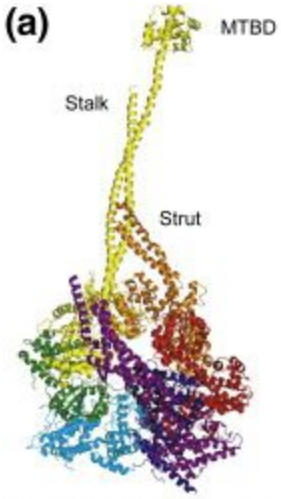
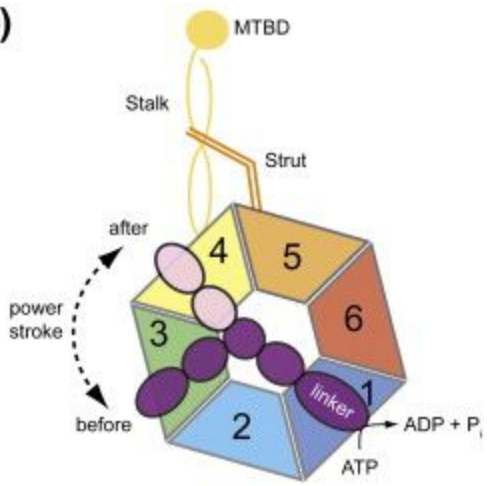
Biology 151

BIOLOGICAL CHEMISTRY

Summer 2021



Dynein motor domain crystal structure



Model for dynein power stroke
(adapted from Kon et al., 2012)

Course Professors: Professor Dail Chapman

BIOLOGY 151 – BIOLOGICAL CHEMISTRY
Summer 2021

Lecture:
Lecture: MTWR 10:00a-12:00p

Lab: T,R 1:00p-3:50p

To Do:

- can schedule change? 2 labs/week
- can't change the schedule: work a few labs into class schedule
- 2 lectures/day = 8 lectures/week
    - condense even more
- add: weekly quizzes (totaling 100 pts)
- advertise: Foundations 1 and 2 teams to make announcements this week

Office Hours: MW 1:00p-3:00p

In addition to the office hours listed above, are also available by appointment.
Please email to set up a mutually agreeable time.

Required Texts:

1) *Lehninger Principles of Biochemistry* by Nelson and Cox, 7th ed., 2017
This manual uses the page, figure, and table numbers from the Lehninger **7th edition**. However, the 6th edition is very similar and may be used for the course, but it will then be up to you to identify the relevant sections.

2) *The Absolute, Ultimate Guide to Lehninger Principles of Biochemistry: Study Guide and Solutions Manual* by Osgood and Ocorr, 7th ed., 2012. (The 6th edition of the problems book is also very similar to the 7th edition).

Tentative Schedule (Schedule will be finalized before classes begin)

