
The Senior Exercise in BIOLOGY and MOLECULAR BIOLOGY

2017-18

In completing the Senior Exercise, students should:

- Use primary literature as the foundation for understanding and developing ideas and arguments.
- Understand and think critically about experimental design and data.
- Identify important questions and design new experiments.
- Integrate material from several courses or subdisciplines.
- Consolidate and synthesize basic biological information.

The Senior Exercise has three required components that are described in more detail below:

- Attending 4 Departmental Seminars
 - Taking an Educational Testing Service Subject Exam in early February; and
 - The written portion of the senior exercise: paper summary and essay in three parts.
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Attending Departmental Seminars

Each semester, the Department sponsors five or six seminars. These seminars, usually by outside speakers, expose students to methods and thinking used in biology. Attending these seminars promotes all of the goals of the Senior Exercise. More information about seminar attendance can be found on page 11 of this document.

You are required during the senior year to attend **four** of the seminars as part of the senior exercise. You should aim to complete this during the first semester of the senior year, but it must be completed no later than the end of **February 2018**. Do not make the assumption that all seminars will be given as scheduled, as illness and bad weather can result in cancellations. Try to get to the seminars earlier in the year if possible, as the winter seminars sometimes result in cancellations. It is your responsibility to sign the attendance list for each seminar you attend and only seminars for which you have signed in can be counted towards the requirement. Students who have conflicts with meeting the required seminar attendance because of participation in intercollegiate athletics or other commitments should contact the Chair of Biology.

ETS Subject Exam

The Educational Testing Service Subject Exam is designed to test your cumulative knowledge in the field of Biology, and serves the Biology department as a useful assessment of both individual students and our overall programs. We ask that you **DO NOT** study for this exam, as we are interested in finding out what you know overall. However, you do need to take the exam seriously, as it is a graduation requirement. Scores will be sent to you after spring break.

Enrollment in 400-level class during Fall term, Senior Year

Enroll in a 400-level class for the fall of your senior year. The choices are the Senior Seminar in Biology (BIOL 475) or Senior Honors (BIOL 497). One function of these classes is to help you with the process of completing the written portion of the senior exercise. There will be two senior seminar sections, each with a slightly different focus within biology. Choose the one that best fits your interest and your schedule.

You **must enroll in one of these classes** during the normal enrollment period for classes during the spring term of your junior year.

Written portion of the Senior Exercise for students enrolled in Senior Honors

The completed honors thesis serves as the written portion of the senior exercise for students enrolled in Senior Honors (BIOL 497). If you enroll in BIOL 497 in the fall and decide not to complete honors, the written portion of your senior exercise will be a copy of the honors thesis introduction that will have been completed by the end of the fall term for BIOL 497.

Written portion of the Senior Exercise for students enrolled in Senior Seminar

To complete the written portion of the Senior Exercise, students enrolled in the Senior Seminar will follow the guidelines presented through page 10 of this document.

The Essays

The written portion of your senior exercise includes a 500 word summary and three essays based on a published journal article. In the first part you will describe, evaluate, and critique the experimental design and data of the article. In the second part you will place the article in a broad biological context, relating it to the other sub-disciplines of biology and explaining the overall significance of the work. In the third part you will describe future work that addresses important questions that arise from the article.

Choosing an article: Choose a recent research study that will lend itself to the type of analysis required in the essay. The article must have been published in a **well-respected journal** (see suggestions below) **within the last five years**, and cannot have been used in the context of a different course.

- Select a journal article in a field that interests you so that you are excited learn more about the topic.
- Choose a paper that makes an important or controversial contribution to the field. It is hard to write an interesting analysis of a boring or insubstantial paper.
- Select a paper that allows you to address each of the essay topics that described in more detail below.

During the senior seminar, you will submit three journal articles for approval. In consultation with the seminar instructor, one article will be selected from those submitted. For your guidance, a list of well-respected journals is provided below. Note that this list is not exhaustive, and that you are not limited to the journals suggested here.

