

## Course syllabus and information

### Course information

Biochemistry and Molecular Biology 461 (BMB461) - Advanced Biochemistry I

11:30 a.m.-12:20 p.m. MWF

Spring semester 2023

In-person; Biochemistry 101

Course website via D2L (d2l.msu.edu)

### Contact Information

| Instructor Information   | Lectures           | Office and Office Hours  |
|--|--------------------|--|
| <b>Dr. Kevin Haudek</b><br><b>Course coordinator</b><br><a href="mailto:haudekke@msu.edu">haudekke@msu.edu</a> (must include "BMB461" in subject line) | 1-18               | 219 Biochemistry Bldg.<br>Office hours (in-person): Mondays 1-2 p.m.<br>Wednesdays 10:15-11:15 a.m.<br>Or by email appointment<br><i>Zoom link by request</i>    |
| Dr. Sophia Lunt<br><a href="mailto:sophia@msu.edu">sophia@msu.edu</a> (must include "BMB461" in subject line)  | 19-29              | 522A Biochemistry<br>Office hours (in-person) during Unit 3:<br>Mondays 2-3 p.m.<br>Or by email appointment<br><i>Zoom link by request</i>                       |
| Dr. Michaela TerAvest<br><a href="mailto:teraves2@msu.edu">teraves2@msu.edu</a> (must include "BMB461" in subject line)                                | 30-41              | 209A Biochemistry<br>Office hours (in-person) during Unit 4:<br>Mondays 2-3 p.m. & Wednesdays 2-3 p.m.<br>Or by email appointment<br><i>Zoom link by request</i> |
| Izzy Adams<br><a href="mailto:adamsis2@msu.edu">adamsis2@msu.edu</a> (must include "BMB461" in subject line)   | Learning Assistant | <i>Review sessions:</i><br>Time & location TBA<br><br><i>Drop in office/help hours:</i><br>Thursdays 5-6 p.m. location TBA                                       |

### Course Materials

All course materials are used in BMB462 as well.

#### Required

- Nelson, D.L. and Cox, M.M. Lehninger's Principles of Biochemistry, 7<sup>th</sup> or 8<sup>th</sup> ed. (2017 / 2021). W.H. Freeman, New York. 1172 pages.
- Access to Macmillan Achieve ([www.achieve.macmillanlearning.com](http://www.achieve.macmillanlearning.com)); an online homework system integrated with an electronic version of the textbook.

Using the older version of the textbook is an option, but if you elect to do so, you are responsible to match the required reading pages/sections appropriately. Alternatively, you may elect to purchase an electronic version of the textbook directly from the publisher.

- i>clicker Cloud account or i>clicker remote

### *Recommended*

- The study guide associated with the Lehninger textbook (*The Absolute, Ultimate Guide to Lehninger Principles of Biochemistry: Study Guide and Solutions Manual* by Marcy Osgood and Karen Ocorr) is an optional resource for this course, but many students have found it helpful in the past.
- Previous students have found another book that nicely explains the chemistry and sequence of reactions in biochemical pathways very helpful:  
Wilkins, Carol A. Understanding Biochemical Pathways: A Pattern-Recognition Approach., 2nd ed. (2021) Cognella, Inc. 226 pages.

## **Course Objectives**

BMB 461 is the first semester of the undergraduate series, BMB 461-462, which provides students with an introduction to biochemistry at the advanced undergraduate level. It is designed primarily for students majoring in Biochemistry or closely related field. BMB 461 is a three credit course that reintroduces basic biochemistry concepts including protein structure and function and focuses on carbohydrate and energy metabolism. The following topics will be discussed during this term:

- |                                 |  |
|---------------------------------|--|
| •Buffers, pH                    | •Glucose Metabolism                            |
| •Protein Structure              | •Pentose Phosphate Pathway                     |
| •Protein Purification           | •Glycogen metabolism and regulation            |
| •Protein-Ligand Binding         | •Citric Acid Cycle, Glyoxylate Cycle           |
| •Enzyme Catalysis and Mechanism | •Electron Transport, Oxidative Phosphorylation |
| •Enzyme Kinetics                | •Photosynthesis                                |
| •Carbohydrates                  |  |

For each of these topics you will be expected to apply basic biochemical principles to explain biological systems and processes and predict how alterations will impact these systems or processes.

