



MASTER OF SCIENCE IN BIOLOGY
PROGRAM

Thesis Format Guide

UNIVERSITY OF GUAM

Unibetsedåt Guahan

**OFFICE OF GRADUATE STUDIES
MASTER OF SCIENCE IN BIOLOGY**

Thesis Format Guide

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Overview

G The Master of Science in Biology Program is designed to serve those students who are pursuing a research-oriented career at the master's level, those using the master's degree as a stepping stone to a doctorate, a career in natural resource management or environmental consulting, and biology teachers who have fulfilled requirements for teacher's certification but seek a broader knowledge of biology.

Program Learning Outcomes

Upon successful completion of the Program, students will demonstrate the following:

- G** The ability to conceive, conduct, and report original research;
- G** The ability to analyze data and design experiments using standard statistical procedures;
- G** The ability to write technical scientific reports and articles;
- G** Knowledge of basic organismal and ecological principles;
- G** Knowledge of basic cellular- and molecular-level principles;
- G** Knowledge of the latest advances in the student's chosen area of biological study; and
- G** The ability to disseminate scientific concepts and research findings in a variety of formats (e.g., written and oral).

Once the student has proposed a program of research and carried out that research, the final step is to prepare a thesis that will present the body of work that has been accomplished. The M.S Biology Program allows two possible formats for this important document: one which is a standard, traditional format and one which is designed to facilitate publication of all or a portion of the thesis. This flexibility is in recognition of the wide diversity of thesis project results, and the challenges that students often face in publishing their work after they have graduated and left the program. In addition to this document, the Graduate Studies Office provides University-wide thesis guidelines which should be consulted.

Thesis Structure

G The Master of Science in Biology (MS Biology) thesis must demonstrate thorough knowledge of the chosen research question and offer an original contribution to the field of biology. By the time a student has completed a thesis project, they should have become uniquely familiar with their field of study, with the body of literature supporting it, and with methods of experimental design and analysis employed to examine a complex data set.

Written theses should accomplish the following:

- G** Define the area of research that was studied;
- G** Review the relevant primary literature, identify knowledge gaps, and explain how previous findings related (complement/contradict) to the thesis topic and how the thesis topic addresses at least one knowledge gap;

- 6 Clearly articulate a set of research objectives that were addressed or a refutable hypothesis that was tested;
- 6 Present a detailed, logical description of the experimental design and methods used to test the hypothesis, including all rigorous statistical analyses applied;
- 6 Present the results of the research in a logical order, both graphically and in written text;
- 6 Critically discuss the findings, in terms of expected and/or unexpected outcomes which supported or refuted the hypotheses, relevance to primary literature, and implications of the results to the broader body of knowledge in the field.

Within this basic framework, two format options are presented below. Students must consult with their thesis committee to determine which option is the best fit.

On the framing of Hypotheses:

A useful definition of an **hypothesis** is “a supposition or proposed explanation made on the basis of limited evidence, as a starting point for further investigation”. A thesis may have more than one hypothesis, depending on the proposed work. It is customary in a thesis to present both *null hypotheses* (assuming that things being compared are not different from each other) and *alternative hypotheses* (assuming that there are differences). Examples of hypotheses are as follows:

H_0 : “There are no observed differences in reef fish abundance between Marine Preserves and fished reefs.”

H_a : “There are significant differences in reef fish abundance between Marine Preserves and fished reefs.”

Thesis Cover Pages

- 6 All theses, independent of the format option taken, must contain standardized thesis cover pages, which include an abstract. The format of these pages is presented in Appendix 1. More guidance on writing an abstract is provided below.

Paragraph Structure

- 6 Most paragraphs in scientific writing have a three-part structure: an opening topic sentence, a body of information which discusses the topic sentence, and a conclusion that ties the entire paragraph together. These items are standard for paragraphs regardless of whether they are narrating, describing, comparing, contrasting, or analyzing information. The organization and linkages among these parts play an important role in effectively communicating with the intended audience. The topic sentence defines a paragraph, provides background, and/or creates a logical transition from the previous paragraph. The body then discusses the supporting knowledge, using facts, arguments, analyses, examples, and other supporting information, while properly giving intellectual credit to the sources of information cited. Finally, the conclusion summarizes the connections between the information presented and states the paragraph’s main point or controlling idea.

