

BIOLOGY 40 WINTER 2025—Biochemistry—G. Eric Schaller

Biol 40 involves studies of molecular structure and function from a biochemical point of view, emphasizing the biochemistry of proteins, lipids, and carbohydrates. Topics include protein structure and function, enzymes and enzyme kinetics, lipids and membranes, and carbohydrates and cell walls. The participation of these biomolecules in metabolism is also examined, with an emphasis upon carbohydrate metabolism. The course concludes with an analysis on how metabolism is integrated.

Lecture (LSC105): MWF 10:10-11:15, X (TH 12:15-1:05) used as indicated in syllabus

Discussion: W 2:10-3:10 (LSC336) or Th 2:25-3:25 (LSC336) (you may attend either section)
Used for going over methods for biochemical problem solving and problem sets (these are not graded but there will be exam questions based on the problem sets). Also to discuss relevant research papers.

Instructor: G. Eric Schaller, Life Sciences Center Room 339, Phone: 646-2525
Email: george.e.schaller@dartmouth.edu
Office Hours: M 4-5 pm (LSC 352), W 3:10-4 PM (LSC336) and by arrangement

Recommended Text: Fundamentals of Biochemistry (Voet, Voet, Pratt, Heilman, and Woski) (6th edition, 2024)

Available: Lecture notes and powerpoint presentations will be posted to Canvas.

Prerequisites: Biology 12/19 (Cell Structure/Function), Chemistry 52 or 58 (Organic Chemistry), or permission of instructor

Exams and grading:	Exam 1	100 points
	Exam 2	100 points
	Exam 3	100 points
	Final Exam	120 points
	Problem sets	10 points
	Quizzes	10 points

The first three exams cover lectures for each section (see Class Schedule for dates and Exams and Grading Policies for format). The final exam is semi-comprehensive, with emphasis is on last section of the course but it will incorporate major information from earlier in the course. Your grade will be calculated using two different methods and you will receive the highest grade of the two.

Method 1: total out of all three exams and the final (i.e. a percentage based on a total of 440 available points). **Method 2:** dropping the lowest of the first three exam grades (i.e. a percentage based on a total of 340 points). In both cases the final exam is always counted.

Lectures and Exams:

Date	Lect #	Topic	Reading 5th ed (6th ed)
M Jan 6	1	Introduction	1-11 (1-12), pdf
W Jan 8	2	Properties of water	23-41 (24-46)
X Jan 9	3	Amino acids	80-96 (47-68)
F Jan 10	4	Primary protein structure and purification	97-108 (64-65, 1051-1063), 119-126 (1073-1076)
M Jan 13	5	Sequencing; 3-D protein structure	110-119 (1064-1071), 131-179 (69-110)
W Jan 15	6	3-D protein structure (cont)	
X Jan 16	7	Proteins: Myoglobin and hemoglobin	180-200 (111-119)
F Jan 17	8	Proteins: Myoglobin and hemoglobin (cont)	
M Jan 20		No class (MLK Jr Day)	
W Jan 22	9	Enzyme Introduction and Kinetics	11-20 (13-21), 322-330 (262-270), 361-382 (303-326)
X Jan 23		Exam Review Session	
X Jan 23		Exam 1 (7-9 pm) covers Lectures 1-8, LSC 105	
F Jan 24	10	Enzyme Kinetics (cont)	
M Jan 27	11	Enzymatic catalysis	330-339 (271-280)
W Jan 29	12	Enzyme Reaction Mechanisms	345-355 (287-297)
X Jan 30	13	Enzyme Regulation	355-357 (297-299), 382-391 (326-334)
F Jan 31	14	Lipids	245-258 (187-200)
M Feb 3	15	Membranes and Membrane Transport	259-276 (201-218), 293-318 (234-260)
W Feb 5	16	Metabolism and Bioenergetics	442-477 (392-426)
X Feb 6		No class	
F Feb 7	17	Metabolism and Bioenergetics (cont)	
M Feb 10		Exam Review Session	
M Feb 10		Exam 2 (7-9 pm) covers Lectures 9-15, LSC 105	
W Feb 12	18	Carbohydrates	221-244 (123-151)
X Feb 13	19	Glycolysis	478-497 (427-449)
F Feb 14	20	Entry and exit from glycolysis	497-502 (454-460), 508-512 (450-454)
M Feb 17	21	Gluconeogenesis	544-549 (461-466)
W Feb 19	22	Regulation of glycolysis and gluconeogenesis	502-507, 549-551 (466-473)
X Feb 20		No class	
F Feb 21	23	Glycogen; pentose phosphate pathway	523-544 (485-506), 512-517 (474-478)

