DALHOUSIE UNIVERSITY

Faculty of Science Course Syllabus
Department of Biochemistry & Molecular Biology
BIOC 4703.03/5703.03 & CHEM 4603.03/5603.03
Structural Biology
Fall 2021

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.

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Lectures: Tuesday/Thursday 1:05-2:25 – McCain 2198

Workshops: Several lectures are substituted with laboratory and/or tutorial-style workshops (locations noted below)

Course delivery: In person (note: we may move online if required due to public health restrictions)

Course Description:

This course covers theoretical and practical aspects of determining and assessing the quality of atomic-resolution biomolecular structures. The underlying theory and applications of X-ray diffraction, NMR spectroscopy, and cryo-electron microscopy are discussed in detail.

Course Prerequisites/Restrictions:

BIOC 3700 or CHEM 3601, or instructor's consent.

Learning Objectives:

1) **Discriminate** and **quantify** the components of the NMR energy function
2) **Use** vector diagrams to **explain** the major NMR experiments employed for protein NMR
3) **Describe** effects of spin-relaxation phenomena upon the experimental observable and the manner in which these are modulated by dynamic processes
4) **Assign** two-dimensional homonuclear and heteronuclear NMR data for a polypeptide and **apply** these assignments for structure determination
5) **Demonstrate** understanding of hydrodynamic characterization by NMR spectroscopy
6) **Describe** crystallization experiments and the properties of protein crystals
7) **Understand** the basis of X-ray diffraction and the concept of reciprocal space
8) **Describe** the phase problem of X-ray diffraction and its solutions
9) **Understand** the basis of protein structure calculation via crystallography and cryo-electron microscopy
10) **Determine** the quality of published biomolecular structures

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Course Materials

All course materials will be posted on Brightspace:

Textbook: No required book; some good books are on reserve and you may want to pick one or more up from chapters/amazon etc. *You will also end up with copious course notes!*

Recommended books:

"Crystallography Made Crystal Clear" by Gale Rhodes ***– 2006 edition is available online from Dal library.*** Provides an in-depth overview of protein crystallography theory and practice.

"Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology" by Bernhard Rupp **–** Provides an in-depth overview of protein crystallography theory with an emphasis on practical aspects of the technique.

"Spin Dynamics – Basics of Nuclear Magnetic Resonance" by Malcolm H. Levitt (2002 or 2008 editions, Wiley) – ***2nd edition available online from Dal library***. *Worth picking up if you are planning to do a lot of NMR in future.*

"Fundamentals of protein NMR spectroscopy" by Rule and Hitchens – ***2006 edition is available online from Dal library.*** Good source of more protein-specific discussion.

"Protein NMR Spectroscopy – Principles and Practice" by Cavanagh, Fairbrother, Palmer, Rance and Skelton – ***2nd edition is available online from Dal library.*** Highly referred to in the field, but of limited utility for this course since the level of the discussion is quite technical.

"Understanding NMR Spectroscopy" by Keeler – **1st ed. (2004) available free from Dr. James Keeler's website and on ResearchGate**; 2nd ed. (2010) available from Dal library. An excellent introduction to fundamentals of NMR spectroscopy both from practical and theoretical perspectives with a more "traditional" approach than Levitt.

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Course Assessment – BIOC 4703/CHEM 4603

Component	Weight (% of final grade)	Date
Tests (2x80 min)	2x15%[1]	Oct. 7th and Nov. 16th
Final exam (3 h)	30%[2]	*(Scheduled by Registrar)*
Assignments	40%[2]	Throughout term

Course Assessment – BIOC 5703/CHEM 5603

Component	Weight (% of final grade)	Date
Tests	2x12.5%[1]	Oct. 7th and Nov. 16th
Final exam	25%[2]	*(Scheduled by Registrar)*
Assignments	30%[2]	Throughout term
Focus topic – seminar	*10%*	Nov. 25th
Focus topic – write-up	*10%*	Nov. 30th

Notes applicable to grading:

[1.] If your final exam mark is higher than the mark on a written test (i.e., you cannot simply skip a test), your lowest test mark will be replaced with the final exam mark.