### *Course Expectations of Students*

BMB461 is a rigorous, fast-paced, advanced biochemistry course. Students that complete the course routinely comment that it is one of the most challenging and rewarding classes at MSU. Habits of previously successful students include studying before or after every lecture, completing homework assignments regularly before the posted deadline, forming study groups and attending review sessions. By examining the textbook and course schedule, you will find that the course covers a lot of material each lecture and week. Be forewarned that academic success in this course will likely take a large amount of effort. The instructors are aware of the challenging nature of this course and have devised a course structure to accommodate these challenges (see appropriate sections below for specifics). For example, we enforce weekly homework deadlines to encourage you to keep up with the course content. The grading scale for each grade level is already lowered to accommodate the difficulty of exams and align with past semester performances of this course. Some notecards and calculators are permitted on exams in

order to assist you with challenging exam questions. These aspects of the course are intended to help you be successful in this course. We encourage you to prepare yourself for success by devoting the required effort and time necessary for this course.

## Assessments

Your grade in BMB 461 will be determined by your performance on the following assessments and weighted by the percentage indicated:

| Assessment        | Weight | Date or information  |
|-------------------|--------|--|
| Exam I            | 20%    |  |
| Exam II           | 20%    |  |
| Exam III          | 20%    |  |
| Exam IV           | 20%    | May 4; per University Final Exam schedule  |
| In class clickers | 5%     | Used during every lecture session with each day weighted equally; drop lowest 10 scores at end of semester |
| Online homework   | 15%    | Weekly assignments; drop lowest 3 scores at end of semester  |

Additional information about each of these assessments is given below. A total of 0.5% bonus can be earned for completion of optional online quizzes or surveys at the end of the course. The purpose of the extra credit is to give you the opportunity to ensure that if you are within 0.5% of a cutoff for a particular grade for the course that you will earn the higher grade. Please check D2L during the last week of class for these optional assessments. No other bonus opportunity or extra credit is offered in this course.

### *Exams*

Exams will contain a mixture of multiple choice, true/false, calculation and free response questions at the instructor's discretion. Each exam contributes to your final course score based on the percentage of indicated above. Exam answer sheets will be provided for all students. Midterm exams will be held in the same room and class time as lectures. Check the university's final exam schedule for details on the final exam location, day and time.

To ensure fairness, we have developed a set of rules. You will enter the room through the specified door(s) and will be assigned to a seat by the instructor or test proctor. Once you are in the room, refrain from talking to your classmates. You must not open the exam until instructed to do so. You will get warnings approximately 15 min and 5 min prior to the end of the exam. Filling in any part of the exam after time has been called is considered cheating and will be dealt with accordingly! When finished, you should put all portions of the exam into the appropriate boxes at the front of the room. You should not talk until you have left the room and/or all of the exams are collected. A copy of the exam with key will

be posted when grades are available. Deadlines for reviewing your exam for errors will be given after each exam.

Calculators without Wi-Fi capabilities *will be allowed* on all exams. Calculators with Wi-Fi capabilities, cellphones, and other Wi-Fi devices *may not be used* during the exams. To encourage higher order learning, you may bring one handwritten, double-sided 4 in. x 6 in. notecard to the exams with notes or equations you deem important. You will be provided with the proper notecard in the week preceding an exam by the instructor. You must use the notecard provided to write your exam notes. The notes must be hand written (i.e. not typed or photocopied), and you must prepare your own note card. Thus, exams will de-emphasize simple memorization of facts. However, you should realize that your note sheets are limited in size and that there is a tradeoff between the amount of material written on those sheets and your ability to efficiently locate it during exams. A well-organized note sheet is a supplement to a solid understanding of the material rather than a replacement for it.

### *In class clickers*

This course will use i-clickers via iClicker Cloud or iClicker remotes during lecture both to assess your knowledge of some basic course content and to facilitate active learning. Clickers may be registered through D2L; instructions are posted there. If you do not register your clicker before the first midterm exam, you will not receive credit for previous clicker questions. *There are no make ups for points associated with clickers, for any reason including failed connection by the iClicker Cloud app.* You must attend class and use your clicker to receive points. Having a friend use your clicker or participating in clicker questions while not in the classroom is a breach of academic integrity and will be treated as such. Through the semester, there may be unannounced attendance checks to verify in-person attendance and participation via clickers.

