Syllabus

General Biochemistry BB450/550 Winter 2020

Professor: Phil McFadden (he/him/his). I often like hearing students calling me Professor Phil for short. Email: phil.mcfadden@oregonstate.edu

Teaching Assistants (TA's):

All are experienced graduate students with research experience!

Jesse Howe (our head TA)	howejess@oregonstate.edu
Monica Franco	vidalfrm@oregonstate.edu
Cat Hoang	hoangc@oregonstate.edu
Sanjay Ramprassad	ramprass@oregonstate.edu

Undergraduate Learning Assistants (LA's):

They took the course last year and must have wanted more!

Saylor Miller	millesay@oregonstate.edu
Mihir Palan	palanm@oregonstate.edu
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Office hours and contact information for Prof McFadden and our TA's will be announced.

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 by Prof McFadden will be held by Zoom, MWF at noon-1pm Pacific Time.

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

The course will be built from week to week as follows:

Unit 1. Weeks 0, 1, 2 and 3: Water, amino acids, protein structure and function

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 3D structures of keratin, collagen, myoglobin, hemoglobin and

other representative fibrous and globular proteins. Saturable oxygen binding by myoglobin and hemoglobin, including subunit-subunit cooperativity.

Unit 2. Weeks 4, 5 and 6: Enzymes, kinetics of enzyme reactions, enzyme mechanisms and inhibitors

Main topics: Substrates, products and active sites of enzymes. Thermodynamics of enzyme reactions. Enzyme kinetics and inhibition. Example mechanisms of enzyme catalysis, including protease mechanisms. Allosteric enzyme regulation.

Unit 3. Weeks 7, 8, 9 and 10: Sugar metabolism, energy, and metabolic regulation

Main topics: Carbohydrate molecular structure (assumes background knowledge from prerequisite courses in organic chemistry). Carbohydrate fuel metabolism, including glycolysis, gluconeogenesis, and the glycogen fuel reserve. Energetics of oxidative pathways. Energy capture by ATP and electron carriers. Reciprocal strategies of catabolism and anabolism. Signal cascades in carbohydrate metabolism. Enzyme regulation by covalent modification, particularly by protein kinases. Enzyme-mediated signal cascades.

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 course points), so your performance relative to 315 possible course points will be used to determine your final letter grade. 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: Zoom lectures and the associated notes will be posted 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: Practice problems and thought questions will be posted on Canvas.

Slack channels for discussion will be available 24/7. Prof McFadden will visit, especially, his office hour channel.

Recitation challenge problems will be offered to you each week.

Textbooks: As references and source of figures and examples, we will refer to two free textbooks:

1. *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

2. Biochemistry, 8th Edition (2015) by Berg, Tymoczko, Gatto and Stryer. You can download the text as a pdf file at either of the following two sites:

https://archive.org/details/JeremyM.BergJohnL.TymoczkoGregoryJ.GattoJr.LubertStryerBiochemistry_201802/page/n399

https://www.academia.edu/38212110/Jeremy_M._Berg_John_L._Tymoczko_Gregory_J._Gatto_Jr._Lubert_Stryer_-_Biochemistry_2015_W._H._Freeman_.pdf

EXPECTATIONS AND COURSE LEARNING OBJECTIVES

What are we looking for from you?

We expect you to diligently study *vocabulary*, *concepts* and *problem-solving techniques* related to the science of biochemistry. A complex topic like biochemistry requires considerable advanced reading and studying prior to attending lectures and recitations. A determined effort to listen actively and then taking sufficient time to study afterwards to put all the strands together is what is usually required to master the material.

What can you expect to learn? (please note that these lengthy descriptions will be broken down into smaller bites as weekly learning objectives in Canvas modules)

- By the end of *Course Unit 1*you can expect to be able to draw the covalent structures of all the amino acids as they exist in water as well as to draw 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 (membrane proteins, taste bud receptors, antibodies, myoglobin, actin filaments, microtubules). Given the "purification behavior" of a protein by chromatography and electrophoresis, you will be able to draw conclusions and state important aspects of the protein's structure, including its mass as determined by mass spectrometry. You will also be able to sketch out the 3D structures of two globular proteins, myoglobin and hemoglobin. 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.

- From *Course Unit 2*, 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.
- *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. The knowledge that you will be able to sketch in diagrammatic format will include the ten enzymatic reactions of glycolysis and the paths by which 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. 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). By studying some 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 (specifically protein phosphorylation) 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. Finally, you will be able to

account for the daily variations in our metabolism (between hunger and satiety, for example) by relating hormonal signals in the blood to intracellular signals and switches that operate at the level of protein phosphorylation reactions.

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.

Student Conduct Regulations are described at http://studentlife.oregonstate.edu/code. Students are expected to be honest and ethical in their academic work. Cheating or plagiarism by students is subject to the disciplinary process outlined in the regulations. 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

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."

