EASTERN MICHIGAN UNIVERSITY
DIVISION OF ACADEMIC AFFAIRS

REQUEST FOR INCLUSION OF A COURSE IN THE GENERAL EDUCATION PROGRAM: EDUCATION FOR PARTICIPATION IN THE GLOBAL COMMUNITY

DEPARTMENT/SCHOOL: BIOLOGY COLLEGE: ARTS AND SCIENCES

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1. Subject Code, Number, and Title: BIOL 311 Laboratory in Ecology
2. Credit Hours 2
3. Course Description

A laboratory and field course with two main objectives: (1) to introduce students to the methods and concepts involved in the study of the distribution and abundance of organisms, and (2) to familiarize students with the structure and function of aquatic and terrestrial communities.

4. This course is (check one):

■ an existing course with no revisions (need not go through the input system)

☐ an existing course with revisions (attach this form to Request for Course Revision form)

☐ a new course (attach this form to Request for New Course form)

5. Check the General Education requirement this course is intended to meet. If the course is to be proposed for more than one requirement, submit a separate form for each one.

☐ **Effective Communication**

☐ **Quantitative Reasoning (*QR designation*)**

■ **Writing Intensive (*WI designation*)**

☐ **Perspectives on a Diverse World**

- ☐ Global Awareness
- ☐ U.S. Diversity

☐ **Knowledge of the Disciplines**

- ☐ Arts
- ☐ Humanities
- ☐ Science
- ☐ Social Science

☐ **Learning Beyond the Classroom (*LBC designation*)**

- ☐ Self and Well Being
- ☐ Community Service, Citizenship, and Leadership
- ☐ Cultural and Academic Activities and Events
- ☐ Career and Professional Development
- ☐ International and Multicultural Experience
- ☐ Undergraduate Research

6. Rationale. Provide a concise, clear, jargon-free explanation of why this is a General Education course and how it fits into this specific area of the program. (The rationale should explain to students why they are taking the course. It should address both why it is part of the General Education program and why it fits into the particular category.) This rationale should appear on the general course syllabus provided here and should be included in specific course syllabi given to students. Note: *The Writing-Intensive courses are designed to provide students with the opportunity to continue to develop their writing through engagement with disciplinary strategies and conventions. Those proposing a WI course should explain in the rationale how and why the course is a writing-intensive course.*

BIOL 311 is designed to enable students to apply the scientific method to answering ecological questions and to learn how to present their findings in papers that strictly adhere to the requirements of the premier journal, *Ecology*. Of the final grade in BIOL 311, 83 percent is based on the writing assignments. Students are provided with the tools to enable them to communicate successfully their scientific findings as scientists. Written and oral feedback on smaller, staged writing assignments, as well as opportunities for revision, provide students with the skills to improve their writing and excel at writing complete scientific papers. The capstone experience in the course involves a student-designed research project, for which each student writes a full-length scientific paper and gives an oral presentation. Students who successfully complete BIOL 311 have the ability to read critically and evaluate peer-reviewed journal articles and present their own research in the same format. As such, BIOL 311 meets the requirements of a Writing Intensive Course in the Major of the General Education program.

Justification for allowing a 2-credit class to serve as a Writing Intensive Course:
Because this course is primarily a writing course, there is clearly much more than the required emphasis on writing than is suggested in the Writing Intensive guidelines. In the typical 3-credit writing intensive course, there is a requirement for 30-60% of the points to come from writing, which translates into a requirement for 45-90% for a 2-credit class. In BIOL 311, 83% of the points come from writing assignments. In addition, it should be noted that this course meets for 4 hours each week, and demands extra time outside of class to carry out the capstone research project.

7. Clearly and concisely explain how this course meets each of the General Education outcomes for the requirement checked in number five (all outcomes should be addressed). To do this, (a) list the General Education outcomes for the requirement and explain how the course meets each outcome; and (b) explain, in general terms, the method(s) of evaluation to be used in the course and how these methods assess the degree to which students have met the General Education outcomes for this requirement.