During a typical lecture you will have one or more opportunities to answer questions using the clicker. You will receive  $\frac{1}{2}$  of a point for sending in any answer and an additional  $\frac{1}{2}$  of a point for sending in the correct answer. Some questions are designed to generate discussion and may not have a single correct answer. In this case, you will receive one point for any answer. Each day of clicker points counts the same in your final grade, regardless of the number of questions in that day. At the end of the semester your lowest ten days will be dropped from your grade. Because of this, you can miss class occasionally for emergencies, illness, or other commitments without seriously impacting your clicker scores. These drops also cover technological problems, like poor connection and app or battery failure. Clicker points for the entire semester are worth 5% of your final grade. It is your responsibility to understand the feedback lights on your clicker or app and verify that your answers are received. If you need to replace or re-register your clicker or there are problems with your clicker grade in D2L, please notify the TA immediately.

### *Online homework*

Homework for BMB 461 is delivered through Achieve. Information about how to register for this site and find the correct course will be delivered during the first week of class. Make sure to follow registration instructions closely. These homework assignments covers some of the key concepts you need to know but are not designed to be exhaustive.

The homework problems over the course of the entire semester are worth a total of 15% of your final grade. There will be a homework assignment due each week. Most of the time, the due date will be on Monday night with the exception of exam weeks, when the due date will be adjusted. It is your responsibility to check Achieve regularly to find when each assignment is due. At the end of the

semester, your lowest three homework scores will be dropped. Your average percentage correct on each of the remaining assignments unit will be used to determine what percentage you earn for your overall homework grade. Because we are dropping some of your homework scores, there will be no deadline extensions or make-up points offered for any reason. This includes, but is not limited to, illness, technical/computer issues, vacations, etc.

You are encouraged to work together on homework problems and help each other learn how to solve these problems but you must log on and solve your own homework problems to receive credit. Posting or sharing of homework answers, at any website, is not allowed, is a breach of academic integrity, and will be treated as such.

There may also be *optional* homework assignments that will neither be collected nor graded, but completing them will help you prepare for the exams. There are also questions in the textbook at the end of each chapter, and you should incorporate these questions into your studies. The answers to these questions are provided in the back of the book. Working in groups on all of the optional problem sets is encouraged as a highly valuable study strategy.

## **Make-up Policy**

There will be no makeup or adjustments to clicker scores or online homework for days you miss class or deadlines, except in the case of an unexpected, severe, and extended illness. There will be no makeup or adjustments to clicker scores or online homework for any technological problem that is not system wide. Each of the assignments (e.g. clickers & homework) has several low scores dropped at the end of the semester to address occasional student absences (for any reason, including illness). Students do not need to provide documentation in order to receive these dropped scores. In the case of an extended (>7 day) illness, students must notify the instructor before or during the absence and must be able to supply relevant documentation as requested by the instructor. When these extended absences have been verified, instructors will suggest possible accommodations for these cases. With the exception of extended technical problems originating in the Macmillan Achieve system, there are no extensions on homework deadlines. For observances of religious holidays, certain exemptions can be made for in-class clicker points and occasionally homework assignments. You must notify an instructor of conflicting religious observances during the first two weeks of the semester and to discuss what exemptions may be possible in a given case.

### *Exam absence*

Scheduled exam dates are provided in the course schedule. If you will miss an exam due to travel to/from an academic or professionally-related event, an MSU sponsored event or religious observance which can be anticipated in advance you must contact your instructor more than one week prior to the exam to determine if you are eligible for alternate exam arrangements.

If you unexpectedly miss an exam due to extenuating and unforeseen circumstances, such as significant illness (e.g. COVID-19) or death of a loved one, you must contact your instructor within 24 hours of the missed exam.

In order to be considered for make up exam arrangements it is your responsibility to provide adequate documentation as requested by the instructor. This may include medical documentation of testing results and/or medical visits. You may or may not be eligible for a make up exam based solely on the discretion of the instructor(s); in some cases a point penalty may be assessed to your make up exam

score. If the instructor determines that you are not eligible for alternate exam arrangements and you do not/did not take the exam, you will earn a 0 on the exam.

For grief absences students must notify the Associate Dean or designee of their college of the need for a grief absence and must provide appropriate verification. The associate dean or designee will work with the student to determine the length of the absence and will notify faculty of the absence period. The policy on grief absence is described here: <https://reg.msu.edu/ROInfo/Notices/GriefAbsence.aspx>.

