Guidelines for Honors Research/Thesis and Graduation with Distinction

Dept of Biological Sciences

University of Denver

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General Requirements:

Graduation with Distinction in the Department of Biological Sciences requires the completion of a thesis after at least 3 quarters of research.

The student must have a GPA of 3.5 or higher.

A student may qualify for the program by either being a member of the Honors Program or by application to the Honors Committee for departmental Distinction.

The thesis must be based on laboratory or fieldwork research.

The research must be approved and guided by a member of the faculty in the Department of Biological Sciences.

Choosing an Advisor

There are several opportunities for you to determine which adviser has research interests closely related to your own.

- Faculty members give 10 minute presentations about their research during a symposium generally held in the winter or spring quarter. These presentations will be advertised in classes and notice will be sent to the Honors Program students by e-mail.
- Each faculty member has a web page. This web site will provide you with information about the research of each faculty member in the department.
- The 2nd and 3rd floor corridor walls in Seeley G. Mudd are lined with posters from Honors students of previous years. You may view these to get an idea about the type of research that Honors students perform in each laboratory.
- Several Honors theses that were selected for the 'Outstanding Honors in Biology award' are available as a link.
- The Department office in Olin 102 has copies of all recent Honors theses. Browsing through these theses will also give you a good idea of the type and extent of research done in each laboratory.

Once you have narrowed down which labs are of greatest interest to you, make an appointment to talk with each of the faculty members. After talking with members of the faculty, choose a faculty advisor and work with him or her to formulate specific plans for a research project.

When to Start

The program requires at least three-quarters of research and some faculty advisors require more. The Research option in the Molecular Biology major requires coursework in addition to the research experience. You should begin inquiring during the sophomore year or early in the junior year at the latest. Given the large numbers of Honors students, limited space in laboratories and the course work, it is wise to find a faculty research adviser as early as possible.

Registering For Credit

You may enroll in either Undergraduate Research (BIOL 3950) or Independent Study (BIOL 3991) for a number of credit hours agreed on with your advisor. Generally, one qtr hour corresponds to at least 3 hours of work per week. This is only an estimate of the time commitment required to successfully achieve honors research. The exact time investment needed to complete the work will be decided upon between you and your advisor. Time demands will vary depending on the complexity of the research question and the research methods being used. Each Honors research student must come to a clear understanding with the research advisor as to what time commitment is required.

There are some important guidelines and limits on how the research/independent study credits can be counted:

- A total of five hours of Undergraduate Research/Independent Study may count toward the total number of BIOL hours required for a major in Biology or Ecology & Biodiversity.
- A total of six hours of Undergraduate Research/Independent Study may count toward the total number of BIOL hours required for a major in Molecular Biology.
- Not more than 60 hours of total BIOL credits can be used in the 183 credits for graduation. If you graduate with more than 183 total hours, then you may earn more than 60 hours of BIOL credits.

Off-Campus Research

Completion of an Honors thesis off-campus requires:

- a qualified research advisor at the off-campus research site,
- a faculty member in the Department of Biological Sciences who agrees to serve as Departmental liaison.

Before beginning off-campus research, a 1-2 page Proposal of Research is required.

This proposal must be pre-approved by:

- the off-campus faculty advisor,
- the Departmental liaison, and
- the Honors Committee.

Proposal of Research Plans

Before beginning a research project a proposal (approximately 2 to 4 pages) should be written which includes the following information in 5 sections:

- Why is the question you are asking important and how does it fit in with the big picture?
- What is your hypothesis and what are the objectives of the research?
- What results do you expect to find and why?
- What is the current status of knowledge in the field (i.e. current literature search)?
- What materials and methods will be needed to answer the research question?

This document should be submitted to your advisor for approval before beginning your research project.

The Written Thesis

A well written scientific report must fulfill two objectives. First, it must clearly and completely describe the procedures that were followed and the results that were obtained. Second, it must place these results in perspective by relating them to the existing state of knowledge and by interpreting their significance for future study.