[2.] Students must receive passing grades for the final exam and assignment components of the final mark to pass the course.

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (<50)
A- (80-84)	B- (70-72)	C- (55-59)	

Notes: Letter grade assignment in BIOC 4703/CHEM 4603 and in BIOC 5703/CHEM 5603 will follow the Faculty of Science recommendation that numbers falling in the interval between letter grades be rounded up if the fraction is 0.5 or greater. For BIOC 5703/CHEM 5603, Faculty of Graduate Studies requires that students achieve a letter grade of B- or higher to pass. A grade below 69.5 for BIOC 5703/CHEM 5603 will therefore result in an F.

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Course Content

Approximate Timeline: Fall 2021 (May be subject to change!)

Class	Lecture	Date	Topic
1 – DL	1	07-Sep	Introduction to protein structure, NMR, cryo-EM, and X-ray diffraction (Rh2,10 & Ru1,2)
2 – DL	2	09-Sep	Protein crystallization, crystal symmetry, reciprocal lattice (Rh3 & Ru3,5)
3 – DL	3	14-Sep	**Workshop:** Visualizing protein structure using pymol (**Tupper 8J**)
4 – DL	4	16-Sep	X-ray diffraction, Bragg's law, data collection and analysis (Rh4 & Ru6,8)
5 – DL	5	21-Sep	**Workshop:** Setting up a crystallization experiment (**Tupper 8J**)
6 – DL	6	23-Sep	The Fourier Transform, electron density, and the phase problem (Rh5 & Ru9)
7 – DL	7	28-Sep	Solving the phase problem: Isomorphous replacement, anomalous diffraction, and molecular replacement (Rh6 & Ru10,11)
	No class	30-Sep	National Day for Truth and Reconciliation
8 - DL	8	05-Oct	**Workshop:** SAD phasing and molecular replacement (**Tupper 8J**)
9	***Test 1***	**07-Oct**	***Test 1 – X-ray diffraction***
10 – DL	9	12-Oct	Model building and validation (Rh7 & Ru12,13)
11 – JR	10	14-Oct	Spectroscopy, NMR Hamiltonian, nuclear spin & the observable *(Le1,2,*5,8*)*
12 – JR	11	19-Oct	Anatomy of NMR spectrometer, components of the Hamiltonian *(Le4,*5,9*)*
13 – JR	12	21-Oct	**Workshop:** Spin energetics under isotropic conditions (**In class;** *Keeler)*
14 – JR	13	26-Oct	Longitudinal relaxation, transverse relaxation, 2D NMR, TOCSY *(Le2,14,17,20)*
15 – JR	14	28-Oct	nOe and NOESY, heteronuclear NMR, triple-resonance experiments & backbone walk (*Le20)*
16 – JR	15	02-Nov	**Workshop**: NMR resonance assignment (**In class**)
17 – JR	16	04-Nov	Protein NMR restraints & structure calculation
	No class	09-Nov	Fall Study Break
	No class	11-Nov	Fall Study Break
18	***Test 2***	**16-Nov**	***Test 2 – NMR spectroscopy***
19 – JR	17	18-Nov	Measuring dynamics at various timescales by NMR (*Le19,20)*
20 – JR	18	23-Nov	Solid-state NMR
21	19	25-Nov	**Grad student presentations**
22 – DL	20	30-Nov	Cryo-electron microscopy (Rh9) – **Grad student papers due**
23 – DL	21	02-Dec	Cryo-electron microscopy and review (Rh9)

Note: DL = Dr. Langelaan; JR = Dr. Rainey. Literature references are starting points for background reading, which may not cover all topics of a given lecture. Le = Levitt; Rh = Rhodes; Ru = Rupp. Number = chapter (or section).