Suggested Journals:

<i>Animal Behavior</i>	<i>J. Neurosci</i>
<i>Am. J. Physiol.</i>	<i>J. Virology</i>
<i>American Naturalist</i>	<i>Molecular and Cellular Biology</i>
<i>Behavioral Ecology</i>	<i>Molecular Microbiology</i>
<i>Biophysical J.</i>	<i>Nature</i>
<i>Cell (and other Cell journals)</i>	<i>Oecologica</i>
<i>Development</i>	<i>Plant Cell</i>
<i>Developmental Biology</i>	<i>Plant Cell and Environment</i>
<i>Ecological Applications</i>	<i>Plant Journal</i>
<i>Ecology</i>	<i>Plant Physiology</i>
<i>EMBO</i>	<i>Planta</i>
<i>Evolution</i>	<i>PLoS journals</i>
<i>Genes and Development</i>	<i>Proc. Natl. Acad. Sci.</i>
<i>Genetics</i>	<i>Proc. Royal Soc. B</i>
<i>J. Bacteriology</i>	<i>Science</i>
<i>J. Biological Chemistry</i>	<i>Toxicol. Sci.</i>
<i>J. Cell Biology</i>	<i>Virology</i>
<i>J. Comp. Phsyiol (A, B, or C)</i>	
<i>J. Exp. Biol</i>	

As part of the senior seminar, an annotated bibliography will be due. The annotated bibliography demonstrates your ability to identify additional sources related to your journal article and represents a start on your literature search. In your subsequent work, you will almost certainly cite additional papers, and some of those included in the annotated bibliography may not ultimately be included in the final senior exercise.

The annotated bibliography must include at least 15 references, and these must mostly be primary peer-reviewed scientific journal articles. No more than 5 references can be review papers. Use the citation guidelines described on page 8 of this document, and follow the citation with a short (2 or 3 sentence) description about the paper. In your annotation be sure to address why this paper will be useful to you as you write your essays.

Example:

1. Gibbons BJ, Brignole EJ, Azubel M, Murakami K, Voss NR, et al. (2012) Subunit architecture of general transcription factor TFIIH. *Proc Natl Acad Sci U S A* 109: 1949-1954.

This paper presents the cryo-EM structure of TFIIH. By combining these data with previous x-ray structures of individual subunits, a well-defined model of this general transcription factor was determined, contributing important information for the overall understanding of the architecture of the RNA pol II pre-initiation complex.

Paper Summary

The purpose of the summary is to demonstrate your understanding of the paper's content, approach, and findings. The summary should function much as an abstract does by relating key information on the question, experimental design, and results presented in the paper. The summary should be no more than 500 words. A revised version must be handed in with the final version of your senior exercise.

Essay 1: Manuscript review (1100 words)

The purpose of the first essay is to demonstrate your ability to understand and think critically about both *experimental design* and *data*. Your overall objective is to evaluate the primary experiments and analyze the results.

Experimental Design. A well-done essay will reflect a thorough understanding of the overall objective and specific experimental aims of the paper. The essay should clearly define the model system and techniques employed, as well as the relative strengths and limitations of other approaches to the same question. Are the model system and experimental design(s) appropriate? Why or why not?

Data and Interpretation. Focus your data analysis on the two or three most important figures or tables. For papers with complicated multiple-panel figures, you may choose specific graphs or panels. Attach these figures to the back of your document (they do not count against the 1100-word limit). We expect you to deal concretely with the data, for example by pointing out particular features of the figures or tables, and by making numerical comparisons.

Strong essays will identify and discuss both the strengths and limitations of the data in individual experiments. An understanding of the logical framework of the paper will also be evident. How do the results of each experiment lead to the overall conclusion? To what degree do the data support the authors' claims? Are there particularly clever or innovative strategies for resolving uncertainties? Discuss alternative interpretations, experiment designs, or relevant controls that would refine or improve the conclusions of the paper.

Advice:

- Be sure to write a *critical analysis* rather than a *summary* (you've already written a summary!).
- Put yourself in the place of a reviewer evaluating a manuscript for publication. **Your role is to convincingly explain to the journal editors the strengths and limitations of the work. You don't need to explicitly make a recommendation as to whether the paper should be published or not (after all, it was published!). Instead, your goal is to clearly and convincingly explain to the editorial board of the journal the strengths and weaknesses of the work in the context of other work done in the same area.**
- Develop the necessary expertise to critique the work. To write an effective analysis, you must consult and cite other relevant papers. Reading beyond your primary paper will also contribute to your efforts on the remaining two parts of your essay.
- Your analysis should focus on both **strengths and weaknesses** of the paper.
- Effective language use will be critical to your success on all three essays. The 1100-word limit puts your prose on a tight budget. Organize this essay and the others by preparing an effective outline; ideas and paragraphs should flow logically. Avoid wordiness, and use care with sentence structure. Don't obscure your meaning with multiple clauses and overly complicated constructions.

