

BCH 496: BIOCHEMISTRY & MOLECULAR BIOLOGY SENIOR RESEARCH

Course Description

Biochemistry/ Molecular Biology senior research is a two-semester long independent research project that culminates in the submission of a written thesis and the presentation of an oral seminar. The student is responsible for selecting, in close consultation with his/her faculty advisor, a suitable project, and for designing and carrying out the necessary experimental work. The results of the research are then presented at the end of the senior year as a seminar for interested students and faculty and in the form of a written thesis.

Biochemistry/ Molecular Biology senior research is designed to serve as a capstone for your educational experience at Lewis & Clark College. It will require that you integrate all the skills and knowledge you have gained in four years here, in courses in Biology, Chemistry, Math, and Physics, as well as in your other courses. It will require your creativity, your critical thinking skills, your library research skills, your time management skills, your organizational ability, your writing skills, and your oral presentation skills.

Invitation

Junior BCMB majors who have earned a 3.5 grade point average both within the major and in the College as a whole and who have had some research experience prior to the senior year, either through a summer research internship or through an independent study or practicum are invited to participate in the honors program.

If you are interested in doing a senior thesis, you should be by talking to a faculty member in your area of interest about whether they would be willing to serve as your advisor. You need to do this sometime in the spring of your junior year. Together you can identify some topics that you might find interesting and feasible. As this person will need to provide you with laboratory space and will be responsible for supervising your work, you must be prepared for them to say no if the topic you want to study is too far from their area of expertise. Once you have identified a topic, you will need to do some reading and begin to focus your direction. You should plan to do this in the summer before your senior year, so that you are well prepared to write up your proposal early in the fall term. Your advisor's agreement to supervise your thesis and permission to do an honors thesis will be contingent on the submission of a satisfactory thesis proposal before the add/drop date of the fall semester of your senior year.

Student Evaluation

Senior research is unlike your other courses in that there are very few milestones along the way by which you can judge your progress. To help you evaluate your progress, we include here an explicit description of our expectations of honors students. To graduate with honors will require that you demonstrate mastery of the following skills:

1. You will need to demonstrate as well as a solid understanding of the scientific issues involved in your project as well as a solid understanding of the techniques you used in your work. You will need to understand why your project is important and where your work fits in the context of previous work. This will require that you diligently research your project, reading reviews and original research articles to develop your knowledge of the field.
2. You will need to demonstrate that you can design sound experiments with the proper controls, adequate sample size, etc.

3. You will need to demonstrate an ability to critically analyze data. This may require knowledge of statistical analysis in some cases. In addition, you will need to demonstrate that you know how to present your data in graphs and tables with appropriate titles and figure legends.
4. You will need to demonstrate that you can express yourself articulately both orally and in written form.

The specific work we will use to judge your mastery of these skills are listed below along with the dates on which the work is due. Each assignment is described in detail below.

Assignment	Due Date	WEIGHT
Research Proposal	Monday of second week of fall semester	15%
Progress Report	Last day of class fall semester	20%
Thesis	3 weeks before last day of class spring semester, revised thesis due Friday of last full week of classes spring semester	50%
Oral Defense	Last week of classes spring semester	15%

To receive **honors** at graduation, you must maintain a 3.5 GPA throughout your senior year and receive an A or A- overall for the work you complete for your thesis as detailed above.

The Research Proposal

The research proposal should be a short 4-6 page paper that includes the following sections.

Introduction. This section should contain a clear statement of the question your study proposes to answer. This section should begin with a critical summary of what is already known/published that is relevant to your research question. Be certain to both critically evaluate existing knowledge and specifically identify the gaps, which your research project is intended to address. State concisely the importance of your research by relating the specific aims of your research to long-term objectives of research in this field. This will be your first attempt to understand the field and will naturally not be as substantial as it will be in your progress report, but we expect you to have made a good effort to prepare yourself for your project.