M	Feb 24	24	The Citric Acid Cycle	558-587 (512-543)
W	Feb 26	25	Oxidative Phosphorylation	588-628 (544-586)
X	Feb 27		Exam Review Session	
X	Feb 27		Exam 3 (7-9 pm) covers Lectures 16-23, LSC 105	
F	Feb 28	26	Fatty acid metabolism	664-700 (633-669)
M	Mar 3	27	Fatty acid metabolism (cont)	
W	Mar 5	28	Amino acid metabolism	718-746 (690-720)
X	Mar 6	29	Integration of Metabolism	773-800 (747-777)
F	Mar 7	30	Integration of Metabolism (cont)	

Final Exam (semi-comprehensive with emphasis on recent material)

Monday March 10, 3-6 PM

Course Goals and Learning Objectives:

1. To gain a solid foundation in biochemistry. Biochemistry synthesizes material from courses you previously took and should put both biological and chemical aspects of these courses into context (e.g. suddenly the phrase “nucleophilic attack upon a carbonyl” will assume an unprecedented relevance to your life). Biochemistry provides the background required for upper-level courses (e.g. BIOL69: Cell Signaling and BIOL78: Molecular Mysteries of Human Biology). Biochemistry provides the background for medicine and graduate studies.

2. To improve quantitative skills. Math skills are essential to science and many other disciplines, but it was discovered that these skills had been waning in recent years because not adequately emphasized at the college level. A student once asked me why I took off points for an exam answer when they had set up the answer correctly but had “just made a math error.” An example of why such an error is important can be found at <http://abcnews.go.com/Health/Story?id=4299616&page=1>. You can find other similar stories by performing a Google search with keywords such as ‘baby’ ‘error’ and ‘dose’.

3. To improve learning skills. Like many biology courses, biochemistry requires learning a ‘vocabulary’ and then applying this vocabulary to scientific questions. For example, you will need to memorize structures of amino acids, the glycolytic pathway, and several enzymatic reaction mechanisms for this course (the vocabulary). We are sometimes asked as to why we consider such memorization an important skill. For those going on the medical school, memorization is a key skill to develop, and is emphasized in medical programs, again for the obvious reason that one must know what to do in immediate response to a crisis, without losing the time it would take to look something up in a text or on-line. Beyond that one must have information in mind in order to be able to make the mental connections that lead to new insights. Applying the biochemical vocabulary is the next step and, for this reason, exam questions will sometimes go beyond what was directly discussed in class and ask you to apply information from the course to novel questions.

Expectations:

Here's what we expect from you:

1. To take detailed notes while you are listening to synchronous lectures and recorded videos
2. To attend and participate in W/Th discussions, mentally prepared to think about Biochemistry
3. To be willing to ask questions and participate in class activities
4. To listen to pre-lecture videos and complete quizzes as scheduled
5. To utilize active learning techniques to master course material
6. To work on the problem set questions and turn assigned problems in on time
7. To observe and follow the academic Honor Principle

Here's what you can expect from me:

1. To bring expertise and enthusiasm to the class
2. To be willing to answer questions and facilitate discussions
3. To challenge you to stretch beyond your comfort zone
4. To encourage you to try new approaches for studying and learning that are “active”
5. To provide opportunities for you to practice problem solving

Course Structure:

We will meet in person for lectures on MWF and Th (during X-hour) at the normal meeting times for the Period 10 timeslot. Discussion sessions will meet on W (2:10-3:10 PM EST) and Th (2:25-3:25 PM EST). You may attend either or both discussion sessions. Discussion sessions will be used for going over selected problems related to the problem sets, or for discussion of research papers relevant to the current exam unit. The lectures will be recorded but will not be simulcast via zoom (note that the Discussion sections will not be recorded). The recordings will be available via Panopto on Canvas. Be sure to read the “Consent to Record” section, since you are agreeing to this by enrolling in the class.