Essay 2: Synthetic review (1100 words)

The purpose of the second part is to demonstrate your ability to place your paper in the context of what you know about biological systems. In doing so you will focus on two primary questions: how does your paper relate to other sub-disciplines of biology that you have studied and what is the overall biological significance of the work? For the latter, consider how previous studies have influenced your paper as well as how your paper has influenced subsequent work in the field of biology.

In composing this essay, draw upon your knowledge of biology and related disciplines as well as your reading of the literature relevant to your paper. In your analysis pay special attention to the different levels of biological organization. For example, if the main focus of your journal article is population biology, you might aim to relate it to landscape ecology, organismal biology, and population genetics. If the main focus of your journal article is cellular biology, you might aim to relate it to organismal biology, molecular biology, biochemistry, and/or evolution. As a strategy you might think first about the implications of your study at one level of biological organization below and one level above the focus of your paper. What insights can you glean from the paper when thinking about larger or smaller levels of biological organization? In light of this, why are the results of this paper significant?

Advice:

- You can envision this essay as a portion of a synthetic review article. Your goal is show readers how the work connects to important questions that span biological disciplines. Go beyond the paper itself to explain how the paper matters to related areas of biology.
- Effective use of the literature is a key to success in this section. You'll need to read broadly on topics related to your paper. Although you may use secondary sources such as textbooks and review articles as a starting point for thinking about the biological context, your writing should focus on analysis of relevant primary literature. Be sure to reference the relevant texts or literature used in your synthesis.
- Address several subdisciplines of biological knowledge that are **biologically relevant** to the topic of your paper. Make explicit links and connections with other areas. Describe and compare experimental data and approaches whenever possible.

Part 3: Specific aims (1100 words)

The purpose of the third part is to demonstrate your ability to identify important questions and to design experiments. Your overall objective is to describe the future work that needs to be done to address the next important questions that arise from your article.

You should describe at least three distinct experiments or research questions in your 1100 word essay. You may describe experiments that extend or confirm the findings of your article. You may also describe other approaches to explore the fundamental research questions in your article. Finally, you may propose new research questions and describe how they might be investigated.

You must describe your proposed future work in detail. Present a research question or specific aim along with a hypothesis. Describe the experimental system and the specific techniques and methods that will be used to test the hypothesis. Where appropriate, describe the control groups and the data analysis that will be employed. State what results would support or contradict the hypothesis. Indicate potential problems that might arise during the experiments and suggest alternate strategies where possible.

Advice:

- The specific aims of a grant proposal are a good model for this essay. Imagine that you are trying to convince a grant review panel to fund the work you are proposing. Why does it need to be done? What approach will you take and why? What kinds of results will you likely obtain and how will you interpret them? How will the proposed work advance our understanding of this research area?
- You may not describe experiments that have already been published as your future work, and it is your responsibility to know the literature well enough to avoid previously published experiments. Reference relevant literature to support your proposed research questions and experiments.
- Be sure to clearly delineate each sub-section of this essay. Many students find subheadings to be useful.

Due Dates and Mechanics

All work will be submitted electronically on **Moodle**. Original written work is screened by **turnitin.com**. Due dates and times will be strictly enforced. See instructions below for specific deadlines.

Apr. 28 [Friday, 4:00 PM] You must be enrolled in a section of BIOL 475 by this date.

Nov. 17 [Friday, 11:59 PM] Revised manuscript including the **three essays, paper summary, references cited, and title page** in electronic form as a single document to **Moodle**. All sections of your manuscript, including the paper summary, should be revised. Also submit the **focal research article** that you analyzed and the **most pertinent primary literature cited** (5-10 primary sources) as PDF documents via **Moodle**.

You will submit portions of your senior exercise as assignments in the senior seminar. Key due dates include:

Sept. 17 [Sunday, 11:59 PM] Paper Summary and Annotated bibliography.

Oct. 15 [Sunday, 11:59 PM] Complete manuscript version of essays and paper summary in electronic form as a single document. Also submit your focal journal article as a PDF document.

Due dates are non-negotiable. If any deadline is not met, the Dean for Academic Advising will be notified, and you may be required to re-do the written portion of the senior exercise with a new journal article. Comments by your faculty mentor will generally be returned within one week following each deadline.

- Failure to meet a deadline automatically results in loss of eligibility for distinction.
- Time stamps on **moodle** define on-time submission.
- Without successful and timely completion of the senior exercise you cannot graduate.