Outcome 1: Develop and employ successful, flexible writing and reading strategies that support sustained inquiry in a discipline

The major goal of this course is to teach students how to carry out scientific research. This process includes: (1) reading the primary literature for crucial background information, (2) formulating a hypothesis, (3) designing the proper methodology, (4) carrying out the research, (5) interpreting the results, and finally, (6) communicating those results. Because students have limited experience with this process when they start the course, the course is designed to guide students through each of these steps in a progressive fashion. In the first half of the course, students carry out field exercises as a class on a series of ecological questions in a variety of terrestrial and aquatic habitats (see syllabus for details). The students have many small writing assignments relating to these field exercises, and these writing assignments involve reading primary literature. The culmination of these class field exercises and introductory writing assignments is an independent research project designed by the students that makes up the second half of the course (see Outcome 3). Two important components of this assignment are reading/evaluating scientific journal articles and writing a complete scientific paper in journal format. Students learn to develop flexible reading and writing strategies for the field of ecology by having multiple writing assignments on different ecological topics (each of which requires an improvement in writing and reading skills), by having many different types of writing assignments, but most importantly, by applying the knowledge gained about writing in one assignment to the next assignment on a different topic.

Evaluation:
Because a major part of doing research involves communicating the results of that research, writing assignments make up 83% of the grade in this class. The writing assignments in the first half of the class are designed to be smaller portions of the larger assignments that come later (see syllabus for details). To aid the students in developing their biological writing skills, rough drafts are required at critical points throughout the course. For example, students write a rough draft of the Introduction and Methods sections of a lab report and a rough draft of the Results and Discussion sections of a lab report (more detail is provided in Outcome 2). Students are also asked to write an

abstract on one of the field exercises. Students will have demonstrated that they have flexible writing and reading strategies if they can apply the skills learned in earlier assignments on future assignments and their finished product shows improvement.

Outcome 2: Use writing strategies that achieve the purposes(s) for writing and address the expectations of audience(s) within a disciplinary context

Learning to write for a scientific audience is specifically addressed when students revise their rough drafts of the different portions of the lab report and turn in a final version. In order to help students learn how to write for a scientific audience, they receive a combination of written feedback on rough drafts and individual conferences with their professor. This constructive criticism about their writing provides them with the best learning experiences and the best results in terms of improving their biological writing. Feedback focuses on how to address the proper audience by providing comments on whether students are writing at the appropriate level for a scientific audience. Feedback focuses on the purpose of scientific writing by providing specific comments on the particular purpose of each section of the papers. After receiving feedback, students are asked to revise these assignments, and turn in a complete lab report. Similarly, after receiving feedback on their abstract, students turn in a revised, final version.

Evaluation:
Students are provided with an 8-page handout entitled "Guidelines for Writing a Scientific Paper" (attached), which provides concrete examples on correct and incorrect ways to write scientifically. This handout also specifically addresses how students should write for the correct purpose in each section of their papers. Students are also provided with detailed rubrics specific to each assignment. These rubrics outline the specific expectations for each section of each report. On these rubrics, there are items listed in the Introduction and General Consideration sections that specifically address writing for a scientific audience (see attached rubrics).

Outcome 3: Formulate research questions and employ strategies for researching and responding to those questions

The most important part of this course is a group research project that is designed by the students. The assignments related to this project make up 51% of the grade in the course (see syllabus for details). In this project, students formulate a research question and specific hypotheses, search the primary literature for other studies on the topic, design the methodology to be used, carry out the experiments and observations, collect data, analyze the data using statistics, and interpret their results in the context of their original hypotheses. This experience provides the students with a hands-on experience of carrying out ecological research. These projects often occur outside in the cold temperatures of November, yet the students remain enthusiastic because they are investigating questions they have designed themselves. According to student evaluations, the satisfaction and pride gained by carrying out their own project is well-worth the many frustrations along the way (both for them and for the professor!). The culmination of this project includes a group presentation and an individual paper (see outcomes 4 and 5).

Evaluation:

There are two major writing assignments involved with this project: a proposal and a final paper. The proposal is the most relevant writing assignment to specifically address this outcome of students' formulating their own research strategies. The project proposal is comprised of five sections: Title, Introduction, Methods, Data Analysis, and Literature Cited (see attached rubric for proposal grading). As can be seen on the attached rubric, an emphasis is placed on formulating clear research questions and presenting the detailed methodology to address those questions. Students again have the chance to revise these sections prior to submitting their final paper (see Outcome 4). The outcome of employing strategies for researching and responding to research questions occurs each week in the second half of the course during meetings about the research projects. In these meetings, students, with their professor, evaluate how the research is progressing and troubleshoot any problems that arise. These meetings provide the students with invaluable feedback and experience in learning how to deal with the complications that almost always occur in scientific research projects. The assessment of final papers is described in detail under outcomes 4 and 5.

Outcome 4: Use discipline-specific genres to communicate information & Outcome 5: Understand conventions for communicating, disseminating and interpreting information within a discipline.

