

CHEM 181: Chemical Biology

Instructor

Prof. Jane M. Liu (SN-216)
jane.liu@pomona.edu

Office Hours

M 9-11 am, T 1:30-3:30 pm; or by appointment

Class

TR 8:10 am – 9:25 am

Prerequisite: CHEM115 PO (Biochemistry)

A Message from Prof. Liu:

Welcome! The Chemistry Department is committed to diversity and inclusion. I want our classroom to be inclusive, equitable, and full of participation. As your instructor, I am committed to creating a classroom environment that welcomes and supports all students, regardless of race, gender, religious beliefs, etc. Regardless of where you're starting out, I am committed to helping you succeed in this class. I expect that your unique background will enrich our learning environment and I am excited to have you in this class. We all have implicit biases, and I will try to continually examine my judgments, words, and actions to keep my biases in check and treat everyone fairly. I hope that you will do the same and that you will let me know if there is anything I can do to make sure everyone is successful in this class. If there are any aspects of the instruction or design of the course that result in barriers to your learning, please let me know as soon as possible. If you do not feel comfortable approaching me directly, please feel free to reach out to one of the Chemistry Department Liaisons.

The primary means that I will communicate with the class is via email. You should expect emails from me each week. Emailing me is a great way to communicate with me!

It is common that college students experience a great deal of stress. In a class of this size, there will likely be a few individuals who are going through hard times and who are experiencing psychological difficulties. If you are feeling miserable, or you think you are experiencing psychological problems, please do seek help! If you think you may benefit from psychological help, please consider reaching out to Monsour Counseling and Psychological Services (MCAPS), 909-621-8202. You may also use TimelyMD which provides 24/7 free and unlimited medical and mental health services. To register and access this service, please visit: <https://timelycare.com/schools/index.php?school=7health&>.

COURSE OVERVIEW

This upper-level course, for students with a background in both organic chemistry and biochemistry, will address the following questions:

- **What is chemical biology?**
- **How can chemistry be used to advance the study of biological systems?**
- **How can chemists understand and control biological systems?**
- **What can chemical biology do to ethically and justly advance science and human health?**

Some historians suggest that the roots of chemical biology lie in research conducted in the 19th century, which set the foundation for the fields of biology and chemistry. In addition, some scientists may also consider the deciphering of metabolic pathways, throughout the 20th century, representative of chemical biology. The journal *Nature Chemical Biology* defines chemical biology as a field that combines the scientific ideas and approaches of chemistry, biology, and allied disciplines to understand and manipulate biological systems with molecular precision. In this course, we will consider this definition and explore examples of each of these views of chemical biology.

Engagement in this course will contribute to your ability to:

- Communicate effectively with others
- Problem solve
- Apply chemical knowledge to solve problems related to human health
- Work effectively with others
- Be an autonomous learner
- Process information and interpret data
- Think critically

INTENDED LEARNING OUTCOMES

After successfully completing this course, students will be able to:

- Articulate their personal responsibility – and those of their STEM colleagues – for eliminating injustice and creating more equitable outcomes in chemistry and biology
- Recognize, draw, and analyze chemical structures of biomolecules
- Compare and contrast how biomolecules are synthesized by living cells and by scientists in the lab
- Explain, with examples, how chemistry can be used to advance molecular understanding of biological systems
- Explain, with examples, how chemists can manipulate or mimic biological systems to do chemistry
- Identify gaps in scientific knowledge by reading chemistry and biology primary literature

COURSE MATERIALS

All course materials will be posted onto the course Sakai site. It is your responsibility to make sure that you have the correct materials. I frequently communicate information regarding the course via email. You are expected to read these emails.

