

# BIOCHEMISTRY 56200

Spring 2023

## **COURSE FORMAT**

M/W/F – 8:30 to 9:20 AM.

In-person lectures on Mondays, Wednesdays, and Fridays in room BCHM 105. Attendance encouraged for effective learning. All lectures will be recorded through BoilerCast and made available on BrightSpace. All quizzes and exams will be online in an open textbook format.

## **INSTRUCTOR**

Elizabeth Tran, Professor of Biochemistry

Office: BCHM 343B

E-mail: [ejtran@purdue.edu](mailto:ejtran@purdue.edu)

Office hours: Arrange meetings via email

## **TEACHING ASSISTANT**

Punyatoya (Punya) Panda, Graduate Student

Office: Bindley Bioscience Center

E-mail: [panda13@purdue.edu](mailto:panda13@purdue.edu)

Office hours: Tuesdays and Thursdays from 4-5pm

Contact Punya by email to arrange meetings at times other than office hours

## **TEXTBOOK** (*Required*)

Berg, J. M., Tymoczko, J. L., Gatto Jr., G. J., and Stryer, L. (2023) *Biochemistry*, 10th edition (W. H. Freeman and Company) ISBN-10:1-319-33362-1

Copies are on reserve in the Lilly library

As an alternative, the 5<sup>th</sup> edition of the textbook is available free online (<https://www.ncbi.nlm.nih.gov/books/NBK21154>)

If you already have a copy of Biochemistry, 9<sup>th</sup> edition, this is also fine too. There are not many changes between the 9<sup>th</sup> and 10<sup>th</sup> edition.

## PREREQUISITES

You are expected to have a basic understanding of organic chemistry and must have a minimum grade of D in one of the following courses (or an equivalent course from other institutions): CHM 25600, CHM 25700, CHM 26200, CHM 26605, MCMP 20500, CHEM C3420.

A sound understanding of proteins, enzymes, and their regulation is crucial for this course. These topics are covered in BCHM 561 (not an official prerequisite) and are often covered in other basic biochemistry and biology courses. If you need to reinforce your grasp of proteins and their properties, you may want to read chapters 2, 8, 9 and 10 in the textbook (*Biochemistry*) or relevant chapters in other biochemistry textbooks. If you have any concerns about your preparation for BCHM 562, please see the instructor as soon as possible.

## DEPARTMENTAL LEARNING OUTCOMES ADDRESSED BY BCHM 56200

BCHM 56200 students will understand the molecular principles of life based on the core disciplines of biology, chemistry and physics, and how the discipline of metabolism contributes to society, including improvements in medicine, agriculture, the economy and the environment.

## COURSE OBJECTIVES

The overall learning objective of this course is to understand the major metabolic pathways that sustain life. Metabolic pathways comprise a series of linked, enzyme-catalyzed reactions. We will focus on deciphering the logic of the enzyme-facilitated chemical transformations of the core metabolic pathways. The structure of selected enzymes, their regulation, and the biochemical mechanisms by which enzymes catalyze metabolic reactions will be analyzed in detail.

Catabolic pathways degrade nutrients and generate energy and the small molecules required to keep cells alive. Anabolic pathways utilize the energy and molecular precursors generated by catabolic processes to drive a distinct set of reactions that synthesize carbohydrates, proteins, nucleic acids, and lipids – the building blocks of life.

We will begin by analyzing energy-producing catabolic pathways. A focus here will be on ultimately understanding how the energy released from the breakdown of carbon fuel molecules is conserved and harnessed in a biologically useful form through the synthesis of ATP, the major energy currency of cells. Required at a rate of around 65 kg per day per person, ATP is a major source of energy in the anabolic pathways of the cell. ATP thus links catabolic and anabolic reactions of the primary metabolism.

Energy derived from the oxidation of NADH and FADH<sub>2</sub>, electron-rich molecules formed during catabolic reactions, are utilized to synthesize ATP in a process known as oxidative phosphorylation. During oxidative phosphorylation, electrons from NADH and FADH<sub>2</sub> are transferred to oxygen via electron carriers embedded in the inner membrane of mitochondria. Electron transport reactions are coupled to vectorial proton transport reactions across the inner mitochondrial membrane, which together build a field strength of about 30 million volts per meter membrane, equivalent to electricity released during a lightning bolt. We will learn how this membrane electrochemical potential drives

the synthesis of ATP through ATP synthase, a marvelous rotary enzyme integral to energy conversion in all three domains of life.