All writing assignments in the course follow the writing format from the most important journal in the field of ecology (*Ecology*). This scientific paper format is the standard genre in written communication in biology. The students learn the conventions of scientific writing by reading journal articles, from the detailed handout on "Guidelines for Writing a Scientific Paper" (attached), and from feedback on rough drafts. The independent research project provides students with an excellent opportunity to learn how to interpret research findings. Students are expected to understand the statistical tests used to test their hypotheses, and to be able to communicate the results of these tests and the resulting conclusions in their final papers (see Results and Discussion sections of rubric for project paper). For example, as outlined in the rubrics, students need to be able to present their results in the correct figure or table format, as well as text format, present the results from statistical tests, evaluate their results in light of their original hypotheses, compare their results to other studies, offer explanations for their results, and draw conclusions. Because we follow the format from a specific scientific journal, there is an emphasis on how research is published. Students are provided with examples of papers in the form for submission for publication in *Ecology* and in the final published form. Copies of actual reviews of manuscripts submitted to *Ecology* are also provided, so that students can understand more about the processes involved in the dissemination of scientific results.

Evaluation:
The capstone writing assignment based on the independent research project is a complete scientific paper, which follows the format of the journal *Ecology*, and includes seven sections: Abstract, Title, Introduction, Methods, Results, Discussion, and Literature Cited (see attached rubric for project paper grading). The feedback on all earlier assignments in the course provides students with the necessary suggestions to improve their writing skills in all of these areas (feedback on rough and final drafts of abstract; feedback on rough and final drafts of lab report; feedback on proposal). The details of all of these assignments, as well as the schedule, can be found in the attached syllabus.

8. Attach a syllabus (1-inch margins and 10-12 pt. font). The syllabus must include the rationale from #6 above and clearly reflect the outcomes and methods of evaluation detailed in #7 above.

Please submit all materials in electronic form.

Action of the Department/College

1. Department

. Vote of department faculty: For ____**13**____ Against _____**0**_____ Abstentions _____**0**_____

T. Greco – a signed copy was sent to the Dean's Office (attn Linda Schott, Assoc Dean) 11/27/06
Department Head Date

2. College

_____ _____
College Dean Date

Action of General Education Advisory Committee

Vote of General Education Committee: For _____ Against _____ Abstentions _____

_____ _____
Chairperson, General Education Advisory Committee
Date

Approval

_____ _____
Associate Vice-President for Undergraduate Studies and Curriculum Date

ECOLOGY LABORATORY SYLLABUS

BIOLOGY 311 **FALL 2006**

Dr. Cathy Bach
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Office hours: Tu 10-12; W 9-11
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e-mail: cbach@emich.edu
Lab: Monday 1:00-4:50; 325 Mark Jefferson
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LABORATORY/FIELD SCHEDULE

Sept 11	Pollination Ecology / Butterfly Mark-Recapture
Sept 18	Forest Communities
Sept 25	Projects / Statistics
Oct 2	Biological Control of Purple Loosestrife
Oct 9	Species Diversity of Stream Invertebrates
Oct 16	Projects (set-up)
Oct 23	Projects
Oct 30	Plant Competition I / Projects
Nov 6	Projects
Nov 13	Projects
Nov 20	Projects
Nov 27	Projects (data analyses)
Dec 4	Plant Competition II / Projects
Dec 11	Project Presentations
Dec 18	Final Discussion (1-2:30)

OBJECTIVES

Most important:

- To expose you to the process of doing science, specifically ecological research
- To improve your skills in communicating results of scientific research

Additional objectives:

- To reinforce concepts learned in BIOL 310 on ecological theory and principles
- To expose you to a variety of methods used in field ecological research
- To give you experience in a variety of different types of biological communities

THIS IS A WRITING INTENSIVE COURSE

BIOL 311 is designed to enable students to apply the scientific method to answering ecological questions and to learn how to present their findings in papers that strictly adhere to the requirements of the premier journal, *Ecology*. Of the final grade in BIOL 311, 83 percent is based on the writing assignments. Students are provided with the tools to enable them to successfully communicate their scientific findings as scientists. Written and oral feedback on smaller, staged writing assignments, as well as opportunities for revision, provide students with the skills to improve their writing and excel at writing complete scientific papers. The capstone experience in the course involves a student-designed research project, for which the students write a full-length scientific paper and give an oral presentation. Students who successfully complete BIOL 311 have the ability to read critically and evaluate peer-reviewed journal articles and present their own research in the same format. As such, BIOL 311 meets the requirements of a Writing Intensive Course in the Major of the General Education program.

COURSE GRADE

ABSTRACT* (15 pts.)

- Rough draft – Oct 30
- Final draft – Nov 13

LAB REPORT** (total of 115 pts.)