Lecture (before class)	Class Date	Day	Lecture Topic	Reading/ Chapter	Feedback and Quizzes	Labs	Assignments
1	12-Jul	M	Introduction/Foundations Water, Acids and Bases	1, 2			Prelab 1
2	13-Jul	T	Protein Structure	3, 4	Feedback 1	Lab 1: Acids, Bases, and Buffers	
3	14-Jul	W	Enzymes 1, & 2, review	6	Feedback 2		Prelab 2 Postlab 1
4	15-Jul	R	Biosignaling, Bioenergetics, and Bioreactions	12, 13	Feedback 3	Lab 2: Hemoglobin and Sickle Cell Anemia	**Weekly Quiz 1**
5	19-Jul	M	Bioreactions: Sugars Review	13, 7	Feedback 4		Prelab 3 Postlab 2
	20-Jul	**T**	**Exam 1 (lectures 1-5, labs 1,2)**			Lab 3: Protein Purification	
6	21-Jul	W	Glucose & Glycolysis, Gluconeogenesis & PPP	7, 14	Feedback 5		Prelab 4 Postlab 3
7	22-Jul	R	Principles of metabolic Regulation, Citric Acid Cycle	15, 16	Feedback 6	Lab 4: Protein Structure	**Weekly Quiz 2**
8	26-Jul	M	Oxidative Phosphorylation and ETC Photophosphorylation	19, 20 Pt 1	Feedback 7		Prelab 5 Postlab 4
9	27-Jul	T	Nucleotides, Lipids, and Membranes	8, 10, 11	Feedback 8	Lab 5: Enzyme Kinetics	
10	28-Jul	W	Fatty Acid Catabolism	17	Feedback 9		Prelab 6; Postlab 5; Presentation Topic
11	29-Jul	R	Amino Acid Oxidation/Production of Urea	18	Feedback 10	Lab 6: Modeling Glycolysis, TCA, and ETC	**Weekly Quiz 3**
12	2-Aug	M	Hormone Regulation and Integration Review	23	Feedback 11		Prelab 7, Postlab 6
13	**3-Aug**	**T**	**Exam 2 (lectures 6-12, labs 3-6)**			Lab 7: Membrane Cases	
14	4-Aug	W	Carbohydrate and Lipid Biosynthesis	20 Pt 2, 21	Feedback 12		Prelab 8; Postlab 7
15	5-Aug	R	Amino Acid and Nucleotide Biosynthesis	22	Feedback 13	Lab 8: DNA structure and Enzymology	**Weekly Quiz 4**
16	9-Aug	M	DNA Metabolism	24	Feedback 14		
17	10-Aug	T	RNA Metabolism	25	Feedback 15	No lab: final review	
18	11-Aug	W	Protein Metabolism	26	Feedback 16		
	12-Aug	**R**	**Final Exam (cumulative)**			**Project Presentations**	

Course website:
We will be using Canvas for class – all of you should see Biology 151-01 on your list of courses, even if you are in a different section. All of the sections have been merged into Section 01. If you do not see this on your list, please contact Prof. Chapman.

Canvas will be used extensively for communication so be sure to check the announcements here often. In addition, we will be using Canvas for weekly online feedback sessions and quizzes – see below.

Prerequisites:
College: We assume that you have already taken General Chemistry I (CHEM-001) and II (CHEM-002) and are currently or have taken Organic Chemistry I* (CHEM-116). In addition, we will be building on content knowledge from Foundations in Biology I (BIOL-103). Additionally, it is advantageous for you to have taken Genetics (BIOL-152) and Foundations in Biology II (BIOL-104), although not absolutely required. Therefore, we will expect you to know many of the fundamental principles that are covered in these courses. It is especially important that you have sufficient background in Organic Chemistry.

NHS: For NHS students, HSCI-280 (Biochem and Molec/Cell: Health and Disease) is required. Alternatively, if you have taken Organic Chemistry I, you may take the course, but be aware that Human Biology I and II (HSCI-101, -102) emphasizes different aspects of Biology compared to Foundations of Biology (BIOL-103 especially but also BIOL-104), and therefore does not provide the same preparation. Be sure to consult one of the professors for material that is confusing to you.

IMPORTANT: Read this if you did not take BIOL-103

This course requires you to build on exam-taking techniques and lab report writing techniques that continue skills first introduced in BIOL-103. Those students who did not take the class, or who have forgotten the skills learned, typically do less well in the early assignments/exams.

To help every student do their best in this class, during the first week of class, we will provide practice questions on:

- Labeling graphs, figures and writing captions in Biology.
- Answering sample Case-Study Exam questions.

These practice questions will be available on Canvas. Our writing tutor TAs will be available (M/T/W 8-10pm) to provide feedback and help guide you through these exercises. We suggest you make use of this opportunity.

Class Structure:
Synchronous classes will be held on MTWR 10:00a-12:00pm.

Before coming to class, you will be asked to watch 2 X 20 minute lecture videos on the topic we will discuss in class that day, and read the relevant sections in the textbook. You will also have to complete an online feedback before coming to class, which contains MCQs that tests your understanding of the key concepts you have learned in the lectures.

In class, we will be focused on concept reviews, case study and applications of the concepts, and problem solving.

Attendance Policy:

You are expected to attend all classes unless you are extremely ill or have some other emergency. If possible, please send an email to Professor Chapman. While in class, you are expected to be an active participant.