Paragraphs must also display consistency in verb tense, point of view, plurality, and subject-verb agreement. Finally, they must be coherently strung together, such that they tell the story in a logical order. Transitions between paragraphs can be made with well-constructed topic sentences and/or closing sentences. So, as the thesis is written, it is important to think about how the various pieces of each section logically fit together.

Abstract

G An **abstract** is a concise, yet complete summary of the thesis. It is written as a single paragraph of 300 words or less, and presents the topic, argument, and conclusions of the study in a prescribed sequence. At a minimum, this sequence includes:

- the issue, central argument, or purpose of the study;
- a brief, yet comprehensive description and explanation of the experimental design, methods, and procedures;
- a brief summary of major findings or trends observed; and
- a brief summary of the implications of the study on practice and theory (e.g., how results tie in with the greater body of knowledge).

In addition, depending on the type of study, it may also be appropriate to include:

- study location, including georeferenced coordinates;
- sample types and quantities;
- sampling locations and dates;
- limitations of the study; and/or
- opportunities for future research.

The abstract appears on the second page of the document and adopts the present tense to describe applicable results (e.g., “These findings indicate...”) and past tense to describe experimental steps (e.g., “Samples were collected...”). An abstract does not typically include any reference citations, nor does it cite any statistical analyses. It may include descriptive statistics, in order to illustrate comparisons that comprise major findings. It should contain key words that are appropriate for a search engine.

Acknowledgements

G **Acknowledgements** should follow the abstract in both thesis formats and should include all individuals who assisted in the project; in data/sample collection, processing, analysis, or writing. Funding sources should also be acknowledged. If the thesis is to be submitted for publication review, the acknowledgements are usually placed at the end of the manuscript, before the reference list (see Option 2 format, below). The agency that funded the work and the grant number are required information, as well.

Table of Contents



A **Table of Contents** should be included prior to the Chapters in both thesis formats. Immediately after the Table of Contents, a **List of Tables** and a **List of Figures** and their page numbers should also be provided.

Option 1: Traditional Thesis Format

There is no required page length for a thesis. Past theses from the University of Guam have ranged from 249 pp. (1969) to 44 pp. (1985). Theses in 2018 ranged from 42 pp. to 153 pp. Page length is dictated by the complexity of the work and the number of tables and figures needed to present the data. In general, it is appropriate to aim for between 50 and 100 pages, but the thesis committee will advise the student how much information is too much or too little.

Chapter 1: Introduction



An **Introduction** is where the student demonstrates knowledge of the current state of science in the selected field of study. If a comprehensive Introduction was included in the original proposal, simply update that Introduction with recent relevant publications and include additional material to reflect any changes in the thesis since the acceptance of the proposal. Additional insight and a deeper understanding of the subject should also be obvious in the updated Introduction.

The **Introduction** section is where the student:

- 1) presents the overall topic;
- 2) explains why it is relevant and important; and
- 3) discusses previous work related to various aspects of the research question(s).
- 4) demonstrates understanding of the current state of knowledge and theory in the field, and the ability to extract information pertinent to the research project; and
- 5) conveys this information in a concise and convincing way

It is important to not underestimate the time necessary to become familiar with relevant literature, and yet understand that not all literature read should be included this section. It is common to have several related topics contributing to a particular question that need to be understood but do not contribute to the logical flow of the final document.

An introduction must be thorough enough to present alternative views, logically organized so it is clear how previous studies relate to each other and, most importantly, should explicitly state how the proposed research makes an original contribution to the current state of the field. Summaries of previous work should be concise, consistent, and logical, and should avoid redundancy while not presenting a laundry list of related findings in chronological order.

