Biomolecular Chemistry Syllabus

Department of Biochemistry & Molecular Biology

BIOC 3700 Fall 2025

Dalhousie University operates in the unceded territories of the Mi'kmaw, Wolastoqey, and Peskotomuhkati Peoples. These sovereign nations hold inherent rights as the original peoples of these lands, and we each carry collective obligations under the Peace and Friendship Treaties. Section 35 of the Constitution Act, 1982, recognizes and affirms Aboriginal and Treaty rights in Canada.

We recognize that African Nova Scotians are a distinct people whose histories, legacies, and contributions have enriched the part of Mi'kma'ki known as Nova Scotia for over 400 years.

Course Instructors

Name	E-mail	Office Location
Dr. Jan K. Rainey (Lecture sections by JKR)	jan.rainey@dal.ca	Tupper 10N
Dr. Stephen L. Bearne (Lecture sections by SLB)	sbearne@dal.ca	Tupper 9J
Dr. Shawn Xiong (Lab Instructor)	shawn.xiong@dal.ca	Tupper 8J-2

Course Description

This course covers structural and functional properties of biomolecules, including the physical bases for their characterization, thermodynamic principles of protein folding and biomolecular interactions, and the kinetics and mechanisms of enzyme catalysis.

Course Prerequisites: BIOC 2300.03, 2610.03, CHEM 2401.03, and CHEM 2402.03 (all with a grade of B- or higher); MATH 1000.03 or 1215.03; or, instructor's consent. CHEM 2201.03 is highly recommended but not required.

Student Resources

Office hours with each of the BIOC 3700 instructors will be provided, with times and locations to be detailed on Brightspace. The **Biochemistry Resource Centre** will be available throughout the Fall term on Tuesdays, Wednesdays, and Thursdays from 12-2 pm in Tupper 8J-01.

Course Structure

Course Delivery

Lectures and laboratories will be in-person, with all tests and the final examination being in-person.

Lectures

8:30-9:20 (Monday/Wednesday/Friday) in LSC C236, supplemented by online content for Dr. Rainey's material. **Note: the start and end times are 5 minutes earlier than "typical" in order to provide a longer buffer time for students who need to cross campus for BIOC 3400.**

Laboratories

1 × 3 h (Monday (section B02) or Tuesday (section B01), 14:35–17:25) in Tupper 8J-01. More information regarding the lab schedule, lab manual, and lab assessment will be provided on Brightspace and by email. Our first labs will take place during the week of September 29.

Tutorials

In Dr. Rainey's section, Pre-lecture Problems are used to provide tutorial-type coverage of content throughout, with additional Tutorials provided in lecture (as time allows) and in video format through Brightspace. In Dr. Bearne's section, Supplemental Learning Exercises are used to provide tutorial-type coverage of key concepts and material.

Course Materials

Suggested textbooks:

Klostermeier, D., & Rudolph, M.G. (either of the 2024 [2nd ed] or 2017 [1st ed] editions are suitable) *Biophysical Chemistry*, CRC Press, Taylor & Francis Group, Boca Raton, Florida.

Segel, I.H. (1976) *Biochemical Calculations*, 2nd Edition, John Wiley & Sons, Inc., New York.

Course website & online content: BrightSpace

Additional References:

Biophysical Chemistry

Atkins, P., & de Paula, J. (2006) *Physical chemistry for the life sciences*, Freeman.

Hammes, G.G. (2000) *Thermodynamics and kinetics for the biological sciences.* Wiley-Interscience, New York. (**QP 517 P49 H35 2000**)

Hammes, G.G. (2005) *Spectroscopy for the biological sciences.* Wiley-Interscience, New York.

> Note: The previous two books comprise Hammes, G.G. (2007) *Physical chemistry for the biological sciences.* Wiley-Interscience, New York.

