Syllabus: General Biochemistry BB450/550 Fall 2018

Professor: Phil McFadden. Campus office: 2151 ALS. Office hours: TuTh 3-4 pm. Contact: phil.mcfadden@oregonstate.edu

Teaching Assistants (TA's): Kayla Jara, Aidan Estelle, Patrick Morar, Jesse Howe, Dan Breysse

Undergraduate Learning Assistants (LA's): Mahtab Brar, Jorie Casey, David Lehrburger, Daniel Trinh

Office hours and contact information for our TA's and LA's will be provided at the first recitation meeting.

Course Prerequisites: Two terms of organic chemistry (CH 331 and CH 332 or CH 334, CH 335, and CH 336).

COURSE SCHEDULE and GRADING

Lectures will be held MWF at noon in LINC 100.

Weekly recitations conducted by our TA's and LA's will provide help in understanding language, concepts and relevant problem solving.

The course will be presented in three successive learning units as follows:

Unit 1: Water, amino acids and proteins

Nine lectures plus recitations. *Main topics*: Protein and macromolecular behavior in aqueous systems. Relationship between pH and protein electrical charge. Amino acids and the peptide bond. Hierarchy of protein structure and folding. Experimental characterization of protein molecules. The structure and function of myoglobin and hemoglobin.

Exam 1: **Friday, October 12 at noon in LINC100**. Will test your comprehension of vocabulary, concepts and problems in Unit 1.

Unit 2: Protein function, enzymes, receptors and enzyme signaling

Nine lectures plus recitations. *Main topics*: Saturable oxygen by myoglobin and hemoglobin. Substrates, products and active sites of enzymes. Thermodynamics of enzyme reactions. Enzyme kinetics and inhibition. Example mechanisms of enzyme catalysis. Allosteric enzyme regulation. Enzyme regulation by covalent modification, particularly by protein kinases. Enzyme-mediated signal cascades.

Exam 2: **Friday, November 9 at noon in LINC100**. Will test your comprehension of vocabulary, concepts and problems in Unit 2.

Unit 3: Sugars, energy, and carbohydrate metabolism

Nine lectures plus recitations. *Main topics*: Carbohydrate fuel metabolism, including glycolysis, gluconeogenesis, and our glycogen fuel reserve. Simple- and complex-carbohydrate structure (assumes background knowledge from prerequisite courses in organic chemistry). Energetics of oxidative pathways. Energy capture by ATP and electron carriers. Reciprocal strategies of catabolism and anabolism. Signal cascades in carbohydrate metabolism.

Exam 3: **Thursday, December 6 at 6pm in LINC100**. Will test your comprehension of vocabulary, concepts and problems in Unit 3.

Final letter grades: Each of the three exams is worth 100 points. Recitation assignments and attendance (you are granted one absence) will contribute an additional 5% (15 points), so 315 points are possible in the course. Exams will be offered only on the announced dates. Excused absences are limited to those allowed under university rules, namely absences due to documented doctor-confirmed illnesses, dire family-related issues, and a limited set of other university-approved situations.

BB 550 students will have additional requirements as explained to them individually; BB550 students are required to contact the course instructor prior to the first exam.

LEARNING RESOURCES

Lecture notes:I will post my lecture notes on Canvas. These notes will undoubtedly not include every detail of what I say, so I strongly suggest taking your own supplementary notes.

Problem solving: I will post on Canvas a selection of practice problems and solutions.

Exams from previous years: I will post these as guides to the style and format of the exams.

Textbook: As a reference and a source of figures and examples, I will often turn to *Biochemistry Free for All*(2016) authored by Kevin Ahern, Indira Rajagopal and Taralyn Tan. You can download the text at iTunes or by going to http://biochem.science.oregonstate.edu/content/biochemistry-free-and-easy

Chapter number and title	Relevant pages
Unit 1 topics. Protein structure	
1. Basic biology, chemistry, water & buffers	24-48
2. Structure and Function. Amino acids & proteins. Note: revisions will be made in class to Figure 2.2.	54-68; 73-96; 109-114; 145-150
8. Toolbox. Chromatography, electrophoresis, mass spectrometry	858-869, 893-894
Unit 2 topics. Protein function	
2. Function of oxygen binding proteins	127-139
4. Enzyme catalysis	336-387
7. Enzymatic signaling, protein kinases	835-844
Unit 3 topics. Enzyme pathways	
2. Structure and Function. Carbohydrates (Review of Organic Chemistry topics)	189-207
5. Energy. Basics. ATP	410-416; 422-425
6. Metabolism. Sugars	482-519

EXPECTATIONS

What am I looking for from you?

I expect you to diligently study *vocabulary*, *concepts* and *problem-solving techniques* related to the science of biochemistry. I expect you to be able to demonstrate your learning on three written exams. A complex topic like biochemistry requires considerable advanced reading and studying prior to coming to class or recitation, a determined effort to listen actively in class, and sufficient time and effort to put all the strands together to master the material.

What can you expect to learn?

