Chemistry
UNIVERSITY OF TORONTO

CHM 209H1 S: Science of the Modern Kitchen

Winter 2025 Course Syllabus

I TEACHING TEAM

INSTRUCTORS

Name: Haissi Cui
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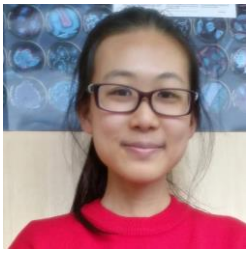
Student hours: Wednesday, 3:15 - 4:15 PM in LM443, available both in person and online. For student hours outside of this time, please schedule by email at least 24 hours in advance.



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TAs

Demo TA:
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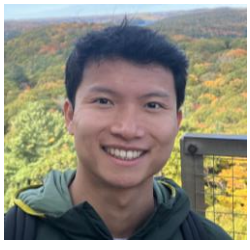

Marking TA:
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II COURSE OVERVIEW

COURSE DESCRIPTION:
CHM209 is intended for non-science majors who wish to acquire an understanding of fundamental chemistry principles relevant to our daily lives and, in particular, food and cooking. It can be used to satisfy breadth requirements in Category 5 (The Physical and Mathematical Universes).

We will examine topics such as the scientific method, molecular structures and interactions, and the nature of chemical reactions. We will discuss the chemical properties of many different types of foods, and how they can be manipulated to achieve desirable transformations in appearance, taste, smell, and texture. Each class is accompanied by a demonstration focusing on a particular ingredient, recipe or technique in food preparation which illustrates concepts covered in lecture.

STUDENT LEARNING OUTCOMES:
Broadly speaking, we hope students will leave this course having developed a greater appreciation for the physical and chemical processes at work on the microscopic level which contribute to what we experience macroscopically. We aim to equip you with foundational chemistry knowledge that would allow you to do more in-depth research into any food chemistry or molecular gastronomy-related topic of your own interest. You will also practice applying the scientific method to everyday problem-solving, and learn to critically examine the vast expanse of food and cooking-related information that is available digitally.

Specific to the chemistry concepts covered in CHM209, upon course completion students should be able to:
- Understand and explain the nature of and relationships between elements, atoms, molecules, ions, and chemical compounds
- Understand the characteristics of different states of matter, and what is required for interconversion between these states
- Explain the chemical basis of smell, taste, and colour
- Describe bonding and interactions in water, and understand its implications for food chemistry
- Understand the nature of and interactions between acids and bases
- Understand what is happening at the molecular level during processes of diffusion, emulsification, phase separation, gelation, and how these processes are useful in food preparation
- Recognize chemical reactions alongside their kinetics and chemical equilibria
- Understand the roles of enzymes in nature and how we can harness their properties to carry out transformations in food chemistry
- Apply molecular concepts in relation to the cellular metabolism of microorganisms
- Apply the chemistry concepts to predict the behaviour and properties of chemical reactions and more complex systems in the kitchen
- Formulate hypothesis and methods to probe scientific questions
- Review and evaluate scientific information and literature on selected topics
- Work collaboratively in group project and clearly present scientific knowledge to a diverse audience in written and visual formats

PREREQUISITE COURSE(S):
CHM209H has no prerequisites, and may be taken by students with no science background (beyond compulsory science education in high school). Student feedback from past years, however, suggests that the course load for CHM209 is most appropriate for those who have taken grade 11 chemistry. We will provide all necessary introductory information needed to succeed in the course, but concepts will grow in complexity at a rapid pace and thus present a greater learner curve to those without senior high school level science background.

COURSE EXCLUSIONS:
Students cannot receive credit for CHM209 if they have already passed any of the following: CHM135H1/CHM136H1/CHM138H1/CHM139H1/CHM151Y1.

READINGS:
There is no required text for this course. Lecture notes will be posted to the class Quercus site ahead of each class, along with virtual demonstration videos and other supplementary materials. The lecture notes and demonstrations contain all content that we expect students to understand and which we consider testable. The references listed below are simply suggestions should you desire to check your understanding using other sources.

A good reference text is "**The Science of Cooking**" by Provost, Colabrov, Kelly, and Wallert (published by Wiley). This is available online through the UofT Libraries catalogue. The guided assignments in the text are useful practice questions, and you do not need to read through entire chapters to work through them. Where relevant, guided assignments from this text will be posted as practice problems on Quercus.

