CHM 379H1: BIOMOLECULAR CHEMISTRY

Winter 2024 Course Syllabus

I   TEACHING TEAM

INSTRUCTORs

Name: Haissi Cui
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Office: Lash Miller, 80 St George St, Room 443

Student hours: Tuesday and Thursday, 3.15 – 4.15 pm in Lash Miller, Room 443, available both in person and online. For student hours outside of this time, please schedule by email at least 24 hours in advance.

TAs

Name: Santiago Tijaro Bulla
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Name: Samuel Nyandwi
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II   COURSE OVERVIEW

COURSE DESCRIPTION:

This is a laboratory-based course in biological chemistry. Students will perform a complete research project to study the structure/function relationships of an engineered protein while learning many of the core techniques in the field. The lectures will discuss the theory behind the techniques and highlight how they are used in modern biological chemistry research and industry. The chemical and biochemical principles learned in earlier courses will be applied, and a basic understanding of organic and biochemistry will be assumed. This information will serve as a basis for independent research and more advanced courses in biological and biophysical chemistry.

STUDENT LEARNING OUTCOMES:

•   Students will learn how to clone protein-coding genes into plasmids and introduce point mutations in these genes using mutagenic primers using the PCR methods.
•   Students will gain proficiency in designing primers and analyzing sequencing data to confirm mutations.
•   Students will learn how to use E. coli for recombinant protein expression and will gain hands on experience of purification of proteins from E. coli using affinity chromatography methods.
•   Students will learn the principles of and gain hands-on experience in using SDS-PAGE to test protein identity and purity.
•   Students will learn the principles of and gain hands-on experience in the characterization of enzyme activity.
•   Students will gain practice with analyzing scientific data and present their results both orally (PowerPoint presentations) and as written reports.

PREREQUISITE COURSE(S):

This course assumes you have a basic understanding of introductory biological chemistry and know the chemical structures of the main components of proteins, DNA, RNA, sugars, lipids.

Prerequisites: (CHM247H1/CHM249H1 with a minimum grade of 63%), CHM347H1, BCH210H1

READINGS:

"Biochemistry" by D. Voet & J. G. Voet, 4th Edition, Wiley 2011. Any other good introductory text, such as "Fundamentals of Biochemistry" by Voet, Voet, & Pratt is also fine. The Molecules of Life (used in CHM220) is also good for sections on protein structure.

LABORATORY OBJECTIVES:

The labs are the central part of this course. Hands-on experience is vital for experimental biological chemistry and full attendance at labs is required. The TAs will help you by showing you how to perform specialized techniques, operate equipment, and interpret data. In preparation for each lab, you will need to read the lab manual and complete pre-lab tasks. Your lab notebook will be evaluated to encourage good record keeping.

III   COURSE ORGANIZATION

CHM209H is divided into classes and laboratory sessions. Generally, classes will be held on Tuesday and Thursdays and labs on Friday, but individual Tuesday and Thursday will be converted to labs (see course schedule). The course will be fully in-person according to university guidelines. Should there be changes in in-person lectures and course organization, we will do our best to notify you at the earliest possible moment.

We highly encourage you to attend the lecture and to ask questions if something is unclear. Full attendance at labs is required. Lecture slides will be uploaded to Quercus prior to each week's class. If the university should decide to transition back to online classes, we may choose to change the format and availability of lecture recordings.

Students will work in **groups of 2 on their Lab Project and will hold presentations in groups of 4.** We have set deadlines for various aspects of the project throughout the term which can also be found in the schedule on the following pages. Lab reports and writing exercises must be submitted individually.

COURSE SCHEDULE & RELEVANT SESSIONAL DATES:

C- Class, L- Lab.

Wk	Mon.	Tues. 2pm	Thurs. 2 pm	Fri. 9 am to 1 pm
Part I				
1	Jan. 8	C-Intro to class: Background on aminoacyl-tRNA synthetases and their activity Flowchart of experiments with timeline will be provided Organize groups	C-PCR and cloning methods, electrophoresis Behind the scenes: TAs provide pcDNA vector with mutations	L-Pipetting Make and autoclave LB Prepare Kanamycin and Ampicillin plates Prepare agarose gel Set up PCR to introduce mutations into RARS1 in pcDNA vector Set up PCR to amplify RARS1 from pcDNA vector