Attendance:

You are expected to attend class in person unless you have made alternative arrangements due to illness, medical reasons, or having to isolate due to COVID-19. For the health and safety of our class community, **please do not attend lecture or discussion sessions when you are sick**, nor when you have been instructed by Student Health Services to stay home. Please note that multiple respiratory viruses (RSV, influenza, and COVID-19 variants) might be spreading widely and rapidly this winter. Be sure to take rest and recover if you are feeling ill. You will be able to view recordings of the lecture on Canvas if you are unable to attend.

Personal Responses via PollEverywhere:

We will be using the technology called PollEverywhere in our course this term to present “clicker” questions during lectures. One purpose for polling during class is that it allows me to gauge your understanding in real time. The best way for me to gain an accurate assessment is if the majority of the class answers each of the in-class questions. Additionally, research has demonstrated that in-class questions help students to engage with the course material, and this facilitates learning and synthesis. It will help me if ALL of you participate (instead of just the ones who are willing to virtually “raise” their hands). You will be answering anonymously – I

will not see what answers you give. Although your grade will not depend on “clicker” question participation, I hope all of you will participate fully throughout the term.

The easiest and most convenient method to respond to polls is with a smartphone. Please download the Poll Everywhere app to do this.

iOS: <https://itunes.apple.com/us/app/poll-everywhere/id893375312>

Android: <https://play.google.com/store/apps/details?id=com.polleverywhere.mobile>

If you are not able to use a smartphone to respond, you may use another internet-enabled device such as a tablet or a laptop. In the app, type **POLLEV.COM/bio40** to join the presentation. If you have any technical questions or problems, please contact edtech@dartmouth.edu - they will be able to assist.

Problem Sets and Research Papers:

Problem sets will be posted each week to help you develop and hone your skill in solving biochemical questions—these problem sets will incorporate problems from the book as well as additional relevant problems. Sometimes, there will be a questionnaire about a relevant research article – selected from the literature to enhance your understanding of a relevant biochemical topic – that will be posted instead of problem set questions. We will use the Discussion sections to cover some representative problems from the problem sets (usually the tougher ones), as well as the research articles.

We will assign a subset of the biochemical problems to be completed prior to the Discussion sections as homework. These are to be completed and submitted on Gradescope through Canvas before going to the Discussion session as part of your participation grade (see Exams and Grading). To receive credit, you must submit the homework by the specified date and time. Late submission will not receive any points. **These assignments will not be graded**, but we will use them (1) to help us assess your understanding of the material and (2) to ensure that you are prepared before coming to the Discussion session.

Pre-lecture Quizzes:

I will use short videos to present introductory or supplementary material that is important for in-class lecture meetings. **Part of your participation grade will be based on short quizzes that you will complete online in Canvas after viewing the pre-lecture recordings.** To receive credit, you must complete the quiz by the time posted **before** the specified lecture class meeting. I will use these quizzes (1) to help me assess your understanding of the material and (2) to ensure that you watch the pre-lecture recordings before class. While taking the quiz you may refer to any notes you took while watching the video.

Exams and Grading Policies:

The exams will be a mixture of testing your mastery of the information and applying your knowledge to problem solving. The exams will be taken in-person on the dates and times indicated in the Lecture and Exams schedule. Once completed, the exams will be scanned and posted to Gradescope on Canvas for grading. Hard copy exams will be retained should there be a problem with any of the pages scanned to Gradescope. Grading of exams will be done through Gradescope.

The following points summarize the grading procedures with respect to exams for BIOL 40:

1. After the exam has been graded, a copy of the answer key will be posted on the Canvas site. Please review the answer key carefully and make sure that you understand the errors in your exam and why you made them.
2. The number of points given for each answer is final. If, after reviewing your answers and comparing them to the posted answer key, you find an arithmetic error or detect an omission by the grader for one of the questions, you must observe the following procedures for error correction:
 - a. Prepare an electronic cover page (file format: Word or PDF) and name the file as “Error correction request – your name”. Specify the page and the question number you are requesting for error correction.
 - b. If you determine that your answer contains all of the information indicated in the answer key, but you did not receive full credit, simply indicate the number of the question to be re-evaluated and state in one or two short, descriptive sentences (must be typed) what makes your answer correct.
 - c. Email your typed cover page to Professor Schaller (George.e.schaller@dartmouth.edu) within 7 days after you receive the graded exam. We will not accept questions regarding errors in grading after the deadline. The error correction process will take a few days. You will be notified through email after the reevaluation is completed.

