CHEM 181: Chemical Biology

Instructor
Prof. Jane M. Liu (SN-216)
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Class
TR 8:10-9:25 am
Prerequisite: CHEM115 PO

Office Hours
Anytime my office door is open or by appointment

COURSE OVERVIEW

This upper-level course, for those 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 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 both the use of chemistry to advance a molecular understanding of biology and the control of biological systems at a molecular level. 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:

- Recognize, draw and analyzes 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

- David van Vranken and Gregory Weiss. *Introduction to Bioorganic Chemistry and Chemical Biology*.

Additional readings not in your textbooks will be posted onto the course Sakai site. It is your responsibility to make sure that you have the correct reading.

Prof. Liu frequently communicates 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%
Journal Clubs:	17%
Homework/Quizzes:	8%
Proposal:	25%
Participation	10%

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

Exams:

There will be three exams comprised of short answer and short essay questions. The questions will be drawn from lectures, in-class activities, journal club discussions, 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 closed book, cumulative and take home. Exam due dates/times will be clearly communicated; **no late exams will be accepted**. No make-up exams will be given. If you know in advance that you will miss an exam, please notify Prof. Liu at least one week ahead of time so that alternative arrangements can be made. If you miss an exam due to a documented health or family-related emergency, your other two exams will each count 20% of your total grade.

Journal Clubs:

Several of the class meetings are reserved for in-class discussion of primary research papers. During these journal clubs, we will focus on the data and methods presented in the figures and tables, and small groups will be asked to present figures from the paper. In addition, for some papers, you will be asked to write a short (**2-2.5 pages**) review describing the main findings of the paper and the implications of the research. Instructions for these reviews will be posted on Sakai and distributed in class.

Homework: Some class assignments will be collected and graded.

Grading Policy: For most written and oral 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 the student's responsibility to meet with the professor to make any adjustments. Please note that Prof. Liu reserves the right to regrade the entire submission, and as a result, she may raise or lower your entire score. After three days, all scores become final and unalterable.

Original Proposal:

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 in a developing country/region of the world (i.e. not the U.S. or Western Europe). 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 Prof. Liu's evaluation of the proposal, all proposals will be reviewed during an in-class study session.

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)
What is your testable question and/or hypothesis? Week 6 (10)
Annotated bibliography of question/hypothesis. Week 8 (25)
Spring Break. Week 9
Specific Aims page. Week 11 (20)
Outline of paper. Week 12 (20)
Full draft. Week 14 (20)
Study Session. Week 15 / 16 (30)
Final Paper. Week 16 / 17 (100)

Late policy: For all assignments, late work will be accepted. However, for every 24 hours that the assignment is tardy, **a 10% deduction** will be applied to your grade on that assignment.

Discussion and Participation: Your participation grade will be determined by your attendance record, level of involvement during in-class activities, and by the quantity and quality of your contributions during journal club presentations and discussions. A rubric for how participation and attendance will be evaluated is provided for you on the course Sakai site.

Special circumstances: If there are special circumstances, such as illness of other form of emergency, which should be taken into account with regard to any of the stated class policies, please inform Prof. Liu as soon as possible so that alternative arrangements can be made.

Academic accommodations: Prof. Liu asks students who may need accommodations to assure their success to see the appropriate staff member in the Dean of Students Office and then come see her during office hours *before* the third week of class.

Academic ethics and integrity policy: You are expected to abide by the Pomona College Standards of Academic Integrity. For the official policy go to: http://pomona.catalog.acalog.com/content.php?catoid=14&navoid=2524. Plagiarism, whether deliberate or unintentional, and cheating on examinations, are not acceptable.

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 in order 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		**Structure, Chemistry and the Synthesis of Life**	
	(1) 1/17	Central Dogma; What is Chemical Biology?	
	(2) 1/19	Proteins and protein folding	
2	(3) 1/24	Peptide sequencing	
	(4) 1/26	Mass spectrum analysis of peptides	
3	(5) 1/31	Peptide synthesis	**2/3: Problem**
	(6) 2/2	Protein synthesis	
4	(7) 2/7	Natural product synthesis (Intro, NRPS)	**2/10: Annot Biblio 1**
	(8) 2/9	Natural product synthesis (NRPS)	
5	(9) 2/14	Natural product synthesis (PKS)	
	(10) 2/16	Natural product synthesis (PKS cont')	
		Exam 1 Handed Out	
6		**Exam 1 Due – Feb 20, 5 pm**	
	(11) 2/21	Nucleic acids and DNA synthesis	**2/24: Question/Hypothesis**
	(12) 2/23	**Journal Club 1**	
7		**The Molecular Biology Toolkit**	
	(13) 2/28	Grant Writing; DNA replication and cloning	
	(14) 3/2	Constructing genes in *E. coli*	
8	(15) 3/7	CRISPR	**3/10: Annot Biblio 2**
	(16) 3/9	CRISPR cont'	
9	3/13-3/17	*Spring Break*	

10	(17) 3/21 (18) 3/23	Reporter genes and small molecule screens **Solving Molecular Problems by Mimicking Biology** Selections and screens **Exam 2 Handed Out**	
11	(19) 3/28 (20) 3/30	**Exam 2 Due – Mar 27, 5 pm** Directed evolution Molecular evolution	**3/31: Specific Aims**
12	(21) 4/4 (22) 4/6	**Journal Club 2** **What Chemists Can Do for Biology** Chemical Genetics	**4/7: Outline**
13	(23) 4/11 (24) 4/13	Orthogonal chemistry Non-natural amino acids	
14	(25) 4/18 (26) 4/20	**Journal Club 3** *Attend Student Symposium*	**4/21: Full Draft for Study Session**
15	(27) 4/25 (28) 4/27	**Study Session I** **Study Session II** **Exam 3 Handed Out**	
16	(29) 5/2	**Exam 3 Due – May 1, 5 pm** **Journal Club 4**	**Final Paper Due:** **5/3 (5 pm, Seniors)** **5/9 (10 pm, Juniors)**