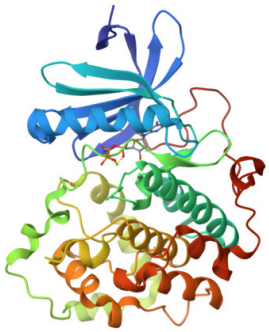
DALHOUSIE UNIVERSITY
FACULTY OF MEDICINE

Department of Biochemistry & Molecular Biology

BIOC 2300 - Introduction to Biochemistry
Winter 2024

Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present.



A kinase in the Hippo pathway

Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

We are all Treaty people.

Instructional Team Information:

Instructor/Facilitator:	Contact:	Office:
Dr. David Langelaan	dlangela@dal.ca	Tupper 8-F1
Dr. Shawn Xiong (primary)	shawn.xiong@dal.ca	Tupper 8-J03
Dina Rogers	BIOC2300@dal.ca	Tupper 8-J01
Nik Brask	BIOC2300@dal.ca	Tupper 8-J01

Meeting Information:

Time:	M/W/F 10:35 AM – 11:25 AM
Location:	Rowe Management Building 1028
Format:	• Jan. 10th – Feb. 14th by Dr. Langelaan: Semi-Flipped • Feb. 16th – Apr. 3rd by Dr. Xiong: in-person Flipped

Course Description:

BIOC 2300 (CREDIT HOURS: 3). This course surveys basic topics and concepts of Biochemistry. The structures, properties and metabolic inter-relations of proteins, carbohydrates and lipids are considered together with an introduction to nutrition and metabolic control. Although mammalian examples predominate, some consideration of special aspects of biochemistry of microbes and plants is included.

Course Prerequisites:

BIOL 1010.03 (or equivalent), CHEM 1011.03 and 1012.03 (or equivalent), all with grades of C or higher, or instructor's consent. Students are advised to also take CHEM 2401.03 and CHEM 2402.03.

EXCLUSIONS: BIOC 2200.03

Prior Knowledge from CHEM 1011/1012 & BIOL 1010:

The following tables highlight the prior knowledge you will need to ease into BIOC 2300. Please use the information provided here as a guide for review and catch-up. It's often abstract to simply look at these terms; and it's much more helpful to see these concepts in questions. As a result, we have constructed prior knowledge inventory in the form an ungraded readiness test, see below for detail.

CHEM 1011:	**CHEM 1012:**
Determining limiting reagents	Equilibrium and reaction quotient
Solution concentration: molarity	Equilibrium constant
Dilution	Relationship between the Equilibrium Constant and Gibbs Energy
Electron affinity	Apply Le Chatelier's Principle to predict the effect of perturbing an equilibrium
Electronegativity	Relate the Reaction Quotient to the Equilibrium Constant
Electrostaic interaction and ionic bonding	Calculate Gibbs Energy under standard and nonstandard conditions
Resonance	Enthalpy
Covalent bonding	Entropy
Non-covalent interactions	Gibbs free energy
Electronegativity and bond polarity	Assigning oxidation number
Molecular polarity and dipole moment	Identifiy oxidation and reduction processes
Column chromatography	Reduction potential and its relationship to Gibbs free energy
Delocalized electron model	Functional groups
Acid and base chemistry (strong vs weak)	Identify chiral centers
Ka and pKa	UV/Vis spectroscopy
pH	NMR
Buffer and buffer capacity	Beer's law
Henderson-Hasselbalch equation	Catalyst and its effect on activation energy and reaction rate

BIOL 1010:
Describe the process by which carbohydrates, lipids and proteins are assembled from monomers and identify their functional roles in the eukaryotic cell.
Describe the structure and function of the organelles found in eukaryotic cells, demonstrating an appreciation for the overall architecture of the cell.
Identify the components of biological membranes, including the various types of membrane proteins.
Explain the fluid mosaic model and describe how membranes exhibit selective permeability.
Describe the role of ATP as the energy currency in the cell and appreciate its importance for driving cellular work.
List the key products and features of glycolysis, the citric acid cycle, and oxidative phosphorylation and understand the flow of energy through the entire process.
Identify the mechanism by which a signal is transmitted into the cell via G protein Coupled Receptors and Tyrosine Kinase Receptors.
List several examples of second messengers and describe how each is involved in signal transduction pathways.
Describe the basic chemical structure of deoxyribonucleic acid (DNA) and how it differs from ribonucleic acid (RNA); what role does each molecule play in the transfer of information from genotype (DNA) to phenotype (protein) and the deciphering of the genetic code.
Describe the basic principles of DNA technology/Biotechnology, its applications and the ethical and societal implications of this technological revolution.
Describe the most basic similarities and differences between Bacteria, Archaea and Eukaryotes.
Describe the phenomenon of (primary) endosymbiosis and its role in the origins of mitochondria and plastids

Biochemistry Readiness Test: To help you review and assess your prior knowledge, we highly encourage you to practice the Biochemistry Readiness Test on *Brightspace*. Please note, this test is not for credit, but rather for you to learn by diagnosing your conceptual weakness and thus providing a means for you to catch up and become better prepared for the upcoming course content. Answer key will be available in the Biochemistry Resources Center.

