Chapter 19

Effective Methods of Training Biology Laboratory Teaching Assistants: Grading Consistently

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Anne is a Senior Lecturer at the University of Toronto. She has been the lab and course coordinator for the 1100-student second year course BIO250Y, Introduction to Molecular Cell Biology, and the tutorial and course coordinator of the 650-student third year course JLM349S, Advanced Eukaryotic Molecular Biology, since their creation in 1991 and 1997, respectively. In addition to the labs in BIO250 and intensive tutorials in JLM, Anne has initiated major writing projects in BIO250Y and a major problem-based learning project in JLM349S. Training graduate student teaching assistants (24 + 17 TAs yearly) is a significant part of her role in both courses. Anne received the Faculty of Arts and Sciences Outstanding Teaching Award in 2001, and has been the recipient of several Dean's Excellence awards over the years.

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Contents

Introduction

This workshop was a continuation of a dialogue on training teaching assistants that began as an ABLE major workshop in Lincoln (Haag *et al.* 2000) and continued at Clemson (Dickey *et al.* 2001). This year, we moved away from a general discussion of training techniques to a specific one focused on training assistants to grade consistently. We compared marking papers with holistic and numeric rubrics. A rubric is a "scoring scale that clearly delineates criteria and corresponding values to evaluate students' performance" (Anderson and Speck 1998, p. 2)

Holistic marking schemes assume that the whole is greater or less than the sum of the parts and that each level of achievement (A, B, C, D) may be defined with explicit criteria. Numeric schemes break the paper down into its required components and assign mark values for these components; the sum of the parts equals the total mark.

We ran the session as one might run a training session for TAs. Participants were given four sample student papers to grade (see Appendices B, C, D, and E), two with a holistic rubric and two with a numeric rubric. The participants were divided into groups such that half the participants marked two of the papers with the numeric and two with the holistic, while the other half marked the reverse two papers with holistic and numeric rubrics. Thus, all four papers were marked by all and all participants had a chance to mark two papers with each type of rubric. At the end of the session, we compared results for the two styles of marking and collated comments on consistency and accuracy of both.

In this article, we provide sample grading guidelines for both holistic and numeric approaches. In addition, we provide sample project instructions for TAs and students, because the key to consistent

grading is clear instructions of what is expected. We also summarize the results of the grading done by workshop instructors, and have summarized comments on the strengths and weaknesses of both methods and touch on useful feedback comments to students. Lastly, we summarize comments supplied on the survey of TA grading practices completed by participants. We have included the instructions used during the workshop, which might serve as the basis for a TA training session on grading (Appendix A), as well as the four sample student papers used in this workshop, appropriate for a TA training session (Appendices B, C, D, E).

Background

One of the most difficult tasks for both teaching assistants and instructors is to arrive at a consensus for grading a set of papers in a manner that is fair and consistent both within sections taught by an individual teaching assistant and among sections taught by a diverse group of assistants. Several components of an assignment affect the grading consistency: (1) the clarity of the written and verbal instructions given the students, (2) the students' understanding of the grading criteria, (3) the TAs' understanding of the goals and objectives of the assignment, (4) the clarity of the grading guidelines for TAs, and (5) the rubric used by TAs for grading (which is returned to the student with the assignment).

This paper deals primarily with a discussion of *holistic* and *numeric rubrics*. The examples also demonstrate that this approach to grading may be adapted for introductory to advanced courses in biology. Rudi teaches a large introductory course, and her graduate student TAs are doing research in ecology and evolution. Anne teaches a large second-year introductory cell and molecular biology course with laboratories and a large advanced third year molecular biology course with tutorials; both courses have graduate student TAs in cell or molecular biology. Rudi has used the holistic rubric extensively for a number of years; Anne started with numeric rubrics, but now uses holistic.