Reach Out for Success: University students encounter setbacks from time to time. If you encounter difficulties and need assistance, it's important to reach out. Consider discussing the situation with an instructor or academic advisor. Learn about resources that assist with wellness and academic success at oregonstate.edu/ReachOut. If you

are in immediate crisis, please contact the Crisis Text Line by texting OREGON to 741-741 or call the National Suicide Prevention Lifeline at 1-800-273-TALK (8255)

OSU COVID POLICES

To contribute to the health and safety of all OSU community members during the ongoing COVID-19 pandemic, and to align with federal and state regulations, executive orders, and guidance, the university has adopted two policies all community members are expected to observe:

(1) Policy on Face Coverings in Public and Common Settings (https://policy.oregonstate.edu/UPSM/04-041_COVID19_face_covering)

This policy requires faculty, staff, students and visitors across all OSU locations to use masks or cloth face coverings, or an appropriate alternative, when in enclosed OSU public and common areas, unless an exception is met; and

(2) Policy on Physical Distancing During Covid-19 Pandemic (https://policy.oregonstate.edu/UPSM/04-040_covid19_social_distancing)

This policy requires faculty, staff, students and visitors across all OSU locations to maintain six-feet of physical distance between others when in enclosed OSU public and common areas, unless an exception is met.

Please review and familiarize yourself with these policies and supplemental guidance (https://covid.oregonstate.edu/sites/covid.oregonstate.edu/files/face_covering_guidance_6-3-20.pdf).

Thank you for contributing to the health and safety of the community. If you have questions about these policies, please contact me or you may submit further inquiries to the Coronavirus Question form (https://oregonstate.qualtrics.com/jfe/form/SV_cTpAHJzw4P3zyQd).

COURSE POLICIES RELATED TO SYNCHRONOUS ZOOM ATTENDANCE

Zoom Classroom Norms

I invite everyone to participate in our scheduled synchronous meetings in Zoom. The sense of community is enhanced when we show our faces on video camera. I recognize that there may be reasons you may not be able to always use your camera such as not having reliable internet access, internet problems at any particular moment, or reasons pertaining to where you are sitting. In these cases you may turn your camera off, but where possible please keep it turned on. You may not have a camera or microphone on your laptops (e.g., if you have an older machine). For these reasons, you may participate by phone. In case you cannot make a synchronous session, you will have access to a recording but given active learning components of class sessions, do strive to attend all of them.

When participating in Class Time or other virtual discussions please consider the following tips. These will help us have a smooth and enjoyable session.

- Set your name and add pronoun or pronunciation.
- Make eye contact with the camera, if you choose to turn on your video camera.
- Mute mics when you're not contributing.
- Find your light! Make sure there is a light source in front of you, not behind.
- Speak in a conversational tone - you won't need to raise your voice.
- If you do not want to share a video or cannot because of internet bandwidth issues, please add your name and a picture under setting. It will help when you ask a question or share a response to be able to use you name.
- Alternatively, you may ask questions or add comments in chat.
- You will enter the meeting with your video feed off. Turning off your video will save bandwidth and improve audio for you.
- Be respectful in your spoken words, chat, and videos.
- Do not screen-share unless you have permission.
- Do not annotate on the whiteboard unless you have permission.
- Click raise your hand in Zoom if you want to share.
- Be kind online.

Zoom Breakout Room Norms

Our recitations will be interactive; it is not practical for our lectures (with up to 400 in attendance) to be as interactive.

Student-to-student interaction is highly valued and encouraged. To ensure that small group assignments in breakout rooms are productive and beneficial to everyone's learning, please follow the lead of the TA's and LA's who are managing the recitations. Practice these widely accepted rules of social behavior:

- Listen actively to the viewpoints of group members; listen more than you talk, encourage equal participation.
- Practice reflective listening; restate and clarify what a group member is saying.
- Use academic and professional language to communicate your answers/contribution to group task.
- Have a positive attitude; provide constructive feedback to group members' viewpoints.
- Weigh the feedback from peers; don't reject it immediately.
- Do not be a passive observer; motivate, and help the group to reach an accurate consensus on the group task/product.

DIVERSITY AND INCLUSION STATEMENT

I (Phil McFadden) have adapted the following statement from Monica Linden's diversity and inclusion statement at Brown University. The sentiments she has expressed from the perspective of a research neuroscientist managed to mirror my own personal perspective as a research biochemist. I have altered her wording with gratitude.

In an ideal world, science would be objective. However, much of science is subjective and is historically built on a small subset of privileged voices. I acknowledge that the readings for this course were authored in the main by white men. Furthermore, the course often focuses on historically important biochemistry experiments which were mostly conducted by white men. Thankfully many have come to realize that integrating a diverse set of experiences is important for a more comprehensive understanding of science. Please contact me (in person or electronically) if you have any suggestions to improve the quality of the course. I would like to create a learning environment for students that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc.) To help accomplish this:

- *If you have a name and/or set of pronouns that differ from those that appear in your official OSU records, please let me know.*
- *If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to inform me. If you prefer to speak with someone outside of the course, Dean Henri Jansen, Associate Dean of the College of Science is an excellent resource who will maintain your anonymity.*
- *I (like many people) am still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to me about it. (Again, anonymous feedback is always an option).*