Sunlight is the ultimate source of energy on earth. Plants, algae and certain bacteria tap into this source of energy by means of photosynthesis, the conversion of radiant energy into chemical potential energy, producing food and feed for virtually all organisms on Earth. Molecular oxygen is a byproduct of this remarkable chemical reaction. About 2.4 billion years ago, photosynthetic microbes known as cyanobacteria started producing oxygen that now makes up about 21% of our atmosphere. Animals, plants, and other aerobic organisms require oxygen as a terminal electron acceptor to generate ATP through oxidative phosphorylation. We will study the process of photosynthesis as carried out by bacteria and the chloroplasts of higher plants. The aim is to understand how light energy absorbed by pigments found in specialized membrane proteins is converted into chemical energy in the form of ATP and NADPH. These high energy molecules eventually drive the synthesis of carbohydrates from carbon dioxide by the Calvin-Benson cycle.

This course will also briefly survey the synthesis and breakdown of fatty acids, amino acids, and nucleic acids – the structural and informational biomolecules whose metabolism is intricately linked to the catabolic and anabolic reactions of sugars.

### TEACHING PHILOSOPHY

I have been at Purdue since 2009. This will be my first semester teaching BCHM 562. Prior to this teaching assignment, I taught BCHM 601 and 610, which are Biochemistry graduate core courses centered on scientific communication, critical thinking, experimental design, and gene regulation. I do not set aside particular office hours for you to meet with me directly, however, I encourage you to arrange to meet through email if necessary. If you have any concerns about your academic preparedness for BCHM 562, please see me or the TA as soon as possible. Our course TA will hold office hours twice a week or by appointment so please utilize your resources wisely.

### HOW TO SUCCEED IN THIS COURSE

This course can be challenging because of the vast amount of material covered and the memorization involved. However, for each metabolic pathway that you learn I urge you to go beyond rote memorization by asking two questions: **why does it matter and how does it work**. This technique promotes understanding as opposed to memorization. Other suggestions include:

- Attend or listen to all lectures, take notes, read textbook on the same day starting with chapter summaries
- Write down or draw pathways on paper
- Work out problems
- Imagine metabolic pathways happening in you and around you
- Some understanding of proteins, enzymes, and their regulation is crucial for this course!
- Use associative memory techniques that rely on real-world examples

- First exam difficult! Overprepare!

## **BRIGHTSPACE**

This syllabus, lecture slides, recorded lectures, course announcements, quizzes and exams, answers to quizzes and exams, and any assignments will be posted on the [BrightSpace](#).

## **LECTURE RECORDINGS**

All lectures will be recorded through BoilerCast and deposited as video files that can be accessed at the course home page on Brightspace.

## **ELECTRONIC DEVICES**

I allow personal computers to be used to write lecture notes during class but no other use of any electronic devices, including phones and cameras, is permitted.

## **CLASS ATTENDANCE**

In accordance with University policy on class attendance, there is an expectation that you will attend every scheduled class. If you have a valid reason for missing class such as an illness, family emergency, bereavement, religious observances, or most University-sponsored activities, any assignments or coursework may be made up at the discretion of the instructor and the instructor or TA will assist you in obtaining information and materials you may have missed. In this course, class attendance is not recorded and will not directly affect your grade. However, students who attend classes regularly fare better in exams on average than students who skip classes. Furthermore, students who do not attend class without a valid excuse should not expect the instructor or TA to provide special help or supply class notes or materials. (For relevant University policy, see: [http://www.purdue.edu/studentregulations/regulations\\_procedures/classes.html](http://www.purdue.edu/studentregulations/regulations_procedures/classes.html))

## **CLASSROOM GUIDANCE REGARDING PROTECT PURDUE**

Any student who has substantial reason to believe that another person is threatening the safety of others by not complying with Protect Purdue protocols is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the [Office of the Student Rights and Responsibilities](#). See also [Purdue University Bill of Student Rights](#) and the Violent Behavior Policy under University Resources in Brightspace.

