completing the assignments by the due dates and reviewing the answers to ensure they are well understood. Carefully review and study the lecture

notes on a weekly basis and prior to exams. Students have the responsibility for attending and completing the exams on their scheduled dates. Students will also be responsible for participating in and contributing equally to the group presentations. For additional explanation ask questions in class, attend office hours or email questions.

Student Concerns:

If a concern arises regarding this course, **your first point of contact is me**: Email or drop in during office hours and I will do my best to address your concern. If I am unable to address your concern, the next points of contact are (in this order):

Note: You can also bring your concerns to Ombuds services.

For additional help, contact science student services:

Science Student Success Centre
3431 Herzberg Laboratories
1125 Colonel By Drive,
Ottawa, ON K1S 5B6

https://sssc.carleton.ca/
Phone: (613) 520-2600 Ext. 3111

IX. Academic Accommodations:

It is the policy and practice of Carleton University to promote equity, diversity and inclusion (EDI) in its learning environments. Carleton is committed to providing academic accessibility for all individuals. You may need special arrangements to meet your academic obligations during the term. The accommodation request processes are outlined on the Academic Accommodations website (https://students.carleton.ca/course-outline/).

If you have a documented disability, you may be eligible for reasonable accommodations in compliance with University policy. Please note, students are not permitted to negotiate accommodations directly with professors. To request accommodations or assistance, please self-identify with the Paul Menton Centre (PMC) for Students with Disabilities at the beginning of the semester.

For more information or to register for services, contact PMC at:
Paul Menton Centre
501 University Centre
1125 Colonel By Drive,
Ottawa, ON K1S 5B6
Email: pmc@carleton.ca
Phone: 613-520-6608

PMC will help make special arrangements to meet your academic obligations during the term. For more details, visit the Equity Services website:
carleton.ca/equity/wpcontent/uploads/Student-Guide-to-Academic-Accommodation.pdf
For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: **carleton.ca/sexual-violence-support**

X. Information Technology Service Desk:

The first point of contact for any technology-related question or problem is Carleton University's Information Technology Service (ITS) Desk. Contact ITS by phone by calling 613-520-3700 or via e-mail at its.service.desk@carleton.ca

ITS is staffed by professionals Monday through Friday from 8 a.m. through 4:30 p.m. ITS provides phone support for most University applications, including Carleton Central, Brightspace Learning Management System, Carleton 360, Microsoft Windows, and the Microsoft Office suite.

For more tips and technical information, go to carleton.ca/its/chat

Statement on Chat GPT/Generative AI usage (See the *Sample Syllabus Statements for AI use in Courses* document for examples)

As our understanding of the uses of AI and its relationship to student work and academic integrity continue to evolve, students are required to discuss their use of AI in any circumstance not described here with the course instructor to ensure it supports the learning goals for the course.

XI. Academic and Professional Integrity Policy:

Students are expected to follow the Academic and Professional Integrity Policy outlined in the Student Guide: Carleton University's Academic Integrity Policy. The specific Academic and Professional Integrity Policy of Carleton University includes:

1. Dependability: candidates are reliable, timely, and consistent in their presence and preparation for courses at the university as well as their field settings.
2. Respect & Empathy: candidates are respectful in their address, writing, language, and physical space toward faculty, university staff, school personnel, peers, students in field.
3. Open-mindedness: candidates respect the context and experience of others; developing skills to use that information in classroom conversation, writing, and lesson planning.
4. Integrity: candidates submit original work, fully cite all sources associated with the development of their work (including information from the internet) and recognize that the university fully supports the use of anti-plagiarism software in support of academic integrity. (Original student work is expected. Any work containing plagiarized material will result in an automatic "0" for the assignment.)
5. Passion for the profession: the right for all students to have access to positive and productive learning environments, and a recognition that the teacher's dedication is to provide a thriving learning environment for all students.

Additional details about this process can be found on the Faculty of Science Academic Integrity website.

XII. Academic Honesty:

Lying, cheating and stealing are not tolerated in civilized society and in scientific work. While you will be encouraged to collaborate, you must follow directions regarding preparing your work independently.

1. Relevant examples of lying include but are not limited to signing in someone else's name on assignments and exams, falsifying documentation or statements to receive an excused absence and claiming to have completed an assignment that you did not complete.

2. Relevant examples of cheating include but are not limited to copying another student's assignment and purporting it as your own or collaborating with another student on an assignment or exam for which collaborating is prohibited.

3. Relevant examples of stealing include plagiarism (purporting another's work no matter the source as your own), removing any items from the classroom that you did not yourself bring in, taking materials from another student's work area without permission. Suspected academic dishonesty will be dealt with summarily and harshly.

4. Accessing unauthorized sites for assignments or tests, unauthorized collaboration on assignments or exams, and using artificial intelligence tools such as ChatGPT when your assessment instructions say it is not permitted.