- By the end of *Course Unit 1*you can expect to have memorized (and to be able to draw) all the amino acid structures as they exist in water and how they are chemically linked together in proteins and affected by noncovalent bonds of several kinds. You should be able to recognize and describe the main primary, secondary, tertiary and quaternary structural elements in any protein molecule displayed in standard formats such as those in the biochemical literature and in publicly accessible internet sources such as the protein data bank. You should also be able to identify which of the functional chemical groups of protein molecules affect their folding and their denaturation (unfolding) in the watery conditions of living cells. As a case in point for quantitatively relating structure and function, you will learn how to use the Henderson Hasselbalch equation, which describes pH buffering, to predict protein charge and functional properties as the pH of a solution is varied. You can expect to be able to explain in conversational terms to anyone with minimal technicalities the structures of kinds of protein fibers that are familiar to all (e.g. collagen of tendons and bone, keratin of skin and hair) or perhaps not so familiar (actin filaments, microtubules). You will also be able to sketch out the 3D structures of two globular proteins, myoglobin and hemoglobin, whose functions will be the first topics of study in Unit 2. Finally, given the "purification behavior" of a protein, you will be able to draw conclusions and state important aspects of the protein's structure.
- From *Course Unit 2*, you can expect to gain an appreciation of the machine-precision of protein function by conceptualizing both in language and in sketches how *myoglobin*and *hemoglobin*function as oxygen binding proteins. You will able to explain how hemoglobin function is dramatically tuned by subtle structural changes, including minor amino acid substitutions, subunit-subunit cooperativity, and the binding of small molecules such as carbon dioxide. In this unit you will learn to name enzymes and describe their catalytic functions. You will be able to quantitatively portray any enzyme reaction as a chemical interconversion between substrates and products, with modulation by activators and inhibitors. You will use *qualitative*rules-of-thumb to compare the catalytic power of enzymes. You will also learn to use formulas and constant terms (Km and Vmax) in a steady state kinetic model (the Michaelis Menten equation) to *quantitatively*predict how the speed of an enzyme reaction varies with the concentrations of substrates, products and inhibitors. By studying the mechanisms of a few well-understood enzymes, including those involved in cutting proteins, you will conceptualize which chemical features of an enzyme active site govern the making and breaking of bonds as substrate is turned to product. By studying some additional

examples of enzymes whose reaction is turned on and off according to physiological needs, you will be able to explain how allosteric regulation and regulation by post-translational covalent modification affect the speed and function of enzymes. Finally, you will learn how cell receptors and intracellular proteins pass information to each other in signal transduction cascades, often involving protein kinase. You can expect to be able to trace the flow of several such cascades that are currently well understood.

- *Course Unit 3* builds from the above concepts toward your understanding of how enzymes are functionally tied together into regulated metabolic pathways. Specifically, you will be able to sketch out pathways to describe how sugar molecules are metabolized by the two centrally important pathways, glycolysis and gluconeogenesis. This knowledge that you will be able to sketch will include the ten enzymatic reactions of glycolysis and how they work in concert in the cytoplasm of all organisms for the purpose of capturing chemical energy from food sugar. From there you will learn to question how various organisms and cells employ glycolysis to serve their varied needs for sugar fuel. Finally, by learning to appreciate the important distinction between catabolic and anabolic pathways, you can expect to be able to logically predict when (and why) various tissues such as liver and muscle turn-on and turn-off their specialized pathways of sugar metabolism (including glycolysis, gluconeogenesis, glycogen breakdown, and glycogen synthesis).

UNIVERSITY POLICIES

The goal of Oregon State University is to provide students with the knowledge, skill and wisdom they need to contribute to society. Our rules are formulated to guarantee each student's freedom to learn and to protect the fundamental rights of others. People must treat each other with dignity and respect in order for scholarship to thrive. Behaviors that are disruptive to teaching and learning will not be tolerated, and will be referred to the Student Conduct Program for disciplinary action. Behaviors that create a hostile, offensive or intimidating environment based on gender, race, ethnicity, color, religion, age, disability, marital status or sexual orientation will be referred to the Affirmative Action Office.

The Department of Biochemistry/Biophysics strictly follows the above university policy on student conduct. Behaviors disruptive to the learning environment will not be tolerated and will be referred to the Office of Student Conduct for disciplinary action. Use of cell phones and excessive talking between neighbors is prohibited in the classroom.

Cheating or plagiarism by students is subject to the disciplinary process outlined in the Student Conduct Regulations (see http://oregonstate.edu/admin/stucon/regs.htm). Students are expected to be honest and ethical in their academic work. Academic dishonesty is defined as an intentional act of deception in one of the following areas:

- cheating- use or attempted use of unauthorized materials, information or study aids
- fabrication- falsification or invention of any information
- assisting- helping another commit an act of academic dishonesty
- tampering- altering or interfering with evaluation instruments and documents
- plagiarism- representing the words or ideas of another person as one's own

Finally, please note: "Accommodations for students with disabilities are determined and approved by Disability Access Services (DAS). If you, as a student, believe you are eligible for accommodations but have not obtained approval please contact DAS immediately at 541-737-4098 or at http://ds.oregonstate.edu. DAS notifies students and faculty members of approved academic accommodations and coordinates implementation of those accommodations. While not required, students and faculty members are encouraged to discuss details of the implementation of individual accommodations."