## **ACADEMIC GUIDANCE IN THE EVENT A STUDENT IS QUARANTINED/ISOLATED**

"If you must quarantine or isolate at any point in time during the semester, please reach out to me via email so that we can communicate about how you can continue to learn remotely. Work with the Protect Purdue Health Center (PPHC) to get documentation and support, including access to an Academic Case Manager who can provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Your Academic Case Manager can be reached at [acmq@purdue.edu](mailto:acmq@purdue.edu). Importantly, if you find yourself too sick to progress in the course, notify your

academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation.”

## **OTHER HEALTH-RELATED ISSUES**

Please **do NOT** attend class if you suspect that you have symptoms of the flu. It is also a good idea to **not** attend classes when you are coughing, sneezing, or have runny eyes and nose owing to a head cold. This will prevent the spread of these diseases to your classmates and others on campus.

## **ACADEMIC MISCONDUCT**

“As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue.” – Purdue Honors Pledge

<https://www.purdue.edu/provost/teachinglearning/honor-pledge.html>

Academic misconduct of any kind will not be tolerated in any course offered by the Department of Biochemistry. Information on Purdue’s policies with regard to academic misconduct can be found at the following website:

[http://www.purdue.edu/studentregulations/student\\_conduct/regulations.html](http://www.purdue.edu/studentregulations/student_conduct/regulations.html)

Any incidence of academic misconduct will be reported to the Office of the Dean of Students. Academic misconduct may result in disciplinary sanctions including expulsion, suspension, probated suspension, disciplinary probation, and/or educational sanctions. In addition, such misconduct will result in punitive grading such as:

- receiving a lower or failing grade on the assignment, or
- assessing a lower or failing grade for the course

Punitive grading decisions will be made after consultation with the Office of the Dean of Students. Please note reported incidences of academic misconduct go on record for reference by other instructors. Further, a record of academic misconduct is likely to influence how current/future situations are handled.

To provide you with an unambiguous definition of academic misconduct, the following text has been excerpted from "Academic Integrity: A Guide for Students", written by Stephen Akers, Ph.D., Executive Associate Dean of Students (1995, Revised 1999, 2003), and published by the Office of the Dean of Students in cooperation with Purdue Student Government, Schleman Hall of Student Services, Room 207, 475 Stadium Mall Drive West Lafayette, IN 47907-2050.

“Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section

III-B-2-a, *Student Regulations*] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]

More specifically, the following are a few examples of academic dishonesty which have been discovered at Purdue University:

- substituting in a course or exam for another student
- paying someone else to write a paper and submitting it as one's own work
- giving or receiving answers by use of signals during an exam
- copying with or without the other person's knowledge during an exam
- doing class assignments for someone else
- plagiarizing published material, class assignments, or lab reports
- turning in a paper that has been purchased from a commercial research firm or obtained from the internet
- padding items of a bibliography
- obtaining an unauthorized copy of a test in advance of its scheduled administration
- using unauthorized notes during an exam
- collaborating with other students on assignments when it is not allowed
- obtaining a test from the exam site, completing and submitting it later
- altering answers on a scored test and submitting it for a regrade
- accessing and altering grade records
- stealing class assignments from other students and submitting them as one's own
- fabricating data
- destroying or stealing the work of other students

Plagiarism is a special kind of academic dishonesty in which one person steals another person's ideas or words and falsely presents them as the plagiarist's own product. This is most likely to occur in the following ways:

- using the exact language of someone else without the use of quotation marks and without giving proper credit to the author
- presenting the sequence of ideas or arranging the material of someone else even though such is expressed in one's own words, without giving appropriate acknowledgment
- submitting a document written by someone else but representing it as one's "own"

Students can report issues of academic integrity that they observe through the Office of the Dean of Students website ([www.purdue.edu/odos](http://www.purdue.edu/odos)), or 765-494-8778 or [integrity@purdue.edu](mailto:integrity@purdue.edu).