Presentation of the Project: Summarizing a Primary Paper

The following assignment was given to students in an introductory biology laboratory and writing class focusing on scientific investigation. Students were given one week to find articles and write their papers. Following the writing assignment below, there are two different grading guidelines: (1) a holistic rubric and (2) a numeric rubric. *(Note: The course has ~300 students per quarter in ~14 lab sections. Each quarter, 6-10 different teaching assistants teach these sections, approximately half for the first time.)*

Student Assignment

This is the first of three writing assignments in Biological Sciences 100LW. A list of journals to choose from and a grading rubric follow. Your job is to locate a recent (last 3 months) primary research report in one of these journals and to write a summary of the article. The summary will be due in lab one week after it is assigned. (Hint: To find recent journal articles, you will need to search the current periodicals room on the second floor of the Science Library.)

After writing this assignment, you should be able to:

- Locate and read a recent journal article on a biological topic in the library.
- Identify the basic format of a primary research article as compared with a review article, news article, and so forth.
- Summarize the content of the primary research article you have chosen. In your summary you will be expected to identify the problem or question being studied, the hypothesis being tested, the methodology used, the results found and the conclusions drawn by the authors.

Your assignment is to write a 1-2 page (typed, double-spaced) summary of a journal article (from the attached list or an alternative one your lab instructor provides) reporting primary research on a biological topic. Take the time to review a number of articles to be sure to pick one that makes sense to you and that you are comfortable writing about.

Since much of the discussion in class is directed at hypothesis-based research, you may want to guide your article choice so that you will end up with a hypothesis-based study. One way to do this is to choose your search terms so that you look for articles with titles that include words like "effect," "cause," "correlation," "relationship," *etc.* Often such terms in the title of an article indicate something about the nature of the research.

Your paper must begin with a complete citation for the paper being reviewed and must be accompanied by a Xerox copy of the article reviewed. Pechenik (2001) explains what to include and shows an example (Ch. 6). Refer to Pechenik in writing your citation.

Refer to the article in the lab manual (Berkelhamer and Watkins 2001) by Jane Hopper entitled "Scientific Research Reports" (pp. 81-84) as well as to the general instructions provided for "Writing a Summary" (pp. 85-86) for information on what to include and what to avoid in your summary.

Your paper will be due in your lab section during the second week of classes. Peer editing is always helpful and you may wish to exchange papers for review with a classmate before you submit your paper for grading. However, there is no formal, graded, peer-editing component to this assignment.

Unless your lab instructor provides other instructions, all 'Summary I' papers must be based on a primary research article chosen from one of the journals below. The date of publication must be *within the past 3 months*. All of these journals may be found in the Current Periodicals Room on the Second Floor of the Science Library where they are arranged alphabetically. *(Note: A list of journals usually follows.)*

Grading Criteria for the Summary Paper: Holistic Rubric

A These papers include a complete but concise summary of an approved primary source. The summary should demonstrate a clear understanding of the original journal paper and its implications. The paper is clearly focused and coherently organized. Thoughts are expressed with superior clarity and precision.

B These papers include an accurate summary but are not as thorough or as effectively organized as an A paper. They may not be as concise as an A paper would be. They show some depth of thought. Organization is coherent and ideas are expressed with clarity.

C These papers include a summary but present only a superficial treatment of the selected primary source. The summary may not make clear all of the important points and may lack depth of thought. However, the reader is left with the impression that the writer understood the basics of the primary source. The writing demonstrates basic fluency, but the language may not effectively communicate the writer's ideas.

D These papers may contain a limited or inaccurate summary of the primary source. It may be extremely simplistic and problems in organization may be evident. The writing may lack fluency and may fail to communicate the writer's ideas.

F These papers may fail to summarize an approved primary source. The summary may be cursory and/or demonstrate an inability to grasp the content of the article. There are marked problems with organization and mechanics that make the language very difficult to follow.

