Biomolecular Chemistry Syllabus

Department of Biochemistry & Molecular Biology

BIOC 3700 Fall 2026

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	Email	Office Location
Dr. Jan K. Rainey (Lecture sections denoted by JKR & Course Coordinator)	jan.rainey@dal.ca	Tupper 10N
Dr. Stephen L. Bearne (Lecture sections denoted by SLB)	sbearne@dal.ca	Tupper 9J
Dr. Charneal Dixon (Laboratory sections B01 and B02)	dixonc@dal.ca	Tupper 8H03
Laboratory TAs	TBA on Brightspace	

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.

Course Structure

Course Delivery

Lectures and laboratories will be in-person. All tests and the final examination are in-person.

Lectures

8:30-9:20 (Monday/Wednesday/Friday) in LSC Psychology P4260, 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 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 14.

Tutorials

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

Course Materials

Problem sets

A series of problem sets will be provided throughout the course. These are ungraded but provide critical opportunities for extra practice and reinforcement on key concepts, "parsing" of questions, and problem solving. Solutions will typically be provided after a delay.

Course website & online content

BrightSpace

Suggested textbooks

Bookstore link:
https://bookstore.dal.ca/CourseSearch/?course[]=SUB,202710,BIOC,BIOC3700,01

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.

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.

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.

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 Mid-term Tests each worth 15% of the final grade will be held during regular class time on **Friday, October 9th** and **Monday, November 16th**.

*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 11-20, 2026.

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 **undergraduate** 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

Department of Biochemistry & Molecular Biology Policy for Students repeating a BIOC course with an integral lab component:

Students who have previously taken 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. Repeating students must request permission to register for the B03 lab section.

BIOC 3700 Policy on Missed Examinations, Mid-terms and Laboratories:

A student who misses a midterm test or lab in BIOC 3700 due to illness must notify the course coordinator (mid-term test) or lab instructor (lab session) prior to or during 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 scheduled 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.

Final exam: SDA Forms are not applicable to final examinations. BIOC 3700 adheres to Dalhousie's policy requiring formal medical documentation or clear communication other mitigating circumstances outside of the student's control for missed final examinations, with SDA forms not being applicable. A 'make-up' exam will be scheduled by the Coordinator for a student who has missed the final examination under exceptional circumstances, normally within 7 calendar days of the missed exam. Please refer to the Undergraduate Calendar for full detail on formal Dalhousie University policy:

https://academiccalendar.dal.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog&catalogid=141&chapterid=9967&topicgroupid=43038&loaduseredits=False

Course Policies related to Academic Integrity & Artificial Intelligence

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.

Course Accessibility

You are eligible for accommodations based on protected characteristics such as religion. If you have religious, cultural, or community-significant observances that conflict with course requirements, reach out to the Course Coordinator to collaboratively find alternatives for completing the course requirements.

To begin the process of requesting a formal academic accommodation, contact the Student Accessibility Centre.

Course Content

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. 9 (W)	**Amino acids→peptide bonds; key concepts in thermodynamics 1.** Amino acid stereochemistry; peptide bond formation; 1st law of thermodynamics.
1 (2)	Sept. 11 (F)	**Key concepts in thermodynamics 2.** 1st law continued & definition of enthalpy.
2 (3)	Sept. 14 (M)	**Key concepts in thermodynamics 3.** 2nd law & definition of entropy.
2 (4)	Sept. 16 (W)	**Key concepts in thermodynamics 4.** Spontaneity & equilibria.
2 (5)	Sept. 18 (F)	**Peptide bonds, polypeptide conformation & polypeptide properties.** Peptide bond properties & their relation to protein conformation; backbone conformational restriction ($\phi/\psi/\omega$).
3 (6)	Sept. 21 (M)	**Intra/intermolecular interactions 1.** Hydrophobicity & hydrophilicity; Interactions that hold together molecules and complexes & ramifications for protein stability.
3 (7)	Sept. 23 (W)	**Intra/intermolecular interactions 2.** Interactions that hold together molecules and complexes & ramifications for protein stability.
Protein Structure (JKR)		
3 (8)	Sept. 25 (F)	**Secondary structure 1.** Helices.
4 (9)	Sept. 28 (M)	**Secondary structure 2 & fibrous proteins.** β-structures & other structures; fibrous protein structures.
4 (-)	Sept. 30 (W)	**University Closed** – National Day for Truth and Reconciliation
4 (10)	Oct. 2 (F)	**Protein folding theory & practice.** Relating folding to stability & thermodynamics; examples to demonstrate predictability of folding.
Structural Biology (JKR) **Online lecture (3) –** NMR chemical shifts – moving from small molecules to proteins.		
5 (11)	Oct. 5 (M)	**Structural biology 1.** Fundamentals of NMR spectroscopy.
5 (12)	Oct. 7 (W)	**Structural biology 2.** NMR spectroscopy – continued.
5 (13)	Oct. 9 (F)	**Midterm test #1 (15% of final grade).** **Content: Lectures 1-11.**
6 (-)	Oct. 12 (M)	**University Closed** – Thanksgiving Day