- Rough draft of Introduction and Methods – Sept 25 (20 pts.)
- Rough draft of Results and Discussion – Oct 2 (20 pts.)
- Final draft – Oct 23 (75 pts.)

INDEPENDENT PROJECT*** ASSIGNMENTS (total of 165 pts.)

- Proposal (group) - Oct 9 (40 pts.)
- Presentation (group) – Dec 11 (25 pts.)
- Paper (individual) – Dec 4 (100 pts.)

DISCUSSION/PARTICIPATION (30 pts.)

TOTAL: 325 pts.

*__ABSTRACT:__ You will write an abstract on your choice of the following field exercises:

- Forest communities
- Biological control of purple loosestrife
- Species diversity of stream invertebrates

****LAB REPORT:** You will write a scientific paper on our first field exercise, Pollination Ecology, following the format outlined in "Guidelines for Writing a Scientific Paper" (e-reserves).

*****INDEPENDENT PROJECT:** You will conduct an original research project in a group of 3-4 people. You will write a project proposal (as a group), conduct the project, give an oral presentation of the project to the class (as a group), and write an **individual** research paper on the project.

ATTENDANCE: Attendance in lab is required; each unexcused absence from class will result in a 10 point/day penalty.

LATE POLICY FOR PAPERS: A 5% penalty per day will be assessed to all late papers. No assignments will be accepted more than one week late.

FINAL GRADES: Final grades will be based on a floating-bottom scale:

90-92 A-	93-96 A	97-99 A (I wish it could be A+!)
80-82 B-	83-86 B	87-89 B+
70-72 C-	73-76 C	77-79 C+
60-62 D-	63-66 D	67-69 D+

ACADEMIC DISHONESTY POLICY: Any student who engages in cheating, falsification, or plagiarism will be given an E for the course.

GRADING SHEET FOR PROJECT PROPOSALS

General Instructions: The body of the proposal (Introduction, Methods, and Data Analysis) should be approximately 2-3 pages long, type-written and double spaced. FIVE references (from scientific journals) that you have used to formulate your project must be cited in the Introduction and listed in the Literature Cited section. [Note that you will need 10 references for your final paper].

_____**Title** (2 pts):
-Does the title adequately describe the nature of the study?
-Is the title concise?

_____**Introduction** (11 pts):
-Is the background material (literature) adequate?
-Is the background material relevant to the objective?
-Is the information presented at the appropriate level for a scientific audience?
-Are the objective (purpose) and hypotheses clearly stated?
-Is the significance or importance of the project evident?
-Is the ecological context of the project evident?

_____**Methods** (11 pts):
-What is the experimental design?
-Do you have adequate controls?
-Where will the project be conducted? Do you have (or need) permission to use this site?
-What observations and how often are measurements to be made?
-How do the design and measurements relate to project objective?
-Is there sufficient detail such that someone else could perform your project?

_____**Data Analysis** (4 pts):
-How do you intend to present the data that you collect?
-What statistical tests do you plan to use to test your hypothesis?
-Given your methods, what are the possible project outcomes?
-How will these outcomes contradict or support your hypothesis?

_____**Equipment List** (2 pts):
-Include a complete list of all items that you will need.

_____**Literature Cited** (5 pts):
-Include a list of at least 5 references from scientific journals that are relevant to your project (see handout for proper format)

_____**General Considerations** (5 pts):
-Are all sections and the paper appropriately organized?
-Are spelling or grammatical problems common?
-Is the writing style clear and concise?
-Is the paper addressed to the proper audience?

GRADING RUBRIC FOR POLLINATION LAB REPORT

_____**Title (2 pts.)**
-Does the title adequately describe the nature of the study?
-Is the title concise?

_____ **Introduction (13 pts.)**
-Is the background information adequate and relevant to the objective?
-Is the information presented at the appropriate level for a scientific audience?
-Is the ecological context of the paper evident?
-Is the general objective/purpose of the study clearly stated?
-Are the hypotheses clearly stated?

_____ **Materials and Methods (10 pts.)**
-Are procedures described in sufficient detail?

_____ **Results (20 pts.)**
-Are the results in the tables/figures adequately described in text?
-Is there a statistical analysis to test each hypothesis?
-Is the data presentation easily interpreted?
-Are the presented results meaningful to the paper and relevant to the study's objective?
-Tables and Figures
    -Are tables/figures numbered and referenced in the text?
    -Do the tables and figures have appropriate legends?
    -Are the axes or columns labeled?
    -Are the data presented only once (*i.e.*, either tables or figures)?