Grading Criteria for the Summary Paper: Numeric Rubric Total = ____/20

(A) outstanding in all areas
(B) very good features
(C) satisfactory overall
(D) some serious inadequacies
(F) inadequate in most respects

Overall: excellent very good good adequate poor

____/ 3 Introduction

- too general / too specific
- provides enough background to introduce main thesis / does not set up the main thesis effectively

____/ 8 Main body

- main thesis clearly stated / missing or vague
- accurate presentation of evidence / inaccurate or questionable
- logical development of argument / rambles and lack continuity
- argument defended in depth / superficial
- thesis and argument relevant to topic / not relevant to topic
- original and creative thought / little evidence of originality

____ / 3 Conclusion

- excellent summation / too general / too specific
- does not tie together the main report
- misses "what's next"

____ /3 Sources

(1) Knowledge and integration of material

- Demonstrated knowledge of material and integrated sources well
- Relied too much on paraphrasing the sources rather than understanding the information and using this knowledge to develop the essay's arguments in your own words.

(1) Citation of references [following the rules]

References cited within the body of the text

- were correct / minor errors / major errors
- some plagiarism / major plagiarism

(1) Inclusion of *appropriate abstracts [attached articles]* from current, peer-reviewed journals on the topic.

- omitted or inappropriate
- current (within last 12 months)
- relevant to topic
- reputable source (from scientific peer-reviewed journal)

__/ 3 (3) Style and mechanics

overall: excellent very good good ok poor

- audience (i.e., peers): appropriate / too simple/too advanced
- ideas and word choice: concise / repetitive
- use of language: fluent / awkward
- legibility: legible & well laid out: / untidy & difficult to read
- grammatically correct: 1-2 mistakes / very poor sentence structure
- correct spelling: 1-2 mistakes / many words are incorrectly spelled
- correct format: minor errors / did not follow prescribed format

Generic Rubric for Writing Assignment (Speck 2000, p. 54)

Organization

- Thesis statement is clearly stated in the introduction.
- Rationale for thesis is developed logically throughout the paper.
- Conclusion is drawn logically from the rationale.
- Transitions are effective throughout the paper.

Content

- Paper focuses on topic and does not bring in subsidiary issues.
- Reasoning is clear, using valid logic.
- Key points are supported by appropriate evidence.
- Creative approach is used to discuss topic.
- Correct use of supporting evidence and citations.

Usage

- Information appropriately divided into logical paragraphs.
- Subjects and verbs agree throughout.
- Correct verb tenses are used.
- No run-on sentences, sentence fragments, or comma splices are used.
- No dangling modifiers are used.

Mechanics

- Punctuation is correct.
- Capitalization is correct.
- Spelling is correct.

Relative weighting/value

Component	Weight/Value	Total points
Organization	3	15
Content	4	20
Usage	2	10
Mechanics	1	5
Total		50

Comparison of Holistic and Numeric Rubrics

The two grading strategies differ philosophically. The holistic approach assumes that if a student does what is asked for in an assignment, they receive the expected or average mark (usually a C). However, the numeric strategy assumes students either start with no marks and earn mark after mark by what they include, or start with a perfect paper from which they lose marks for omissions or errors.

The numeric rubric is easier to explain to TAs and defend with students; it provides detailed feedback yet may easily be tied to details and miss the big picture. Positive aspects of the numeric rubric include that it is quantitative, objective, has criteria more explicitly defined, and is easier for TAs to grasp initially. The negative features include that it has less flexibility and is less likely to give top marks (see Table 1)

The holistic rubric allows for the big picture analysis, yet is not as specific in the feedback to student. While a grader may give a higher mark than a paper deserves using the numeric rubric based on the summation of component marks, the holistic rubric allows for subjective insight and is more flexible allowing for creativity. However, the holistic rubric requires a more thorough training of graders and explanation to students. It also has fewer, broader criteria providing less specific feedback.