Proposed Experiments. This section should explain the following: (1) What you intend to do? (2) What has already been done? (3) How are you going to do the work? Describe the research design and the procedures to be used to accomplish the objectives of your proposal. Include how the data will be collected, analyzed and interpreted. This section should be detailed enough for the reader to be able to discern whether the proposed experiments will answer the question proposed or not. In writing the proposal you might want to read a grant proposal written by your advisor to get an idea of how such proposals are written. Your proposal will, of course, be much shorter and we do not expect the kind of detail necessary to obtain a national research grant, but it will inform you as to style and to the kind of information that should be included. You should prepare your proposal in consultation with your advisor. You should submit your

proposal to the Biochemistry chair(s). The Biochemistry faculty will read all proposals and will grant (or deny) permission to proceed by the add/drop date fall semester.

The Progress Report

At the end of the fall semester, you will need to submit a progress report to your advisor and your reader. This report is essentially a first draft of your thesis. It should be written in the style of a scientific paper with four discrete sections: Introduction, Materials and Methods, Results and Discussion. The Introduction section should be essentially complete at this point. You should have completed the library research on your project by this time and be able to write a more thorough, fully referenced background section than that which you prepared for your proposal. You should expect that the introduction section of your finished thesis will look very similar to the Introduction you write for the Progress report. The Materials/Methods section can also be quite detailed at this point. All procedures that you have used so far in your research must either be described in detail (if not published) or referenced if a published protocol was used (see below). Your report should include whatever results you have by this time with analysis and interpretation of those results. Finally, you should describe your plans for completing the project in the spring semester.

This progress report will be graded, but you will receive only a CR/NC on your transcript. It will be returned to you with suggestions. You will need to make an appointment with both our thesis advisor and your reader to discuss their comments on your progress report. You should plan on revising your progress report to incorporate their suggestions in December or early January when their ideas are still fresh in your mind.

The Thesis

The thesis is the culmination of your honors research. It is our intention that the research proposal and the progress report will serve to prepare you for writing your thesis. A thesis is written in the form of a scientific research paper with separate introduction, methods, results, and discussion sections. It must be well organized; both in terms of the overall construction of the paper and in terms of individual paragraph construction. We cannot appreciate your work unless your ideas are developed in a clear and logical manner. It must be free of errors of grammar, spelling, and punctuation. You should avoid the use of scientific slang or jargon; a thesis is a formal piece of writing. Abbreviations must be defined. It should be written at the appropriate level, neither too elementary nor assuming too much; a good strategy is to aim to make it understandable to a fellow Biochemistry senior student. A thesis does differ from a scientific paper in one important way; in a thesis, both positive and negative results can be reported. Experiments that are not publishable in a scientific paper can and should be detailed in a thesis. You need to record not only the experiments that yielded positive results, but also procedures that you attempted.

Introduction. You need to place your work in the broader context of other work related to your research. You will need to understand the work leading up to your project in detail and this requires a thorough search of the current relevant literature. In this section, you should describe previous work critically, but no original data from other papers is included. You should discuss the strengths and weaknesses of previous work if appropriate and address the issue of how your work addresses gaps in our knowledge.

Methods. The methods section is used to provide the reader with the technical information needed to repeat the experiment. This usually includes information such as the temperature of incubation, the final concentration of the components of the reaction, the voltage at which you ran the gel. All procedures that you have used in your research must either be described in detail (if not published) or referenced if a published protocol was used. Any modifications from the published procedure must be noted.

Results. This section is usually organized into subsections, each describing one experiment. Within each section, it helps to briefly state the purpose of the experiment (one sentence will do) and the expected results. The actual results are then summarized and the reader is referred to the appropriate table or graph. The meaning of the result can then be stated, but extensive discussion of the results must be reserved for the discussion section.

Sometimes, despite your best efforts, a project is recalcitrant and even a year is not sufficient time to complete a project. If you are unlucky in this regard, the faculty will not penalize you if they are persuaded that you made the best possible effort to obtain results. In this case, we expect you to write in detail about what went wrong, why it might have gone wrong, how you could test your speculations, and what you might do differently another time. This will show us that you learned something important from the experience.

