Course Syllabus – STBIO 411

Course Information

Course Number: STBIO 411 FA25
Course Name: Structural Biology and Biophysics I
Term: Fall 2025
Start Date: 09/03/2025
End Date: 12/05/2025
Credits: 3.0

Meeting Days / Times

Mondays, Wednesdays, and Fridays, 9:30-11:00am PT / 12:30-2:00pm ET
(See Calendar in Canvas for the most up-to-date schedule.)

Location

CA: Graduate Office Dining Room (Hazen Theory Building)
FL: C212. **Moved to A312 (*exception Oct 15 & Nov 12 in B387*)**

Course Managers

Role	Last Name	First Name	Email Address
Course Director	Lasker	Keren	klasker@scripps.edu
Course Director	Park	Raphael	dopark@scripps.edu
Course Director	Wilson	Ian	wilson@scripps.edu
TA	Bruciaferri	Niccoló	nbruciaferri@scripps.edu
TA	Mann	Matthew	mmann@scripps.edu

Course Description

This course covers all aspects of structural biology from primary to quaternary structure and deals with the 3D structure of proteins and nucleic acids. The enzyme section deals with kinetics, mechanism and drug design. Macromolecular assemblies and higher-order structures include oligomers, viruses, molecular machines, metalloproteins, membrane proteins, immune complexes, and biological complexity. Structure prediction, molecular docking, and AI-based methods are covered in lectures and hands-on practicals.

Program Learning Outcomes

By the end of the program, students will have accomplished these objectives:
PLO1: Original Research – graduate students are expected to develop the skills critical for generating high-quality research output. This would include absorbing, recalling, and contextualizing scientific knowledge, evaluating scientific information and data, creating testable hypotheses and investigating

hypotheses, understanding the range of scientific tools and techniques available to structural biology and biophysics, displaying ethical behavior, and receiving and giving feedback.
PLO2: Communication – graduate students are expected to demonstrate the oral, written, and media skills to be able to effectively communicate the impact of a study, methodology, or a body of work to colleagues, the greater scientific community, and to the public at large.
PLO3: Critical Thinking – graduate students are expected to develop a self-directed process to analyze information, form opinions or judgments, and use this process to improve the quality and breadth of their scientific thoughts and interests, navigate problems, and make informed decisions.
PLO4: Intellectual Curiosity – graduate students are expected to acquire the capacity to build their intellectual curiosity and demonstrate problem solving approaches that serve their professional growth and ability to impact a field.
PLO5: Career and Professional Development – graduate students are expected to develop a variety of transferable skillsets throughout their graduate experience, including management and leadership, inclusiveness, resilience, scientific rigor, collaboration, accountability, time management, teamwork, networking, and career planning

For a detailed description of each outcome and specific success indicators, please refer to this web page: https://education.scripps.edu/graduate/doctoral-program/.

Course Learning Outcomes

By the end of this course, students will be able to:

CLO1: Analyze and evaluate methods/techniques for structure determination of biological macromolecules.
CLO2: Evaluate how structure leads to biological function.
CLO3: Assess the evolution of structure and function.
CLO4: Understand the architecture and building blocks of proteins.
CLO5: Evaluate protein folds and the nature of the protein universe.
CLO6: Understand protein folding and misfolding.
CLO7: Understand the architecture and building blocks of nucleic acids.
CLO8: Understand how enzymes function and the basis of structure-based drug design.
CLO9: Understand the basics of enzyme kinetics.
CLO10: Construct homology and AI based models of proteins and complexes.
CLO11: Computationally dock ligands to proteins.
CLO12: Understand protein-nucleic acid interactions.
CLO13: Understand the structure and function of membrane proteins.
CLO14: Understand the structure of selected molecular machines.
CLO15: Understand how viruses assemble.
CLO16: Evaluate biological complexity and how integrative structural biology addresses such questions.
CLO17: Evaluate the significance, quality of data, and robustness of conclusions in recently published work.

Background Preparation (Prerequisites)

Students are encouraged to review background material relevant to each class that can be found in *Textbook of Structural Biology* by Liljas et al. Students typically have taken an undergraduate-level course in biology or biochemistry, but this is not required.

Course Materials

Useful to Consult: Liljas et al. (2009). *Textbook of structural biology*. ISBN: 978-9812772084.

Course Requirements

The midterm and final each constitute 25% of the final grade. Group projects/presentations will constitute 35%. Homework assignments will constitute 5%, and class participation constitutes the remaining 10%.

Instructor Policies

Case studies

One recent original research paper in the relevant area of structural biology will be required reading for each case study class, and will be the basis for the class discussion. One short, topical review to accompany each research paper may also be provided, if appropriate. The required reading list will be posted on the course website.