## **EXAMINATION AND GRADING POLICIES**

*Exams and Grades* – Semester grades are calculated from scores on eight quizzes and four exams that count toward the final grade. All quizzes and exams will be conducted in an online format in Brightspace. The links for the quizzes and exams will be posted as announcements in Brightspace with a specified completion time. Because of the open textbook or internet nature of exams, questions will be framed to assess higher level of understanding and critical thinking rather than simple recollection of facts. Exams 1-3 will only cover material since the last exam. However, the final exam will be cumulative. The dates of all exams and quizzes are included in the lecture schedule shown below.

*Failure to take an exam at the scheduled time will result in the assignment of **zero** points.* As described below, under certain specific circumstances makeup exams can be arranged.

The maximum score on each exam is 150 points, and each quiz is worth 50 points. Grades will be assigned according to the following grading schemes:

Grade	Percentage of total points (%)
A	90 - 100
B	80 - 89
C	70 - 79
D	60 - 69
F	≤59

***Extra Credit* – There is no official mechanism for earning extra credit in this course. However, there may be opportunities that come about during the course. Stay tuned!**

*Makeup Exams and Quizzes* – Make-up exams will only be given for the following reasons: another conflicting evening exam, a University-sponsored activity, religious observance, illness or medical emergency, or bereavement. If you have a conflict because of *another evening exam*, a *University-sponsored activity*, or *religious observance*, you must let the instructor know at least two weeks before the exam. If you cannot attend the exam because of an *illness* or *serious injury*, please let the instructor know as soon as it becomes clear that you will be unable to take the exam, preferably at least 24 h in advance of the exam time. Notification of an illness or medical emergency, should be sent to the [instructor](#) (cc the TA) via email. We recognize that advance notice may not be possible for certain illnesses or injuries. In this case, you should contact the instructor or TA as soon as you are able to do so. Any request to be excused from a quiz or exam must include official documentation (doctor's note, request from academic advisor, etc.) explaining why the exam was or will be missed. In cases of bereavement, we adhere to the University's Grief Absence Policy for Students (GAPS). See:

[http://www.purdue.edu/studentregulations/regulations\\_procedures/classes.html](http://www.purdue.edu/studentregulations/regulations_procedures/classes.html)

*Final Exam Conflicts* – We adhere to the following University Policies on Final Exam Conflicts: “Students scheduled for more than two examinations in one calendar day are entitled to reschedule any examinations in excess of two. Similarly, students faced with a direct exam conflict are entitled

to reschedule either examination. It is the responsibility of the student to make the necessary arrangements before the last week of regularly scheduled classes.” The Final Exam (IV) will only be rescheduled in cases that meet the University Policies such as certain professional or University-related activities, illness or family emergencies. Do NOT make travel plans that require your departure before the final exam because you will not be allowed to reschedule the exam for this purpose.

*Grade Appeals* – Every effort will be made to accurately grade exams, but in a class of this size, mistakes are unavoidable. Answers to the exam will be posted and the TA or instructor will be available (during office hours) to discuss the answers. If you feel that grading errors have been made, you may submit a **written request** for a regrade to the TA. Regrade request should be submitted by email from a Purdue account. The written request should give a clear and specific reason why you believe your answer(s) should be reconsidered. The only exceptions to the written request are cases where the total points are miscalculated (arithmetic errors). *Requests for regrades must be submitted to the TA no later than 6:00 PM on the fourth day of the test.*

## **EMERGENCY PREPAREDNESS**

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. To get information about changes in this course consult the class Brightspace site or e-mail the instructor. Under these circumstances, please check your Purdue email as well as the course site on Brightspace frequently since we may need to communicate information and instructions about the course.

## **EMAIL POLICY**

The instructor will attempt to respond to all emails sent to schedule meetings, handle exam conflicts, or manage administrative issues or problems. However, responses to emails regarding questions on biochemical subject matter will not be guaranteed and will be at the instructor’s discretion.

## **PURDUE COUNSELING AND PSYCHOLOGICAL SERVICES (CAPS)**

- If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack, <https://purdue.welltrack.com/>. Sign in and find information and tools at your fingertips, available to you at any time.
- If you need support and information about options and resources, please see the Office of the Dean of Students, <http://www.purdue.edu/odos>, for drop-in hours (M-F, 8 am - 5 pm).
- If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765)494-6995 and <http://www.purdue.edu/caps/> during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

## **NON-DISCRIMINATION POLICY STATEMENT**

Purdue University's non-discrimination policy will be upheld in this classroom. Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University views, evaluates, and treats all persons in any University related activity or circumstance in which they may be involved, solely as individuals on the basis of their own personal abilities, qualifications, and other relevant characteristics.

