BIOL 372: Structural Biology

Instructor: Rou-Jia Sung
Office: Hulings 308
Office phone: 507-222-4391
Email: rsung@carleton.edu

Class: TTh 10:10-11:55a, Old Music 106

Office hours: By appointment

COURSE MATERIALS:

Required texts:
The majority of the course readings will come from current primary literature. All course materials will be posted to Moodle or sent to your @carleton.edu email; *I expect you to check both regularly*. Please let me or ITS know if you are not comfortable using Moodle. **No textbook is required**.

Required materials:
A large portion of the class discussions will entail using Pymol and other online tools during class time, and so it will be helpful for you to bring a laptop with you to class. In addition, you will also find a three-button mouse to be useful for navigating around protein structures in Pymol. Please let me know **ahead of time** if you need a laptop/mouse, and I can arrange to have a spare one handy so that way everyone can participate!

LEARNING OBJECTIVES

After successfully completing this course, you should be able to:

1. Use Pymol to inspect and manipulate 3D structures stored in PDB format.
2. Generate high quality images of proteins that clearly represent key structural features using Pymol.
3. Critically evaluate the quality of solved and modeled protein structures.
4. Identify the appropriate technique to address questions related to protein structure (for example, when would NMR be preferred over X-ray crystallography?).
5. Use a given protein structure to develop hypotheses about protein function.
6. Critically evaluate the logic and supporting data for a given hypothesis.
7. Interpret data presented in primary literature articles.
8. Effectively work together in a group situation to complete independent work.
9. Communicate and share knowledge about protein structure and function to a non-expert audience.

ASSESSMENT OF LEARNING OBJECTIVES

Discussion leader:	30% (15% for each presentation)
Reading comprehension questions:	20%
Final project:	25%
Class participation:	25% (12.5% given mid-way through semester, 12.5% given at the end)

Discussion leader
You will work in self-chosen pairs of 2 and **AS A GROUP** you and your partner will be responsible for initiating and sustaining class discussion on at least two primary literature articles. The topics and articles for Weeks 3-6 will be assigned by me; the topics and articles for Weeks 7-10 will be selected **by you**! Keep in mind that you are not *presenting* the paper, you are *leading a class* discussion on the paper. I will provide a rubric on Moodle that outlines how I will assess your role as discussion leaders. I will meet with each group **one week prior** to their scheduled presentation date to provide feedback on discussion ideas/go over any unfamiliar techniques used in the article.

Each group must submit:

- 3 reading comprehension questions related to their paper. These questions should be designed to assist the reader in navigating key points or confusing points in the article.
- A "cheat sheet" containing definitions of commonly used but unfamiliar terms, descriptions of new techniques, or other information to help your classmates fully understand your paper.

Your discussion questions and cheat sheet are due **by 5pm on the Friday prior to your discussion**. I will forward each group the responses to their reading comprehension questions the night before their presentation so that your group has a sense for what things were particularly confusing/interesting to your peers.

For the first round of presentations (Weeks 3-6), you will be required to design and incorporate a Pymol-based activity in their discussion. The purpose of this activity is two-fold: it should be used to enhance your understanding and interpretation of the structure at hand as well as provide a good opportunity for everyone to get in some Pymol practice!

For the second set of presentations (Weeks 7-10), groups are free to design their presentations how they please ☺ We do have access to a 3D printer in Academic Technologies; if you'd like to incorporate 3D models into your presentation, you'll need to set up a time to talk with me about 1) how you plan to use your models to *teach* the class about the structure, and 2) give us enough lead time to design the print file and fabricate the model. The paper topics for this round of presentations will be **chosen by you/your groups**— each group needs to send me their selected papers **two weeks prior** to their presentation date. The selected paper should be at a similar level of scientific rigor as the papers we have been discussing thus far.

Reading comprehension questions
To help you prepare for discussion, I will post online discussion questions prior to our class meetings. These questions are designed to help you navigate the reading (which may initially seem like an overwhelming mishmash of jargon and unfamiliar terminology), identify the most important concepts, and help you identify confusing points that you'd like me or your classmates to discuss during class. The questions should be completed by **11:30pm the night before class.** I will give you one free pass during the semester for a time when you may have more pressing commitments. Your responses will be graded on a combination of effort and accuracy.