Expectations and Logistics for Case Studies

1) Student teams: Teams of two or three students each will volunteer to present specific papers. These teams will rotate over the duration of the course, such that every team will lead 1-2 classes. The student team assigned to each paper will meet with or contact the relevant faculty discussant 1 week before the paper is presented to get help and suggestions in identifying and understanding the literature that will be used to prepare the separate Introductions and Conclusions and to discuss potential next experiments. Teams will also prepare necessary PowerPoint slides of each figure and table for discussion by the class (see below). Each of the students in the team should plan to send their PowerPoint presentation to the faculty discussant at least 2 days before their presentation, so the faculty can give some feedback for modifying it, if necessary.

All students will submit a document to the TA(s) prior to the beginning of class that describes two strengths and two weaknesses of the case study, as well as one future experiment. This document can be referred to during the final discussion regarding strengths, weaknesses, and next experiments.

2) Written assignment (non-presenting students). All students must read the assigned research paper(s) prior to class, and submit a document describing two strengths and two weaknesses of the case study, as well as one future experiment. The two strengths and two weaknesses should provide clear reasoning and justification for the decision. In doing so, the student should demonstrate understanding of the experimental approaches in the paper and analytical reasoning justifying the conclusions. “Weaknesses” sections need not merely focus on errors in experimental analysis, insufficient data supporting the claims, etc. The students are encouraged to explore deeper implications, or lack thereof, of the assigned paper. The "strengths" and “weaknesses” sections should each be less than half a page of single-spaced printed text (12 pt Times New Roman or 11 pt Arial). The “next experiment” should produce an amount of data that would be expected to fit into one figure. The short description of each “next experiment” should include (1) a rationale for doing the experiment, (2) a brief description of the experiment, including experimental methods and controls, and (3) the expected outcome(s) and a rationale of why they are expected. The description of the “next experiments” should be short (e.g. ~4-6 sentences each), and the text “next experiments” should also be less than half a page of single-spaced printed text. Concise, focused descriptions that cover the points above will be rewarded. No more than 1.5 pages total should be submitted for the whole assignment. A short review(s) related to the topic of the discussion paper may be provided for papers on the reading list. *No late submission of these “written assignments” will be allowed, except under extenuating circumstances previously approved by the course director or TA. If you do not submit the “written assignment” for a particular class, no score will be awarded and your grade will be diminished proportionately.*

3) Class format:

Student Team presentation: At the beginning of each journal club type class, the student team will give an introduction of the paper including (1) biological background and (2) experimental background and setup. Then (3), the students will cover the main figures from the paper. If necessary, figures from supplementary information can also be used. Presenters are encouraged to pose questions to the class during their presentation to promote engagement and participation. After the student team presents the (4) discussion and conclusions, the student team will lead a conversation about (5) strengths, weaknesses, and future experiments, with non-presenting students discussing their discussion points prior to the team's. All presentation should be in PowerPoint or equivalent format, and all 5 numbered points above should be covered by the team. The members of the team should divide the presentation equally between them.

All students in the class are expected to participate in the discussion during the whole presentation. Each student will be graded based on his/her contribution to the overall discussion. Time required for the class discussion should be considered when the student team prepares the presentation. Asking help from the faculty moderator during the presentation preparation is strongly recommended.

The faculty moderator will help the student team to prepare for the presentation and guide the students through the class discussion. The student team can ask for help from the moderator when answering some of the questions, but the team is expected to lead the discussion and address the majority of the questions.

Selection of Papers/Student Teams: The discussion paper for each class (together with a related short review) will be posted on the Structural Biology course website in early September. Students are asked to review this list, and send an email to the Course TA indicating 1st, 2nd, and 3rd choices. Every effort will be made to assign students to the paper(s) of their choice; however, decisions will generally be made on a first come/first served basis. Students may submit choices as individuals (and end up with a second team member arbitrarily) or as a team with a second person with whom they would like to work. Everyone will have the chance to present at least 2 times, including the final presentation. *If students do not sign up for specific papers, they will be assigned to paper(s) randomly by the course directors.*

Additional Help in Understanding Papers: Students who would like additional help for understanding any paper prior to the designated class meeting are asked to directly contact the Course TA.

