BMB470: Advanced Molecular Biology
FS25

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Course Information

Course Number: BMB 470
Credit Hours: 4
Course location: BCH 101, BCH 113, BCH116, BCH 117, Zoom, D2L, LON-CAPA
Course webpage: https://d2l.msu.edu/d2l/home/2440963
Course Modality: In person

Instructors

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Course Introduction

Welcome to BMB 470. This course is designed as an immersive, hands-on introduction to the scientific method, where you will not just learn about molecular biology—you will *do* it. Over the course of the semester, you will function as a member of a research team embarking on a single, cohesive project: to engineer a protein, the human cellular retinol binding protein II (hCRBPII), and transform it into a tunable light sensor.

This course reflects a typical workflow of a research project and is modeled on modern and impactful research conducted here at Michigan State University. It is not a series of disconnected "cookbook" labs with predetermined outcomes. Instead, you will engage in a sequential and interdependent research workflow where each experiment builds upon the results of the previous one. You will face authentic challenges, interpret unexpected results, and apply critical thinking to drive the project forward. Our goal is to provide you with a genuine research experience that develops your skills, confidence, and identity as a scientist.

Course Description: Engineering a Light-Sensing Protein

This course introduces the scientific method through a semester-long, project-based research experience focused on recombinant DNA technology and protein biochemistry. The central

project is inspired by groundbreaking research conducted at Michigan State University to systematically tune the color of light a protein absorbs. We will follow in those footsteps, using the principles of protein engineering to rationally design and create novel variants of hCRBPII.
Our experimental project is structured into three distinct phases:

- Phase 1
    - DNA Manipulation & Vector Construction (Weeks 1-8). In this phase, you will build the genetic "blueprints" for our engineered proteins. You will use modern molecular biology techniques like PCR, site-directed mutagenesis, and Gibson Assembly to create and verify a series of expression plasmids, each encoding a specific hCRBPII mutant.
- Phase 2
    - Protein Expression & Purification (Weeks 8-10). Here, you will use the plasmids to turn bacteria into protein-producing factories. You will induce the expression of your hCRBPII variants and then purify them from the complex cellular environment using chromatography, assessing their purity and yield along the way.
- Phase 3
    - Biophysical Characterization & Analysis (Weeks 10-12). This is the payoff phase where you will test the function of your purified, engineered proteins. Using spectroscopy, you will analyze how your specific mutations have altered the protein's ability to bind its light-sensitive partner, retinal, and how they have tuned its absorption of visible light.

Learning Objectives

Upon successful completion of this course, you will have developed the skills and understanding necessary to:

- Master core recombinant DNA techniques
    - Design and execute PCR, cloning, and mutagenesis experiments.
- Express and purify proteins
    - Use recombinant and chromatographic methods for protein production and purification.
- Investigate protein structure-function relationships
    - Explore the impact of mutations on protein structure and function and apply this knowledge to protein engineering strategies.
- Execute experimental protocols and analyze results
    - Formulate hypotheses, implement established research protocols, and troubleshoot unexpected results through critical data analysis.
- Analyze and interpret scientific data
    - Use appropriate software and statistical methods and apply critical thinking to draw meaningful conclusions.
- Develop critical thinking and problem-solving skills
    - Apply logical reasoning and analytical skills to overcome experimental challenges and data analysis.
- Communicate scientific findings

    - Articulate scientific concepts, methods, and findings through well-maintained laboratory notebooks and a formal written report.
- Integrate theoretical knowledge with practical laboratory skills
    - Connect fundamental classroom concepts to their real-world applications.
- Maintain professional laboratory practices
    - Adhere to thorough record-keeping, safety protocols, and ethical standards in scientific research.
- Collaborate effectively
    - Practice teamwork and communication skills by working with peers to execute experiments and analyze results.

Course Structure

The weekly schedule of lectures, labs, and recitations is intentionally designed to scaffold your learning and support your progress through this semester-long research project.

- Weekly Lectures
    - Lectures provide the essential scientific and theoretical background for each stage of the project. Here, we will explore the principles behind the techniques you are using, connect your work to the broader scientific context, and consistently revisit the project's overall narrative arc to ensure you always understand *why* you are performing a particular experiment.
- Laboratory Periods
    - The lab is the heart of this course. This is where you will actively engage in the process of science—generating reagents, collecting data, and building the project week by week. You will work collaboratively in teams, learning to navigate the challenges and successes inherent in authentic research.
    - **Dress code**
        - While in the lab, students must wear lab appropriate attire. This includes safety glasses (unless informed chemical splash goggles are required; will be informed ahead of time), close-toed shoes, full-length shirts (no bare mid-drifts), and long pants (no torn pantlegs). Put simply, no skin may be exposed beneath the waist.
- Weekly Recitations
    - Recitations are dedicated to helping you make sense of your results. This is a time for data analysis, group problem-solving, and deeper discussion of the experimental design. These sessions are designed to help you overcome common hurdles and develop the critical data interpretation skills of a research scientist.
- Weekly Problem Sets
    - To help you prepare for the week's lab and reinforce key concepts, you will complete weekly pre-lab problem sets on LON-CAPA. These assignments are designed to test your level of preparation and supplement the material from lectures and the lab manual, ensuring you arrive at the lab ready to think critically and engage with the experiment.