***How to Learn and Ace Biochemistry* Sessions:**
Biochemistry is an interdisciplinary subject that emphasizes using chemistry to shed light on biology. Because of the interdisciplinarity and the expectation of applying and transferring knowledge, many students have found the course challenging. To help you quickly adjust to the course/discipline expectation, acquire necessary learning strategies in biochemistry, and promote better metacognition, we will provide three drop-in sessions on *How to Learn and Ace Biochemistry:*

- The time and locations will be announced in class and on Brightspace on a rolling basis.

Course Objectives / Learning Outcomes:

Welcome to *Introduction to Biochemistry*, where you will begin to learn how life works at the molecular level. Biochemistry is at the nexus of the physical, natural and medical sciences, yet has developed its own language and culture that are distinct from those disciplines. The knowledge and tools of biochemistry (along with the closely related discipline of molecular biology) will continue to be at the forefront of discoveries in medicine and biotechnology, driving advances in such areas as molecular and personalized medicine, nanotechnology, agriculture, environmental remediation, and evolution. The concepts and skills obtained in this course will prepare you for more advanced training in biochemistry & molecular biology for careers in biotechnology, biomedical research, medicine, and other health professions.

At the end of this course, you will be able to:

1. Use your knowledge of fundamental principles of chemistry and physics (e.g. molecular bonding, thermodynamics, kinetics) to explain important concepts in biochemistry.
2. Describe and interrelate the hierarchical levels of protein structure (1˚ to 4˚) and provide examples of how this structure relates to the function (or dysfunction) of various classes of proteins.
3. Explain how enzymes can increase the rates of biochemical reactions at the molecular level, and how enzymes may be inhibited and regulated.
4. Outline the major pathways by which precursor biomolecules (carbohydrates, lipids, amino acids) are synthesized and degraded, and the key points at which these pathways are regulated.
5. Describe how organisms obtain, store, and utilize energy through metabolic interconversion of biomolecules.
6. Understand how metabolic pathways are controlled to maintain homeostasis of organisms under normal physiological conditions, and how this may be disrupted by certain pathological states.
7. Place biochemical events within a genomic and cellular context.
8. Relate/apply the fundamental biochemical concepts to your life and your daily activities.

Course Delivery:

Access all course materials via Brightspace at https://dal.brightspace.com/

	Course Expectation – Dr. Langelaan Semi-Flipped	Course Expectation – Dr. Xiong Flipped
Pre-class	• Mon. & Wed. - preview notes • Fri. – watch the video lectures to prepare for flipped class	• Watch "Khan Academy" style videos on your own to acquire lecture information (30-50' in total)
In-class	• Mon. & Wed. – Interactive lectures • Fri. – Practice on worksheets# in the flipped class	• Requested review • Work on case studies# (10') • Practice on worksheets# (20-25') • 1st attempt of quizzes in class (5-10')
Post-class	• Complete quizzes before next class • Work on additional practice questions^	• Complete the 2nd attempt of the quizzes before next class as needed • Work on remaining practice questions^

***Why "Flipped" format*:** In addition to the massive amount of evidence supporting active learning methods, our choice of flipping the class also have "local" reasons:

1. In the past, we have consistently seen only about 170 people out of 390 regularly attend in-person lectures. Since the majority of the students watch videos on their own as a way of acquiring content information, we can afford to do more than just lecturing in class to help you.
2. Most students find BIOC 2300 challenging. One of the key reasons is the new expectation for transferring/applying chemical concepts to understand biological systems. In fact, questions on exams assess how well you can transfer, apply, and integrate chemical, biological, or even physical concepts together to solve real-life problems. If we know most students struggle with applying information rather than obtaining information, shouldn't we devote our precious class time on actively practicing "applying" instead of listening passively?
3. Another reason past students found BIOC 2300 challenging is the lack of community support from peers. Based on my incomplete observations, students who have regular study groups/partners are better engaged with the class and thus consistently practice over the entire semester. As a result, students who have peer support find the course more enjoyable and perform better, at least anecdotally. Having flipped class offers everyone a chance to work in a community of practice and meet peers that may eventually develop into a study group. In addition, flipped class allows learning assistants (undergraduate students who just completed BIOC 2300 successfully) to join us, provide peer support, and share their expert knowledge from students' point of view.
4. Students learn more when they are actively engaged in the classroom than they do in a passive lecture environment. Extensive research supports this observation, especially in college-level science courses. It's worth noting that students often feel that they learn less in an "active" classroom than in a "passive" lecture, despite the evidence showing that students in the active classroom significantly outperforms their peers in the passive learning environment on quizzes and exams. Why is that? We will explore the reasons briefly in our first class. Access the study here.

 # Answers to In-class worksheets and case studies will not be published online but will be available during Biochemistry Resources Center.
^ Answers to additional practice questions outside of the classes will be published online.

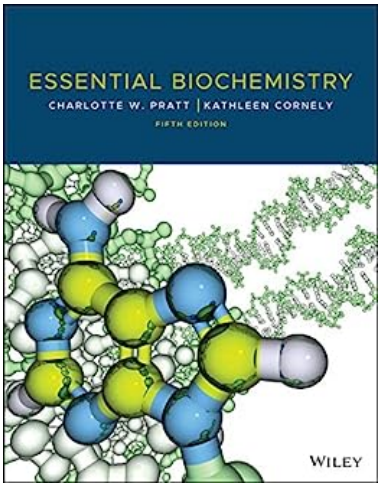
Student Support:

Within our class, there are multiple ways to keep in touch with the instructional team. Below, we highlight the purpose of each method of communication:

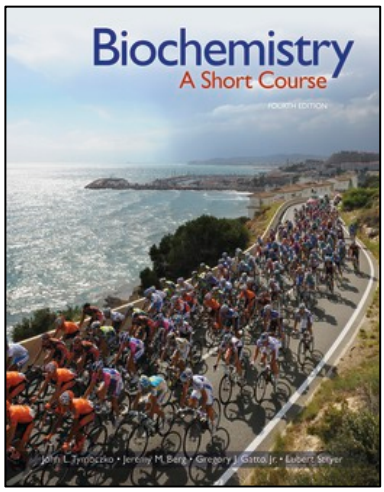
Method of Communication	Purpose	Advantage
Brightspace Discussion Board	Ask any questions on the course content & administration.	Fast response, easily accessible, open for everyone to see and share.
Course email: BIOC2300@dal.ca	Ask **short** course content related questions.	Managed by our TAs, respond within 24 hrs, only for short course content questions.
Teaching assistants help sessions: *Time: Mon. 2-3 PM* *Thr. 10-11 AM* *Venue: Tupper 8-J01*	• Provides in-person 1-on-1 or 1-on-a few targeted support. • Resolve any questions that cannot be easily answered through email.	• In-person twice per week. • Good for resolving difficult/complex questions. • Discuss learning strategies.
Dr. Langelaan's *MS Bookings* (click on the link)	Request 1-on-1 or 1-on-a few meetings for feedback, exam review, content help and others.	• Short but highly effective and efficient; • Confidential.
Dr. Xiong's *MS Bookings* (click on the link)	• Questions on course administration. • Request 1-on-1 or 1-on-a few meetings for feedback, exam review, content help and others.	• Short but highly effective and efficient; • Confidential.
Dr. Langelaan's email: dlangela@dal.ca Dr. Xiong's email: shawn.xiong@dal.ca	In case *MS Bookings* does not fit your schedule, we can meet at a time that works for you.	Flexible and private.
Biochemistry Resource Centre • *Time: Tue. – Fri. 11:30 AM – 2:00 PM* • *Venue: Tupper 8-J01*	• Provides an open and accessible place to study and work individually or in a small group. • Nurture a community of learning biochemistry.	• In-person available Monday to Friday. • Work and learn in a supervised environment. • Clarify general misconceptions/confusion. • Discuss learning strategies.
Anonymous Feedbacks (click on the link)	To provide us with your constructive feedback so that we can improve throughout our class rather than getting it at the end, which is often too late.	Easy to complete, anonymous, and concerns get addressed immediately.
How to learn & ace biochemistry workshops	Learn metacognition and evidence-based learning strategies.	Acquire and implement effective learning strategies to improve course performance.

Course Textbook:

The following two books are recommended but NOT required for those who are interesting in reading in depth about the topics we discuss in class.