All drafts submitted must show professional English style and usage throughout, including *page numbers* and *proper reference format*. If deficiencies appear, you will be required to work with a scientifically literate tutor at the Writing Center or your faculty mentor before submitting the revised manuscript. Revised manuscripts that still show serious deficiencies in style will not satisfy the senior exercise.

Academic Honesty and Plagiarism. You must write in your own words. Relying on close paraphrasing of other's work does not constitute "*in your own words*". Ask your mentor about paraphrasing if in question, particularly regarding methods, introductory comments from research papers, and discussion comments. **DO NOT** use direct quotations in your essays. You should describe the work of others in your own words and cite the work properly in text and in listed references. Turnitin.com automatically checks for plagiarism. Results of this check are available to you prior to each deadline. Collegiate standards for academic honesty will be followed to the letter. Please see the [course catalog](#) for details.

Citations and References. Appropriate credit must be given to the author(s) of any reference material you use in your paper. If an idea is not your own, you must correctly attribute credit, even when the wording is your own. Citations are given in (author, date) form in the body of the text in parentheses (see formatting guidelines, below).

REFERENCES CITED

A successful senior exercise will cite at least 12 primary journal articles overall and include cited works in each of the three essays. Overreliance on review papers is explicitly discouraged.

This final section of your manuscript is an ordered list of the references cited in your paper. Include **all** those specific references cited in the text. Do not include references that are not cited. **A single References Cited section** should be provided that covers the references for all three essays and your summary.

Use a citation manager program to format your citations. Citations must be in the format of a major journal in the discipline of your focal paper. They must include: authors, title, journal, volume, pages, and year. The following examples come from the PLoS web site:

- **Published papers.** Hou WR, Hou YL, Wu GF, Song Y, Su XL, et al. (2011) cDNA, genomic sequence cloning and overexpression of ribosomal protein gene L9 (rpL9) of the giant panda (*Ailuropoda melanoleuca*). *Genet Mol Res* 10: 1576-1588.
Note: Use of a DOI number for the full-text article is acceptable as an alternative to or in addition to traditional volume and page numbers.
- **Accepted, unpublished papers.** Same as above, but “In press” appears instead of the page numbers.
- **Electronic journal articles.** Huynen MMTE, Martens P, Hilderlink HBM (2005) The health impacts of globalisation: a conceptual framework. *Global Health* 1: 14. Available: <http://www.globalizationandhealth.com/content/1/1/14>. Accessed 25 January 2012.
- **Books.** Bates B (1992) *Bargaining for life: A social history of tuberculosis*. Philadelphia: University of Pennsylvania Press. 435 p.
- **Book chapters** Hansen B (1991) New York City epidemics and history for the public. In: Harden VA, Risse GB, editors. *AIDS and the historian*. Bethesda: National Institutes of Health. pp. 21-28.

In text citations should use (author, date) format. The words in the citations count towards the 1100 word limit for essays 1-3.

- **Single author papers:** (Cruz, 1976)
- **Two-author papers:** (Takamata and Artisomov, 2012)
- **Multiple author papers:** (Liu, *et al.*, 2017)

Organization of the Complete Manuscript

All work must be double-spaced in 12-pt font with one-inch margins. Include numbers on every page.

Submit your complete manuscript and revised complete manuscript with the following sections.

- Title page. The title page must include your name and your mentor's name, the full citation of your focal paper, and the word count for each of the three essays.
- Paper summary.
- Essays 1, 2, and 3.
- References Cited. A single references section services all previous portions of the manuscript.
- Figures. Any figures you include should be grouped with in the back of your manuscript, not embedded in the text. Be sure a legend is included below each figure.

Evaluation Process. The Department will assign a second reader. Each Senior Exercise will be read by at least two faculty members and the department as a whole will approve the final evaluation.

You will be notified by the Department Chair by e-mail and/or letter of the decision of the Department regarding satisfactory completion of the essays. Decisions will be made by the end of the first semester. Should you not pass the written portion of the senior exercise, you can attempt the exercise again in the second semester, according to a schedule arranged by your mentor and the department chair. Should you not satisfactorily complete **any** component of the senior exercise in biology **you cannot graduate in May.**

Distinction. Senior Exercises receiving Distinction are usually marked by originality and outstanding scientific writing, analysis, organization and flow of discussion, and use of primary literature. The results of your ETS exam are a pre-requisite to earning distinction on your senior exercise. Distinction is rewarded when your work is judged to be of "A" quality on all the essays and the ETS exam is completed satisfactorily.