GRADES

Final Grade Calculation

Exams, 2 highest scores:	30%
Exam, lowest score:	10%
Participation:	15%
Figure Facts:	15%
Proposal:	30%

Grading Scale

A	93-100	C	73-76
A-	90-92	C-	70-72
B+	87-89	D+	67-69
B	83-86	D	63-66
B-	80-82	D-	60-62
C+	77-79	F	≤59

Grading Policy: For most assignments, you will be provided rubrics beforehand that clearly lay out the expectations for the assignment and how you will be graded. Any query regarding scores on graded assignments or exams should be presented within three days of return of the assignment/exam. It is your responsibility to reach out to me to make any adjustments. Please note that I reserve the right to regrade the entire submission, and as a result, I may raise or lower your entire score. After three days, all scores become final and unalterable.

Exams: There will be three exams comprised of short answer and short essay questions. The questions will be drawn from lectures, in-class activities, as well as relevant primary literature that you may not have been previously assigned. Your lowest exam grade will count as 10% of your final grade, and the other two exams will each count 15%. All three exams will be open notes, cumulative, and take home. Exam due dates/times will be clearly communicated. No make-up exams will be given. If you know in advance that you will miss an exam, please notify me at least one week ahead of time so that alternative arrangements

can be made. If you miss an exam due to an emergency, your other two exams will each count 20% of your total grade.

Participation: This course is designed for you to come to class and participate. That being said, life happens. I have designed assignments and assessments so that you can miss a certain number without affecting your grade. In addition to mastering the material yourself, you are responsible for assisting the other members of the class in their understanding of the material. Unless you have developed an alternative agreement with me, you should try to not miss class. Please be respectful to me and your fellow classmates and show up to class on time. You can expect your grade to drop substantially with 3 or more absences. Valid reasons for missing class include illness, religious observations, or family emergencies. **You are responsible for handing in all assignments on time and obtaining all activities, regardless of missed classes.** Participation will be graded according to the rubric available on Sakai (resources).

This course will make extensive use of primary literature. Different types of assignments are assigned to help you develop different skills related to primary literature.

Figure Facts: These assignments will allow you to focus on data-interpretation and the “take home points” of primary research articles. Each Figure Facts will be graded on a scale of 1-5, with the grading based on whether your answers contain sufficient detail and are written in your own words. Your lowest Figure Facts score of the semester will be dropped.

Grant Proposal Project: This assignment will allow you to engage, independently, with scientific literature and contribute to the field by proposing the next experimental step along a trajectory of scientific discovery. Throughout this course, you will be exposed to many innovative experimental approaches being developed and used by chemical biologists to address questions in biology and chemistry. Based on your experience with this material, each student will develop a novel research proposal that uses chemical biology to address a problem concerning human health that disproportionately impacts a marginalized community. Students will generate a single, testable question (or hypothesis) and write an **8-page** grant proposal to the National Institutes of Health (NIH). In addition to my evaluation of the proposal, all proposals will be reviewed during an in-class study section. **Rubrics will be provided.**

What is the human health problem you want to address? Week 3 (10 points)

Annotated bibliography of problem. Week 4 (15)

Meeting with Prof. Liu to discuss question / hypothesis. Week 6 (10)

Annotated bibliography of question/hypothesis. Week 8 (25)

Spring Break

Specific Aims page. Week 9 (20)

Outline of paper. Week 11 (20)

Full draft. Week 13 (20)

Study Section. Week 14 (30)

Final Paper. Last Day of Classes or Finals Week (100)

Due date extension policy: In general, I expect work to be turned in by the communicated due date, which were all decided with careful consideration of all the assignments throughout the semester, along with assignments and exams in other courses that students are commonly cross-enrolled in. Learning to manage due dates and multiple responsibilities will also be helpful for future jobs and internships. However, I recognize that the lives of students are *busy* and in life the only thing that one can really expect is the unexpected. The current state of the world also likely places you under increased pressures and disruptions. Thus, in this class, you each will have **three “Flex Tokens”**. Application of the Flex Token allows you to receive a no-questions-asked deadline extension. By the original due date, you should communicate your use of the Flex Token to Prof. Liu and together you can determine an alternate due date. Note that Flex Tokens **may not** be used for the Final Grant Proposal Paper or Exam 3.