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Course Policies

Department of Biochemistry & Molecular Biology Policy on Missed Examinations and Assignments

A student who misses an evaluation component of the course (midterm test, assignment, presentation, etc.) due to illness should, if possible, notify the instructor, course coordinator, or department office either prior to, or within 48 h of the scheduled time or due date for that component. The student must also submit a **Student Declaration of Absence Form** (through the course Brightspace page or to their instructor via e-mail) within three **(3) calendar days** following the last day of absence. Special 'make-up' tests (if offered) will normally be written within 7 calendar days after the missed test. Absence for non- medical reasons is not ordinarily acceptable unless prearranged with the instructor. A missed evaluation component for which no satisfactory arrangement has been made will be given a mark of zero. The Student Declaration of Absence form can only be submitted up to two (2) separate times per course during a term. Students who exceed this limit must inform their course instructor(s) and will be required to register with an Advisor at Student Academic Success (SAS). If students have recurring short-term absences and do not register with SAS, it is at the instructor(s)' discretion to disallow any further Student Declarations and deny alternate coursework arrangements.

Assignments must be submitted either in class (preferably) or in person to the indicated professor no later than 5:00 pm on the designated due date. Extension of the due date may be granted upon submission of a Student Declaration of Absence Form. Extension of the due date will not normally exceed 7 calendar days. **In all other cases, the grade for assignments/projects will be reduced by 10% for each day after the due date.**

Department of Biochemistry & Molecular Biology Statement on Plagiarism

What is plagiarism?

"Dalhousie University defines plagiarism as the submission or presentation of the work of another as if it were one's own[†]." The Department of Biochemistry & Molecular Biology is committed to protecting honest students against the devaluation of their work by students who resort to plagiarism.

Some examples of plagiarism include (but are not restricted to):

> Submitting as your own work any material created, in whole or in part, by someone else, including **material created in collaboration with other students**, unless specifically allowed by the class instructor and credited appropriately.

> Paraphrasing extensively or copying from sources such as the Internet, journal articles, or books (including textbooks) without crediting the original author or source.

> Using another student's laboratory data, unless specifically allowed by the lab instructor and credited appropriately.

> Submitting, in whole or in part, any work that has been submitted in another class, or re-submitting the same work in different years of the same class.

How can plagiarism be detected?

If required by the Instructor, work submitted for credit must be submitted in electronic as well as hard copy form. Submissions may be screened by one or both of the following methods:

> A pattern recognition program that compares all submissions with one another as well as submissions from previous years. Every individual has a unique pattern of writing. This program will detect submissions that are derived from a common source, even if words or phrases have been changed.

> A third-party computer-based assessment system that compares submissions against a large database including previous submissions and Internet sources.

What are the consequences of plagiarism?

"Plagiarism is considered a serious academic offence that may lead to the assignment of a failing grade, suspension or expulsion from the University. If a penalty results in a student no longer meeting the requirements of a degree that has been awarded, the University may rescind that degree.[†]" At Dalhousie University, the Department is obligated to refer any cases of suspected plagiarism to an Academic Integrity Officer, who will then conduct a hearing to evaluate the innocence or guilt of students alleged to have committed an act of plagiarism.

How can accusations of plagiarism be avoided?

You can avoid accusations of plagiarism by:

> Preparing all submissions independently and ensuring that they are expressed in your own unique writing style.

> Never sharing any written or electronic material with other students. You may not work with another student while preparing materials you are planning to hand in.

> Acknowledging any material paraphrased extensively or copied from sources such as the Internet, journal articles or textbooks. Paraphrasing of short phrases from the class textbook need not be acknowledged.

> Guarding all your work, both drafts and final submissions, to ensure that no one else can copy it. If you provide access to your work and someone (including a student taking the same class in a future year) copies it, then you may be aiding in the commission of an academic offence. If you suspect that someone has taken any of your work, notify your class instructor immediately.

> Using only laboratory data that you actually collected in the lab. Altering laboratory data is not permitted. If your data are unusable, you must still report your own data along with any explanation as to why the data are unusable. You may then use data supplied by the lab instructor for analysis, but you must acknowledge such use.

[†] Dalhousie University Undergraduate Calendar, 2016/2017, University Regulations, Intellectual Honesty.

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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://www.dal.ca/academics/important_dates.html

University Grading Practices

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

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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/academic-advising.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/services-support/student-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