CHEM 121: Chemical Biology

Instructors
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Class
MF 2:30-3:45 pm

Office Hours
Tu, F 9:15-10:15 am; Th 2-3 pm

PRE-REQUISITES: CHEM 117

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 manipulate or mimic biological systems to do new chemistry?**
- **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, 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 harnessing of biology to advance chemistry. In this course, we will consider this definition and explore examples of each of these views of chemical biology.

Learning outcomes: The successful completion of this course will contribute to your

- Ability to communicate
- Ability to problem solve
- Ability to think critically
- Ability to apply chemical knowledge to solve problems related to human health
- Ability to work with others
- Ability to learn independently
- Ability to process information and interpret data

COURSE OBJECTIVES

- Be able to recognize, draw and analyze chemical structures of biomolecules
- Be able to compare and contrast how biomolecules are synthesized by living cells and by scientists in the lab
- Be able to explain, with examples, how chemistry can be used to study biological systems
- Be able to explain, with examples, how chemists can manipulate or mimic biological systems to do chemistry
- Be able to read, interpret and present primary literature in the field of chemical biology
- Be able to develop a testable question or hypothesis stemming from previous work in the field of chemical biology

COURSE MATERIALS

- Miller and Tanner. *Essentials of Chemical Biology.*
- Waldmann and Janning. *Chemical Biology: Learning through case studies.*

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

GRADES

Exams, 2 highest scores (13.5% each)	27%
Exam, lowest score	8%
Journal Clubs	20%
Homework/Quizzes	10%
Paper	25%
Participation	10%

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 8% of your final grade, and the other two exams will each count 13.5%. 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 17.5% 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 (or 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 pages**) review describing the main findings of the paper and the implications of the research. Instructions for these reviews will be posted on Moodle and distributed in class. Your reviews should be submitted to Moodle prior to class.

Homework: Some class assignments will be collected. At the end of the semester, your lowest homework grade will be dropped.

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 non-developed country/region of the world. Students will generate a single, testable question (or hypothesis) and write a 10-page grant proposal to the National Institutes of Health (NIH). In addition to Dr. 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)
Annotated bibliography of problem. Week 4 (15)
What is your testable question and/or hypothesis? Week 5 (10)
Annotated bibliography of question/hypothesis. Week 8 (25)
Specific Aims Page. Week 9 (20)
Outline of paper. Week 11 (20)
Final draft. Week 13 (20)
Study Session. Week 14 (30)
Final Paper. TBA (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. *You are allowed two unexcused absences without penalty.* A rubric for how participation and attendance will be evaluated is provided for you on the course Moodle 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 me as soon as possible so that alternative arrangements can be made.

Academic accommodations: Should you require accommodations, you must file a request with the Office of Educational Affairs (BC 114, extension 3327). It is your responsibility to self-identify with the Office of Educational Affairs and to provide me with the appropriate documentation from that office at least one week prior to any request for specific course accommodations. There are no retroactive accommodations.

Academic ethics and integrity policy: You are expected to abide by the Drew University Standards of Academic Integrity. For the official policy go to: http://www.depts.drew.edu/composition/Academic_Honesty.htm. Plagiarism, whether deliberate or unintentional, and cheating on examinations, are not acceptable. Any such incidents will be referred to the Academic Integrity Committee.

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):

Week	Date	Topic	Paper Assignments Due 5 pm
1		**Structure, Chemistry and the Synthesis of Life**	
	1/24	Central Dogma What is Chemical Biology?	
	1/28	Proteins Peptide sequencing	
2	1/31	Mass spectrum analysis of peptides	
	2/4	Peptide synthesis	
3	2/7	Protein synthesis	**2/9: Problem**
	2/11	Natural product synthesis	
4	2/14	Natural product synthesis	**2/16: Annot Biblio 1**
	2/18	Natural product synthesis	
5	2/21	**Exam 1**	**2/23: Question/Hypothesis**
	2/25	**Journal Club 1**	
6	2/28	Nucleic acids and DNA synthesis	
		The Molecular Biology Toolkit	
	3/4	How to clone a gene	
7	3/7-3/11	**Spring Break**	
8	3/14	Screens versus selections	**3/16: Annot Biblio 2**
	3/18	GFP and reporter genes	

9	3/21 3/25	**Solving Chemical Problems by Mimicking Biology** Directed evolution Directed evolution	**3/23: Specific Aims**
10	3/28 4/1	**Exam 2** **Journal Club 2**	
11	4/4 4/8	Organization and origins of life **What Chemists Can Do for Biology** Chemical genetics	**4/6: Outline**
12	4/11 4/15	Orthogonal chemistry Non-natural amino acids	
13	4/18	Proteomics	**4/20: Final Draft for Study Session**
14	4/25 4/29	Special topics **Study Session**	
15	5/2	**Exam 3**	**Final Paper Due: TBA**