Hypotheses are presented in the last paragraph of the Introduction, and should follow a logical presentation of a gap defined in the body of knowledge that the study is addressing. The student may elect to provide an overall **Statement of Purpose** prior to

framing **Hypotheses**, which may be useful if there are several hypotheses put forth that will be presented in the thesis. Hypotheses should state both null and alternative.

Introductions are expected to be reasonably exhaustive of the current literature but concise; a limit of eight to ten pages (double spaced) is suggested. As a guide, Introductions should include a minimum of 20 to 30 of the most important (highly cited) publications in the field. It is essential to avoid the mistake that recent work is the only pertinent information. The student must demonstrate knowledge of key historical articles that define current theory. As an example, many of the seminal studies on coral reef ecology were done in the 1960s and 1970s.

Chapter 2: Methods

G The **Methods** section should describe all aspects of what was done, providing a clear description of all experimental methods and statistical procedures used. While standard methods do not have to be described in detail, the seminal reference describing the method should be cited. Other methods should be described in enough detail that they could be replicated by someone reading the paper. In general, Methods are written in the past-tense, third person.

Authors should address the following in their **Methods**:

- G** When, where, and how study organisms were obtained and handled;
- G** Clear descriptions of what, where, and when experiments were conducted, and by who;
- G** The design of experiments (i.e., number of study replicates and samples, measurements taken, technology and equipment used, description of study site(s), and number of times the study was repeated), including an appropriate power analysis for each (as appropriate); and
- G** The statistical methods and software used, their appropriateness in analyzing such data, and how results were interpreted (both + and -).

Organization is key, particularly if multiple experiments were conducted; Methods should follow a logical order to describe the study in its entirety. Distinct groups of the Methods can be logically divided into subsections using descriptive subheadings.

It should be made clear why each method was chosen and how it contributed to testing the stated hypotheses (e.g., "to characterize the effect of X on Y, this method was applied during summer 2017..."). It is important to remember that the final shape of a thesis project may have shifted from that originally proposed. In addition, there may be some pilot or trial experimentation that is not necessarily suitable for inclusion in the final thesis; this should be discussed with the advisor as the student writes the thesis. Depending on the nature of the study, statistical tests could be presented either with the experimental design (for example, if there are several experimental components) or discussed separately in logical sequence at the end of this chapter. Schematics, diagrams, and other visual representations help outline experimental designs, particularly if manipulation of independent variables was undertaken.

Chapter 3: Results

G The **Results** section presents the results and nothing else. It is not a place for speculation, explanation, or further descriptions of what was done. In general, the order of the results should follow a logical flow, with the most significant results presented in the first paragraph. Results may, and usually do, contain several subheadings, to organize the various components of the study and make it easier for the reader to follow. The most compelling and important results are presented first and the least important results are presented last. A few rules to guide the writing of the Results section are presented on the following page:

- G** Organize paragraphs as described above, using a strong topic sentence that provides clear information regarding the result the paragraph is discussing.
- G** Do not begin a sentence by naming a statistical test (i.e. "A One-Way ANOVA indicated that there was no significant difference between treatments"). Rather, start your sentence with the actual result and put the stats results in parentheses at the end of the sentence: "There were no significant results between treatments (ANOVA F: 1.4563; $p > 0.05$).". If the Methods were written well, there should be no need to further describe which stats test was used for which result.
- G** Design graphics carefully (more on that, below); do not present the same data in both a table and a figure; choose the one best presents your data. Human readers are visual; a graph/figure will usually present a more compelling story but there are times when complex data sets are best summarized in a table.
- G** Do not rely on your graphics to tell the entire story; always explain your results in the text.
- G** Consider placing large volumes of data in Appendices, rather than in the body of the Results section.
- G** Avoid citing other published works in this section.