_____ **Discussion (20 pts.)**
-Are the results integrated with relevant literature to provide an adequate interpretation of the data?
-Is the discussion/interpretation of the results thorough?
-Is the discussion in the context of the purpose of the study?
-Are the conclusions justified?

_____ **Literature Cited (4 pts.)**
-Are all references in the text included in the Literature Cited section?
-Does the Literature Cited section include only cited references?
-Are all citations in the proper format?
-Are there at least 2 citations from scientific journals?

_____ **General Considerations (6 pts.)**
-Is the proper paper format followed, *i.e.*, Abstract, Introduction, etc.?
-Are all sections and the paper appropriately organized?
-Are spelling or grammatical problems common?
-Is the writing style clear and concise?
-Is the paper addressed to the proper audience?

_____ **Bonus Points**
-Is the production of the paper unusually good, *e.g.*, tables and figures?
-Are more than a minimal number of references used?

-Is the creativity and/or originality of the paper exceptional?

GRADING RUBRIC FOR PROJECT PAPER

_____ **Title (3 pts.)**
-Does the title adequately describe the nature of the study?
-Is the title concise?

_____ **Abstract (10 pts.)**
-Is the abstract a shortened version of the report?
-Is an objective stated?
-Is a statement of methodology included?
-Are the results summarized?
-Is there a conclusion sentence?
-Is the abstract too long or too short?

_____ **Introduction (16 pts.)**
-Is the background information adequate and relevant to the objective?
-Is the information presented at the appropriate level for a scientific audience?
-Is the ecological context of the paper evident?
-Is the general objective/purpose of the study clearly stated?
-Are the hypotheses clearly stated?

_____ **Materials and Methods (10 pts.)**
-Are procedures described in sufficient detail?

_____ **Results (23 pts.)**
-Are the results in the tables/figures adequately described in text?
-Is there a statistical analysis to test each hypothesis?
-Is the data presentation easily interpreted?
-Are the presented results meaningful to the paper and relevant to the study's objective?
-Tables and Figures
    -Are tables/figures numbered and referenced in the text?
    -Do the tables and figures have appropriate legends?
    -Are the axes or columns labeled?
    -Are the data presented only once (*i.e.,* either tables or figures)?

_____ **Discussion (23 pts.)**
-Are the results integrated with relevant literature to provide an adequate interpretation of the data?
-Is the discussion/interpretation of the results thorough?
-Is the discussion in the context of the purpose of the study?
-Are the conclusions justified?

_____ **Literature Cited (7 pts.)**
-Are all references in the text included in the Literature Cited section?
-Does the Literature Cited section include only cited references?
-Are all citations in the proper format?
-Are there at least 10 citations from scientific journals?

_____ **General Considerations (8 pts.)**
-Is the proper paper format followed, *i.e.*, Abstract, Introduction, etc.?
-Are all sections and the paper appropriately organized?
-Are spelling or grammatical problems common?
-Is the writing style clear and concise?
-Is the paper addressed to the proper audience?

_____ **Bonus Points**
-Is the production of the paper unusually good, *e.g.*, tables and figures?
-Are more than a minimal number of references used?
-Is the creativity and/or originality of the paper exceptional?

GUIDELINES FOR WRITING A SCIENTIFIC PAPER

I. GENERAL COMMENTS:

Precise scientific thought should be expressed in precise writing. Unfortunately, a glance at almost any scientific journal will reveal that the ideal is not attained often. Indeed, many of the accusations by the non-scientific community of "obscurity" and "elitism" within the scientific community probably originate in the sad fact that many scientists are not capable of expressing their hypotheses and conclusions clearly and simply. Fortunately, much of the confusion can be dissipated if two guidelines are followed: 1) consider writing as part of the methodology of science, and 2) substitute simplicity of expression for flamboyance. The first implies that ***as much effort and consideration should be given to the organization of the paper as was given to the execution of the study.*** The second implies that the writer should employ short, crisp sentences uncluttered by multiple clauses and prepositional phrases.

Before you accept the following suggestions as dogma, you should be aware that different journals use different styles. The practices outlined here are simply the most common.

The first half of this handout deals with paper organization. The second half discusses common mechanical problems found in scientific writing and offers suggestions for avoiding them.

II. FORMAT:

The scientific paper has the following elements: Title, Abstract, Introduction, Methods, Results, Discussion, and Literature Cited. The actual words "Introduction," "Methods," etc. are used to head the sections of your paper. These words are centered and followed by the text for that section. You do not have to begin a new page for each section. Illustrative tables and figures are placed at the end of the text and before the Literature Cited, which is always last. Tables and graphs must be fully labeled with a descriptive explanation of what is being shown and referred to specifically by number (e.g., Table 1, Fig. 1) in the text. Text should be in the 'first person active' voice. For example, "I (we) removed 50% of surrounding vegetation" not "50% was removed" (supernaturally, evidently). However, there are occasions where passive voicing is appropriate, e.g., "The eggs were incubated at 37^{o}C for 7 days" rather than "I(we) incubated...".