We understand that many of you will be preparing for medical school, graduate school, or jobs during the summer; please send an email well ahead of time to Professor Chapman. However, we expect you to be present on all exam days.

Attendance in classes will be recorded, and there will be grades for attendance in class.

Overall Grades for the Semester:

Your semester grade will be determined by your performance on examinations (three in-class exams and the final exam), laboratory work, online feedback (free points!), online quizzes (to help you prepare for the exams) and a poster project with a partner.

The point distribution for the semester will be as follows:

Hourly Exams (2)	100 points each	200 points total
Weekly Quizzes (4)	25 points each	100 points total
Online Feedbacks (16)	3 points each Can miss one	45 points total
In class & Lab Attendance (25)	1 point each	25 points total
Laboratory		200 points total
Poster Project		80 points total
Final Exam		350 points total

Total available for the session – 1000 points.

Exams:
Each in-class exam will cover some fraction of the course material (as indicated on the schedule). Note that for all exams, material from the labs is also considered fair game. These exams will include questions that are similar to those found in the problems in the book, the case studies, and what we cover in class. They will require you to analyze and interpret data. Exams from previous years will be on Canvas (with and without the answers), so be sure to look here to see what kinds of questions we've asked in the past.

The dates of the hourly exams are

- Tuesday, Jul 20th
- Tuesday, Aug 3rd

These times are fixed – make note of them now!

Exams are open note, and open book, but not open internet.

Exams will be timed at 55 minutes, conducted as Canvas Quizzes. The normal time for taking this exam will be during the scheduled class, starting at 11 a.m. Accommodations for alternative times can be considered and made on a case by case basis; we will discuss this early during the semester. Please let us know as soon as possible if there are circumstances that make it difficult/impossible for you to take the exam on these scheduled dates and times as soon as possible.

There is a tendency when exams are open-book for students to check every answer they write against their notes. Because this is a timed exam, if you do that, you will run out of time. We strongly suggest that you go through the exam like a closed book exam the first-time round, coming back with your notes to check only when most questions have been completed.

We ask that you are on Zoom while taking the exam (your video and mic can be off), in case we need to provide instructions, or if you have any questions.

Final Exam:
The final exam is scheduled for the last day of class, Thursday Aug 12th**.** This will be a cumulative final with some additional emphasis on material since Exam 2. This exam will count for 35% of your final grade and will be similar in format but longer than the exams.

Weekly Quizzes:
Our exams are hard; we're aware of this. Once a week, we will ask you to take an online multiple-choice quiz. These quizzes will cover the material we expect you to know for the exam. Each quiz will be worth 25 points, with 10-15 multiple choice questions. Correct answers matter here. You will have an hour from start to finish to complete the quiz, and you will see the questions 1 at a time (but you will be able to take it any time during the weekend). The fourth quiz will be open for 24 hours on the first day of final exams.

Exam is open book and open note, but not open internet. Be aware that you will need to have a reasonable grasp of the material before you attempt the quiz.

Quiz	Opens (Noon)	Closes (9 am)	Notes
1	16-Jul (Fri)	19-Jul (Mon)	Preparation for Exam 1
2	23-Jul (Fri)	26-Jul (Mon)	Preparation for Exam 2
3	30-Jul (Fri)	2-Aug (Mon)	Preparation for Exam 2
4	6-Aug (Fri)	9-Aug (Mon)	Preparation for Final Exam

Online Feedback:
There will be 16 short online feedback forms with MCQs; each worth 3 points, for a total of 45 points. (You can skip one or drop your lowest one).

Basically, we want to know your understanding of the key concepts within that chapter, especially what you're having trouble with so we can address these points in class. This also allows us to ensure that you are keeping up with the lectures, and therefore able to contribute meaningfully during class discussion.

The passing grade for each feedback is 50%. Answer at least 50% of the questions in an online feedback correctly, and you will obtain 3 points. If you complete the online feedback but fall below that threshold, you will get 1.5 points. This is to prevent students from simply completing the quiz without any preparation. Online feedback is not timed, but must be completed before class (M, T, W, R 11am).