Course Materials

All course material is provided through the course D2L webpage.

- Lab Manual
    - This comprehensive manual contains the background, objectives, requirements, and procedures for every experiment in the course.
- Notebook templates
    - Pre-formatted documents to guide you through preparation and completion of laboratory work and post-lab data analysis.
- Experimental video library
    - Videos show completion of course experiments, as well as provide helpful commentary about the benchwork
- Data analysis video library
    - Videos detail methods of data analysis focusing on calculations, graph generation and formatting, image analysis, plasmid DNA map and sequence analysis, and more.

Course Meeting days and times

- Weekly Lectures
    - Mondays 12:40 - 1:30 pm, BCH101
- Laboratory Periods
    - Tuesday - Thursday (Sections 1-3) 12:40 - 4:40 pm
- Recitations
    - Fridays 12:40 - 1:30 pm, BCH101
- Quizzes
    - Taken during the Friday Recitations according to the course schedule
    - Recitations 1:10 - 1:30 pm
    - Hosted through D2L
- Office Hours
    - Office hours are hosted in-person. This is a complex and busy course. Be sure drop in with questions!
    - If the times listed there do not work for you, please feel free to email any of the instructors to set up an individual appointment either in person or via zoom video conferencing software
        - Dr. TerBush
            - Monday 10:30 am-12:20 pm (BCH116A)
        - Dr. Kim
            - Wednesday 3-4 pm (BCH513A)
        - Dr. Hovde
            - Friday 11:30 am-12:30 pm (BCH113; teaching lab)
        - Dr. Martinez-Hackert
            - Friday 1:30-2:30 pm (BCH509A)

Grading

Final grades will be based on the following weighted components:

Gradebook Category	%	Description
Laboratory notebooks	40%	Assesses your preparation, documentation of procedures and data, data analysis, and interpretation of results
Experiment Success	5%	Points awarded for experiments that yield evaluable data, assessing your practical application of laboratory methods.
LON-CAPA problem sets	5%	These pre-lab assignments reinforce key concepts and calculations for the upcoming experiments.
Lab Report	25%	A formal scientific report detailing the methods, results, and conclusions from the first half of the semester's project.
Quizzes	25%	Assess conceptual and practial understanding from the preceding lectures and labs.

- Laboratory notebooks are due at 12:30 pm EDT before the lab period for each section as noted in the course schedule.
- LON-CAPA problem set are due on Tuesdays at 12:30 pm EDT as noted in the course schedule.
- Quizzes will be administered during the in-person Friday recitations from 1:10-1:30 pm EDT as noted in the course schedule.

Final grade cutoffs:

Grade	% cutoff
4.0	90
3.5	82
3.0	75
2.5	70
2.0	65
1.5	60
1.0	50

- Grade cutoffs subject to minor adjustments in the downward direction. A passing grade will be awarded to any student who completes and submits all Problem Sets, Lab Reports and Notebooks on time, participates in all laboratory sessions (except for excused absences), and earns at least 50% of the points.

Assessments

- Laboratory Notebooks
    a. Proper maintenance of a laboratory notebook is essential for a professional career in science. Learning how to keep a laboratory notebook is, therefore, central to the BMB 470 learning experience. For each lab period, read the protocol for each experiment to familiarize yourself with the work for that week. After your experimental data are available, complete your laboratory write-up to develop skills in data analysis and organization and interpretation of results.
- Laboratory Report
    a. A key component of BMB 470 is the lab report, which follows the style of a scientific manuscript. This documents your findings and communicate their significance. Instructions for preparing the laboratory report can be found in the Laboratory Report template. Additional information will be provided as the due date approaches, including Q&A opportunities. When preparing your lab report remember that a good lab report is not just a list of findings. You should guide the reader through your story of your work in the lab and that you you understand the concepts underlying these findings.
- Quizzes
    a. Knowledge and comprehension based on the previous two lectures and lab periods will be evaluated in bi-weekly quizzes. Quizzes will include practical math and data anslysis problems like those used in the preceding labs and conceptual questions pertaining to the experiments and lecture content.
- Problem Sets
    a. Pre-lab Problem Sets are available to test your level of preparation for the lab period and to supplement reading, lectures, and class notes. These modules are accessed through LON-CAPA.
- Class data
    a. When needed, class data will be available on D2L. If your research team fails to produce interpretable data for an experiment, use the data from another team to complete your laboratory write up. Give appropriate attribution to your colleagues who prepared the data. Also discuss your own data and explain why they are unsuitable.
- Success of Experiments
    a. Each experiment that results in data that can reasonably be evaluated (plates, gels, etc.) will be graded for the level of “success”. The instructors will use their discretion in selecting which experiments will be subject to this evaluation.
- Challenging grades
    a. If you believe an assignment was graded incorrectly, you have 1 week from the time grades and feedback are published to email Dr. Hovde to challenge the grade.
    b. You must include a listing of the criteria that you believe were graded incorrectly and a description of where in the assignment you earned those points.
    c. Grade challenges after 1 week will not be considered.

