Biophysical Characterization of Macromolecules Syllabus

Department of Biochemistry & Molecular Biology and Department of Chemistry

BIOC 4702/5702 and CHEM 4602/5602 Winter 2025

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. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.

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

Course Instructor(s)

Name	Email	Office Hours
Jamie A. Davey	james.davey@dal.ca	To be announced
David N. Langelaan	dlangela@dal.ca	To be announced
Jan K. Rainey	jan.rainey@dal.ca	To be announced

Course Description

This course covers methods allowing determination of global structuring and state; molecular interactions; and, supramolecular assembly of biomacromolecules including: calorimetry, fluorescence and electronic circular dichroism spectroscopy; hydrodynamics measurements and scattering; and, single molecule methods.

Course Prerequisites

BIOC 3700.03; or (CHEM 3601 AND CHEM 2301 AND CHEM 2304); or instructor's consent.
Recommended: PHYC 1190.03 and 1290.03, or 1310.03 and 1320.03

Student Resources

All three instructors will be providing office hours – the times and locations for these will be posted on the course's BrightSpace page.

Course Structure

Course Delivery

In-person

Lectures

Mondays & Wednesdays – Tupper Building Theatre C

Course Materials

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

Recommended books:

"Biophysical Chemistry" by Klostermeier and Rudolph – ***one copy on reserve in Kellogg***. *Good theoretical overview of many of the techniques covered in lecture.*

"Principles of Physical Biochemistry", 2nd Edition by van Holde, Johnson and Ho – ***one copy on reserve in Kellogg***. *A decent "long term" reference to have on your bookshelf, but written at a highly technical and theoretical (vs. practical) level so definitely not to everyone's taste!*

"Principles of fluorescence spectroscopy" by Joseph R. Lakowicz (3rd edition - 2006, Springer; older editions also good) – ***available online from Dal library; one copy also on reserve at Kellogg.*** *If you see yourself doing a lot of fluorescence, this is a great (although pricey) book to pick up.*

Assessment

BIOC 4702/CHEM 4602:

Component	Weight (% of final grade)	Date
Tests	2x17.5%[1]	Feb. 3 *& Mar. 24, 2025* In class; 80 minutes
Final exam	25% (*pass required to pass course*)	*Scheduled exam period* 3 hours (cumulative)
Assignments	20%	Throughout term
Critique of article (presentation)	15%	*To be assigned starting week of March 17 th*
Peer feedback/questions	5%	*During student presentations*

Note applicable to BIOC/CHEM 4X02 grading only:

[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.

BIOC 5702/CHEM 5602

Component	Weight (% of final grade)	Date
Tests	2x15%	Jan*. 27 & Feb. 24, 2025* In class; 80 minutes
Final exam	20% (*pass required to pass course*)	*Scheduled exam period* 3 hours (cumulative)
Assignments	20%	Throughout term
Dissent in the literature (presentation)	25%	*To be assigned starting week of March 17th*
Peer feedback/questions	5%	*During student presentations*

Conversion of numerical grades to final letter grades follows the Dalhousie Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (0-49)
A- (80-84)	B- (70-72)	C- (55-59)	

Course Policies on Missed or Late Academic Requirements

Policy for assignment submission

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 (protocol detailed below). Extension of the due date will not normally exceed 7 calendar days. **In all other cases, a grade of zero will be received for that assignment.**

Policy on missed evaluation components

A student who misses an evaluation component of the course (midterm test, assignment, presentation, final examination) due to illness should notify the course coordinator (Dr. Jan Rainey) 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) 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. **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.

Course Policies related to Academic Integrity

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.

> 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, 2024/2025, University Regulations, Intellectual Honesty.

Learning Objectives

1) **Understand** mechanisms of protein folding and theories of protein interactions

2) **Demonstrate** understanding of thermodynamics and the applicability of calorimetric methods to characterizing protein interactions and folding.

3) **Draw** energy level diagrams showing the quantum mechanical basis of electronic absorption and emission spectroscopy with specific reference to the Franck-Condon principle

4) **Analyze** optical spectra (absorption, emission, fluorescence anisotropy) with respect to polypeptide structure and environment and with relation to quantum mechanical basis of a given spectroscopic technique

5) **Understand** fundamental underpinnings and **demonstrate** application of 1D and 2D ^{1}H-^{15}N correlation NMR spectroscopy-based methods that allow interactions with macromolecules to be characterized.