A final note about exams and grades:

You are not competing against each other for grades in Biol 40. All grades, up until the final letter grade is decided, are recorded as numerical points. I do not assign letter grades to individual exams. Here are three important points about grades in BIOL 40:

- (a) A grade of 90% or above will always be at least an “A-.” No one will be penalized for learning what we teach. Thus, it is entirely possible for everyone in the class to receive a grade of “A-” or better.
- (b) In order to receive a D, you have to achieve a final grade of at least 50%. In other words, a final grade less than 50% is an E.
- (c) The median grade for this course will most likely be a “B+”. That means if the median numerical score for the course were 70%, then a grade of 70% is a “B+”.

Missing an Exam:

In case of documented illness, family emergency, or academic conflict, special arrangements for taking the examination can be made, but only if (1) you notify me in advance prior to the scheduled time for the exam, and (2) your need to take the exam at other than the scheduled time is clearly justified. Failure to take an exam at the scheduled time, or failure to submit the exam within the allotted time, will result in a grade of zero for that exam. In the event you are ill and unable to prepare for or write an exam, you must seek medical attention to determine if you need treatment; this is for your own health and for the health of others around you.

Academic Honor Principle: Specific Expectations for BIOL 40:

Dartmouth’s Academic Honor Principle states "Academic integrity is foundational to a Dartmouth education. All members of the Dartmouth community—faculty, staff, and students—

are responsible for maintaining a culture of integrity, honesty, and respect in teaching, learning, scholarship, and creative work. By upholding this principle, we foster an atmosphere of intellectual growth and personal development both within and beyond Dartmouth."

Dartmouth's Academic Honor Principle and the Arts and Sciences Academic Honor Policy as applied to BIOL40 affects exams and pre-lecture quizzes. These include (but are not limited to the following):

- (a) All exams (including the final exam) are closed-book assessments. All pre-lecture quizzes are open book, but they are not open person or open web. You must complete both the exams and pre-lecture quizzes entirely by yourself, without any assistance from any person or the internet (the only permissible exception is that students may request clarification of any exam question from the course instructor who is present expressly for that purpose). **The answers that you provide must be entirely your own work.** Any communication prior to the examination, or during the examination, with anyone having knowledge about the content of the exam would constitute a breach of the Dartmouth's Academic Honor Principle and the Arts and Sciences Academic Honor Policy for Undergraduates.
- (b) Our policy permits the re-submission of exams for potential error correction by the instructor. Any alteration of the answers between the time when the graded exams were returned to the student and the time when the exam was submitted for error correction would constitute a breach of the Dartmouth's Academic Honor Principle and the Arts and Sciences Academic Honor Policy for Undergraduates.

Honesty is the foundation of the academic pursuit of knowledge. In recognition of this, I will not overlook any violations of the Academic Honor Principle. **Violations of any of the above will result in a grade of zero for the exam, with the exam also counted toward your final grade in the course.** Potential honor code violations will also be reported to the Dartmouth Committee on Standards.

Use of Generative Artificial Intelligence:

While the use of Generative Artificial Intelligence (GenAI) technologies has become more common, the use of GenAI is not appropriate for how I teach and grade BIOL40, and would impair your ability to perform well in the course. GenAI is treated similarly to other resources that you have access to (e.g. the internet), and its use on exams and prelecture quizzes constitutes a violation of the Dartmouth's Academic Honor Principle and the Arts and Sciences Academic Honor Policy for Undergraduates. Please see section on *Academic Honor Principle: Specific Expectations for BIOL 40*.