Expected Outcome

The course is intended to provide a fundamental understanding of the main techniques used in structural biology to determine the structures of biological macromolecules, complexes and systems at various levels of resolution. The course is also intended to provide hands-on experience with protein structure prediction and analysis. This is not intended to be a course covering any one method or field in detail. The expectation is that students will be able to use the knowledge gained in this course to accurately evaluate structures deposited in structural databases, and research articles published in the biophysics field. The course is designed to help students use published structural biology work to effectively further their own research, regardless of their field of research whether in biology, biophysics, immunology, neuroscience, chemical biology, biochemistry, or molecular medicine. The course is suitable for biologists, biophysicists, and chemists, or anyone interested in gaining a good understanding of structural biology and biophysics methodologies as applied to biological problems. The course is updated each year to reflect any new developments in the field, including methods used to determine macromolecular structures. The intent is to emerge with a clear understanding of the major techniques used in structural biology and biophysics, and when and how to best use these techniques. Students are expected to actively participate in the course by asking questions and engaging with the lecturers and TA to probe deeper into the topics so as to gain the maximum benefit. A question and answer session at the end of each lecture is recommended. The TA will attend all the lectures, practicals and discussion sessions, and will assist the lecturers, provide guidance on the course to the students in the class, address questions as they arise, and organize review sessions on request.

Lectures are intended to provide the students with familiarity to the method or topic. The lecturer will focus on basic concepts, practical aspects, advantages and disadvantages of the technique or remaining challenges in the field. The lectures will lay the groundwork and background and will equip the course participants to understand and evaluate current research articles in the field. Lecturers will generally assign an appropriate review article for their section, if the course books do not cover the material, and it will be helpful to read this material prior to the lecture. Students are encouraged to ask questions during the lecture. Concepts taught in the lectures will form the basis for further discussion in the papers assigned as case studies. Faculty discussants are expected to choose the paper for discussion, aid the students in their presentations, lead the discussion of the paper and evaluate and grade the written assignments, oral presentations and class participation.

Attendance Statement

Attendance is mandatory for all classes and a portion of the grade is based upon class participation. Failure to participate will result in a reduction in credit for that portion of the course. Students who are unable to attend class must seek permission for an excused absence from the course director or teaching assistant, and if permission is granted, they must watch the recorded lecture and turn in a 1-page summary (single spaced, (12 pt Times New Roman or 11 pt Arial) of the topics presented in the lecture. Unapproved absences or late attendance for three or more classes may result in a lower grade or an “incomplete” for the course.

The "written assignments" must be submitted immediately prior to the class to which they pertain. No late submission of written assignments will be allowed except under extenuating circumstances that are approved by the course directors. If a student does not submit a written assignment for a particular class, no credit for that portion of the material will be awarded.

All students will be required to prepare and present at least two PowerPoint presentations during the course.

Scientific and Professional Ethics

The work you do in this course must be your own. Feel free to build on, react to, criticize, and analyze the ideas of others but, when you do, make it known whose ideas you are working with. You must explicitly acknowledge when your work builds on someone else's ideas, including ideas of classmates, professors, and authors you read. If you ever have questions about drawing the line between others' work and your own, ask the course professor who will give you clear guidance. Exams must be completed independently. Any collaboration on answers to exams, unless expressly permitted, may result in an automatic failing grade and possible expulsion from the Graduate Program.

Technology Requirements and Support

For issues related to Canvas, please contact the Graduate Office by email at: gradprgm@scripps.edu or by phone at: 858-784-8469.

Course Grading

Grading is in accordance with the academic policies of the Skaggs Graduate School. The breakdown of grading is as follows:

- Midterm Exam: 25%
- Final Exam: 25%
- Group Project/Presentation: 27%
- Homework Assignments: 15%
- Class Participation: 8%

Grading

Letter Grade	**Percent**	**GPA**	**Description**
A	93-100	4.00	Outstanding achievement. Student performance demonstrates full command of the course subject matter and evinces a high level of originality and/or creativity that far surpasses course expectations.
A-	90-92	3.67	Excellent achievement. Student performance demonstrates thorough knowledge of the course subject matter and exceeds course expectations by completing all requirements in a superior manner.
B+	87-89	3.33	Very good work. Student performance demonstrates above-average comprehension of the course subject matter and exceeds course expectations on all tasks as defined in the course syllabus. There is notable insight and originality.
B	83-86	3.00	Satisfactory work. Student performance meets designated course expectations and demonstrates understanding of the course subject matter at an acceptable level.
B-	80-82	2.67	Marginal work. Student performance demonstrates incomplete understanding of course subject matter. There is limited perception and originality.