Roussel, M.R. (2012) *A Life Scientist's Guide to Physical Chemistry,* Cambridge University Press. (**Available as an online book, Dal Library)**

Tinoco, I., Sauer, K., Wang, J.C., & Puglisi, J. (2002) *Physical chemistry: Principles and applications in the biological sciences*, Pearson/Prentice Hall, Upper Saddle River, N.J.

Allen, J.P. (2008) *Biophysical Chemistry*, Oxford Press/Wiley-Blackwell, Hoboken, NJ.(**QT 34 A427b 2008**)

Correia, J.J., & Detrich, H.W. (Eds.) (2008) *Biophysical tools for biologists* (volumes 1 & 2), Academic Press, Burlington, MA. (**QH 581 P929m**)

Creighton, T.E. (1993) Proteins: *Structures and molecular properties*, 2nd Ed., W.H. Freeman and Co., New York.

Bergethon, P.R., & Simons, E.R. (1990) *Biophysical chemistry: molecules to membranes*, Springer-Verlag, New York (**QH 505 B397 1990**)

Cantor, C.R., & Schimmel, P.R. (1980) *The conformation of biological macromolecules* (parts 1-3), W. H. Freeman, San Francisco. (**QH 345 C36**)

Van Holde, K.E., Johnson, W.C., & Ho, P.S. (2006) *Principles of physical biochemistry*, Pearson/Prentice Hall, Upper Saddle River, N.J. (**QD 453.2 V256p 2006**)

Freifelder, D. (1982) *Physical biochemistry: applications to biochemistry and molecular biology*, W.H. Freeman, San Francisco. (**QU 4 F862 1982**)

Kinetics & Enzyme Chemistry

Fersht, A. (1999) *Structure and Mechanism in Protein Science*, W.H. Freeman and Co., New York. **(QU 55 F399s 1999)**

Cook, P.F., & Cleland, W.W. (2007) *Enzyme Kinetics and Mechanism*, Garland Science, New York. **(QU 135 C771e 2007)**

Silverman, R.B. (2000) *The Organic Chemistry of Enzyme-Catalyzed Reactions*, Academic Press, San Diego, CA.

Dugas, H. (1996) *Bioorganic Chemistry. A Chemical Approach to Enzyme Action*, Spriger-Verlag, New York. **(QU 135 D866b 1996)**

Segel, I.H. (1975) *Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems*, John Wiley & Sons, Inc., New York. **(QU 135 S454e 1993)**

Roberts, D.V. (1977) *Enzyme Kinetics,* Cambridge University Press, New York. (**QU135 R45 1977)**

General Textbooks

Abeles, R.H., Frey, P.A., & Jencks, W.P. (1992) *Biochemistry*, Jones and Bartlett Publishers, Boston. (**QU 4 A139 1992**)

Branden, C., & Tooze, J. (1991) *Introduction to protein structure*, Garland Publishing, Inc., New York. (**QU 55 B816i 1991**)

Petsko, G.A., & Ringe, D. (2004) *Introduction to protein structure and function*, New Science Press Ltd., London, UK. (**QU 55 P498p 2004**)

Nelson, D.L., & Cox, M.M. (2008) *Lehninger: Principles of Biochemistry*, 5th Ed., W.H. Freeman and Co., New York. (**QU 4 L523p 2008**)

Voet, D. & Voet, J.G. (2011) *Biochemistry*, 4th Edition, John Wiley & Sons.

Assessment

*Laboratory (30% of final grade**)*

A detailed breakdown of laboratory assessments and their timing will be provided in the lab.

Tests (30% of final grade)

Two 50-minute Midterm Tests each worth 15% of the final grade will be held during regular class time on **Monday, October 20th** and **Monday, November 17th**.

*Final exam (40% of final grade**)*

A three-hour final examination will be scheduled by the Registrar during Dalhousie's Fall Exam Period of December 11-21, 2025.