Student Accessibility Services:

Students requesting disability-related accommodations and services for this course are encouraged to schedule a meeting with me as early in the term as possible. This conversation will help to establish how your accommodations will be implemented in my course and what role Student Accessibility Services (SAS) or its [Testing Center](#) may play in assisting. In order for accommodations to be authorized, students are required to register with SAS ([Getting Started with SAS webpage](#); student.accessibility.services@dartmouth.edu; 603-646-9900) and to request

an accommodation email be sent to me in advance of the need for an accommodation. If students have questions about whether they are eligible for accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.

Wellness Concerns:

I recognize that academic terms at Dartmouth are challenging and intensive, and that classes are not the only demanding part of your life. There are a number of resources available to you on campus to support your wellness, including:

- [Primary Care and Dartmouth College Health Service \(Dick's House\)](#)
- [Counseling Center at Dick's House](#), call 603-646-9442, available 24/7
- [Student Wellness Center](#) in Berry Library
- [Pastoral Counseling](#) through the William Jewett Tucker Spiritual Center
- [Dartmouth Student Mental Health Union](#) if you would like to speak to a peer support listener
- Your [Undergraduate Dean](#)

Your well-being is very important to me. Please make me aware of anything that will hinder your success in this course.

Title IX Safety and inclusivity:

At Dartmouth, we value integrity, responsibility, and respect for the rights and interests of others, all central to our Principles of Community. We are dedicated to establishing and maintaining a safe and inclusive campus where all have equal access to the educational and employment opportunities Dartmouth offers. We strive to promote an environment of sexual respect, safety, and well-being. In its policies and standards, Dartmouth demonstrates unequivocally that sexual assault, gender-based harassment, domestic violence, dating violence, and stalking are not tolerated in our community.

The Title IX Website (<https://sexual-respect.dartmouth.edu>) at Dartmouth provides a wealth of information on your rights with regard to sexual respect and resources that are available to all in our community.

Please note that, as a faculty member, I am obligated to share disclosures regarding conduct under Title IX with Dartmouth's Title IX Coordinator. Confidential resources are also available, and include licensed medical or counseling professionals (e.g., a licensed psychologist), staff members of organizations recognized as rape crisis centers under state law (such as WISE), and ordained clergy (see <https://sexual-respect.dartmouth.edu/get-help-emergency-0>).

Should you have any questions, please feel free to contact Dartmouth's Title IX Coordinator. Their contact information can be found on the Title IX website at (<https://sexual-respect.dartmouth.edu/compliance/title-ix/title-ix-coordinator>)

Religious observances:

Dartmouth has a deep commitment to support students' religious observances and diverse faith practices. Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the

course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

Consent to Recording:

As indicated, lectures will be recorded, and by enrolling in the course, you make the following consents to recording. These consents apply to in-person as well as remote (e.g. Zoom) recordings.

(1) Consent to recording of lecture and group meetings

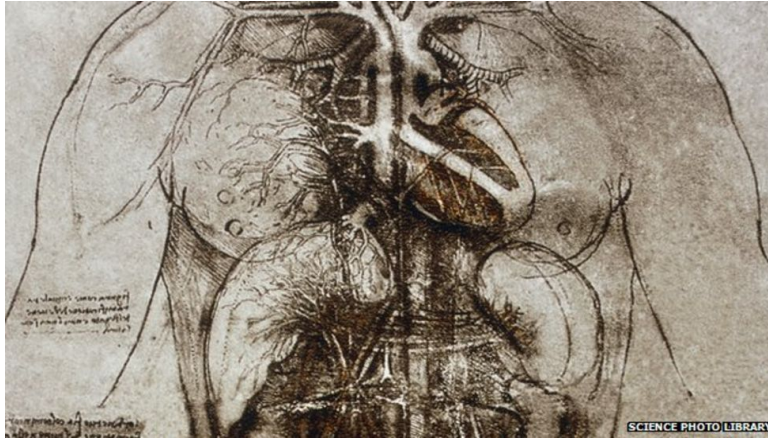
- a) By enrolling in this course, you affirm your understanding that this course and any associated group meetings involving students and the instructor, including but not limited to scheduled and ad hoc office hours and other consultations, may be recorded within any digital platform used to offer in-person or remote instruction for this course.
- b) You further affirm that the instructor owns the copyright to their instructional material, of which these recordings constitute a part, and distribution of any of these recordings in whole or in part without prior written consent of the instructor may be subject to discipline by Dartmouth up to and including expulsion.
- c) You authorize Dartmouth and anyone acting on behalf of Dartmouth to record your participation and appearance in any medium, and to use your name, likeness, and voice in connection with such recording; and
- d) You authorize Dartmouth and anyone acting on behalf of Dartmouth to use, reproduce, or distribute such recording without restrictions or limitation for any educational purpose deemed appropriate by Dartmouth and anyone acting on behalf of Dartmouth.