A. TITLE: The title should contain three elements:

1) the name of the organism studied;
2) the particular aspect or system studied;
3) the variable(s) manipulated.

Don't be afraid to be grammatically creative here. These variations on a theme are all appropriate as titles:

THE EFFECT OF TEMPERATURE ON CORN GERMINATION

DOES TEMPERATURE AFFECT CORN GERMINATION?

TEMPERATURE AND CORN GERMINATION: IMPLICATIONS FOR AGRICULTURE

B. ABSTRACT: The abstract (or summary) is a one or two paragraph condensation of the entire work described completely in the article. The abstract should be a self-contained unit capable of being understood without the benefit of the text. It should contain these four elements: 1) the purpose of the study; 2) a brief statement of what was done (Methods); 3) a statement of what was found (Results); 4) a brief statement of what was concluded. The major portion of your abstract should be presentation of results. A well-written abstract is crucial to your paper. For many published papers, this may be all anyone ever reads; if it is poorly written, this is ensured even more.

Tips for writing abstracts:

Purpose: Be sure to clearly state the objective or purpose of the study. Avoid very general beginnings. Remember that other ecologists will be reading your abstract.

Methods: You don't need to provide specific details of sampling methods. Information such as size of quadrats, how many quadrats, how the quadrats were located, etc. is not necessary.

Results: Be as specific as possible in describing results, but try to avoid reporting actual data values. e.g.,: "Light levels were three times higher in the hardwood forest than in the cedar swamp." is much better than stating the actual light levels in the 2 habitats. Be sure to also mention whether your comparisons were significant or not. The results section of an abstract is the most important and should be the longest. After reading an abstract, the reader should be able to understand the basic findings of a study.

Conclusions: The last part of your abstract should be a short, general conclusion. i.e., What can you conclude about your hypothesis based on the results from your study? Don't mention difficulties or problems with your study. You should discuss the limitations of a study in the discussion section of a paper. Interpretations of your data also belong in the discussion section of a paper, not in an abstract.

General comments: Use past tense. Write concisely. Avoid sentences that are uninformative. e.g., "Our results were not very conclusive, but a few trends were apparent" OR "Our results showed that a number of factors were important", etc.

C. INTRODUCTION: The function of an introduction is to present the question being asked and place it in the context of what is already known about the topic. Background information that suggests why the topic is of interest and related findings by other scientists are mentioned here. In other words, this section should contain three elements:

1) a description of the nature of the problem and sufficient information to establish our current understanding of this problem. You should put your study into a general ecological context by first providing background information with appropriate literature (references to journal articles). What major findings have been published on the question you are attempting to answer? How does your study fit in? Why is this question interesting?

2) a statement of the purpose, scope, and general method of investigation in your study. The purpose is the question the study is asking. Identify independent and dependent variables.

Examples:

correct: "The purpose of this study was to determine the effect of ambient temperature on the germination rates of corn seedlings."

incorrect: "In this study I observe (or measure) germination rates at different temperatures." (Observations and measurements are the methods, not the purpose, of the investigation.)

3) hypothesis/hypotheses and predictions. An hypothesis is a tentative answer to the question presented in the statement of purpose. It should seem reasonable based on the background information contained in the opening paragraphs. "Because ambient affects soil temperature (Smith 1983), germination rates should be directly proportional to air temperature."

After writing your Introduction, ask yourself:

1) Is it informative, concise and complete?
2) Is the purpose of the study explicitly stated?
3) Are your hypotheses and predictions stated in such a way that they are testable (i.e. quantifiable)? What evidence would support your hypothesis? What evidence would cause you to reject it?

D. METHODS: The function of this section is to explain clearly all of the experimental procedures. Briefly, how are they relevant to your question, i.e. to determine if food was limiting, I sampled..... You may want to add a section on the biology of the organisms if this is important for understanding your results. For field studies, be sure to describe your research site.

If there is more than one part to the experiment, describe your methods and present your results in the same order in each section. This may not be the same order in which the experiments were performed--it is up to you to decide what order of presentation will make the most sense to your reader. Always use past tense to describe methods.

It is also helpful to your reader to explain why each procedure was done, i.e., what variable were you measuring and why?

