



Instructor: Lars Plate

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Lecture location: Stevenson Center 5211 (Building 5, Sci & Engr)

Lecture times: TR 9:35 – 10:50 AM

Office Hours: Thursdays at 11 AM

Course Description: This course will introduce fundamental principles in Bioorganic Chemistry, which is also often referred to as *Chemical Biology*. Chemical Biology is an exciting interdisciplinary scientific discipline that bridges concepts from chemistry, biology and physics. The field aims to understand important biological processes at the molecular, cellular, and even organismal level through placing focus on underlying chemical principles that govern these processes. At the same time, Chemical Biologists develop and use chemical tools, such as small molecules, to manipulate and thereby interrogate biological processes. These new insights can then also be applied to re-engineer biological pathways or systems to produce useful chemical compounds or materials. Overall, Chemical Biology encompasses many integrated sub-fields that create transformative applications in biomedicine, energy production, or materials development. For instance, “chemical genetics” is aimed at identifying and developing small molecules that modify a specific protein or enzyme function and thereby serve as new drug leads. “Synthetic biology” reprograms metabolic pathways to produce useful biomolecules such as pharmaceuticals or biofuels. And “Bioanalytical chemistry”, which develops new analytical methods and instruments, is required to characterize the biological molecules and processes.

Prerequisites: It is assumed that you have mastered the material taught in Organic Chemistry 2221 and 2222 as a pre-requisite for this course.

Course Content:

- I. Amino acids, peptides and proteins
 - a. Structure, properties
 - b. Reactivity and chemical modifications
 - c. Chemical and biological synthesis
 - d. Analysis
 - e. Applications
- II. Nucleic acids, RNA and DNA
 - a. Structure, properties
 - b. Chemical and biological synthesis
 - c. Analysis
 - d. Applications
- III. Enzyme catalysis, mechanisms, metabolism
 - a. Bioenergetics
 - b. Principles of enzyme catalysis, catalytic side chains, reaction mechanism
 - c. Role of cofactors in enzyme catalysis
 - d. Secondary Metabolism
 - e. Applications
- IV. Special topics in Chemical Biology (selection)
 - a. Synthetic Biology
 - b. Small-molecule screening/drug discovery
 - c. CRISPR/Cas9 based gene editing
 - d. Proteomics applications

Textbooks: There is NO required textbook for the course. Exams and assignments will be entirely based on the material discussed during lecture and in the course notes. However, you may find the following textbooks useful for your own reference. Textbooks have been placed on reserve in the Science & Engineering Library or can be accessed online. I will also upload review articles as additional references on Brightspace. During lectures, I will refer to the relevant articles or chapters in the textbooks as best as I can.

1. The Organic Chemistry of Biological Pathways (2nd Edition) John E. McMurry, Tadhg P. Begley
(on reserve in the Science & Engineering Library)
2. Chemical Approaches to the Synthesis of Peptides and Proteins P. Lloyd-Williams, F. Albericio, E. Giralt, CRC Press, Boca Raton, 1997
(on reserve in the Science & Engineering Library)
3. Nucleic Acids in Chemistry & Biology (3rd ed) Michael G. Blackburn, Michael J. Gait, Jane A. Grasby, Royal Society of Chemistry, Cambridge, 2006

- (available as digital version through the library)*
4. Introduction to Enzyme and Coenzyme Chemistry, (3rd Edition)
Tim Bugg, Wiley, Hoboken, NJ, 2012
(on reserve in the Science & Engineering Library)
 5. Fundamentals in Biochemistry (5th Edition) Donald Voet, Judith G. Voet, Charlotte W. Pratt
(on reserve in the Science & Engineering Library)

I will occasionally post links to review articles on Brightspace, which might be useful for different section of the course. The links will point directly to the webpage of the article where you can download the pdf (this makes it easier to deal with copyrights). You have to be logged into the Vanderbilt Network to access the full articles and pdf files. If you want to access the files from anywhere else, you can set up Remote Access through a VPN service. Instructions can be found here:

<https://it.vanderbilt.edu/security/secure-communications/remote-access/>

Brightspace: I will maintain a Brightspace site for the course, where I will post reading material, lecture notes, and practice problems and make class announcements. ENSURE that you are signed up to receive Brightspace ANNOUNCEMENTS to your email address or mobile device. Let me know if you have questions on how to enable this option in your Brightspace account.