Essential Biochemistry
(5th edition, 2022) by Pratt & Cornely



Biochemistry: A Short Course
(4th edition, 2019) by Tymoczko; Berg; Gatto; & Stryer

Course Assessment:

Assessment	Date	Weight (%)
Online quizzes[a]	Per class	15
Test 1[b]	Jan. 31st 6:30 – 8 PM	15
Test 2	March 7th 7:00 – 8:30 PM	15
Test 3	April 5th 6:30 – 8 PM	15
Final exam[c]	*Scheduled by registrar*	40

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale: https://www.dal.ca/campus_life/academic-support/grades-and-student-records/grade-scale-and-definitions.html

Note: Numeric grades will be rounded to the nearest whole number before being converted to a letter grade. **No exceptions will be made.**

[a.] **Online quizzes** consist of 3-5 multiple choice questions that will be:

- released during or right after each class
- due before the next class
- 2 attempts, the highest score taken for grade calculation
- best 27 out of 30 will be taken for the final grade calculation.

b. **Midterms** are non-cumulative and will take place on:

- Jan. 31st 6:30 – 8:00 PM (Rowe 1028 & McCain Auditorium 2)
- Mar. 7th 7:00 – 8:30 PM (Rowe 1028 & McCain Auditorium 1)
- Apr. 5th 6:30 – 8:00 PM (Rowe 1028 & McCain Auditorium 2)
- Each test will consist of relatively equal distribution of multiple-choice and short answer questions.
- **Cue sheet** will be provided before and during each test.

c. **Final exam** is cumulative and will be scheduled by the registrar during the final's week in April.

- **Cue sheet** will be provided before and during the final exam.
- To recognize that learning is a process, students' final exam score will be automatically used to compare and **replace any written term tests** that had a lower percentage.

Course Policies on Missed or Late Academic Requirements:

Missed or late quizzes: Due the nature of the online quizzes, extensions will not be provided for missed quizzes, and a grade of 0 will be given to any late submissions. There will be a total of 30 quizzes, and we take the best 27 out of 30 quizzes for final grade calculation.

Missed term test(s): Term tests are non-cumulative. There will be no make-up term tests. For any missed term-tests, the credits will be automatically transferred to the accumulative final exam. You do not need to provide any reasons for missing term tests. We will assume that students who missed the term test(s) have legitimate causes and the transfer of credits from term test to final will be automatically applied.

- You do not need to submit an SDA form for a missed term test.
- You may maximally miss 2 out of 3 term tests. Missing all three term tests will result a 0% for the term test 3 (cannot be replaced by the final exam grade).

Missed Final exam: Final exam is cumulative. In response to the recent changes in the provincial health care regulation – *Nova Scotia employers can no longer request a sick note unless an employee is absent for more than five working days or has already had two absences of five or fewer working days in the previous 12-month period*, Dalhousie University no longer requires a doctor's note for missing final exams. Instead, an additional SDA is accepted for missing the final exam. Students must notify both course instructors prior to the absence and submit the completed SDA form for the final exam no later than 48 hours after the scheduled exam to be considered for a make-up exam. The date and time of the make-up exam will be available to qualified individuals within 72 hours after the scheduled exam. Unless for extreme circumstances (such as unforeseen medium to long term disabilities), there will be no additional or alternative make-up final exams.

Please note, even though we are not strictly asking for explanation of absence nor the submission of SDA (for greater accessibility), our course still operates under the guidance of the university policies on short and long leave of absence. In accordance with the short leave of absence policy - *Students can submit a maximum of two separate Student Declaration of Absence forms per course during a term and one SDA for the final exam*.