Make-up exams are administered at the instructor's convenience, typically within 48 hours of the original exam or as soon as medically allowed and may be scheduled without consulting students. Make-up exams typically consist of essay and calculation questions but instructors retain the right to offer multiple choice makeup exams or exams of mixed formats.

## Grading Criteria

This grading scale shows the percentage you must earn at the end of BMB461 to guarantee a particular grade. We have used this scale in previous semesters with good success. If there is a significant disruption or change to the course due to COVID-19 or other unforeseen disruption, the instructors may revisit or adjust the scale. This will be done on a class-wide basis, not for individual students. Your overall course grade percent will be rounded to the nearest tenth. Grades for graduate students will be determined from the undergraduate distribution.

### *Honors option*

Students may elect to take BMB461 with an H-option provided they obtain a grade of 3.0 or higher in the course. The honors option consists of a term paper that addresses an unsolved biochemical question related to a topic and research article provided by the instructors. Students interested in the honors option should check D2L during the first week of class for more information and deadlines.

### *Attendance policy*

This course follows the General University Attendance Policy. Attendance itself is not a required component of the course, although students that attend class regularly perform better in the course and students are able to earn in-class clicker points on every non-exam day. There may be unannounced attendance checks to verify clicker participation. If you miss a class, it is expected that students learn the material covered in class that day on their own. See the Make-Up Policy section for information about missing graded assessments.

| Grade | Percentage |
|-------|------------|
| 4.0   | ≥ 85.0     |
| 3.5   | ≥ 79.0     |
| 3.0   | ≥ 72.0     |
| 2.5   | ≥ 65.0     |
| 2.0   | ≥ 57.0     |
| 1.5   | ≥ 48.0     |
| 1.0   | ≥ 40.0     |
| 0.0   | < 40.0     |

## Course Management Software

We will use D2L to post lecture handouts, lecture recordings, grades, and other general course information. We will use the news feature and the e-mail feature in D2L to provide information about the course. It is expected that students are regularly checking D2L for updates about the course.

Achieve will be used for online homework assignments. There are help resources within this system to help you learn how to use and navigate the assignments. More information about how to register for the system will be delivered during the first week of class.

## Resources

This course extensively uses Desire2Learn (D2L) for the posting of lecture material. Students are expected to check these sites regularly for newly posted material. As members of a learning community, students are expected to respect the intellectual property of course instructors. All course materials presented to students are the copyrighted property of the course instructor and/or textbook publisher. As such you may not post the recordings or other course materials online or sell or distribute them to anyone not enrolled in the class without the advance written permission of the course instructor and, if applicable, the publisher and/or any students whose voice or image is included in the recordings. Any student violating this restriction may face academic disciplinary sanctions.

### *Lecture Learning Materials*

Learning materials for a given day in the course will be posted on D2L in advance of each day. These learning resources are designed to aid your study of the material, note taking during lecture and reading the text. They are not a substitute for reading the textbook. It is highly recommended that you bring these materials to class and read the assigned reading in the text prior to lecture.

### *Course Recordings*

When possible, audio-video recordings of the lectures will be provided on D2L. The purpose of these recordings is to allow review of lectures as you study. **BMB 461 is not an online course**, and these recordings are not a substitute for attending lectures and taking notes. **You should not depend on these recordings**: some lectures may not be available, truncated or may be of poor quality due to technical difficulties. In such cases, there will be only the poor quality recording or no recording posted. In addition, it is at the instructor's discretion to turn on the recording only after announcements regarding exams, etc. have been made.

### *Previous Exams*

Exams from a few previous semesters will be posted on D2L. Please note that some of these exams may be from semesters when exam policies or course schedule differed from the current semester. The exam keys will be posted no later than three days prior to each exam date.

### *Instructor review sessions*

There will be scheduled exam review sessions led by a course instructor before each scheduled exam. These review sessions take the form of "question and answer" sessions, where students should come prepared to ask questions about course material. The exact dates, times and locations of these review sessions will be announced before each exam.

### *Extra course help*

Students are strongly encouraged to use the optional TA-led review sessions, instructor-led exam review sessions and visit the regularly scheduled office hours for help in the course. For students desiring additional help, potential course tutors can be found at:

<https://bmb.natsci.msu.edu/undergraduate/tutoring/>

## Accommodations

Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Requests for accommodations by persons with disabilities or for wearing a mask indoors may be made by contacting the Resource Center for Persons with Disabilities at

517-884-RCPD or on the web at [rcpd.msu.edu](http://rcpd.msu.edu). Once your eligibility for an accommodation has been determined, you will be issued a Verified Individual Services Accommodation ("VISA") form. Please present this form to the course coordinator at the start of the term and/or two weeks prior to the accommodation date. Requests received after this date may not be honored.