Other course requirements

** Both the laboratory and the final exam must be passed in order to pass the course.

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)	

Department of Biochemistry & Molecular Biology Policy for Students repeating a BIOC course with an integral lab component (BIOC 3300, BIOC 3400, BIOC 3700):

Students who have previously taken BIOC 3300, BIOC 3400, or BIOC 3700 and passed the laboratory component will not be allowed to retake the lab component if they redo the course. The previous lab marks will be used to assign the grade for the lab component based on the weight given to this component in the syllabus for the course in the year it is retaken.

BIOC 3700 Policy on missed examinations and mid-terms:

A student who misses a midterm test or lab in BIOC 3700 due to illness must notify the instructor or course coordinator prior to the scheduled time 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. ***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 instructors 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 instructors' discretion to disallow any further Student Declarations and deny alternate coursework arrangements.

Course Policies related to Academic Integrity

All students are expected to be familiar with and follow Dalhousie's general regulations on Academic Integrity. Cheating on tests and examinations will be addressed through Dalhousie's formal Discipline process. Detailed policies on Academic Integrity (i.e., what constitutes plagiarism, appropriate/inappropriate use of generative AI, and on individual vs. group work expectations) are outlined in the BIOC 3700 laboratory manual.

Learning Objectives

1. Discriminate between and calculate the roles of entropy, enthalpy, and molecular interactions in protein stability, folding and ligand binding.
2. Given the architecture of an enzyme active site, write a mechanism and show how general acid/base, covalent, or electrophilic catalysis may occur.
3. Given the kinetic mechanism (with or without inhibition), derive an initial velocity equation using either the steady-state assumption or the rapid equilibrium approach.
4. Draw the structure of a peptide with defined stereochemistry at a given pH.

5. Given the substrates, products, and cofactors for a particular class of enzyme-catalyzed reaction, write a mechanism for the reaction.
6. Analyze implications of molecular spectroscopy (absorption, emission, CD, NMR) results on polypeptide structure and environment in direct context of the physical basis of the technique in question.
7. Given an enzyme mechanism, design a reversible or irreversible inhibitor.
8. Apply peptide bond properties and hydrogen-bonding to predict primary and secondary structuring preferences.
9. Present and analyze experimental data in a prescribed format for a formal scientific report.
10. Demonstrate proficiency in biochemical laboratory techniques, including liquid handling, pH measurements, visible range spectroscopy, enzyme assays and determination of kinetic parameters, thin layer chromatography, protein isolation and quantification, and SDS-PAGE.

Course Content

Under emergency circumstances that have a serious impact on the delivery of this class, *there may be a need to alter the syllabus*.

Week (Class)	Date (Day)	Lecture topic/Assessment component
Protein Chemistry, Stability & Thermodynamics (JKR) **Online review lectures (1&2)** – Acid-base equilibria & amino acids.		
1 (1)	Sept. 24 (W)	**Amino acids→peptide bonds; key concepts in thermodynamics 1.** Amino acid stereochemistry; peptide bond formation; 1st law of thermodynamics.
1 (2)	Sept. 26 (F)	**Key concepts in thermodynamics 2.** 1st law continued & definition of enthalpy.
2 (3)	Sept. 29 (M)	**Key concepts in thermodynamics 3.** 2nd law & definition of entropy.
2 (4)	Oct. 1 (W)	**Key concepts in thermodynamics 4.** Spontaneity & equilibria.
2 (5)	Oct. 3 (F)	**Peptide bonds, polypeptide conformation & polypeptide properties.** Peptide bond properties & their relation to protein conformation; backbone conformational restriction ($\phi/\psi/\omega$).
3 (6)	Oct. 6 (M)	**Intra/intermolecular interactions 1.** Hydrophobicity & hydrophilicity; Interactions that hold together molecules and complexes & ramifications for protein stability.
3 (7)	Oct. 8 (W)	**Intra/intermolecular interactions 2.** Interactions holding molecules and complexes & ramifications for protein stability; tutorial questions.