When Flex Tokens are not used, **late work will be accepted** for all assignments (except exams). However, for every 24 hours that the assignment is tardy, a 10% deduction will be applied to your grade on that assignment.

Office Hours: These are guaranteed times when I can be found in my office, ready and waiting for you to come by. You can come by with specific questions. Lots of students do this: they've organized their class notes, homework, etc. and they bring those documents with them and ask specific questions. Some students take notes while we chat. If you do not have a specific question, you can still come to office hours! It may help if you have at least a starting point for the conversation. If you do not have a specific question and you do not have a starting point for the conversation, that is OK too! By just chatting about the course, questions will surely evolve.

Special circumstances: If there are special circumstances, such as illness or other form of emergency, which should be considered regarding any of the stated class policies, please inform me as soon as possible so that alternative arrangements can be made.

Accommodations: Your experience in this class is important to me. Pomona College is committed to making all courses accessible for everyone and **I am committed to making this course accessible to you.** I encourage you to meet with me early in the semester to discuss your Accessibility Resources and Services (ARS) authorized accommodation needs for this course. If you need academic accommodations or have any questions about the accommodations procedure, please contact ARS in the Dean of Students office at disability@pomona.edu or 909-621-8017.

Religious Observances Policy: Our community is strengthened by our great diversity, including various religious and spiritual identities. If you have religious accommodation needs, with respect to specific religious holidays that will affect class attendance and participation, remember the structure of the course is set up to provide flexibility for such instances. You are also welcome to speak to me about your needs. For further advice and consideration, please reach out to the chaplains' office, chaplains@claremont.edu.

Academic ethics and integrity policy: It is important that you develop the ability to work independently as well as the ability to problem-solve with others. I want you to learn how to collaborate with others and at the same time develop your own deep understanding of the course material. Any work that you turn in for a grade should be your own work, written by you – unless collaboration was explicitly assigned as part of the work. You are expected to abide by the Pomona College Standards of Academic Integrity. For the official policy go to: <https://catalog.pomona.edu/content.php?catoid=46&navoid=9114>. Anyone found responsible for violating the College's Academic Honesty Policy will receive a failing grade on that assignment and the Dean of the Students will be notified in accordance with policy. Plagiarism, whether deliberate or unintentional, and cheating on exams is not acceptable.

The use of previously posted solutions in the preparation of your assignments is strictly prohibited. This includes referring to solutions associated with homework or exams turned in by a student in a previous version of the course or answers you find online.

The use of generative AI (genAI), and specifically large language models (e.g., ChatGPT), is permitted on the condition that you are (1) transparent in your use of this tool and (2) that such use does not undermine the learning outcomes of the course. For example, using genAI to write your assignments would undermine your ability to communicate scientific concepts in your own words and develop your scientific writing skills and therefore is strictly prohibited. For any assignment in which genAI is used, you must:

- Provide a cover letter to your assignment indicating both why and how you have used AI in your assignment.

- At the end of your assignment, include a transcript of your interaction with the AI, which can be downloaded directly from most systems.
- If your AI-output includes data/information, you are responsible for verifying accuracy, identifying appropriate academic sources, and citing them properly within your assignment.
 - In this class, it is not appropriate to cite the AI tool itself.
 - It is not uncommon for large language models to fabricate sources and citations, so you will need to seek out the full text to verify the existence and usefulness of any sources you include in your assignments.

PUBLIC HEALTH

The College has guidelines in place to protect public health. In our class specifically, if you are required to wear a mask, I will gently remind you to do so. These guidelines may change during the semester to reflect changing conditions and knowledge; I will let you know if this happens. If you forget your mask, ask me, I may have one for you. If a student is unwilling to do their part to preserve public health in in-person classes, then I will ask them to leave the class. As in-class participation is a major part of the class, this could affect your grade in the class.