## Academic Honesty

[The Spartan Code of Honor](#) states, "As a Spartan, I will strive to uphold values of the highest ethical standard. I will practice honesty in my work, foster honesty in my peers, and take pride in knowing that honor is worth more than grades. I will carry these values beyond my time as a student at Michigan State University, continuing the endeavor to build personal integrity in all that I do." In addition, Article 2.III.B.2 of the [Student Rights and Responsibilities \(SRR\)](#) states that "The student shares with the faculty the responsibility for maintaining the integrity of scholarship, grades, and professional standards." This course adheres to and strictly enforces the policies on academic honesty as specified in General Student Regulations 1.0, Protection of Scholarship and Grades; the all-University Policy on Integrity of Scholarship and Grades; and Ordinance 17.00, Examinations. (See [Spartan Life: Student Handbook and Resource Guide](#) and/or the MSU Web site: [www.msu.edu](http://www.msu.edu).)

Therefore, unless authorized by your instructor, you are expected to complete all course assignments, with the exception of homework and in-class clicker questions, without assistance from any source. Students who violate MSU academic integrity rules may receive a penalty grade, including a failing grade on the assignment or in the course. *Using multiple clickers to send in answers for classmates who are not present or participating in in-class clicker questions while not in-person attendance is considered academic dishonesty.*

## SIRS

Michigan State University takes seriously the opinion of students in the evaluation of the effectiveness of instruction, and has implemented the SIRS (Student Instructional Rating System) process to gather student feedback. This course utilizes the "online SIRS" system, and you will receive an e-mail sometime during the last two weeks of class asking you to fill out the SIRS at your convenience. As a reminder to be sure to fill out the SIRS evaluation form, the final grade for this course will not be accessible on STUINFO during the week following the submission of grades for this course unless the SIRS online form has been filled out. You have the option on the online SIRS form to decline to participate in the evaluation of the course.

## COVID-19 Pandemic

We will adhere to the expectations of MSU for this semester relating to COVID policies. These MSU regulations may change over the course of this semester, in which the expectations of our classroom will follow. We will encourage distancing in the classroom as much as possible. Please check here for information about MSU's policies regarding the COVID-19 pandemic: <https://msu.edu/together-we-will/>

If you feel sick, *please stay home*. Please follow CDC guidelines if you have been exposed to a known case of COVID-19. If you have a confirmed case of COVID-19, *please isolate* and let your instructor know as soon as possible to discuss possible make up arrangements. **Remember that daily attendance is not required and the course includes multiple drops of all assignments.**

If the semester is disrupted by the COVID-19 pandemic (e.g. move to remote only instruction), the instructors will communicate with the class about changes to the course and new expectations as soon as possible. Adjustments to the course based on a disruption may include changing the type and/or weight of assignments, modification to the grading scale or adjusting the course schedule and topics. In such cases, a new course syllabus and/or schedule will be published for all students.