The workshop participants who had not used a holistic rubric before were initially uncomfortable with this approach, but agreed by the end that it more clearly reflected the merit of the student's work and was easier to use. Both Rudi and Anne have seen the same reaction from their TAs.

Table 1. Comparison of Holistic & Numeric Grading Rubrics

Paper Number	Holistic H Numeric N	Number of graders selecting this grade A 20-18	B 15-17	C 12-14	D 11-10	Total # graders	Mean score/20	SD
1	H	3.5	3.5	3	1	11	15.5	2.67
1	N	0	4	2	0	6	15.5	1.67
2	H	6	3	1.5	0.5	11	17.0	2.65
2	N	0	2	2	0	4	15.1	1.31
3	H	1	3	0	0	4	16.4	1.82
3	N	1	6	2	0	9	15.6	1.76
4	H	0	0	2	3	5	11.6	1.34
4	N	0	1	3	3	7	13.4	2.76

Table 1 contains the data from the grading done during our workshop session. We divided the 20 participants into groups after they initially read the papers and graded on their own. The grades recorded in Table 1 are consensus grades from the groups. One hour was insufficient time to grade papers and skim the accompanying primary papers, thus the number of grades per paper was not the same. Regardless, several trends were emerging:

- Even among experienced graders, we saw that some papers (*e.g.,* Papers 1 and 2 in Table 1) were difficult to grade consistently. Those papers would require the most discussion in a TA training sessions to clarify expectations.
- It seemed to be easier to identify weak papers than excellent papers comparing the standard deviations for papers 1 and 2 versus 3 and 4.
- The numeric rubric produced no exceptional marks, while the holistic rubric recognized at least one.
- The results from this small sample size and brief training show a greater range (high standard deviation) of grades using the holistic method reinforcing the need for training.

Workshop Participants' Discussion of Grading Practices

1. TA grading consistency?

- [Bill Wilchusen, Louisiana State] Group TA discussions, review of some work, TA training course.
- [Kristen Lewis, University of Notre Dame] Answer key for normal assignments, numeric rubric for scientific paper. Adjust TA scores at end if necessary; urge TAs to be consistent at least within a section!
- [Mary Schaeffer, Virginia Tech] Give TAs expected course average and talk about grade inflation and what not to do. We have a Grading of Writing Workshop at the beginning of term for all TAs.
- [Linda Rankin, University of Northern British Columbia] Give grading sheet with each lab broken down into parts with marks assigned for each. I mark the first group and if I find discrepancies from the original marking sheet I adjust accordingly.
- [Charlene Waggoner, Bowling Green State University] Using rubrics has improved TA consistency enormously, though training the TAs in how to use/interpret rubric is critical.

2. Student grade inquiries on specific pieces of work and requests for remarks?

- [Bill Wischusen, Lousiana State] Refer them to their TA. If there is still a problem review material myself.
- [Kristen Lewis, University of Notre Dame] Usually redirect to TA and give student the option to come back to me if they feel that questions/concerns have not been addressed.
- [Mary Schaeffer, Virginia Tech] Meet with TA to discuss rationale used in grading. We do not have these requests. [Eow, I want to see how she does it!]
- [Linda Rankin, University of Northern British Columbia] I go over the lab reports and marking sheets with the students to explain how marks were distributed in a standardized way.

3. TA training for grading consistently; what works well for you (best practices)?

- [Bill Wischusen, Lousiana State] We require all new instructors to attend a semester-long TA training seminar.
- [Kristen Lewis, University of Notre Dame] Grade one paper with all TAs as a group before they begin, but we still have some problems.
- [Carl Vaughan, University of New Hampshire] Be sure TAs understand the content/concepts in the assignment as a thorough understanding is as important as grading guidelines.
- [Helene d'Entremont, Acadia University] We have undergraduate TAs who assist in lab and sometimes they don't come as prepared as they should so I ask TAs to send me lab quizzes before the lab via email.
- [Mary Schaeffer, Virginia Tech] We have the Grading Writing Workshop for all TAs at the beginning of the year and use student peer review of each other's papers before they hand in first drafts.
- [Linda Rankin, University of Northern British Columbia] I always suggest TAs read papers and make comments first and then go back to assign the marks.
- [Charlene Waggoner, Bowling Green State University] Using rubrics makes TA grading more consistent, also grades are more consistent and higher (the good news and the bad news!). Since expectations are clear, students are doing better. I have also initiated a new approach in our non-majors courses called reflective assessment involving the students more in the process from design to self-assessment.