Important Note for Weekly Quizzes and Online Feedback Sessions: As we all know, the internet occasionally falters. Therefore, DO NOT wait until the last minute to answer these questions. If you miss the deadline for whatever reason (Canvas failure or you just didn't get to it in time or you were stranded on a desert isle without access to the internet) you will not earn the points for that session.

Exam Policy:

A. General Information:
Exams will take place during regularly scheduled lecture or lab times. Professors will answer questions during regular office hours or by appointment before each exam and will offer review sessions prior to each exam (see "Tutoring" below).

On the day of the exam: Please make sure you are on time for exams so as to make sure you have plenty of time to complete the exam and not disturb your classmates by coming in late.

IMPORTANT NOTE: Material from both Lecture and Laboratory will appear on each and every exam.

A Few Test Taking Strategies:

- Download the exam as a pdf
- Read the exam over first; remember to look at the back page.
- Read each question carefully. If you don't understand, ask.
- Answer on a Word document on your computer, so that if Canvas somehow hangs, you will still have the answers you typed out, and can cut and paste onto the Canvas quiz.
- Answer the easy questions first to save time for the more difficult ones.
- Don't waste time writing a long paragraph when a short phrase will do. The number of points should be indicative of the length of your answer and the details we expect.

B. Missed exams:
Three exams are scheduled during the semester. There will be no make-ups. In the *extraordinary event* that you miss one, your grade on the final exam can be substituted, *if and only if* you have a documented illness or a documented family emergency. In either case, appropriate documentation will be required (a note from your doctor or the Dean). For athletic events and graduate/professional school interviews, please discuss with Prof. Chan *well ahead of time*.

C. Practice exams:
Relevant parts of last year's exams are available on Canvas, a blank version and a version with the answers. Some find it helpful to take the practice exam in a 50minute window to help you practice budgeting time during the real thing.

D. Extra Time and Other Accommodations:
Paperwork must be given to Dr. Chan at the beginning of the semester from the Office of Academic Affairs. We will discuss the proper arrangements.

If you do not have official accommodations, but want to discuss your circumstances, please come to speak with me. We are always looking for ways to make sure that our students have what they need to succeed in this course.

~~Weather Emergencies:~~

~~If the University is closed for the day because of bad weather, we won't have class (call 202-687-SNOW or look on the main University webpage). In the event that happens, you will receive an email by 10 a.m. at the latest. Information will also be posted on Canvas.~~

~~If bad weather persists, lectures will be captured and provided on Canvas.~~

~~In the event that a weather emergency falls on a day scheduled for an exam, the exam will be given at the **next** class meeting. The schedule will be adjusted according.~~

~~If we need to cancel a laboratory section, that will also be announced on Canvas. In that case, it may be necessary to cancel all sections in a given week so that we stay in step. Again, pay attention to announcements on Canvas for up-to-date information.~~

Internet Emergencies:

If there is one thing we have learned from our semesters of online learning, it is that a reliable internet connection is necessary for success in online courses. If you do not have reliable internet, please let us know at the beginning of the semester and we will do what we can to help. You can also consult this website for further assistance from the school.

If there are times during the semester when you have unreliable connections, please let us know as soon as possible. These things happen, we will try to accommodate and help however we can.

Honor Code:

Georgetown's Honor System outlines the Standards of Conduct you are expected to uphold as a member of the Georgetown Community. The honor code will be strictly enforced. All work must be your own. In-class exams are *NOT* open-book or open-notes. In no situation are any of the exams (online or in-class) to be done in groups.

For more details about the general University policy, see the following website: http://gervaseprograms.georgetown.edu/honor/system/53516.html. You are expected to be cognizant of all the details contained here.

For this course, in addition to those standards listed in the Bulletin, the following will also apply:

- Although you will be working in groups to gather data in the laboratory, **all written work that is to be turned in for a grade must be your own.**
    - Names of your partners must be included in your write-up. Problem sets may be worked together, but you must list the names of your coworkers. In either case, your name must be at the top. If it looks like you and your lab partner have collaborated extensively on the writing (meaning you both turn in identical words to the same questions, or that your graphs are identical), this will be considered plagiarism.
- If you use information from the scientific literature or web sites in the preparation of any material to be turned in, even if in rough draft form, the information must be appropriately cited. Note, too, that use of citations without quotes means that you are citing someone else's *ideas*, not their *exact words*. Anything else is plagiarism and will be dealt with accordingly.
- For the case studies that we do in lecture and lab, you may search for information on the internet, but by no means should you copy and paste directly from the website. In addition, if you have obtained substantive information from a particular site, you must give the URL.
- Obviously, anyone caught cheating on exams or other class work will be turned over to the Honor Council, too.