Tables and Figures

These are key elements of any Results section, and should be decided upon with the thesis committee prior to beginning the writing process. In a very real sense, deciding on the basic figures and tables should be the first step in writing; the Results section will be much easier to write once the data are presented graphically in a clear and logical order and the writer has a clear idea of the story. Keep in mind that some data are better disseminated when depicted in tabular, rather than graphical form; this decision should be guided by which form best presents the story most clearly. Graphics provide a powerful visual image of the results, but if the actual numbers are essential to the story, then a table may be more appropriate. The most readable formats and styles are often demonstrated by highly-cited publications within a respective field that present similar types of information. The best tables and figures are those which clearly present results in a logical order, are aesthetically balanced, and do not contain nonessential details that conceal the overall message.

Chapter 4: Discussion

G Most writers find the **Discussion** to be the most challenging part of the document. The Discussion is the part of the thesis where the Results are “dissected”, analyzed, and compared to previous studies. This analysis needs to be introspective and thoughtful, and should demonstrate that the author understands how their results fit into—and contribute to—the current body of knowledge. It must be more than a simple regurgitation of results, yet the writer must be careful to keep focused, and to avoid getting sidetracked by superfluous explanations, the overstating of results, and/or over-speculation. The writing must be concise, yet provide a critical analysis of the results. Relevant publications should be cited and discussed. The Discussion is where the author presents the implications of any assumptions that were made regarding the methods or results, details regarding the

interpretation of results or problems and issues encountered that may have affected them, and other possible explanations for the results observed.

The Discussion section should start out with a paragraph summarizing the strongest and most important results; these should refer back to any hypotheses that were being tested. The section can be organized according to the subheadings used in the Results section; i.e., the writer should provide a discussion of all the major findings in the thesis. The Discussion should end with a strong summary paragraph that puts the study into a broader perspective.

Many graduate committees also suggest that a short section on **Future Work** be included at the end of the Discussion. This may present ideas or concepts that could be investigated in the future, as a result of the study.

Literature Cited

In-text citations

In-text citations are needed when the author refers to, summarizes, paraphrases, or quotes from another source. For every in-text citation in the thesis, there must be a corresponding entry in the reference list. In-text references should immediately follow the title, word, or phrase to which they are directly relevant, rather than appearing at the end of long clauses or sentences. In-text references should always precede punctuation marks and the APA citation format should be used. APA in-text citation style uses the author's last name and the year of publication, for example: (Field, 2005). For one or two authors, both names are written; for more than two authors, "et al." (Latin, for "and others") is used after the first author's name. Below are examples of using in-text citation.

When the author's name is in parentheses:

One study found that the most important element in comprehending non-native speech is familiarity with the topic (Gass & Varonis, 1984).

When the author's name is part of the narrative:

Gass and Varonis (1984) found that the most important element in comprehending non-native speech is familiarity with the topic.

When there are multiple publications cited, separate each work with semi-colons:


Research shows that listening to a particular accent improves comprehension of accented speech in general (Gass & Varonis, 1984; Krech-Thomas et al., 2004).

Literature Cited section:

A **Literature Cited** section should fully acknowledge all references cited in the document, including grey literature and websites. Please refer to this link for guidance in formatting various types of documents: https://www.nlm.nih.gov/bsd/uniform_requirements.html. This guide provides standard formats which are easily adopted for theses.

Option 2: Publication-Ready Format

Rationale

 In an effort to encourage the publication of student theses, the Graduate Biology Program is offering a second format for the thesis, based on formatting the thesis for potential submission to a peer-reviewed journal. The reason for this is that M.S. students are usually not in the program long enough to produce a publication (2.5-3 yrs). Thus, most theses are not published until after the student has graduated. This becomes challenging when the student is either working full-time or in a Ph.D. program, and away from the M.S. advisor. Formatting a thesis for potential publication can reduce the amount of effort required to get a manuscript ready for submission for review. However, it requires a slightly different approach than Option 1.

The main difference between Options 1 and 2 is the fact that a manuscript submitted for peer review must be much more concise and distilled than a traditional thesis. Thus, there may be aspects of the work performed that should not be included in a

publication. The format presented below provides a guide for both meeting the requirements of a thesis within the M.S. Biology Program, while facilitating peer-review readiness.