(2) Requirement of consent to one-on-one recordings

By enrolling in this course, you hereby affirm that you will not under any circumstance make a recording in any medium of any one-on-one meeting with the instructor without obtaining the prior written consent of all those participating, and you understand that if you violate this prohibition, you will be subject to discipline by Dartmouth up to and including expulsion, as well as any other civil or criminal penalties under applicable law.

Access to Campus Resources:

Many of you may be facing greater challenges than usual given the sudden changes to your living and learning environment, public health concerns, and a host of other factors (e.g., housing or food insecurity, new or changing caregiving responsibilities, visa and accessibility concerns, access to health and mental health support, and so on). We want you to be aware of the campus resources available to support your needs. While the situation is constantly evolving, many offices are prepared to meet with you via phone or Zoom. For concerns about health and wellness, you may reach out to the [Dartmouth Health Service](#) (603-646-9400 or Secure Message in DartHub), [Counseling Services](#) (603-646-9442), and the [Student Wellness Center](#). For academic needs, you may contact your [undergraduate dean](#) (603-646-2243), [Student Accessibility Services](#) (603-646-9900), and the [Academic Skills Center](#) (603-646-2014). Students with concerns related to campus employment may connect with the [Student Employment Office](#) (603-646-3641). Those with visa-related concerns may reach out to the [Office of Visa and Immigration Services](#) (603-646-3474). We encourage you to take advantage of these resources, and to speak with us if you need support in the class.



Advice about learning, from Leonardo da Vinci:

We know for certain that sight is one of the most rapid actions we can perform. In an instant, we see an infinite number of forms; still, we only take in thoroughly one object at a time.

Suppose that you, Reader, were to glance rapidly at this entire written page. You would instantly perceive that it was covered with various letters; but you could not, in that short time, recognize what the letters were, or what they were meant to tell. Therefore, you would need to see them word-by-word, line-by-line, to be able to understand the letters. Again, as another example, if you wish to go to the top of a building, you must go up step by step; otherwise, it will be impossible for you to reach the top.

Thus I say to you, whom nature prompts to pursue this art, if you wish to have a sound knowledge of the forms of objects, begin with the details of them, and do not go on to the second step until you have the first step well fixed in memory and in practice. And if you do otherwise, you will throw away your time, or certainly greatly prolong your studies.

Ten recommendations for doing well in BIOL 40:

1. Keep up with readings in the text. Read the text before class. Do problem sets and recommended problems in the text. Go over the material again the same day as covered in lecture.
2. Attend lectures. The lectures do not simply re-iterate material from the text. Exams are primarily based on material from the lectures and problem sets.
3. Ask questions in class. If you have a question, someone else probably also has the same question.
4. Use PollEverywhere in class. Besides allowing for group participation and immediate feedback, the physical act of responding with your device has been shown to improve comprehension and learning of material. Make it work for you.
5. Attend discussion. The recitation will be used to go over problems and discussion papers not covered in the lecture. You will not necessarily be able to do every problem in the problem sets before discussion, but examples of the most important problems will be gone over in the discussion section.

6. Come to office hours. I approach office hours as a way to have smaller discussions on the areas that you find most important or troublesome.
7. Form study groups. Working with other people on problems and concepts invariably helps with learning the material.
8. Use information on Canvas. Posted under Syllabus, Lectures (Powerpoints, Class notes, and sample Exam questions), and Problem Sets (Problem sets, Readings).
9. Be well rested before taking the exams. When tired one can sometimes remember information memorized from an all-nighter, but it will be almost impossible to apply that to a novel situation.
10. Think about how the material applies to your own life. Some examples will be brought up in class, but you may find other examples at home and play. Feel free to share these with me.