| Date     | Lec. # | Topic  | Reading Pages    | Instructor |
|----------|--------|--|------------------|------------|
| 9-Jan    | 1      | Course Introduction; Aqueous solutions & pH                        | 43-64            | Haudek     |
| 11-Jan   | 2      | Buffers; Solving acid/base problems                                | 43-64            | Haudek     |
| 13-Jan   | 3      | Amino acids and peptides   | 70-83            | Haudek     |
| 16-Jan   |        | <b>MLK Jr Day - No classes</b>                                     |                  |            |
| 18-Jan   | 4      | Proteins: Primary structure & evolution                            | 90-92; 96-100    | Haudek     |
| 20-Jan   | 5      | Proteins: Secondary structure                                      | 107-116          | Haudek     |
| 23-Jan   | 6      | Proteins: Three-dimensional structure                              | 116-128          | Haudek     |
| 25-Jan   | 7      | Proteins: Structure and Folding                                    | 128-136          | Haudek     |
| 27-Jan   | 8      | Protein purification   | 83-90            | Haudek     |
| 30-Jan   | 9      | Protein-ligand binding: Myoglobin and hemoglobin                   | 148-164          | Haudek     |
| 1-Feb    | 10     | Enzyme catalysis and mechanism                                     | 177-188          | Haudek     |
|          |        | Optional Q and A by Instructor                                     |                  |            |
| 3-Feb    |        | <b>Exam I: Lectures 1-9</b>  |                  |            |
| 6-Feb    | 11     | Enzyme catalysis and mechanism                                     | 177-188; 203-210 | Haudek     |
| 8-Feb    | 12     | Enzyme kinetics: Introduction                                      | 188-197          | Haudek     |
| 10-Feb   | 13     | Enzyme kinetics: Inhibition  | 197-203          | Haudek     |
| 13-Feb   | 14     | Enzyme kinetics: Regulation and allostery                          | 213-223          | Haudek     |
| 15-Feb   | 15     | Enzymology and medicine  | 756-757          | Haudek     |
| 17-Feb   | 16     | Bioenergetics: Principles  | 465-478          | Haudek     |
| 20-Feb   | 17     | Bioenergetics: High-energy compounds and phosphoryl transfer       | 479-488          | Haudek     |
| 22-Feb   | 18     | Bioenergetics: Redox reactions and energy balance                  | 488-496          | Haudek     |
|          |        | Optional Q and A by Instructor                                     |                  |            |
| 24-Feb   |        | <b>Exam II: Lectures 10-18</b>                                     |                  |            |
| 27-Feb   | 19     | Carbohydrates: I   | 229-241          | Lunt       |
| 1-Mar    | 20     | Carbohydrates: II  | 241-253          | Lunt       |
| 3-Mar    | 21     | Introduction to metabolism   | 461-464          | Lunt       |
| 3/6-3/10 |        | <b>Spring Break; No classes</b>                                    |                  |            |
| 13-Mar   | 22     | Glucose metabolism: Glycolysis                                     | 510-521          | Lunt       |
| 15-Mar   | 23     | Glucose metabolism: Glycolysis                                     | 521-525          | Lunt       |
| 17-Mar   | 24     | Glucose metabolism: Glycolysis and Fermentation                    | 525-533          | Lunt       |
| 20-Mar   | 25     | Glucose metabolism: Gluconeogenesis                                | 533-539          | Lunt       |
| 22-Mar   | 26     | Regulation of Glycolysis and Gluconeogenesis                       | 539-546          | Lunt       |
| 24-Mar   | 27     | Glucose metabolism: Pentose phosphate pathway                      | 546-552          | Lunt       |
| 27-Mar   | 28     | Glucose metabolism: Pentose phosphate pathway                      | 546-552          | Lunt       |
| 29-Mar   | 29     | Pyruvate dehydrogenase complex                                     | 574-578          | Lunt       |
|          |        | Optional Q and A by Instructor                                     |                  |            |
| 31-Mar   |        | <b>Exam III: Lectures 19-29</b>                                    |                  |            |
| 3-Apr    | 30     | Citric acid cycle  | 578-589          | TerAvest   |
| 5-Apr    | 31     | Citric acid cycle and glyoxylate cycle                             | 590-596;735-736  | TerAvest   |
| 7-Apr    | 32     | Mitochondrial electron transport I                                 | 659-674          | TerAvest   |
| 10-Apr   | 33     | Mitochondrial electron transport II                                | 659-674          | TerAvest   |
| 12-Apr   | 34     | Oxidative phosphorylation I  | 674-696          | TerAvest   |
| 15-Apr   | 35     | Oxidative phosphorylation II                                       | 674-696          | TerAvest   |
| 17-Apr   | 36     | Glycogen metabolism  | 556-565          | TerAvest   |
| 19-Apr   | 37     | Regulation of glycogen metabolism                                  | 565-571          | TerAvest   |
| 21-Apr   | 38     | Photosynthesis: Light-driven ATP and NADPH synthesis I             | 700-719          | TerAvest   |
| 24-Apr   | 39     | Photosynthesis: Light-driven ATP NADPH synthesis II                | 700-719          | TerAvest   |
| 26-Apr   | 40     | Photosynthesis: Carbon fixation I                                  | 719-740          | TerAvest   |
| 28-Apr   | 41     | Photosynthesis: Carbon fixation II                                 | 719-740          | TerAvest   |
|          |        | Optional Q and A by Instructor: TBA                                |                  |            |
| 4-May    |        | <b>Exam IV: Lectures 30-41 (May 4, 12:45-1:45 p.m. in 101 BCH)</b> |                  |            |