6) **Demonstrate** understanding of hydrodynamic characterization through fluorescence spectroscopy, NMR spectroscopy, and scattering methods

7) **Understand** the benefits and limitations of several biophysical methods.

8) **Interpret** data to develop working models of protein systems.

9) **Demonstrate** critical thinking when evaluating primary literature, as evidenced during a formal presentation to the course instructors and peers.

Course Content

Please note that the following schedule may be modified for, e.g., pandemic situations, requirement of further time to fully cover a given topic, or other unforeseen circumstances.

Class	Lecture	Date	Topic	Lecturer	Klostermeier & Rudolph
1	1	06-Jan	Protein structure & interactions	**DL**	**Ch. 16**
2	2	08-Jan	ITC (theory & examples)	**DL**	**Ch. 27**
3	3	13-Jan	DSC (theory & examples)	**DL**	**Ch. 27**
4	4	15-Jan	SPR (theory & examples)	**DL**	**Ch. 26.3**
5	5	20-Jan	Correlative evaluation of ligand binding thermodynamics	**DL**	
6	6	22-Jan	Intro to optical spectroscopy (Jablonski diagrams; fluorescence vs. phosphorescence)	**JD**	**Ch. 19**
7	7	27-Jan	Emission spectroscopy (environmental effects; quenching to evaluate binding)	**JD**	**Ch. 19**
8	8	29-Jan	Intro to hydrodynamics (translational vs. rotational motion)	**JD**	**Ch. 4/19.5.9.3**
9	**MT1**	03-Feb	***Midterm 1 - Covering lectures 1-7***		
10	9	05-Feb	FRET/Fluorescence anisotropy (including evaluation of rotational motion)	**JD**	**Ch. 19**
11	10	10-Feb	DLS/SLS (evaluation of translational motion)	**JD**	**Ch. 21**
12	11	12-Feb	NMR theory & background (including relaxation & FID)	**JR**	**Ch. 20**
--		17-Feb	Break		
--		19-Feb	Break		
13	12	24-Feb	NMR - titration-based evaluation of ligand binding	**JR**	**Ch. 20**
14	13	26-Feb	NMR - other methods to evaluate ligand binding	**JR**	**Ch. 20**
15	14	03-Mar	NMR - experimental building blocks & relaxation measurement	**JR**	**Ch. 20**
16	15	05-Mar	NMR - rotational diffusion evaluated by relaxation	**JR**	**Ch. 20**
17	**MT2**	10-Mar	***Midterm 2 - Covering lectures 8-14***		
18	16	12-Mar	NMR - translational diffusion evaluation	**JR**	**Ch. 20**
19	17	17-Mar	Presentations (~3 x 4X02 + 1 x 5X02)		
20	18	19-Mar	Presentations (~3 x 4X02 + 1 x 5X02)		
21	19	24-Mar	Presentations (~3 x 4X02 + 1 x 5X02)		
22	20	26-Mar	Presentations (~3 x 4X02 + 1 x 5X02)		
23	21	31-Mar	Presentations (~3 x 4X02 + 1 x 5X02)		
24	22	02-Apr	Review (additional presentations if needed)	All	
	Final	TBD	Final exam – as scheduled by Registrar		

Notes: Lecturer: **DL** – David Langelaan; **JD** – Jamie Davie; **JR** – Jan Rainey. References from Klostermeier & Rudolph are starting points for background reading, which may not cover all topics of a given lecture. Lectures will be posted to Brightspace before class.

University Policies and Statements

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 at 1321 Edward St or elders@dal.ca. Additional information regarding the Indigenous Student Centre can be found at: https://www.dal.ca/campus_life/communities/indigenous.html

Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about-dal/internationalization.html

Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all 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. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/about-dal/agricultural-campus/student-success-centre.html)

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

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 (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: http://www.dal.ca/cultureofrespect.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. The full Code of Student Conduct can be found at: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Fair Dealing Policy

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/dept/university_secretariat/policies/academic/fair-dealing-policy-.html

Originality Checking Software

The course instructor may use Dalhousie's approved originality checking software and Google to check the originality of any work submitted for credit, in accordance with the Student Submission of Assignments and Use of Originality Checking Software Policy. Students are free, without penalty of grade, to choose an alternative method of attesting to the authenticity of their work and must inform the instructor no later than the last day to add/drop classes of their intent to choose an alternate method. Additional information regarding Originality Checking Software can be found at: https://www.dal.ca/about/leadership-governance/academic-integrity/faculty-resources/ouriginal-plagiarism-detection.html

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.