Final project

Communication is an absolutely vital skill for any career you choose to pursue when you leave Carleton—whether it is explaining to a patient why it is important to finish a course of antibiotics, explaining to a grants agency why they should fund your work, explaining what you do/have done to the HR screener during a job interview, or even just explaining to others what you've been studying for 4 years! In many of these situations, it's not just about how well *you* know the material—it's also about how well can you *teach* someone else about the material!

Our course focuses on the beauty of protein structure, and how knowing the structure can greatly expand our understanding of protein function. However, in order to appreciate the importance of structure, we also need to be able to appreciate the importance of proteins themselves! You have taken extensive coursework that allows you to have a nuanced understanding of the importance of proteins in our biological systems; however, for many in the general public, the first thing that comes to mind when they hear "protein" is tofu, meat, soy—namely, just proteins as (admittedly tasty) food sources!

For your final project, you and a partner will design an interactive activity to be implemented at the Minnesota Museum of Science on May 19th (Saturday). You have spent the term learning the skills to communicate to each other the importance and beauty of protein shape; the purpose of the activity is to build communication skills to teach a new, novice audience (in this case, ranging from pre-school to middle-school kids as well as their parents) about why proteins and their shapes are important!

Your activity will address one of the following three questions:

- What is a protein? What do they do?
- Why is the shape of a protein important?
- What happens if the shape changes? Are there consequences?

You will have access to the following resources:

- Me! I can help purchase materials for your activity, talk through ideas, etc.
- The 3D printer at Academic Technologies: you can print 3D models of proteins/parts of proteins that you want to use as part of your activity (I will help you with preparing the files for the printer).
- CCCE office: they have several student fellows who can help out with any mass production necessary for preparation of your activity (i.e say you need 35 pieces of paper cut out, etc).

The grade for your final project will be broken down as follows:

Project proposal	10%
Peer review + activity revisions	10%
Activity 'presentation' at museum + reflection	5%

Your project proposal is due ***Friday April 27th.*** The proposal includes which question (of the three above) you will be addressing, how you plan to address it **while making it approachable to your audience,** an outline of your proposed activity with associated learning goals, a list of necessary materials for your activity, and a timeline for fabrication (if you plan to use the 3D printer).

We will have an in-class peer review session on **Tuesday May 8th** in which you will have a chance to 'practice' your activities on each other! You should come prepared to the session with a solid version of the materials needed for your activity. Following the review session, you will have a chance to revise your activity and submit a revision based on peer feedback. Your grade for the peer review session will take into account the degree of preparation for the session.

The final activity presentation will take place all day on Saturday May 19th at the Science Museum. Meals and transportation will be provided; the schedule is TBD. **Please let me know if you cannot make this date**. Afterwards, you'll be required to submit a 1 page reflection on the activity (details will be provided).

Classroom participation
You are expected to be an active participant in class. The ability to ask questions, discuss ideas, and solve problems in a group setting is essential to your development as a scholar. Class participation will be assessed on the basis of timely attendance, individual participation during class discussions, and participation in groups during group activities. To give you a sense of your progress in the class, half of your participation points will be assessed mid-way through the semester, while the remaining half will be assessed at the end of the semester. Some of the things I take into account when assigning the participation grade are:

- Timely attendance (coming in 5-10m late does not count as timely attendance)
- Sincerely asking and responding to questions during class discussions, either within your group or to the whole class
- Fully participating in group activities during class or student-led discussions
- Coming to class prepared by having done the reading comprehension questions

I understand some of you may not feel comfortable speaking up in class, but I strive to create a safe and non-threatening environment in my classroom where everyone can practice and improve upon these skills. These skills are things I am constantly striving to improve myself! Please come see me if you are uncomfortable with this component of the course.

FIELD TRIP TO KAHLERT STRUCTURAL BIOLOGY LABORATORY AT UNIVERSITY OF MINNESOTA

We will have the opportunity to visit the Kahlert Structural Biology Laboratory at the University of Minnesota on **April 30th!** The Kahlert is home to their X-ray crystallography, NMR, and cryo-EM facilities, all of which have extensive equipment dedicated towards small molecule and protein macromolecular structure determination. The staff there has kindly consented to letting our class come visit to see the various types of equipment (massive robots and machines!) used to collect crystallographic data.

I recognize that April 30th is midterm break; however, since this will be about a half-day excursion that was the best option for scheduling reasons. As such this field trip is **entirely optional** and does not count towards/against your class participation grade—it is purely just for educational entertainment!