The following is a list of criteria that the Biology department uses when assessing senior exercise essays. Students should refer to the full senior exercise guidelines for detailed instructions for each essay. We share this with students as a supplementary indication of our expectations. We caution against use of this list as a simple checklist. Simply addressing each criterion does not necessarily guarantee a satisfactory senior exercise.

1. Analysis (particularly essay 1):

- Evaluates the study's model system, experimental design, and techniques.
- Describes study's results and how well they support its conclusions.
- Explores both strengths and weaknesses of the article
- Directly discusses actual data and figures from the article.
- Proposes alternate approaches, experiments, analyses or controls that could improve the study.
- Compares and contrasts methods and results to those of similar research articles.

2. Synthetic ability (particularly essay 2):

- The article is placed in an appropriately broad, integrative biological context. The essay extends beyond the material covered in the introductory lecture course that the paper would fall into.
- The essay articulates why someone in another field would benefit from reading the article. It shows how the paper has influenced other fields or how it has been influenced by other fields.
- Primary literature is used as a foundation for integrating disciplines.
- The overall significance of the article is clearly described.

3. Creative thinking (particularly essay 3):

- Important further research questions are identified.
- Appropriate experimental designs are proposed.
- Hypotheses are clearly stated, and results that would contradict or support hypotheses are proposed.
- Proposed experiments use methodologies and approaches different from the paper's.
- Possible experimental or interpretive difficulties are mentioned.
- Proposed experiments demonstrate an understanding of the relevant primary literature.

4. Written skill (all 3 essays):

- Each essay is well organized.
- The writing is succinct, clear, and direct.
- Grammatical and spelling errors are absent.
- Proper citation format is used.

5. Comprehension of material content (all 3 essays):

- Concepts are explained accurately.
- A deep understanding of the paper's research area is demonstrated.
- Primary literature is effectively used to support arguments. At least 10-15 primary research articles are incorporated into the essays.

The Biology Seminar Series: Information for Students

Why do we require seniors and research students to attend seminars?

- The seminar series is an important part of our departmental emphasis on the process of science. Just as you have learned about the process of science by reading research papers in classes, you will also learn about how science works by attending seminars.
- Seminars are a common means for communicating scientific information, and being comfortable with this format is an important skill for biologists.
- The seminar series is also an important opportunity for both students and faculty to interact with scientists from other institutions. We often invite students to have lunch or dinner with seminar speakers – if you'd like to be invited, let us know.

What sort of information is presented in a seminar?

- In a typical research seminar, the speaker will present findings and ideas that are not yet published. Thus, the content in a research seminar may be less polished or less finished than the final product that is printed in a peer-reviewed journal.

What are the benefits to the speaker and the audience?

- Speakers benefit by presenting their work at an early stage. They receive important feedback from the audience, usually in the form of questions during or after the seminar.
- The audience benefits by hearing about results before they reach print form. Students can benefit by seeing an actual example of how scientists interact with each other in the real world.

How can I enjoy and benefit from my seminar attendance?

- Prepare beforehand. If you have the chance, read a paper written by the seminar speaker or read a review article on the topic. Having an understanding of the topic before the seminar will greatly enhance your enjoyment and understanding.
- Take notes. Generally, research seminars move fast and speakers often lapse into the jargon of their discipline. It is possible to get swamped by a tsunami of vocabulary. The beginning of a research seminar usually contains background on the research area, similar to the Introduction section of a paper. It helps to jot down unfamiliar names and acronyms. Later in the talk you might forget that eNAC stands for epithelial sodium channel, that TEWL is total evaporative water loss, or that a pika is a short-eared mammal that lives at high altitudes. Having your notes to remind you, you'll be able to keep up with the talk.
- Think critically. When reading a research paper, scientists try to critically evaluate the evidence that is presented. Try to do the same during a seminar. Look carefully at the data. Do they support the stated conclusions? Even if you miss some of the details, you can always assess the quality of the data that are presented.
- Understand what you can. You may not understand every aspect of a research seminar, especially if it is outside of your major area of biology. Don't worry about it. Probably only a few experts in the field understand the work entirely. And even the speaker may not exactly know how everything fits together. Remember that speakers often present research in progress and there are almost certainly aspects that are still not understood.
- Observe how effectively the speaker presents the seminar. You can learn a lot by watching how scientists present their work. Are the slides clear? Did the speaker give enough background information? Are the data presented effectively? Even if you don't understand a word of the science, you can learn how to effectively present your work. You might also note some mistakes and vow never to make them yourself.
- Ask questions: You are encouraged to ask questions at seminars. Our students often do, and speakers are appreciative and impressed.