I will do my best to post lecture notes the night ahead of each class. I encourage you to print out the notes (or bring them in digital format) to class so you can take notes on them.

Grading and Exams: There will be 3 midterm exams and a final exam at the end of the semester. Please refer to the schedule for dates. In addition, there will be a short 5 min oral presentation on a research paper of your choice (with approval from me) on a topic in Bioorganic Chemistry/Chemistry Biology. The overall grading will be based on the following rubric:

Assignment	Points
Exam 1	100
Exam 2	100
Exam 3	100
Oral Presentation	80
Attendance and Participation	20
Final Exam (cumulative)	100

Regrade Requests: Requests for regrades will be accepted for up to 1 week after I return the exams to you. Please explain your reason for the request in writing on a separate sheet of paper (no more than 1 page). Make no marks on the actual exam! Please note that I reserve the option to regrade the entire exam, and not just the part in question. Some exams will be photocopied at random to ensure that all regrade requests are legitimate.

Course Policies: Make-up work will be given for excused absences only according to the Rules and Regulations set forth by Vanderbilt University. If you meet the requirements for a make-up exam, you have one week from the time of the scheduled exam to complete such work. Exceptions will only be made in rare cases.

Accommodations: If you are in need of any accommodations, please let me know as soon as possible. I will make every effort to meet student's needs and to foster an inclusive learning environment.

Academic Integrity:

Vanderbilt's Honor Code governs all work in this course.

Honor Code Pledge: I pledge to pursue all academic endeavors with honor and integrity. I understand the principles of the Honor System, and I promise to uphold these standards by adhering to the Honor Code in order to preserve the integrity of Vanderbilt University and its individual members.

Tentative Schedule*:

Date	Topic
Aug 24	Structure and properties of amino acids, peptides, and proteins
29	Chemical modifications of amino acids and proteins
31	Chemical synthesis of peptides
Sep 5	Chemical synthesis of peptides and proteins, biosynthesis of proteins
7	Biosynthesis of proteins (cont'ed), bioorthogonal reactions, applications
12	Analysis of peptides and proteins: sequencing and mass spectrometry
14	Structure and Properties of nucleosides/nucleotides, nucleic acids
19	Biosynthesis of nucleic acids
21	Chemical synthesis of nucleic acids, chemical modification, applications
26	First Exam
28	DNA sequencing
Oct 3	Bioenergetics
5	Enzyme catalysis and reaction mechanism
10	General acid/base catalysis, covalent catalysis: protease mechanisms
12	<i>Fall Break</i>
17	Aldol reactions, Claisen condensations, glycolysis, TCA cycle
19	Cofactor Chemistry – Pyridoxal dependent enzymes

	24	Cofactor Chemistry – Thiamine pyrophosphate dependent enzymes
	26	Cofactor Chemistry – Nicotinamide dependent enzymes
	31	Second Exam
Nov	2	Cofactor Chemistry – Flavin dependent enzymes
	7	Cofactor Chemistry – Heme, Vitamin B12, and SAM dependent enzymes/applications (Choice of paper for oral presentation due)
	9	Cofactor Chemistry – Heme, Vitamin B12, and SAM dependent enzymes/applications
	14	Secondary Metabolism
	16	Special topics in chemical biology (choice)
	21	<i>Thanksgiving</i>
	23	<i>Thanksgiving</i>
	28	Special topics in chemical biology (choice)
	30	Third Exam
Dec	5	Oral Flash Talks
	7	Oral Flash Talks
	14	Final Exam 9 AM

*some adjustments to the class schedule may become necessary and will be announced in class throughout the semester