Breakfast and lunch will be covered, as well as transportation to and from Minneapolis (if anything, I support your attendance for simply the chance to eat food outside of Northfield ☺). In order to get an accurate head count for budgeting purposes, **please let me know by the end of Week 3 (Friday, April 13th!) if you plan to come!**

ADDITIONAL POLICIES

Late work
If you anticipate turning an assignment in late, please let me know **at least 2 days in advance** to work out an arrangement. Otherwise, I expect all assignments to be turned in on time. Late submissions lose 5% for every day they are late.

Accommodations for students with disabilities
If you have a disability and require accommodation, please contact me early in the semester so that your learning needs may be properly met. Please inform me if you have red-green colorblindness so I can modify my powerpoint slides accordingly.

Electronic devices (cell phones, computers, etc)
I support the use of technology in the classroom, so cell phones and computers are permitted. **HOWEVER**, these devices should be used **solely** for activities pertaining to our classroom (please refrain from texting, email, Facebook, Snapchat, Twitter, whatever newfangled app it is this year, unless you are using those mediums to communicate how awesome you think Structural Biology is). Please be courteous to your classmates and myself by silencing cell phones and refraining from conducting personal business on your phone or computer. If you are distracted by the use of classroom technology, please come see me privately so we can work out an arrangement to accommodate everyone.

Attendance
If you anticipate that you will have to miss a class, please let me know as far in advance as possible to work out an arrangement (more importantly, you will need to let your presentation partners know). I understand that it is not always possible to predict when you may need to miss a class, but please let me know as far in advance is possible. Please respect the efforts of your classmates to budget the appropriate amounts of time for their presentations by making every effort to arrive in class **on time**. Timely attendance is taken into account as part of your class participation grade.

Group work
Learning how to work well together in a group is a critical skill that will serve you all well regardless of the career path you choose to pursue. However, it is equally critical that **each group member contributes** to the work at hand, and I reserve the right to inquire about how the work was divided between individual group members. If you feel an arrangement has become imbalanced, please come see me privately so we can work out an arrangement to suit everyone.

Course feedback and input
One of my goals as your instructor is to create an inclusive, non-threatening environment for our class, such that you feel comfortable and welcome as a member of our classroom community to share your thoughts/questions with me and/or your peers. I have created a gmail account (carletonfeedback@gmail.com; password: carl3t0n!) to serve as a digital anonymous "suggestion box" for our class. If you see something in class that you think could be adjusted to improve our classroom environment, you can log-in to this account and use it to send me an anonymous email with your thoughts.

Please use this account ***conscientiously*** (for example, don't use this email to sign-up for online promos or spam) and ***constructively***. I will do my best to address concerns as they arise!

Special circumstances: If there are special circumstances, such as illness of other form of emergency, which should be taken into account with regard to any of the stated class policies, please inform me as soon as possible so that alternative arrangements can be made.

COURSE SCHEDULE

Weekly readings will be posted to Moodle. The syllabus will be updated to reflect any changes. The tentative schedule is below, but is subject to change.

Week	Date	Tuesday topic	Thursday topic	Discussion leaders	Unit	Major Assignments due
1	Mar 27-29	Welcome! Class overview Proteins in solid state: X-ray crystallography part I	Proteins in solid state: X-ray crystallography part II + Cryo-EM	-- --	Methods in Structural Determination	
2	Apr 3-5	Proteins in a liquid state: NMR + light scattering	Proteins in a digital state: Molecular dynamics + structure prediction	-- --	Methods in Structural Determination	
3	Apr 10-12	Pymol boot camp: Nucleosome paper	DNA repair	--	The Central Dogma: DNA→DNA	
4	Apr 17-19	DNA polymerase	RNA polymerase / Ribosome (?)		The Central Dogma: DNA→RNA→protein	
5	Apr 24-26	Class is canceled Skype meetings to discuss proposal	Ion channels: Piezo	--	Signaling pathways	Final project proposal
6	May 1-3	GPCRs	Kinases / G-proteins (?)		Signaling pathways	
7	May 8-10	In-class peer review session	Student-selected	--		Peer review
8	May 15-17	Student-selected	Student-selected			Museum presentations (Saturday 5/19)
9	May 22-24	Student-selected	Student-selected			
10	May 29	Student-selected	No class			

*No class on Tuesday 4/24; instead, you and your partner will sign up for 15-20 minute skype sessions to discuss your museum project ideas with me (and I highly recommend using the time to polish up your proposal…).

**Thursday presenters for Weeks 4 and 6 can choose which topic (of the two listed) they want to present on.