While it is necessary for your thesis to be complete, it is also essential that it be well organized and concise. A general format for the structure of scientific reports in biology has gradually evolved and is now in wide use. The format is designed to achieve clarity and conciseness. It organizes the text into five main parts: abstract, introduction, materials and methods (or procedures), results, discussion. Please read below for a further discussion of these parts, the manner of presentation of data in tables and figures, and the format for citation of other scientific work.

The specific organization and style used in many biological journals are covered thoroughly in the CBE Style Manual (6th ed.), published in 1994 by the Council of Biology Editors. For detailed applications of these guidelines, you should examine a current issue of a journal that is widely relied upon and cited in your lab or field. Other books, which treat the writing of papers in biology, are given below in "Selected Bibliography."

A scientific report in biology is usually organized into the following ten sections:

- Title Page
- Abstract
- Introduction
- Materials and Methods (or Procedures)
- Results
- Discussion
- Acknowledgments

- Literature Cited
- Tables
- Figures

Type all text double-spaced with appropriate margins (1" or more).

Number pages of the body of the text, i.e. from Introduction through Literature Cited.

Title Page and Abstract

The title page is also the cover page for your thesis. It should include a carefully chosen title for your work, your name, the institutional address, the date, and the guiding professor's name, with a line above for her/his signature. The abstract should follow on the next page. It should be shorter than 250 words, and occupy a page of its own. Your abstract should be drafted last, to summarize the questions/hypotheses addressed, the most salient points of the results, and the most novel information in the discussion.

Introduction

This section should explain exactly what the objectives of the study are, and why the questions posed are worthwhile to pursue. In this section it is important to relate your objectives to current literature in the field and to how your work fits into the larger scope of research performed on the topic being studied. This section is written in the present tense.

You should include or answer the following points in the Introduction:

- Why did you undertake this study?
- What questions are being asked?
- What objectives, questions or testable hypotheses will be addressed by your work?
- What is the existing state of knowledge about this topic? (Typically numerous references are included in this section of your thesis)
- How might your results advance "knowledge" in the field?

Materials and Methods

This section includes the "process" (methods) and materials used in your experiments. The detail should be sufficient to allow the reader to repeat your experiments under the same conditions and to repeat and/or extend your results. One way to complete this section is to include information on what, when and where, and how was the study conducted.

WHAT. In the case of a particular organism, give a description of the species. Describe the relevant features of the organism such as tissues, organs, cells,

and/or organelles. Explain why this is an appropriate unit of study for the research. Italicize all scientific names; use a capital for the genus, lower case for the species.

WHEN and WHERE. If such details are relevant to the data, give the time periods during which the organisms were collected and/or the work was done (year, month, day, time of day); describe the special conditions of the organism (developmental or reproductive state) in the context of the seasonal (annual) cycle, or within other natural cycles; describe where you did the work.

HOW. Explain the techniques of collecting data or conducting experiments; describe the equipment used; identify the source of chemicals and other materials used. Where procedures and equipment are standard, shorten your text by referring to other publications. Otherwise, describe them in enough detail that a reader can duplicate them. State the techniques used to record, summarize, and analyze the data.

You should organize each aspect of materials and methods into a paragraph, and lead your reader to a needed section either by a well-crafted topic sentence for each paragraph, or by brief subheadings, underlined or bold, at the beginning of each paragraph. Write in the past tense.

Caution: Do NOT explain your results in this section

Results

This section should contain, in summarized form, the data and observations obtained in the study. It is best to start with the data from the controls to give the reader a "baseline" in which to interpret your experimental results. This section can include graphs, charts, appendices that are clearly explained in the text. Choose to present data in either a table or a figure, depending on which form best supports interpreting the data. To be complete and concise in the text, concentrate on general patterns, trends and differences in the results and not on the details of the numbers themselves.

