

**Carleton University**  
**Faculty of Science | Department of Chemistry**  
**CHEM 4207A and 5010A**  
**Bio-Organic Chemistry**  
**Fall 2023**  
**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: 8:30-10 AM, and by appointment

**II. Course Meetings:**

- Tuesdays and Thursdays 10:05 am – 11:25 am, location: Richcraft Hall (RH) 3201

**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 and CHEM 3202, or permission of the department
- 0.5 credit lecture only

**IV. Course Materials:**

**Recommended (Not Required)**

1. John McMurry and Tadhg Begley, *The Organic Chemistry of Biological Pathways*, 2<sup>nd</sup> edition, 2016, Roberts and Company Publishers, ISBN-10: 193622156X | ISBN-13: 978-1936221561
2. John McMurry, *Organic Chemistry with Biological Applications*, 3<sup>rd</sup> 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](http://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, 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 and chemical biology

## VII. Grading:


### 1. Assignments (20%), Tuesday October 17 and Tuesday November 28, 2023

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%) and will contain problem solving questions similar to those on exams.

### 2. Group Presentation (25%), Tuesday December 5<sup>th</sup> and Thursday December 7<sup>th</sup>, 2023

Description: Students will be assembled into small groups (2-3 students) and will select a presentation topic in bio-organic chemistry based on a recent research communication (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 October 31, 2023 in RH 3201 (Happy Halloween)

Description: exam will cover lecture topics on Carbohydrates, Nucleic Acids,  Amino Acids, Peptides and Proteins

### 4. Final exam (25 %), December 10<sup>th</sup>-22<sup>nd</sup>, location: TBD

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

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

## VIII. Class Schedule (*tentative*)

### Week 1: September 7<sup>th</sup>

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

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

### Week 2: September 12<sup>th</sup> and 14<sup>th</sup>

#### *Topics: Carbohydrates*

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

### Week 3: September 19<sup>th</sup> and 21<sup>st</sup>

#### *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
- Solid-phase synthesis of (modified) oligonucleotides
- Template enzymatic synthesis
- Semi-synthesis and ligation methods

### Week 4: September 26<sup>th</sup> and 28<sup>th</sup>

#### *Topics: Amino Acids*

- Structure, Stereochemistry and Acid-Base Properties
- Classical synthesis of Amino Acids (*eg.* Gabriel, Strecker, Aldehyde condensations and Molecular rearrangements)
- Modern synthetic methods: Asymmetric synthesis (solution *vs* solid-phase)
- *C* and *N*-terminal modifications
- Un-natural amino acid synthesis (chiral auxiliaries and biocatalysts)

### Week 4: October 3<sup>rd</sup> and 5<sup>th</sup>

#### *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 peptide bio-conjugates

- Ligation strategies (chemical vs biological synthesis)

**Week 5: October 10<sup>th</sup> and 12<sup>th</sup>**

*Topics: Proteins*

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

**Post assignment 1.**

**Week 6: October 17<sup>th</sup> and 19<sup>th</sup>**

**Assignment 1 due**

- Assignment Review
- Mid-Term Tutorial Session

**Week 7: October 24<sup>th</sup> and 26<sup>th</sup>**

**No Lectures: Fall Break!**

**Week 8: Tuesday October 31<sup>st</sup>**

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

Mid-term will cover topics from weeks 2-5 (inclusive) on Carbohydrates, Nucleic Acids, Amino Acids, Peptides and Proteins

**November 2<sup>nd</sup>: In-class mid-term exam review**

**Week 9: November 7<sup>th</sup> and 9<sup>th</sup>**

*Topics: Lipids*

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

**Week 10: November 14<sup>th</sup> and 16<sup>nd</sup>**

*Topics: Terpenes*

- Types of terpenoids
- Prostaglandins and Eicosanoids
- Chemical Synthesis (eg. Citral, Dipentene, Geraniol,  $\alpha$ -Terpineol,  $\alpha$ -Pinene, Menthol, Camphor)
- Selective functionalization
- Asymmetric catalysis
- Applications in natural product synthesis

**Week 11: November 21<sup>st</sup> and 23<sup>rd</sup>**

*Topics: Heterocycles*

- 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 12: November 28<sup>th</sup> and 30<sup>th</sup>**

**Assignment 2 due**

- Assignment 2 review.
- Final Exam Review

**Week 13: December 5<sup>th</sup> and 7<sup>th</sup>**

**Group presentations**

**Week 15-16: December 10<sup>th</sup> – 22<sup>nd</sup>**

**Tentative dates for final exam**

**Location: TBD**

Final exam will cover topics from weeks 9-11 (inclusive) on Lipids, Terpenes, and Heterocycles

#### **VIV. Course Policies**

##### **Attendance:**

All lectures will begin promptly at the scheduled time. Do not be late or you may not be admitted to that 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 mis-understood, ask your instructor, he is here to help! Instructor questions may be asked directly during lecture or email questions that will be later addressed. Participate in office hours and tutorial sessions held by instructor. Email questions or schedule appointments if scheduling conflicts with office hours and tutorial sessions.

**Student Responsibilities:**

Students will be responsible to attend lecture, take notes and ask questions. Students also have the responsibility of obtaining lecture notes from classmates, for any missed lectures, which should be reviewed before the next class. Keep pace with the lecture material on a weekly basis. Students also have the responsibility of completing the assigned problem set, review answers and ensure responses are well understood. Carefully review and study lecture notes and assigned problems on a weekly basis and prior to exams. If additional explanation is required, ask questions in class, attend office hours or email questions. 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

**X. 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.

## **XI. 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](mailto: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](http://carleton.ca/its/chat)

## **XII. Academic Accommodations:**

It is the policy and practice of Carleton University to promote equity, diversity and inclusion (EDI) in its learning environments. 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:

Email: [pmc@carleton.ca](mailto:pmc@carleton.ca)

Phone: [613-520-6608](tel:613-520-6608)

Fax: [613-520-6608](tel:613-520-6608)

Paul Menton Centre  
501 University Centre  
1125 Colonel By Drive,  
Ottawa, ON K1S 5B6

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](http://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](http://carleton.ca/sexual-violence-support)

### **XIII. Academic and Professional Integrity Policy:**

Students are expected to follow the Academic and Professional Integrity Policy outlined in the Student Guide. 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.