6 (14)	Oct. 14 (W)	**Structural biology 3.** NMR spectroscopy – continued; X-ray crystallography.
6 (15)	Oct. 16 (F)	**Structural biology 4.** X-ray crystallography – continued; cryo-EM.
Optical Spectroscopy of Proteins (JKR)		
7 (16)	Oct. 19 (M)	**Optical spectroscopy 1.** Vibronic states & absorption spectroscopy; circular dichroism spectroscopy.
7 (17)	Oct. 21 (W)	**Optical spectroscopy 2.** CD spectroscopy – continued; emission spectroscopy.
7 (18)	Oct. 23 (F)	**Optical spectroscopy 3.** Emission spectroscopy – continued.
Enzyme Kinetics (SLB)		
8 (19)	Oct. 26 (M)	**Fundamental kinetics 1.** Rate equations.
8 (20)	Oct. 28 (W)	**Fundamental kinetics 2.** Progress curves and graphs of initial rates.
8 (21)	Oct. 30 (F)	**Enzyme kinetics 1.** Rapid equilibrium and steady-state kinetics.
9 (22)	Nov. 2 (M)	**Enzyme kinetics 2.** Enzyme assays and analysis of kinetic data.
9 (23)	Nov. 4 (W)	**Enzyme kinetics 3.** Inhibition models and determination of inhibition constants (K_i).
Enzyme Catalysis & Mechanism (SLB)		
9 (24)	Nov. 6 (F)	**Reactivity of amino acids revisited.** Side chain chemistry, covalent modification.
–	Nov. 9 (M)	**No Class** – Fall Study Break
–	Nov. 11 (W)	**University Closed** – Remembrance Day
–	Nov. 13 (F)	**No Class** – Fall Study Break
10 (25)	Nov. 16 (M)	**Midterm test #2 (15% of final grade)** **Content: Lectures 12 & 14-24.**
10 (26)	Nov. 18 (W)	**General acid-base catalysis 1.** Why are nonenzymatic reactions slow? Transition state stabilization.
10 (27)	Nov. 20 (F)	**General acid-base catalysis 2.** Mechanisms of isomerases.
11 (28)	Nov. 23 (M)	**Promoting hydrolysis reactions 1.** Covalent catalysis.
11 (29)	Nov. 25 (W)	**Promoting hydrolysis reactions 2.** Electrophilic catalysis.
11 (30)	Nov. 27 (F)	**Design of enzyme inhibitors.** Transition state analogues, suicide inhibitors, activity profiling.

12 (31)	Nov. 30 (M)	**Stabilization of carbanions 1.** Pyridoxal phosphate as a coenzyme.
12 (32)	Dec. 2 (W)	**Stabilization of carbanions 2.** Thiamine pyrophosphate as a coenzyme.
12 (33)	Dec. 4 (F)	**Redox reactions 1.** NAD^+ as a coenzyme.
13 (34)	Dec. 7 (M)	**Redox reactions 2.** FAD as a prosthetic group with coenzyme function.
13 (35)	Dec. 8 (Tu/[M])	**Bond-forming reactions 1.** Phosphoryl transfers and positional isotope exchange.
13 (36)	Dec. 9 (W)	**Bond-forming reactions 2.** Biotin as a prosthetic group.
Final Examination (40% of final grade): To be scheduled by the Registrar during the Exam Period of December 11-20		

Syllabus Appendix

(Formerly University Policies and Statements)

Follow the link below:

Syllabus Appendix: Student Supports & University Statements, Policies, and Guidelines