General Format

G Abstracts, Acknowledgements, Table of Contents, and Lists of Tables and Figures are all required elements for Option 2, as they are for Option 1. The publication-ready format consists of three main chapters:

- G** Chapter 1: Introduction and Literature Review
- G** Chapter 2: Publication-formatted manuscript
- G** Chapter 3: Appendices for additional/supplementary data

Chapter 1: Introduction and Review of Literature

G The **Introduction and Review of Literature** should provide an exhaustive review of the current body of literature supporting your thesis topic. If the student prepared their proposal well and did not deviate significantly from the original plan, then the proposal Lit Review should be a good starting point and simply require some updating and reshaping to reflect the student's increased depth of knowledge of the topic. This chapter should be able to stand on its own and demonstrate that the student is proficient in their thesis topic and well-versed in the literature relating to it. **Introductions are expected to be reasonably exhaustive of the current literature but concise; a limit of eight to ten pages (double spaced) is suggested.** There should be at least 30 publications cited, including the most highly cited and key papers in the field. The Introduction should end with a complete list of references cited, using the format provided in Option 1.

Chapter 2: A publication-formatted manuscript

G The manuscript which comprises Chapter 2 should be formatted for the journal that the thesis committee chooses to submit to, after discussion with the student and careful attention to the quality of the results. Therefore, the format is dictated by the journal selected; information that is available on the journal's website. The journal selected should be clearly indicated below the title of the manuscript, as such: "This chapter is prepared for submission to XXXXX Journal". Due to time limitations within the M.S. degree program, **it is not required that the thesis be in review or published prior to thesis defense.** This option is provided simply to facilitate the submission of a manuscript as soon as possible after the student successfully defends the thesis.

As Chapter 2 is a formatted manuscript, it will, in most cases, have multiple authors, with the student as first author. Again, the student should be guided by discussion with the committee regarding who should be included as co-authors on the manuscript. However, it remains the right and responsibility of the first author to make this final decision regarding co-authors.

In general, journals will require a format similar to that outlined and described in Option 1: Introduction, Methods, Results, Discussion, Literature Cited, and Acknowledgements. However, journal writing is, as was stated previously, very succinct. It is highly likely that some of the work accomplished by the student as part of the thesis will not go into the final manuscript, and can be presented in Chapter 3 (see below). The student must work closely with the thesis committee to identify the key story line for the manuscript, editing out elements that do not directly contribute to the story. It is not necessary that the manuscript be submitted for review prior to the student's defense and graduation; what is necessary is that Chapter 2 is complete and correctly formatted and written to the best of the student's ability at the time of the defense. The student and her/his co-authors must be prepared to continue the revising and editing process after the student graduates.

In addition, many journals are now requiring **Supplemental Information** as part of the manuscript submission, as most journals have digital formats that are not page-limited. Supplemental Information most often refers to the raw data files on which statistical analyses are based, but may also be additional data sets that are relevant and potentially useful to readers but are tangential to the main body of the paper. If the student has such data sets and there is a plan to include them in the submission, then these data sets should be cleanly formatted and included in Chapter 2, after the Literature Cited list. Format for these files should follow journal instructions. These files must also be appropriately cited in the body of the text (i.e., "*Zooxanthellae counts were undertaken, but were not significantly different between treatments (please refer to Supplemental File S2.)*").

Chapter 3: Additional Information and Appendices


G In preparing a manuscript, it will become apparent that some results completed in the course of the thesis may not directly contribute to the pared-down manuscript version of the thesis. Pilot studies, for example, or an experiment which may have been necessary initially but ultimately does not contribute to the main story, may be suitable to present in Option 1, but must be eliminated from Option 2, Chapter 2. In these cases, such data sets, and the methods employed to obtain them, may be summarized briefly and placed in an **Appendix** in Chapter 3. This ensures that the student gets full credit for all the work accomplished.