Example:

not helpful: "First I removed the frog muscle and then I poured Ringers solution on it. Next, I attached it to the kymograph."

helpful: "I removed the frog muscle and poured Ringers solution on it to prevent it from drying out. I then attached the muscle to the kymograph in order to determine the minimum voltage required for contraction."

Mathematical equations and statistical tests are considered mathematical methods and should be described at the end of the Methods section. Mention which statistical tests you used to analyze your data.

After writing your Methods, ask yourself:

1) Can the work be repeated on the basis of the methods given?
2) Are unwieldy or unfamiliar terms defined?
3) Are the methods and organisms used shown to be appropriate for testing the hypotheses?

E. RESULTS: The function of this section is to summarize general trends in the data *without comment, bias, or interpretation.* What was discovered in this investigation? Describe your results in words, referring to tables and figures to support your statements. It is important to remember that tables and figures do not substitute for a written summary of the findings. In short, the text should be able to be understood by someone who has not seen your figures and tables.

Example:

Incorrect: "The results are given in Figure 1."

Correct: "Temperature was directly proportional to metabolic rate (Fig. 1)."

Statistical tests applied to your data are reported in this section although conclusions about your original hypotheses are saved for the discussion section. Statements about results should always be backed up with statistical tests. For example, "Trees were significantly taller in the wet lowland area than in the dry upland area ($t=3.8$, $df=20$, $P<0.05$)".

After writing your Results, ask yourself:

1) Are all results presented including those which do not support the hypotheses?
2) Do the results contained in the figures and tables support the statements made in the text?

F. DISCUSSION: The function of this section is to analyze the data and relate them to other studies. To "analyze" means to evaluate the meaning of your results in terms of the original question or hypothesis and point out their biological significance. Attempt to integrate your results with the relevant literature to provide an adequate interpretation of the data.

Try to offer explanations of unexpected results and those results that do not conform to your hypothesis and predictions. Compare your results and interpretations with those of other professional investigators. Do your results support or contradict results from other studies? Why or why not? Obviously, this section should include pertinent information from reference books and periodical literature for purposes of comparison. However, remember that your job is to analyze your own results. You should not dedicate whole paragraphs to describing other researcher's studies; their findings should be integrated with your own in order to formulate causal explanations of your results.

In describing what may be concluded from your results, be direct and succinct. These are the ideas that you want your reader to remember. Tell us your major findings first, then add your lesser findings. The discussion section can also mention briefly what problems arose and how they could be avoided in the future, but only after discussing your major results. The discussion section can also include mention of where your study leads us. Speculation is valuable for stimulating further thought but it should not be taken as a result. In its totality, the discussion section should integrate your data with the relevant literature to provide a detailed interpretation of the research data and research question(s).

After writing your Discussion, ask yourself:

1) Are the data clearly related to the hypothesis?
2) Are ALL the results, including those unexpected or inconsistent, interpreted both in the context of your purpose and in the context of previous findings?
3) If the discussion contains any speculation, is it justifiable and consistent with the findings of other studies?
4) Are major conclusions succinctly summarized at the end of the paper?

ONCE YOU ARE ABLE TO ANSWER "YES" TO ALL OF THE ABOVE QUESTIONS, REREAD YOUR PAPER AND EXTRACT ALL UNNECESSARY PHRASES AND SENTENCES--ANYTHING THAT SEEMS EXTRANEOUS OR PERIPHERAL TO YOUR HYPOTHESIS AND PREDICTIONS. EVERY STATEMENT YOU MAKE SHOULD RELATE BACK TO THE PURPOSE OF THE STUDY AS EXPRESSED IN THE INTRODUCTION.

G. FIGURES AND TABLES: Figures (graphs and diagrams) and tables are independent units of information. They must possess descriptive headings that will allow them to be understood by someone who has not yet read the paper. An important recommendation is to present the data visually whenever possible because relationships are much more readily visualized in a figure than as columns of numbers on a table. And remember that some data that cannot be graphed on coordinates can, nevertheless, be expressed in pictorial graphic form in a histogram. There are two types of illustrative material:

1) Figures

a. graphs

--use to give a quick visual illustration of significant trends in experimental data. The independent variable is plotted on the x axis and the dependent variable on the y axis. Only connect points on graphs that contain continuous variables.

b. maps and diagrams

--use to illustrate a complex experimental procedure or show the location of study sites if this information is important. Biological processes and models can also be presented this way.

2) Tables

--use only when there are so many treatments or variables that plotting them on a graph would result in a big mess (tables are boring).