Protein Structure (JKR)		
3 (8)	Oct. 10 (F)	**Secondary structure 1.** Helices.
4 (–)	Oct. 13 (M)	University Closed – Thanksgiving Day
4 (9)	Oct. 15 (W)	**Secondary structure 2 & fibrous proteins 1.** β-structures & other structures; introduction to fibrous proteins.
4 (10)	Oct. 17 (F)	**Fibrous proteins 2, protein folding & globular protein structure.** Protein fibres; Folding; 3° and 4° structuring.
5 (11)	Oct. 20 (M)	**Midterm test #1 (15% of final grade)** **Content: Lectures 1-10.**
Enzyme Kinetics (SLB)		
5 (12)	Oct. 22 (W)	**Fundamental kinetics 1.** Rate equations.
5 (13)	Oct. 24 (F)	**Fundamental kinetics 2.** Progress curves and graphs of initial rates.
6 (14)	Oct. 27 (M)	**Enzyme kinetics 1.** Rapid equilibrium and steady-state kinetics.
6 (15)	Oct. 29 (W)	**Enzyme kinetics 2.** Enzyme assays and analysis of kinetic data.
6 (16)	Oct. 31 (F)	**Enzyme kinetics 3.** Inhibition models and determination of inhibition constants (K_i).
Enzyme Catalysis & Mechanism (SLB)		
7 (17)	Nov. 3 (M)	**Reactivity of amino acids revisited.** Side chain chemistry, covalent modification.
7 (18)	Nov. 5 (W)	**General acid-base catalysis 1.** Why are nonenzymatic reactions slow? Transition state stabilization.
7 (19)	Nov. 7 (F)	**General acid-base catalysis 2.** Mechanisms of isomerases.
–	Nov. 10 (M)	No Class – Fall Break
–	Nov. 12 (W)	No Class – Fall Break
–	Nov. 14 (F)	No Class – Fall Break
8 (20)	Nov. 17 (M)	**Midterm test #2 (15% of final grade)** **Content: Lectures 12-19.**
8 (21)	Nov. 19 (W)	**Promoting hydrolysis reactions 1.** Covalent catalysis.
8 (22)	Nov. 21 (F)	**Promoting hydrolysis reactions 2.** Electrophilic catalysis.
9 (23)	Nov. 24 (M)	**Design of enzyme inhibitors.** Transition state analogues, suicide inhibitors, activity profiling.

9 (24)	Nov. 26 (W)	**Stabilization of carbanions 1.** Pyridoxal phosphate as a coenzyme.
9 (25)	Nov. 28 (F)	**Stabilization of carbanions 2.** Thiamine pyrophosphate as a coenzyme.
10 (26)	Dec. 1 (M)	**Bond-forming reactions.** Phosphoryl transfers and positional isotope exchange.
Optical Spectroscopy & Structural Biology of Proteins (JKR)		
10 (27)	Dec. 3 (W)	**Optical spectroscopy 1.** Vibronic states & absorption spectroscopy; circular dichroism spectroscopy.
10 (28)	Dec. 5 (F)	**Optical spectroscopy 2.** CD spectroscopy – continued; emission spectroscopy.
11 (29)	Dec. 8 (M)	**Optical spectroscopy 3.** Emission spectroscopy – continued; tutorial questions.
11 (30)	Dec. 10 (W/[M])	**Structural biology.** Comparing & contrasting the three principal methodologies: X-ray diffraction, NMR spectroscopy, cryo-EM.
Final Examination (40% of final grade): To be scheduled by the Registrar during the Exam Period of December 11-21		

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 Mi'kmaq and Indigenous Relations (including the Elders in Residence program, Land Acknowledgements, Understanding Our Roots, and much more) can be found at: https://www.dal.ca/about/mission-vision-values/mikmaq-indigenous-relations.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/mission-vision-values/global-relations.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/campus_life/ssc.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: https://www.dal.ca/about/mission-vision-values/equity-diversity-inclusion-and-accessibility/about-office-equity-inclusion.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/content/dam/www/about/leadership-and-governance/governing-bodies/code-student-conduct.pdf

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/content/dam/www/about/leadership-and-governance/university-policies/fair-dealing-policy.pdf

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.