"**The Kitchen as Laboratory**", edited by Vega, Ubbink, and van der Linden is another good reference on molecular gastronomy, also available through UofT libraries.

Other good references which are available through public libraries: "**On Food and Cooking – The Science and Lore of The Kitchen**" by Harold McGee, "**The Food Lab – Better Home Cooking Through Science**" by J. Kenji Lopex-Alt, "**Culinary Reactions – The Everyday Chemistry of Cooking**" by Simon Quellen Field, and "**Cooking for Geeks – Real Science, Great Hacks, and Good Food**" by Jeff Potter.

III COURSE ORGANIZATION

CHM209H is organized into weekly units. With the exception of Reading Week (February 17 - 21, 2025), and the day during which the Midterm Assessment takes place (February 26, 2025), **class will be held each Wednesday from 1:00 to 3:00 PM**. 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 participate in activities, work through practice problems given in class, and to ask questions if something is unclear. Lecture slides will be uploaded to Quercus prior to each week's class.

Post-class assignments for each week will be available on Quercus. These take the form of 10 multiple choice questions pertaining to the key concepts of each week's class, and are intended to keep you on track as concepts covered later in the course rely on understanding of concepts introduced in earlier classes. Each assignment opens immediately after class (Wednesday at 3:00 PM) and closes at the start of the following week's class (Wednesday at 1:00 PM), with the exception of due dates that would fall during Reading Week or Final Exam Period. See course schedule on following pages for full list of assignment due dates.

Students will also work in **groups of 4 or 5 on a Term Project**. This is an opportunity to research a food/cooking-related question of your choice, and to apply the concepts learned in class to a specific topic which interests you. The results of this literature search will then be distilled into a 5-minute movie. Documents containing details on the Term Project can be found on Quercus. We have set deadlines for various aspects of the project throughout the term (choosing a topic, finding key references, writing a script, etc) which can also be found in the schedule on the following pages.

COURSE SCHEDULE & RELEVANT SESSIONAL DATES:

WEEK	CLASS DATE	CLASS TOPICS **Deadlines and Reminders**
1	Jan 8	The Science of the Modern Kitchen ▪ science and its connection to everyday cooking ▪ introduction to the scientific method and how it can help you become a better cook **Form groups of 4-5 for term project (ASAP) and brainstorm project topics**
2	Jan 15	Chemical Bonds and their Properties ▪ introduction of elements and the periodic table ▪ discussion of the different kinds of bonds: ▪ molecular properties of water ▪ solutions **Assignment 1 due Jan 15 at 1:00 PM**
3	Jan 22	Taste & Smell ▪ the connection between taste and smell ▪ molecular structures that convey a fragrance ▪ the concept of functional groups ▪ stereochemistry ▪ introduction to proteins **Assignment 2 due Jan 22 at 1:00 PM** **Term Project:** **submit by Jan 22 to ensure sufficient time for review and approval** **finalized topic approved by Jan 23, 11:59 PM**

4	Jan 29	Acids and Bases ▪ introduction to reactions ▪ chemical equilibria ▪ pH and pKa ▪ food as pH indicators **Assignment 3 due Jan 29 at 1:00 PM**
5	Feb 5	Colours and Colour Changing Foods ▪ light and colour ▪ single and double bonds ▪ molecular orbitals ▪ conjugated systems ▪ edible coloured compounds ▪ the science behind changing colours in the kitchen **Assignment 4 due Feb 5 at 1:00 PM** **Term Project: list of references due Feb 5, 11:59 PM**
6	Feb 12	Fats, Lipids & Emulsions ▪ non-covalent, dipole-dipole interactions ▪ hydrophobicity vs. hydrophilicity ▪ hydrophobic effect ▪ properties of lipids and how we use them in cooking ▪ how understanding phase separation, emulsifiers and stabilizers helps in cooking **Assignment 5 due Feb 12 at 1:00 PM**
-	-	*READING WEEK*
-	Feb 26	**MIDTERM ASSESSMENT** (in class, no new material this week) **Assignment 6 due Feb 26 at 1:00 PM**
7	Mar 5	Carbohydrates ▪ monomers vs. polymers ▪ monosaccharides, disaccharides, polysaccharides ▪ glycosidic bonds ▪ hydrolysis ▪ starch vs. fiber ▪ amylose and amylopectin ▪ colloids and hydrocolloids ▪ diffusion ▪ spherification and reverse spherification in molecular gastronomy