If you use statistical analyses, you should make every attempt to combine statements about the significance of differences with a precise indication (in parentheses) of the test used and the probability test chosen. For example, one might say, "The difference between means of two samples was highly significant (paired t test; $t = 6.35$, $DF = 11$, $P < 0.01$; (Sokal and Rohlf, 1981).)"

Whenever possible, use international units (meter, m; gram, g; liter, L; and second, s) with their multipliers (kilo, k, 10^3; milli, m, 10^{-3}; micro, femto, f, 10^{-15}; etc...).

Write numbers as numerals whenever they are associated with measurement units (*e.g.,* 3 mm) or are parts of dates or mathematical expressions. In other cases, spell them out for numbers less than 10 (*e.g.,* five cells), and give them as

numerals for larger values (*e.g.,* 21 species); except that you must spell out a number which starts a sentence, so that it can be capitalized.

The Results section should be free of interpretation of the data. This is frequently difficult because it is very tempting, when first presenting data, to explain why the results turned out as they did, or what the results mean. Force yourself to maintain the critical distinction between results and their interpretations; this practice will allow readers to draw their own conclusions about the meaning of your results. On the other hand, it is important to present your data with logical flow. A brief comment relating how the last result led to the next experiment may encourage the reader to read on. You can write in the past and present tense. For instance you can state: "We did this and we concluded that ..."

Discussion

This is the appropriate section in which to interpret the data in relation to the original objectives or hypotheses given in the introduction, and to relate the interpretations to the current state of knowledge and future needs for research.

In relating your work to others', try to avoid extensive quotations, but be sure to give credit where it is appropriate for ideas that are not yours. To cite the ideas of others without specifying their origin is plagiarism.

A common mistake in the Discussion is to repeat the results at some higher level of generality instead of making the discussion section genuinely interpretive. Following the outline below may help:

- Reach conclusions about the initial question(s) or hypothesis(es)
- Compare your conclusions to those of others
- Identify sources of error and basic inadequacies of technique
- Suggest improvements in methods and/or approaches
- Speculate upon broader meanings of the conclusions reached
- Identify needed steps in research on the problem

Acknowledgments

In this section, give credit to those who helped you in the study by contributing work, advice, permission, technical assistance, supplies, funds for conducting the work, and help with the preparation of the thesis.

Literature Citations in the Text

To refer to published work of others within your text, do not use footnotes. Instead use references in parentheses that give names and/or dates keyed to the Literature Cited section. This may be done in several ways:

"Barbee and Evans (2006) found that..." or

"In their work on Accessibility of targeted DHPR sites Lorenzon and Beam (2007) propose that..."

If there are more than two authors, it is common to abbreviate with (Sadler *et al.* 1997). The abbreviation et al. is for the Latin phrase et alia, meaning "and others," so that there is a period after "al" but not after "et".

Literature Cited Section

This section should contain, in alphabetical order by first author, only those items specifically referred to in the text. The format recommended by the CBE Style Manual is followed by many American journals, but not by most book publishers. For your honors thesis, please follow the simple format outlined below that provides all the essential information:

- Journal article:
  Withington, C. L., and R.L. Sanford, Jr. 2007. Decomposition rates increase with altitude in the forest-alpine tundra ecotone. Soil Biology and Biochemistry 39:68-75. This reference includes the names of all the authors, the year of publication, the article title, the fully spelled journal name, and the volume and page numbers of the article.
- Book:
  Arthur W., 2007. Molecular Biology of Human Cancers. 508 pages. Springer Netherlands. This reference gives the author, date of publication, title, and the publisher's name and location.
- Article in an edited volume:
  Patterson D. 2006. Aging and Susceptibility to Alzheimer's Disease, pp 35-51 in Down Syndrome Neurobehavioral Specificity, Rondal JR, Perera J, Eds. Wiley Liss, Publishers. This reference includes the article's author, the date of publication, the article title, pages in volume, volume title, names of volume editors, and the publisher's name and location.

Tables and Figures

Every table and figure must be referenced within the text of your thesis and they must be referenced in the correct order.

Place tables and figures on pages separate from the text, one table or figure per page.