				Digest pET vector
2	Jan. 15	L-Agarose gel, analyze PCR product	C-restriction enzymes, ligases, Gibson assembly, Golden Gate assembly	L-Purify PCR product and digested pET vector Assembly reactions Heat shock transformation Writing and research skills
3	Jan. 22	C-plasmids Plan restriction enzyme digest (computational lab)	L-Set up mini-prep cultures Prepare agarose gel	L-Mini-prep DNA, quantify plasmid DNA Analytical restriction enzyme digests & Agarose gel Prepare plasmid DNA for Sanger sequencing Prepare LB medium for large scale expression
4	Jan. 29	C-Sequencing & bioinformatics Check sequences (computational lab) Behind the scenes: TAs transform into BL21 Codon plus (RIPL)	C-Protein expression Techniques UV/Vis, Expasy etc. Behind the scenes: TAs inoculate overnight cultures	L-Inoculate large scale expression culture Measure OD, collect data for growth curves Collect sample for SDS PAGE Induce with IPTG Make buffers for purification (Ni-NTA lysis buffer, Ni-NTA elution buffer, anion exchange loading buffer, anion exchange elution buffer) Behind the scenes: TAs harvest bacteria in the evening and collect sample for SDS PAGE
5	Feb.5	L-SDS PAGE on cells to check expression	C-Chromatography and protein purification	L-Lyse cells, Centrifuge lysate Column chromatography - Ni-NTA Digest for 30 min with SUMO protease Column chromatography - Ni-NTA Collect samples for SDS PAGE

				Quantify and freeze protein
6	Feb. 12	L-SDS-PAGE of purified protein	C-Recap before presentation day	***Presentation Day#***
	Feb. 19	***Reading week***		
Part II				**Characterization**
7	Feb. 26	C-Review	Midterm test (29.02.)	L-FPLC: Anion exchange followed by SDS PAGE NMR theory Behind the scenes: TAs concentrate and freeze purified protein
8	Mar. 5	C-CRISPR/Cas9 theory and planning (computational lab)	C-NMR of proteins with lab visit (group I) protein folding, protein structures (CD, fluorescence) installation of Pymol (group II)	L-Testing protein stability: Measuring melting temperature with fluorescence
9	Mar. 12	C-NMR of proteins with lab visit (group II) protein folding, protein structures (CD, fluorescence) installation of Pymol (group I)	C-X-ray and cryo-EM for structure determination of proteins	L-CRISPR/Cas9 and Golden Gate assembly
10	Mar. 19	C-Pymol, part 1 (computational lab)	C-Pymol, part 2 (computational lab)	L-Testing enzyme activity: ATP consumption
11	Mar. 26	C-protein mass spectrometry Behind the scenes: TA submit sample for analysis by mass spectrometry	C-Recap before presentation day	***Presentation Day***
12	Apr. 1	C-Review before the final exam	C-Reports Due	

IV   EVALUATION/GRADING SCHEME

OVERVIEW:

Class test	15%
Final exam	35%
Lab total	50%

ASSESSMENT DATES & MARK BREAKDOWN:
1. Class Test (February 29th): 1h during class time.
2. Final Exam (in exam period)
3. Labs:

Formal Lab Report (due April 4th)	20%
Lab presentation (Feb. 16th and March. 29th, best out of 2)	10%
Lab performance and notebook (due April 4th)	10%
Writing exercise (Jan. 26th)	10%

For students missing the term test for a valid reason, a makeup test will be offered.
Makeup labs and makeup presentation dates will not be offered.

V   COURSE POLICIES

- Each member of this course is expected to maintain a:

(i)   professional and respectful attitude during all course activities, including classes, laboratories, tutorials, and online activity.
(ii)   personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met.
(iii) collection of notes recorded independently based on concepts covered in course activities (students registered with Accessibility Services requiring a class note-taker will have access to this accommodation)
(iv)   familiarity with the university policy on Academic Integrity (overleaf)

- The University of Toronto is committed to equity, human rights, and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. As a Course Instructor, I will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wish to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, we encourage you to reach out to the staff in our Equity Offices.

- If you are absent from your studies due to illness or other reasons and unable to complete course work (e.g., a term test or an assignment) then a piece of written documentation is required. The following four items are the recognized forms of documentation:

  1. Absence Declaration via ACORN (please note the circumstances under which an absence declaration can and cannot be submitted)
  2. U of T Verification of Illness or Injury Form
  3. College Registrar's letter
  4. Letter of Academic Accommodation from Accessibility Services

  Students who complete the ACORN Absence Declaration form must additionally contact me/the course coordinator/the course administrator to discuss their situation within five business days of the missed piece of work. This is essential action for any consideration to be granted.

  For extended absences and for absences due to non-medical reasons, make sure to contact your College Registrar's Office. They can help you decide between a request for an extension or other types of academic consideration.