What do to if you are not feeling well: One of the most important things you can do is to stay home if you are sick. We often have a culture of trying to “push through” when we are not feeling well, saying things like, “Yeah, I am sick, but I will be OK – I can still go to class”. While this sort of perseverance in general is a good thing, coming to class when you are sick puts other people’s health at risk. So, if you have any symptoms at all, stay home. Again, the structure of the course is set up to provide flexibility for such instances.

What to do if you are seriously ill. If you have an illness or injury that interferes with your ability to do working our class, talk to me! The Accessibility Resources and Services (ARS) office helps students with short-term injuries and illnesses – concussions, broken bones, etc. Please know that you can also always reach out to your class dean for support in navigating these challenges. If you are sick or hurt, I will work with you and with ARS and/ or your class dean to do whatever I can to accommodate your condition.

COURSE TOPICS

In many ways, traditional enzymology and drug discovery fit the definition of chemical biology in that these fields use small molecules to modulate protein function. More recently, technological advances have allowed chemical biologist to employ both large libraries of small molecules and robust screens for biological activity to decipher complex biological systems. This approach benefits from both a firm grasp of synthetic chemistry and an understanding of molecular biology, representing a true intersection of the two fields.

Chemical biologists may also apply their knowledge of chemistry to design tools that advance the study of biology. Chemists have synthesized or engineered dyes, fluorescent proteins, and chemical probes to address an increasing desire to understand biology at a molecular level. In addition, chemists have applied fundamental principles of biology, such as evolution and self-replication, to achieve new chemistry. These are all purported examples of chemical biology that will be explored in this course, along with their implications to science and health, at large.

Schedule (Subject to Change):

Wk	(Lecture) Date	Topic	Proposal Assignments Due 12 pm (noon)
1	(1) 1/16 (2) 1/18	Structure, Chemistry, and the Synthesis of Life What is Chemical Biology? Proteins and protein folding; Bias, STEM and society;	
2	(3) 1/23 (4) 1/25	Protein sequencing Peptide identification	
3	(5) 1/30 (6) 2/1	Peptide synthesis Native chemical ligation	2/2: Problem
4	(7) 2/6 (8) 2/8	Protein synthesis; Bioconjugation Natural product synthesis (NRPS)	2/9: Annot Biblio 1
5	(9) 2/13 (10) 2/15	Natural product synthesis (NRPS) Natural product synthesis (PKS); Exam 1 Handed Out	
6	(11) 2/20 (12) 2/22	Exam 1 Due – Feb 19, 5 pm Nucleic acids Nucleic acids	2/22 or 2/23: Meet with Prof. Liu
7	(13) 2/27 (14) 2/29	The Molecular Biology Toolkit Grant Writing; DNA replication and cloning Overexpressing genes in <i>E. coli</i>	
8	(15) 3/15 (16) 3/17	CRISPR CRISPR	3/8: Annot Biblio 2
	3/11-3/15	<i>Spring Break</i>	
9	(17) 3/19 (18) 3/21	Reporter genes and small molecule screens Solving Molecular Problems by Mimicking Biology Selections and screens	3/22: Specific Aims
10	(19) 3/26 (20) 3/28	Molecular evolution Molecular evolution; Exam 2 Handed Out	
11	(21) 4/2 (22) 4/4	Exam 2 Due – April 1, 5 pm What Chemists Can Do for Biology Chemical probes Orthogonal pairs	4/5: Outline 4/5: Outline
12	(23) 4/9 (24) 4/11	Expanding the genetic code Induced proximity	
13	(25) 4/16 (26) 4/18	CAR-T Cell Therapy TBA; Exam 3 Handed Out	4/19: Full Draft for Study Section
14	(27) 4/23 (28) 4/25	Exam 3 Due – April 22, 5 pm Study Section TBA	
15	(29) 5/3	Last Class; TBA	Final Paper Due: May 1, 12 noon (SR) May 9, 10 pm (JR)