Number tables (Table 1., Table 2. etc.) and title them fully in a legend placed above the table itself. Within the body of the table, use headings to identify clearly the nature and units of the data given. Number figures (Figure 1., Figure 2., etc.) and provide a full legend placed below the figure. The axes of the figure should be specified clearly and the units identified and scaled appropriately. Legends for both tables and figures should contain enough information so that each can be understood without reference to the text. Leave adequate margins on pages with tables and figures, just as for text pages. Make reference to each table and figure in

the text at an appropriate point, using parentheses if needed, *e.g.,* "...other data (Table 3) support the conclusions drawn from Figure 2."

Any additional questions about thesis preparation may be referred to your advisor, or to members of the Honors Committee. Examples of excellent theses are available in the Department office. Ask your advisor which student's theses would be most helpful for you.

Selected Bibliography

Allen, A. 1977. Steps toward better scientific illustrations. 2nd ed. Allen Press, Lawrence, Kansas, USA.

Booth, V. 1979. Writing a scientific paper. 4th ed. The Biochemical Society, Colchester, Essex, U.K.

Clarke, G.M. 1994. Statistics and Experimental Design, an Introduction for Biologists and Chemists. 3rd ed. Halstead Press/ John Wiley & Sons, Inc., New York, NY, USA

CBE Style Manual Committee. 1994. CBE style manual. Council of Biology Editors, Bethesda, Maryland, USA.

Cox, G. W. 1990. Laboratory manual of general ecology. 6th ed. Wm. C. Brown Publishers, Dubuque, Iowa, USA.

McMillan, V. E. 1997. Writing Papers in the Biological Sciences, 2nd ed. Bedford Books, Boston, Massachusetts, USA

Pechenik, J.A. 2004. A Short Guide to Writing about Biology. 5th ed. Pearson Longman, New York, NY, USA

Sokal, R. R. and F. J. Rohlf. 1997. Biometry. 3rd ed. W. H. Freeman and Co., San Francisco, California, USA.

Tufte, E.R. 1983. The visual display of quantitative information. Graphics Press, Chelsire, Connecticut, USA.

Poster Presentation

The poster is much less formal than the written paper, and often a very efficient way to communicate your work. It is a departure point for a conversation, not intended to be all-inclusive; its function is to draw the interested observer to talk with you, and inquire about your work in as much or little detail as you both wish. Keep your poster brief and inviting, but clear enough so that you need not spend most of your time merely explaining the poster to a succession of visitors.

Arranging Material

It is convenient to fit your poster on one or two standard poster boards, with total dimensions of 32 x 40" or 40 x 64".

The top line(s) of the poster should include the title and author, in lettering at least 1" high. Because this is your thesis work, co-authors would be inappropriate.

An Introduction, placed in the upper left, sets the stage by providing background and the question(s) you addressed. The Conclusion, placed at the lower right, summarizes major findings and relates them to other work in the literature. Both Introduction and Conclusions should be in large type.

Between the Introduction and Conclusions, present your results, in the form of illustrations: figures, tables, drawings or photographs. Arrange them in columns, rather than rows; viewers need to move systematically across the poster rather than zig-zag. Guide the reader through the sequence by numbering the illustrations; use numbers at least 1" high, preferably in bold print; omit "Fig." or "Figure".

Each illustration stands alone, and should have a heading of one or two lines stating the "take-home message" in large type. Detailed information comes in a legend below, in smaller type. The illustration on the poster bears a heavier burden than the illustration in the thesis, because no other text accompanies it; the legend contains commentary that would appear in the body of a manuscript. The legend describes the content of the figure or table and the conclusions derived. Details of methodology, rendered very briefly, follow at the end of the legend.

Keep the illustrations simple, legible from a distance of several feet. Concentrate on making them easily digestible, free of nonessential information. Aim at the level of knowledge of the expected audience.

Further Guidance

Examples of Honors posters are on the walls of the second and third floors of the Mudd building.