8	Mar 12	Proteins ▪ amino acids ▪ peptide bonds ▪ protein structures ▪ reaction coordinate diagrams ▪ free energy of reaction (ΔG) ▪ energetically favourable vs. unfavourable reactions ▪ equilibrium constant (K_{eq}) ▪ two-state equilibrium ▪ enthalpy and entropy ▪ hydrophobic effect ▪ cooking is just protein aggregation and denaturation **Assignment 7 due Mar 12 at 1:00 PM**
9	Mar 19	Reactions ▪ reactants, products, and transition states ▪ free energy of activation ▪ rate of a reaction ▪ concentration and temperature effects ▪ what everyone has been waiting for: the Maillard reaction! ▪ pH effects ▪ caramelization ▪ other reactions important in cooking **Assignment 8 due Mar 19 at 1:00 PM** **Term Project: draft for peer-to-peer review due Mar 19, 11:59 PM**
10	Mar 26	Enzymes ▪ kinetics ▪ the concept of catalysis ▪ free energy of activation (ΔG±) ▪ examples of how enzymes are used in food preparation ▪ substrates, active sites, enzyme-substrate complexes ▪ enzyme specificity ▪ cofactors, apo-enzymes, holo-enzymes ▪ vitamins and what they actually do **Assignment 9 due Mar 26 at 1:00 PM** **Term Project: Peer-to-peer review comments due Mar 26, 11:59 PM**
11	Apr 2	Fermentation ▪ microorganisms and how they help us to make food ▪ yeast ▪ the science of bread (autolysis, amylase, gluten) ▪ disulfide bonds ▪ Ideal Gas Law

		▪ metabolism ▪ lactic acid and ethanol fermentation **Assignment 10 due Apr 2 at 1:00 PM** **Term Project: Final Project due Apr 4, 11:59 PM***** **Assignment 11 due Apr 9 at 11:59 PM***** (Officially, no due dates can be set after the last day of classes on April 04. We will, however, set up Quercus to accept submissions without penalty until the date of the final assessment.)

IV EVALUATION/GRADING SCHEME

OVERVIEW:

Assignments (x11; only highest-scoring 10 will be counted): 20%
5% completion (automatic if assignment is opened and submitted)
15% accuracy of answers

Group project: 35%
5% approval of topic and key hypothesis by instructors before deadline
5% scientific rationale and list of references
5% script and storyboard
5% peer-to-peer review (contingent on submission of draft for review)
15% completed movie

Midterm and Final Assessments: 45% total
15% Midterm + 30% Final OR 20% Midterm + 25% Final

ASSESSMENT DATES & MARK BREAKDOWN:

Midterm Assessment: a two-hour written assessment to be held on February 26, 2025, during regular class time
15 or 20% of course grade; combination of multiple choice and short answer questions.

For students who miss the Midterm Assessment for valid reasons, the weight of the Midterm will be transferred to the Final Assessment (i.e. the Final Assessment will contribute to 45% of the student's final grade).

Final Assessment: to be held during exam period (date TBD)
25 or 30% of course grade; combination of multiple choice and short answer questions.

A missed, in-person Final Assessment will require rescheduling through the Faculty Registrar Services.

IMPORTANT: if an unexpected technical issue occurs with a university system (e.g., Quercus services, network outage) that affects availability or functionality, it may be necessary to revise the timing or weighting of the assessments.

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, Gemini, Claude, Microsoft Copilot 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 (haissi.cui@utoronto.ca, yongjia.bu@mail.utoronto.ca). Include "CHM209H" 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: CHM209 > 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 (Quercus assignments as well as Term Project components), for a maximum late submission period of 5 days, after which the assignment will receive a grade of 0. For example, a submission on the 3rd day after the original deadline results in a maximum grade of 70%.

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

- Weekly assignments take the form of Quercus quizzes and thus must be submitted through Quercus. Components of the Term Project vary in submission format. Details can be found in the Term Project Guidelines document.

- Weekly assignments are automatically graded by Quercus. If you believe there is an error, please email us (haissi.cui@utoronto.ca, yongjia.bu@mail.utoronto.ca, or angus.chiang@utoronto.ca). 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/student-policies-guidelines/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.

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.

ACCOMMODATION 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.