Course Policies

- Students are responsible for checking the documents that are uploaded to D2L assignment dropboxes. Export your Word documents to a PDF and submit those. Students may submit assignments as many times as needed. We will grade the last file submitted to the assignment dropbox.
- The **late penalty** for Notebooks and Lab Reports is 25% of the points for the assignment for each 24-hour period past the deadline (including weekends). Assignments turned in more than 4 days late will receive no credit but will be assessed and annotated for student feedback.
    - Additionally, objects (data tables, graphs, chart tracings, etc) placed into incorrect sections of the notebooks will result in no credit given for the affected objects.
- Quizzes
    - No late quizzes will be accepted, except by special arrangement coordinated with Dr. Hovde before the quiz.
    - The quizzes on D2L will be open for exactly 20 minutes and will test lecture and lab materials from the preceding two weeks.
- Absence from a Laboratory Session
    - An authorized reason for an excused absence must be documented in writing and, if possible, in advance. Medical excuses will be accepted up to 3 days after the missed class period. Other excuses must be authorized in advance by Dr. Hovde.
- Request for assignment extensions
    - The rationale must reflect some documentable situation that prevented you from completing your assignment.
    - To request such an extension, email Dr. Hovde with a description and documentation of your situation (no need for sensitive details) **before** the assignment is due. Proactivity on such circumstances is appreciated.
- RCPD accommodation letters
    - If you have an RCPD accommodation letter that details accommodations relevant to BMB470, please email it to Dr. Hovde at the beginning of the semester. Accommodations cannot be applied retroactively.
- Unexcused absences
    - Unexcused absences will result in no success of experiment points being awarded for any missed lab period and you will not be entitled to your partner's lab data. You may request official course data at a 50% deduction on the notebook.
    - Students with **3 or more unexcused absences** from laboratory periods will be assigned a failing grade (0.0) in the course.
- Lab reports
    - Failure to submit an acceptable laboratory report will result in a **failing grade in the course** (0.0). To receive a grade in the course (above 0.0), the laboratory report must be submitted, even if the report is so late it does not receive a score.

- Plagiarism
    - Do your own work. Graphs, figures, or text that are equivalent between laboratory partners or others in the class will not be evaluated for either individual (grade of 0.0). No points will be given for such submissions for laboratory notebooks, homework, or laboratory reports.
    - Feel free to work together and collaborate with fellow students, but do not submit the work of others as your own or allow others to directly reproduce your work. It is great to share ideas and discuss course topics but go off on your own when it comes time to analyze data, complete your notebook, or write your report.
    - **A breach in the student's code of conduct for academic integrity will result in mandatory reporting to the university.**
- Policy on Artificial Intelligence (AI) Use in Writing Assignments
    - BMB470 students are encouraged to develop critical thinking and effective writing skills by thoughtfully engaging with notebook assignments and reports. Responsible use of Artificial Intelligence (AI) tools (e.g., chatbots, large language models) is encouraged to support this learning process. Specifically, AI may be used collaboratively to brainstorm ideas, explore scientific concepts, gather background information, structure arguments, and provide feedback to refine your drafts. However, your final submission must reflect your own analytical thinking, synthesis of ideas, and original expression. AI-generated content should be treated as a collaborative starting point, to be critically evaluated and built upon by you, not a final product. Assignments that rely heavily on unmodified AI-generated text or involve minimal student input undermine the educational objectives of this course and are considered breaches of academic integrity. Any use of AI that breaches the code of academic honesty policy and may result in a failing grade for a portion or the entire assignment. Please consult with the instructor if you have questions about appropriately using AI in this course.
    - **AI tools are also banned from use during all Quizzes**