C+	77-79	2.33	Unsatisfactory work. Student performance demonstrates incomplete and inadequate understanding of course subject matter. There is severely limited or no perception or originality. Course will not count toward degree.
C	73-76	2.00	Unsatisfactory work. Student performance demonstrates incomplete and inadequate understanding of course subject matter. There is severely limited or no perception or originality. Course will not count toward degree.
P	73-100	0.00	Satisfactory work. Student performance demonstrated adequate understanding of course subject matter. Course will count toward degree.
F	0-72	0.00	Unacceptable work/Failure. Student performance is unacceptably low level of knowledge and understanding of course subject matter. Course will not count toward degree. Student may continue in program only with permission of the Dean.
I		0.00	Incomplete is assigned when work is of passing quality but is incomplete for a pre-approved reason. Once an incomplete grade is assigned, it remains on student's permanent record until a grade is awarded.
W		0.00	Withdrew from the course with Dean's permission beyond the second week of the term.

- All courses will be recorded and maintained in the student's permanent academic record; only courses that apply towards the degree will appear on the academic transcript. Non-credit or audited courses will not appear on the transcript.
- 4 core courses taken for a letter grade (pass = B- or higher for a core course)
- 2 elective courses taken pass/fail (pass = A, B, C for an elective)

Case Studies / Journal Clubs (27% of overall grade)

60% of case studies grade will be derived from your **'strengths, weaknesses, and next experiments'** assessment, which must be submitted for every case study class. For each case study, the students must submit a written assignment describing two strengths, two weaknesses of the assigned paper and one next experiment, which will normally be graded by the faculty discussant of the day or occasionally by the TA. Excellent weaknesses will point out any flaws or caveats in the interpretations, if there are any, and/or suggest better, less ambiguous, or alternate ways to demonstrate the findings. Next experiments will test your understanding of the paper and its results and show whether you can use the knowledge acquired in the course, or from your reading, to briefly propose two next experiments that would follow on from the results presented in the assigned paper in the case study.

Learning Purpose: Supports points 1-6 of learning outcomes, and allows assessment of mastery of course material.

20% of case studies grade will be determined by the **PowerPoint presentation** that each student will give at least once in the case studies section of the course. Presentations will be graded on a 5-point scale – one point assigned for addressing each of five sections: (1) biological background; (2) experimental background and setup; (3) figures; (4) discussion and conclusions; (5) weaknesses and future experiments. Because students will present in groups of 2 or 3, each group as a team must make sure that the relevant sections are covered (example 1: presenter 1 provides the biological background, experimental background, and first figures, while presenter 2 provides the second set of figures, discussion and conclusions, and weaknesses and future experiments; example 2: both presenters split the 5 sections).

Learning Purpose: Supports points 1-6 of learning outcomes, involves active learning and allows assessment of mastery of course material.

20% of case studies grade will be based on **"Participation in class discussion"** of each case study paper. All students, not just the presenters, will be expected to contribute to interpretation and assessment of the figures, tables and results in the assigned paper, to discuss alternative experimental approaches and to consider any still unanswered questions related to the study. Students will receive a score for each presentation: 0 – no contribution to discussion; 1 – some contribution to discussion; or 2 – outstanding contribution to discussion.

Learning Purpose: Supports points 1-7 of learning outcomes, involves active learning, and allows assessment of mastery of course material.

Final Presentation (25% of overall grade)

Each team will select a novel drug target, which is preferably an enzyme (small molecule or other therapeutic). The enzyme target cannot have a drug in phase II clinical trials or be on the market (Google search to check).

Each team will create a 5-slide presentation (no animations allowed) that will cover the following topics:

- Description of the enzyme target (biology behind the target and disease area)
- Justification for why it would make a great and novel drug target
- Approach(es) to develop the novel therapeutic
- Potential problems and how they might be overcome
- Any additional information you think might be helpful to convince your colleagues of your selection

The content of these slides must be covered in a 10-minute presentation, and each member must participate in the presentation. The presentation will be stopped at the 10 minute mark, and then 5 minutes will be allowed for questions and discussion from students and judges.

60% of final presentation grade. **Power point presentation (15 mins including questions):** Grading will assess the quality of each of the 5 sections described above on a 0-4 scale.

Learning Purpose: Supports points 1-7 of learning outcomes, and allows assessment of mastery of course material.

20% of final presentation grade. **Participation in class discussions** of each presentation presented – graded as class participation in final presentation.

Learning Purpose: Supports points 1-6 of learning outcomes, and allows assessment of mastery of course material.

20% of final presentation grade. **Grading and evaluation** by each student of every presentation other than own presentation.

Learning Purpose: Supports point 2 and 6 in particular of learning outcomes, and allows assessment of the ability to critique others and develop peer-review skills.