If you are found to have been in violation of the honor code, it will adversely affect your grade in this class.

Be aware that we use Turnitin software to evaluate any materials turned in online.

Because your written work will be turned in through Canvas, it will be automatically submitted for a Textual Similarity Review to Turnitin.com for the detection of plagiarism. All submitted papers will be added as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers in the future. Use of the Turnitin.com service is subject to the terms of use agreement posted on the Turnitin.com site, and by enrolling in this course, you agree to these terms. Here again, though, we want you to think of the TurnItIn function as helpful to you and not a “gotcha” feature. You can see your TurnItIn score immediately upon submission of any piece of writing. Check it out and see where it detects plagiarism as a means to becoming better at catching these problems yourself. You can always delete the submission, correct the problems, and resubmit if you plan a bit in advance!

IMPORTANT: READ THIS!!!!!

Hints for Mastering Biochemistry:

Start with the Study Guide. We cannot emphasize this enough. The book is encyclopedic, and the lectures will make little sense until you know the main points we will emphasize in a particular chapter. At a MINIMUM, you need to have read the Study Guide for that chapter before you attend lecture, and have made notes about the main points you should get from the lecture.

ATTEND LECTURES! For some chapters, we will explain things in a slightly different way from the book; we will tell you details you should know, and details you do not need to know. You need to attend lectures, and, of course, pay attention. As stated above, we plan to use Panopto to capture the lectures, but these can't take the place of actually being in class.

Read. We cover 27 chapters in the span of a semester. Reading assignments are a part of every chapter we cover in class. Read the book, with emphasis on the portions emphasized in the Study Guide. You are expected to have read the assigned Chapter *before the class that deals with that topic*, and then review the reading in detail after the class.

Do the problems. In the Study Guide, we assign questions for each chapter, both from the textbook and the ultimate guide. The answers appear in detail at the end of the *Absolute, Ultimate Guide*, but try the problems first without looking at the answers. Note too that there is a glossary in the back of the textbook. Use the "Topics for Discussion" questions in the *Absolute, Ultimate Guide* by reading the relevant sections of the text to help you learn this material. (More instructions below).

Keep Up. Plan to spend 6-8 hours/week studying for the lecture portion of this course on a *routine basis*. (Labs are an additional 2-4 h of work for each report.) The content from each chapter is foundational for subsequent chapters. This means that if you fall behind, you will find the current chapter difficult to understand. For example, if you did not understand enzyme kinetics, you will find chapters of metabolic control more difficult to understand. Staying up all night before an exam will not take the place of consistent study habits and is very counterproductive – you'll be too tired to think! Reviewing class notes, working problems, and reading the text should all be part of your regular routine.

Understand the material. Memorizing a bunch of details (and there are LOTS of them here) is not the optimal way to learn this material. You need to learn the underlying principles for how and why a process occurs the way it does, so that you can then apply this principle to a new situation.

Work in Groups. Many people find that a regular study group is helpful. Most graduate students and Medical/Dental/Health students study in groups. This does not mean you do not need to study alone, but group time is a great way to test your understanding by asking questions and trying to answer questions. This is the best way to test if you really understand something (enough to explain it).

Ask for Help. We have office hours throughout the week, not only with faculty, also Teaching Undergrad Teaching Assistants. Use these resources. Visit faculty during office hours (or make an appointment) to ask questions about the material. Biochemistry is hard! No one will think you're stupid if you ask for help!

Tutoring:

Biochemistry is elegant but it can be convoluted and extremely detailed. We generally will not ask you to memorize material, rather, we will ask you to apply basic knowledge to new situations. Nevertheless, approaching this material for the first time can seem daunting. To help, we will have a couple of options for you:

- Ask us and come to office hours
- Use GUSS and talk to the SAAs
- Professor Chapman will run Exam Reviews prior to each of the exams.