## **ON-LINE COURSE EVALUATIONS**

During the last two weeks of the semester, you will be provided an opportunity to evaluate this course and your instructor(s). To this end, Purdue has transitioned to online course evaluations. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have two weeks to complete this evaluation. Your participation in this evaluation is an integral part of this course. Your feedback is vital to improving education at Purdue University.

## **DROPPING BCHM 562**

Refer to the Purdue Academic Calendar and pay close attention to the drop dates and to your course grade.

*The Lecture Schedule listed on the following pages should be viewed as tentative. Major changes and updates will be presented in class and/or announced on Brightspace.*

Lecture	Date	Day	Ch	TOPIC
1	01/08	M	15	Course Policy / Metabolism: Basic Concepts
2	01/10	W	15	Metabolism: Basic Concepts
3	01/12	F	16	Metabolism: Basic Concepts/Glycolysis
	01/15	M		Martin Luther King Jr. Day, no lecture
4	01/17	W	16	Glycolysis
5	01/19	F	16	Glycolysis
6	01/22	M	16	Glycolysis
7	01/24	W	16	Gluconeogenesis
8	01/26	F	16	Gluconeogenesis
9	01/29	M	21	Glycogen Metabolism
10	01/31	W	21	Cancer Metabolism – glycolysis (reading assignment)
11	02/02	F	21	QUIZ 1
	02/05	M		Exam 1 (Lectures 1-11), Online
12	02/07	W	17	Citric Acid Cycle
13	02/09	F	17	Citric Acid Cycle
14	02/12	M	17	Citric Acid Cycle
15	02/14	W	17	Mitochondria
16	02/16	F	18	Electron Transport
17	02/19	M	18	Electron transport
18	02/21	W	18	Oxidative Phosphorylation
19	02/23	F	18	Oxidative Phosphorylation
20	02/26	M	18	Oxidative Phosphorylation
21	03/28	W	18	ATP Synthesis
	03/30	F	18	Cancer Metabolism - metabolites (reading assignment)
	03/05	M		Exam 2 (Lectures 12-21), Online
22	03/07	W	19	Photosynthesis (light reactions)

Lecture	Date	Day	Ch	TOPIC
23	03/09	F	19	Photosynthesis (light reactions)
	03/11-03/16	M-F		Spring break, no lectures
24	03/19	M	19	Photosynthesis (light reactions) & (CO <sub>2</sub> fixation)
25	03/21	W	20	Photosynthesis (CO <sub>2</sub> fixation)
26	03/23	F	20	Photosynthesis (CO <sub>2</sub> fixation)
27	03/26	M	20	Photosynthesis (CO <sub>2</sub> fixation)
28	03/28	W	20	Video ( <a href="https://www.youtube.com/watch?v=_hefhfxpECI">https://www.youtube.com/watch?v=_hefhfxpECI</a> )
29	03/30	F	20	Pentose Phosphate Pathway
30	04/02	M	22	Fatty Acid Metabolism
31	04/04	W	22	Fatty Acid Metabolism
32	04/06	F	22	QUIZ 3
	04/09	M		Exam 3 (Lectures 22-32), Online
33	04/11	W	23	Amino Acid Degradation
34	04/13	F	23	Amino Acid Degradation
35	04/16	M	23	Urea Cycle
36	04/18	W	24	Amino Acid Biosynthesis
37	04/20	F	24	Amino Acid Biosynthesis
38	04/23	M	25	Nucleotide Metabolism
39	04/25	W	25	Nucleotide Metabolism
40	04/27	F	25	Cancer and Amino Acids (reading assignment)
	TBD			Final Exam 4 (Lectures 33-40), Online
<p><b>Note:</b> This schedule is intended to serve as a general guide to the chapters that will be covered in the course and the order in which they will be discussed. It is likely that there will be deviations from this schedule as the course progresses. It may be necessary to omit some scheduled topics. We will keep the class informed of any major deviations from this schedule.</p>				