Course schedule 2023

Month	Date	Date	Lecture #	Class	Instructor
January	8th	Mon.	1	Introduction & Orientation	Entire Instructional Team
	10th	Wed.	2	Aqueous chemistry	Langelaan
	12th	Fri.	3	Acid-base chemistry & buffers (**Flipped**)	Langelaan
	15th	Mon.	4	Amino acids and proteins: primary structure	Langelaan
	17th	Wed.	5	Secondary, tertiary and quaternary protein structure	Langelaan
	19th	Fri.	6	Nucleic acids, genomics, and DNA technology (**Flipped**)	Langelaan
	22nd	Mon.	7	Isolating and analyzing proteins	Langelaan
	24th	Wed.	8	Protein function I: hemoglobin and antibodies	Langelaan
	26th	Fri.	9	Protein function II: structural & motor proteins (**Flipped**)	Langelaan
	29th	Mon.	10	Protein function III: light absorption and emission	Langelaan
	31st	**Wed.**	**11**	**Review for Term Test 1** **Term Test 1 @ 6:30 - 8:00 PM (Locations to be announced later)**	
February	2nd	Munro Day	No Class		
	5th	Mon.	12	How enzymes work	Langelaan
	7th	Wed.	13	Enzyme kinetics and inhibition	Langelaan
	9th	Fri.	14	Lipids and membranes (**Flipped**)	Langelaan
	12th	Mon.	15	Membrane transport	Langelaan
	14th	Wed.	16	Molecular interactions (**Flipped**)	Langelaan
	16th	Fri.	17	Carbohydrate: Form & Function (Flipped)	Xiong & LAs
	19th	Study Break	No Class		
	21st				
	23rd				
	26th	Mon.	18	Glycobiology: Sugar Beyond Energy Storage (Flipped)	Xiong & LAs
	28th	Wed.	19	Glycogenolysis: Breaking Down Glycogen (Flipped)	Xiong & LAs
March	1st	Fri.	20	Glycogenesis: Building Up Glycogen (Flipped)	Xiong & LAs
	4th	Mon.	21	Glycolysis: Nuts & Bolts of Glycolytic Reactions (Flipped)	Xiong & LAs
	6th	Wed.	22	Review for Term Test 2	Xiong & LAs
	7th	**Thur.**		**Term Test 2 @ 7 - 8:30 PM (Locations to be announced later)**	
	8th	Fri.	23	Glycolysis & Fermentation in Health & Diseases (Flipped)	Xiong & LAs
	11th	Mon.	24	Thermodynamics: Flux of Biochemical Reactions (Flipped)	Xiong & LAs
	13th	Wed.	25	Gluconeogenesis: the “Reverse” of Glycolysis? (Flipped)	Xiong & LAs
	15th	Fri.	26	Tricarboxylic Acid Cycle (TCA): When Breath Becomes Air (Flipped)	Xiong & LAs
	18th	Mon.	27	Oxidative Phosphorylation I: Electron Transport Chain (Flipped)	Xiong & LAs
	20th	Wed.	28	Oxidative Phosphorylation II: Tabulating ATP Production (Flipped)	Xiong & LAs
	22nd	Fri.	29	Fatty Acid Oxidation: Nuts & Bolts of β-oxidation (Flipped)	Xiong & LAs
	25th	Mon.	30	Fatty Acid Oxidation in Health & Diseases (Flipped)	Xiong & LAs
	27th	Wed.	31	Fatty Acid Synthesis: Nuts & Bolts of Fatty Acid Synthesis (Flipped)	Xiong & LAs
	29th	Good Friday	No Class		
April	1st	Mon.	32	Fatty Acid Synthesis in Health & Diseases (Flipped)	Xiong & LAs
	3rd	Wed.	33	Introduction to Amino Acid Metabolism (Flipped)	Xiong & LAs
	5th	**Fri.**	**34**	**Review for Term Test 3** **Term Test 3 @ 6:30 - 8:00 PM (Locations to be announced later)**	
	8th	Mon.	35	Final course review 1	Langelaan
	9th	Wed.	36	Final course review 2	Xiong
Final Exam Scheduled by Registrar					

DALHOUSIE UNIVERSITY
FACULTY OF MEDICINE

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Code: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness

Statement: http://www.dal.ca/cultureofrespect.html

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates)
https://academiccalendar.dal.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog&catalogid=117&chapterid=-1&topicgroupid=31821&loaduseredits=False

University Grading Practices

https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Student Resources and Support

Advising

General Advising https://www.dal.ca/campus_life/academic-support/advising.html

Science Program Advisors: https://www.dal.ca/faculty/science/current-students/undergrad-students/degree-planning.html

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Black Students Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports

Library: https://libraries.dal.ca/

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Studying for Success: https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Copyright Office: https://libraries.dal.ca/services/copyright-office.html

Fair Dealing Guidelines https://libraries.dal.ca/services/copyright-office/fair-dealing.html

Other supports and services

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness.html

Student Advocacy: https://dsu.ca/dsas

Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Safety

Biosafety: https://www.dal.ca/dept/safety/programs-services/biosafety.html

Chemical Safety: https://www.dal.ca/dept/safety/programs-services/chemical-safety.html

Radiation Safety: https://www.dal.ca/dept/safety/programs-services/radiation-safety.html

Scent-Free Program: https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html

Dalhousie COVID-19 information and updates: https://www.dal.ca/covid-19-information-and-updates.html