Navigating the Text and Problems Books:

Included in this notebook are suggestions about problems to try both from the end of each chapter in the textbook and from the *Absolute Ultimate Guide*. You are ***strongly advised*** to work through the problems as part of your study regime. Similar problems may appear on exams!

To help you with the material in each chapter of the text:

- Review the Summary that concludes each section within the chapter.
- Review the Key Terms found at the end of each chapter – there will be page numbers pointing you to context within the chapter. Additionally, bolded words are found in the Glossary at the end of the book (before the Index).
- For the problems in the text, abbreviated solutions appear at the end of the book (AS pages) but more detailed solutions appear in the 2nd half of the *Absolute Ultimate Guide* (S pages).

To help you with the material in each chapter of the *Absolute Ultimate Guide*:

- First, recognize that Chapter 1 of the *Guide* reviews the same material as Chapter 1 of the textbook, Chapter 2 with Chapter 2, etc.
- Have a good grasp of the "Major Concepts" that begin each chapter.
- Read the "What to Review" section to identify places where you might need extra help.
- The "Topics for Discussion" may come up in lecture or lab. Reading the textbook along with the *Absolute, Ultimate Guide* will help you fill these in. However, note that we are not covering each part of each chapter to the same depth, so focus on the sections that are noted by ** or * in the details for each chapter.
- The "Do You Know the Facts?" and "Applying What You Know" sections will be the ones most likely to appear on exams! The answers to these appear at the end of each chapter, but try each question before you peek.

A few general words: The more problems you do, the better prepared you will be to handle anything you see on the exams. Even if some of these problems are not specifically assigned, you might want to look at them anyway. For example, we won't assign the crossword puzzles, but the more you look, the better understanding of the vocabulary you'll develop. The problems we suggest convey something important and have a reasonable probability of appearing on an exam!

Additional resources:

Oregon State University has put its Biochemistry course by Professor Kevin Ahern online. You can access the videos, etc., here:
https://itunes.apple.com/us/course/biochemistry-for-pre-meds/id556410409
Note the book this course is based on is not the same one we use. Further, you can expect different emphases on the topics. However, this might be a good way to hear the material again to help you review.

The Biochemistry course at the Online Learning Initiative (OLI) at Carnegie Mellon University is also good. You will need to sign up for an account (it's free). We will have pointers to specific modules in the OLI course throughout the Lecture Notes for those who are interested. Some of this material is more detailed than we will expect you to know. However, if you feel confident with the material provided there, you will be able to handle anything you see on the exams. The initial page to get started is here: https://oli.cmu.edu/courses/biochemistry-open-free

One Final Note:
With effort and dedication, everyone can do well in this course! Ways to help improve your scores include:

- Attending class on a regular basis
- Turning your work in on time, especially your lab work
- Participating in the online feedback sessions
- Studying Biochemistry for an hour each day (rather than for 10 hours the night before an exam). Your study efforts should include (in this order)
  - working the problems: end of chapter problems; *Absolute, Ultimate Guide* problems, OLI at CMU problems
  - reviewing your notes
  - asking questions during office hours
  - reading the textbook in detail (the book is a great resource for you, but is encyclopedic in its coverage – do NOT memorize!)

Copyright:
The materials used in Georgetown University courses ("Course Materials") generally represent the intellectual property of course instructors which may not be disseminated or reproduced in any form for public distribution (e.g., sale, exChoige, etc.) without the written permission of the course instructor. Course Materials include all written or electronic documents and materials, including syllabi, current and past examination questions/answers, answer keys to labs, lab manual, other distributed material and presentations such as lectures, videos, PowerPoints, etc., provided by a course instructor. Course Materials may only be used by students enrolled in the course for academic (course-related) purposes. Published course readings (book chapters, articles, reports, etc.) available in Canvas are copyrighted material. These works are made available to students through licensed databases or fair use. They are protected by copyright law, and may not be further disseminated or reproduced in any form for distribution (e.g., uploading to websites, sale, exChoige, etc.) without permission of the copyright owner.