Discussion. In this section you explain what you think your results mean. Here you can discuss what limitations there might be to your interpretation, what other possible interpretations there are and whether these alternatives can be excluded or are less likely.

The Seminar

The seminar is your chance to celebrate with your friends (hopefully this includes us!) the culmination of your work. You should plan to present this seminar as part of the Biochemistry Senior Seminar 410 course. How to present a seminar is detailed in the syllabus for this course. Biochemistry honors students will be scheduled to present seminars in that course in the last two weeks of the term.

The Oral Defense

Your thesis defense will normally follow immediately after your presentation. In the defense, we will try to clear up any unanswered questions we had after reading your thesis. The better your thesis, the shorter your defense! Sometimes students understand their own work better than their thesis implies and we want to know this in determining your final grade.

Some Advice

Reading. To write a good thesis requires that you be well read. You will need to understand the work leading up to your project in detail. Your bibliography should include perhaps 5 reviews and 15 or more original research papers. The introduction section of your advisor's grant proposal is a good starting place for relevant research papers, but you will also need to have the library staff show you how to use Medline if you do not already know. We strongly suggest that you plan on reading several papers during the summer preceding your thesis and a paper a week during fall term of your senior year. You should take notes on these papers just as if you were in a course. In addition to content, note carefully how scientific papers are written. Note the construction of the sections and how ideas are organized.

Research. All researchers encounter some technical difficulties. As you approach problem solving these technical problems, be sure you know the variables in your technique and which ones are important and why. We will expect to see evidence of this in your thesis. There are a number of publications that contain information about the theory behind lab procedures; ask your advisor for some suggestions. For molecular biologists, *Current Protocols in Molecular Biology* by Ausubel et al. is often a good resource for background information.

Ask lots of questions about how and why as you do your lab work. Be constantly thinking about your work. It will not be sufficient to just do the experiments; you will need to understand your own work at a deeper level than you may be used to doing. Present your data to someone besides your advisor if you have a chance. Outsiders will approach your work with a different set of assumptions and can often point out flaws in your analysis that both you and your advisor may miss.

Time Management. Because this "class" does not meet on a regular basis, and there are few assignments except the final product (welcome to the real world!), it will be your responsibility to make sure you are making steady progress toward successful completion of your project and of your thesis. We expect that you will give your thesis as high or higher a priority as your other classes and that you will not let your research slide when assignments and tests in your other classes come due. Experience suggests that successful completion of honors research requires that you do not! A good rule of thumb to keep in mind is that you should expect to spend four hours per credit hour of time in the lab each week. As the thesis is a four-credit course, this translates to sixteen hours of work on your thesis per week.

A previous thesis student suggested another trick for time management that some of you might find helpful. Require of yourself that you hand in to your advisor a 1-2 page report of what you have done, what you think about it, and what you plan to do next every 2-3 weeks. As he pointed out, writing it will require you to think through what you are doing. And, when it comes time to write your thesis, there it will be on your computer disc, already analyzed and organized. You can even edit your reports on an ongoing basis. Writing the thesis is a big job and you need to work on it on a continuing basis and not expect to begin thinking about your work in the last three weeks of spring term.

Writing. You should plan on visiting either the Chemistry Department or Biology Department office and asking the secretary to show you where we keep previous theses. Spend some time reading one or two. An example is worth a thousand words of description. You should expect to write multiple drafts of both your progress report and your thesis. You should plan on getting feedback on your writing from your research advisor before you turn in a final copy to your advisor and reader. Your advisor may also suggest that you get feedback from the Writing Center before he/she reads your draft if your research advisor thinks that you would benefit from some extra help in writing.

Good Luck!

Our good will and experience are at your service. We hope you will find this experience a truly demanding, rewarding, and enriching one.