Graphs, maps, and diagrams are labeled as "figures" (Fig. 1, Fig. 2, etc.) and the descriptive heading is placed BELOW the illustration. Tables are labeled as "tables" (Table 1, Table 2, etc.) and the descriptive heading is placed ABOVE the table.

H. LITERATURE CITED: This is the last section of a scientific paper. Every paper or book cited in the text of the paper must be listed here. References are listed **alphabetically** by author, as indicated in the following sample list. In the cases of more than two authors, you should use "et al." (Latin for "and others") in the text of your paper (Jones et al. 1983), but in the literature cited sections, all authors must be named. ***No reference is listed in the L.C. unless it was cited in the text somewhere.***

1. Citing references in the Literature Cited: (Note: The format for these references is the Harvard style of citation. The CBE style manual is a valuable source for helping you with citation format**.** Individual journals may prefer slight variations on this theme).

a) Journal:

Gannon, A. J., C. E. Bach, and G. K. Walker. 1994. Feeding patterns and attachment ability of *Altica subplicata* (Coleoptera: Chrysomelidae) on sand-dune willow. Great Lakes Entomologist 27:89-101.

Tilman, D. 1997. Community invasibility, recruitment limitation, and grassland biodiversity. Ecology 78:81-92.

b) Book:

Howe, H. F. and L. C. Westley. 1988. Ecological relationships of plants and animals. Oxford University Press, New York.

c) Article in a book:

Werner, P. A. 1979. Competition and coexistence of similar species. Pages 287-310 in Solbrig, O. T., S. Jain, G. B. Johnson, and P. Raven, eds. Topics in plant population biology. Columbia University Press, New York.

2. Format for Citing References in the Text (used almost universally):

You must cite another's research whenever you refer to his/her results, conclusions, or methods in your paper. You will probably have occasions to use citations in the Introduction and the Discussion sections only (with a few exceptions--as when using a particular methodology invented by someone else for a specific experiment). **References are made only to the author's name and date of publication (known as Harvard system).** There are 3 ways of doing this:

a) Both the name and date can go inside parentheses if the name is not actually part of your sentence: For example:

"Enzymes are inhibited by cyanide (Grubb 1977)."

"Because enzymes are inhibited by cyanide (Grubb 1977), I expect to find..."

Notice that the parenthetical citation is placed at the end of the sentence or clause containing the reference and the punctuation (period or commas) FOLLOWS the citation.

b) Another way to cite a study is to make the last name of the researcher the subject or object of the sentence or clause and follow it immediately with a parenthetical containing the date of the study. This strategy is especially effective if you wish to emphasize the name of the researcher, i.e., if his/her study is very important to yours:

"Grubb (1977) found that cyanide inhibits enzymes."

"Because Grubb (1977) found that cyanide inhibits enzymes..."

"These data support the conclusions of Grubb (1977)."

c) The only method of citation that is INCORRECT is separating the date of publication from the author's name:

Incorrect: "Grubb found that cyanide inhibits enzyme action (1977)."

d) Finally, if you wish to cite more than one study per reference, i.e., if more than one author has reached the same conclusion or worked on the same problem independently, you may list them together in the same parentheses and separate their names by commas:

"Cyanide has been found to inhibit enzyme action (Grubb 1977, Smith 1980, Taylor 1983)." Conventionally, these citations are listed in chronological order.

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A significant amount of the information above was borrowed from Ambrose H.W. and K. P. Ambrose. 1981. A Handbook of Biological Investigation. H. Hunter Textbooks, Winston-Salem, N. C.

III. REFERENCES ON SCIENTIFIC WRITING

Council of Biology Editor's Style Manual (CBE Manual). American Institute of Biological Sciences: Washington, D.C. The book to consult on how to prepare a paper for publication in a scientific journal.

Day, R. A. 1998. How to Write and Publish a Scientific Paper, 5th edition. ISI Press: Philadelphia, PA. 160pp.

Katz, M. J. 1985. Elements of the Scientific Paper: A Step-by-Step Guide for Students and Professionals. Yale University Press, New Haven, CT.

McMillan, V. E. 2001. Writing Papers in the Biological Sciences, 3rd edition. St. Martin's Press, NY.

Miller, C. and K. Swift. 1980. A Handbook of Nonsexist Writing. Barnes and Noble, NY.

Pechenik, J. A. 2001. A Short Guide to Writing about Biology, 4th edition. Little Brown and Company, Boston.

Strunk, W. and E. B. White. 2000. The Element of Style, 4th edition. MacMillan: N.Y. (An excellent book on how to write clearly and concisely)

The Chicago Manual of Style. 13th ed. Univ. of Chicago Press, Chicago.