- If you suspect or know that you have a disability that is affecting your studies, learn about the services and supports available through Accessibility Services. A disability can be physical disability, sensory disability, a learning disability, mental health disorder or a short-term disability like an injury. If you are not sure whether you have a disability, you can confidentially contact Accessibility Services with your questions.

- The use of generative artificial intelligence tools and apps is strictly prohibited in all course assignments unless explicitly stated otherwise by the instructor in this course. This includes ChatGPT and other AI writing and coding assistants. Use of generative AI in this course may be considered use of an unauthorized aid, which is a form of cheating.

- Please send emails from your mail.utoronto.ca email to the instructor's utoronto.ca addresses (listed in Section I). Include "CHM379H" in the subject line to ensure that we can prioritize your emails. Students are required to monitor their mail.utoronto.ca emails regularly.

  In addition, the email function in Quercus can be used (Inbox > Compose a new message > Course: CHM379 > Recipient: Teachers). Efforts will be made to respond to all emails within 24 hours on weekdays.

- Course materials are provided for the exclusive use of enrolled students. These materials should not be reposted, shared, put in the public domain, or otherwise distributed without the explicit permission of the instructor. These materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by

copyright. Students violating these policies will be subject to disciplinary actions under the Code of Student Conduct.

- A penalty of 10% per day is applied to all coursework for a maximum late submission period of 10 days, after which the assignment will receive a grade of 0. For example, a submission of the writing exercise (10% total) on the 3rd day after the original deadline results in a maximum grade of 7% (70% of 10%).

- *Inform the instructors and your group members* as soon as possible if you are unable to complete coursework for an extended period of time. Depending on the situation, missed project components may be reweighted onto other components where you have contributed.

  - Submission of coursework will be through Quercus if not mentioned otherwise.

  - If you believe there is an error in an assessment, please email us. We will assess whether a grade adjustment (applicable to the entire class) is warranted.

    Non-multiple choice questions on the Midterm and Final Assessments are manually graded according to answer keys containing specific grading schemes. You may request a regrade, but the regrade occurs on an all-or-none basis. A request for regrade of a single question will result in the entirety of the assessment being regraded. Alerting us of arithmetic errors in tallying of scores does not constitute a regrade request.

VI   TECHNOLOGY REQUIREMENTS

- Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here: https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/

- Advice for students writing online assessments (quizzes etc.): https://studentlife.utoronto.ca/task/online-exams-and-tests/

- This course requires the use of computers, and technical issues are possible. When working on a piece of academic work, students are responsible for scheduling enough time to allow for reasonable delays due to technical difficulties to be overcome, so such issues will not be acceptable grounds for deadline extension. Particularly, maintaining an up-to-date independent backup copy of your work is strongly recommended to guard against hard-drive failures, corrupted files, lost computers, etc.

- A laptop or a comparable device that can support 1) an internet browser, 2) Pymol, and 3) A plasmid Editor software will be needed for computational labs**.**

VII   INSTITUTIONAL POLICIES & SUPPORT

ACADEMIC INTEGRITY

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

On quizzes and term tests:
1. Using or possessing unauthorized aids. **Please note that the use of websites (such as Chegg.com or the course discussion board) to post quiz/term test questions or to post/access answers to questions is an academic offence under the University of Toronto's Code of Behaviour on Academic Matters. Alleged instances of this nature are forwarded to the Faculty of Arts & Science Student Academic Integrity office.**
2. Looking at someone else's answers or collaborating/discussing answers during a quiz or term test.
3. Misrepresenting your identity.

In general academic work:
1. Falsifying institutional documents or grades.
2. Falsifying or altering any documentation required by the University.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see www.academicintegrity.utoronto.ca/).

Plagiarism Detection

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the

purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq).

COPYRIGHT

If a student wishes to copy or reproduce class presentations, course notes or other similar materials provided by instructors, he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited.

ACCESSIBILITY NEEDS

Students with diverse learning styles and needs are extremely welcome in this course. The University of Toronto is committed to accessibility: if you require accommodations for a disability, or have any other accessibility concerns about the course, please contact Accessibility Services as soon as possible.

ACCOMMODATIONS FOR RELIGIOUS OBSERVANCES

Following the University's policies, reasonable accommodations will be made for students who observe religious holy days that coincide with the due date/time of an assignment, tutorial, class or laboratory session. Students must inform the instructor **before** the session/assignment date to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT
The following are some important links to help you with academic and/or technical service and support:

- General student services and resources at Student Life
- Full library service through University of Toronto Libraries
- Resources on conducting online research through University Libraries Research
- Resources on academic support from the Academic Success Centre
- Learner support at the Writing Centre
- Information for Quercus Support

ACKNOWLEDGEMENT OF TRADITIONAL LANDS

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca and, most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.