Sexual Misconduct Policy:
Georgetown University and its faculty are committed to supporting survivors of sexual misconduct, including relationship violence, sexual harassment and sexual assault. University policy requires faculty members to report any disclosures about sexual misconduct to the Title IX Coordinator, whose role is to coordinate the University's response to sexual misconduct.

Georgetown has a number of fully confidential professional resources who can provide support and assistance to survivors of sexual assault and other forms of sexual misconduct.

More information about campus resources and reporting sexual misconduct can be found at http://sexualassault.georgetown.edu.

My personal statement of inclusivity and diversity:
I am a Scientist and Educator of Color interested in teaching and promoting increased diversity in STEM through my courses and service work.

Increasing diversity in STEM increases the pace of discovery and advancement in the field. More importantly, increasing diversity in STEM is the right thing to do; it's corrective of past and current injustices; it's fundamentally about building a just and more equitable future. Every person deserves a chance to have a career and role in the field of their choosing.

Within the context of this course, it is important that all students have a reasonable chance to learn and succeed in the course. You each come with different strengths and have areas where you need help. My hope is that we will build a class culture where each of you feel confident enough to share your strengths and help one another where appropriate. It is also important that you feel safe and have a sense of belonging in the community we will build together, such that you can bravely share your vulnerabilities and learn to correct and improve on your weaknesses.

I hope you will agree to this conscious, open mindset. I hope that you will join me in building this community.

If during the course of this semester, you face external or internal challenges and factors that affect your ability to succeed in the course, please tell me. I will try to help. Of course, you are also welcome to reach out to your dean or health professionals. Remember that we are here to help you succeed. Every one of us; every one of you.

As all of you know, an important part of the philosophy of Foundations I, one that every faculty in Foundations I shares and works hard to achieve, is that we want to provide each and every student in our course a reasonable opportunity to succeed. As SAAs in Foundations I, as part of the teaching team, we ask that you share this philosophy, and this mission with us. We need your help, each and every one of you, to help us achieve this goal. We will work hard with you to give you the tools needed for you to be effective in this task. We will teach you to be effective teachers, to grade fairly, to help your students academically, as well as teach you how to help students develop the underlying skills necessary to become successful students.

But the desire to help your fellow students, the buy-in, that must come from you. We have the utmost confidence in your desire to help. It's why you were selected as SAAs. If you ever have any concern that a student is not succeeding in Foundations, please tell us. We will work to provide the support they need.

Thank you.

Department of Biology Learning Goals

Insight into the Process and Product of Science

1. Integration of new knowledge into existing intellectual frameworks
    - Deepen your understanding of the molecular aspects of living systems

2. Engagement with scientific inquiry
    - How hypotheses are generated, how experiments are performed to test those hypotheses, and what conclusions can be drawn from the results of the experiments
    - Improve your skills in data interpretation and experimental design

3. Representing and interpreting data in quantitative and statistically meaningful forms
    - Gain facility with interpretation of graphs, charts and tables

4. Communicating scientific understanding in oral and written forms
    - Practice scientific writing and presentations
    - Understand big picture scenarios and be able to explain them

5. Appreciating the epistemology of science
    - How do we know what we know?
    - How do historical precedents inform our thinking? What are these historical precedents?

Fundamental Biological Concepts

6. Organization of molecular, cellular and ecological systems
    - Building blocks of biological systems (amino acids, monosaccharides, nucleotides)
    - Structure/function relationships
    - Hierarchy of biological organizations (molecules, cells, tissues, organisms)

7. Evolution as a framework for understanding biological systems
    - Theories of and evidence for evolution – impact on cells, tissues, and organs in closely and distantly related species

8. The flow of biological information
    - Central dogma of information flow
    - Signaling pathways

9. Flow of energy and matter in biological systems
    - Metabolic pathways

10. Interdependence and interactions within biological systems and their emergent properties
    - Interactions between genetic and environmental factors leading to emergent properties of phenotypes
    - Homeostasis of biological systems
    - Intracellular, and intercellular communication and interactions