Class Participation (8% of the overall grade)

Students will receive a score for their level of participation during each class lecture. This includes asking questions during class, answering questions posed by the lecturers, or contributing to discussion. These scores will be averaged at the end of the semester and curved for 10% of the final grade. Scoring is as follows:

- 0 – no contribution to discussion
- 1 – minimal or forced contribution to discussion, such as responding to a question with a one word answer, participating in a Zoom poll, or being called upon by the lecturer when no one has volunteered an answer.
- 2 – answering or asking one or more questions unprompted during class.

No participation points are awarded for unexcused absences. For excused absences, 1 point will be awarded for turning in the summary. 2 points will be awarded if you email the lecturer with a question pertaining to the presented material (cc the instructors and TAs on the email).

Course Summary

Date	Details
Mon Sep 1, 2025	Labor Day (No Class)
Wed Sep 3, 2025	Introduction to Biophysical Concepts & Structural Databases (Lander)
Fri Sep 5, 2025	Protein Secondary and Supersecondary Structure (Wilson)
Mon Sep 8, 2025	From Structural Classification of Proteins and Protein Families to Structure and Function Prediction (Adam Godzik, UC Riverside)
Wed Sep 10, 2025	Intro to X-ray Crystallography I (Robyn Stanfield)
	Amino Acid Quiz
Fri Sep 12, 2025	Intro to X-ray Crystallography II (Robyn Stanfield)
Mon Sep 15, 2025	Chimera tutorial I (Olivia Swanson)
Wed Sep 17, 2025	Intro to NMR (Jane Dyson)
Fri Sep 19, 2025	Journal Club 1 (Dyson)
	JC1 Pre-Class
Mon Sep 22, 2025	Cryo-electron tomography (Grotjahn)
Wed Sep 24, 2025	Intro to CryoEM I (Lander)
Fri Sep 26, 2025	Intro to CryoEM II (Lander)
Mon Sep 29, 2025	X-ray Scattering (SAXS) defines conformation, assembly, & dynamicity (John Tainer)
Wed Oct 1, 2025	Cutting edge X-ray diffraction methods (James Fraser, UCSF)

Fri Oct 3, 2025	EM and X-ray data interpretation and model building (Stanfield, Nettles)
Mon Oct 6, 2025	Journal Club 2 (Raphael Park)
	JC2 Pre-Class
Wed Oct 8, 2025	ChimeraX tutorial II (TAs)
Fri Oct 10, 2025	Introduction to Molecular Modeling & Protein Design (Marco Mravic)
	Homework 1 Due
Mon Oct 13, 2025	Introduction to AI-based structure prediction (Keren Lasker)
Wed Oct 15, 2025	Journal Club 3 (Keren Lasker)
	JC3 Pre-Class
Fri Oct 17, 2025	Intro to Molecular Dynamics (Massimiliano Bonomi, Institut Pasteur)
Mon Oct 20, 2025	AI-based protein design Demo/Tutorial (Torben Schiffner) [FL LOCATION: B387]
Wed Oct 22, 2025	Biophysics of Membrane Proteins (Marco Mravic)
Fri Oct 24, 2025	Structures and Classification of Membrane Proteins (Fabien Cannac)
Mon Oct 27, 2025	Structural Immunology (Andrew Ward)
Wed Oct 29, 2025	Journal Club 4 (Fabien Cannac)
	JC4 Pre-Class
Fri Oct 31, 2025	Macromolecular Machines in Protein Folding & Unfolding (Wiseman)
	Midterm
Mon Nov 3, 2025	Nucleic Acids - Chemistry and Secondary Structure (MacRae)
Wed Nov 5, 2025	Nucleic Acids - Tertiary Structure (Williamson)
Fri Nov 7, 2025	RNA - Protein interactions (MacRae)
Mon Nov 10, 2025	DNA - Protein interactions (Wright)
Wed Nov 12, 2025	Journal Club 5 (Megan Ken) [FL LOCATION: RM 387]
	JC5 Pre-Class
Fri Nov 14, 2025	Enzyme Kinetics (Jamie Williamson)
Mon Nov 17, 2025	Protein evolution and dynamics (Dorothee Kern)
	Homework 2 Due
Wed Nov 19, 2025	History of Rational Drug Design (Jeff Kelly)
Fri Nov 21, 2025	Virtual screening (Stefano Forli)
Mon Nov 24, 2025	Autodock Demo/Tutorial (Niccolo Bruciaferri)
Wed Nov 26, 2025	Thanksgiving Break (No Class)
Fri Nov 28, 2025	Thanksgiving Break (No Class)
Mon Dec 1, 2025	Considerations in early-stage drug discovery (Michael Erb)
Wed Dec 3, 2025	Structural Biology "Shark Tank" Competition