Ethics & Standards

G *Ethics as a foundation.* UOG research is guided by the Research Council, which is responsible for providing advisory services for research-related concerns, including compliance with federal regulations. Misconduct in research refers to fabrication, falsification, plagiarism, mistreatment of research subjects, and other practices "that deviate from those that are commonly accepted within the academic and scientific community for proposing, conducting, exhibiting, or reporting research" (UOG Rules, Regulations and Procedures Manual, 2015).

Students are expected to produce a thesis which is their own original work, thus, a thesis proposal must be authentic and original, with the student as the principal author. However, it is understood that the student's committee comprises a team of advisors and collaborators that may assist the student in various aspects of their work. Other students may also assist in data collection, as field work requires a buddy system for safety purposes. Anyone who assists in any aspect of the work (project conception, data collection, data analysis, logistical support) must be credited and acknowledged. Additional acknowledgements may include other experts in the field who have assisted or advised the project, or who have developed an original protocol or method which is used in the study.

Ethical treatment of humans and animals is guided by UOG's Institutional Review Board (IRB) for human subjects, and by UOG's Institutional Animal Care and Use Committee (IACUC) for vertebrate animal subjects. Research making use of subjects that fall within either category requires the appropriate permit, which must be obtained prior to beginning research. Consult the UOG RRPM for guidance.

 ***Intellectual Property.*** The University of Guam encourages and supports the development of intellectual property. Intellectual Property is defined as any original idea or data subject to competing claims and legal protection. It includes patents, copyrights, trademarks, trade secrets and plant protection certificates. All members of the University including faculty, research associates, staff, students, graduate assistants and research assistants in any combination of study, research and teaching shall be subject to the provisions of this policy.

A graduate student of the University of Guam owns the copyright of his or her thesis or special project. However, as a condition of being awarded the degree, the student grants the University the non-exclusive right to retain, copy, use and distribute the thesis or special project, together with the right to require its publication for archival use.

A graduate student may delay or restrict release of his or her thesis or special project or a portion thereof for up to two years in cases where part or all of the thesis or special project is being published elsewhere or the work is subject to patent disclosure requirements.

If copyrighted material is used in a thesis or special project, the permission of the original copyright holder must be obtained since deposit in the University library is a form of publication for these purposes. A copy of the permission will be retained at R.F.K. Library.

Appendix 1: Sample Authorization Memo

MEMORANDUM

TO: Robert F. Kennedy Library

FROM: Jose Santos

SUBJECT: THESIS

Transmitted herewith is an original copy of the above subject from:

Student's Name: Jose Santos

Title of Thesis: A THESIS: SAMPLING FORMS USED IN CREATING A MODEL FOR OTHER THESIS PROJECTS AT THE UNIVERSITY OF GUAM

Number of Pages: 89 (including abstract and approval pages)

I hereby grant permission to the University of Guam to furnish upon request copies in whole of the Thesis described above, in written or electronic format, as determined by the library.

I am aware that a graduate student of the University of Guam owns the copyright of his or her thesis or special project. However, as a condition of being awarded the degree, I grant the University the non-exclusive right to retain, copy, use and distribute the thesis or special project, together with the right to require its publication for archival use.

I am further aware that a graduate student may delay or restrict release of his or her thesis or special project or a portion thereof for up to two years in cases where part or all of the thesis or special project is being published elsewhere or the work is subject to patent disclosure requirements.

SIGNATURE

DATE

Appendix 2: Thesis Cover Pages

Thesis Title

BY

Author Name

**A thesis submitted in partial fulfillment of the
requirements for the degree of**

MASTER OF SCIENCE

IN

BIOLOGY

UNIVERSITY OF GUAM

Date

AN ABSTRACT OF THE THESIS of (student's name) for the Master of Science in Biology presented, (date)

Title: (provide the title of the thesis)

**Approved: _____
(Name of Advisor), Chair, Thesis Committee**

(Body of Abstract)

TO THE OFFICE OF GRADUATE STUDIES

**The members of the committee approve the thesis of (student's name)
presented on (date of defense).**

(Chair name), Chair

(Faculty name), Member

(Faculty name), Member

ACCEPTED:

Troy McVey, Ed.D.
Director of Graduate Studies

Date