Literature Cited

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Appendix A: Format for TA Training Session

TA Grading Workshop

Instructions for teaching assistants

Today's workshop will be a comparison of two techniques for grading (marking) student papers. In this packet, you are provided with the student assignment, two different rubrics for grading student papers on this assignment and a feedback form for summarizing your experience using the two rubrics to grade the student papers provided. In a separate packet, you will be given four student papers to grade. Half the workshop group will grade papers 1 and 2 with the "holistic" rubric and 3 and 4 with the "numeric" rubric. The other half will do the opposite. Then we will compare the grading results for each paper using the two different rubrics.

Before you begin grading the four papers, please read the student assignment that follows. The papers you will be grading are the final drafts for this assignment. An earlier draft was peer reviewed. The articles students have used for their papers follow their respective papers.

Student Summary II Paper Assignment Overview (as given to students)

This is the second of three writing assignments in Biological Sciences 100LW. You will be assigned a topic by your TA to research during the library exercise. Use this topic for your Summary II paper. Your first job is to locate and read several published primary research reports on your topic using the search tools from the Library Lab (week 3). You should then choose one of these articles for your Summary II paper. A first draft of the paper is due in lab week 4. This draft will be graded for completeness and content (not grammar), so take it seriously. One of your classmates will review your paper in lab week 4 and will provide you with review comments. You should read these comments and respond to those you find relevant by making appropriate changes when you revise your paper. The final draft is due in lab week 5.

Goals for Students

<u>After writing this assignment, you should be able to:</u>

- Locate and read journal articles on a specific biological topic in the library.
- Be increasingly familiar with the basic format of a primary research article as compared with a review article, news article, and so forth.
- Summarize the content of the primary research article you have chosen. In your summary you will be expected to identify the problem or question being studied, the hypothesis being tested, the methodology used, the results found, and the conclusions drawn by the authors.
- Improve your writing by following several important steps in the writing process:
  - Write multiple drafts of your paper, revising and improving the paper with each draft.
  - Incorporate feedback from previous papers (*e.g.*, Summary I paper) into your writing.
  - Incorporate feedback on your current paper (provided by a peer reviewer) when revising.
  - Incorporate increased awareness of common writing errors gained reviewing a peer paper.

Beginning the Assignment: Choosing your Article and Paper Format

Your assignment is to write a **1-2 page** (typed, double-spaced) **summary** of a journal article reporting **primary research** on your assigned topic. **Take the time to review a number of articles** to be sure to pick one that makes sense to you and that you are comfortable writing about.

Since much of the discussion in class is directed at hypothesis-based research, you may want to guide your article choice so that you will end up with a hypothesis-based study. One way to do this is to choose your search terms so that you look for articles with titles that include words like "effect," "cause," "correlation," "relationship," *etc.* Often such terms in the title of an article indicate something about the nature of the research.

Your summary paper must begin with a complete citation for the paper being reviewed, and must be accompanied by a copy of the article reviewed. Pechenik (2001) explains what to include and shows an example (Ch. 6). (***Note*** this format may be found on the "Numeric Rubric" in the citation section.)

Refer to the general instructions provided for writing a summary (below) for information on what to include and what to avoid in your summary.

General Instructions for Writing a Summary

The ability to summarize material is essential to the serious student. It is unlikely that you will remember all of the information you read or hear, so you must develop the habit of selecting the essence of it and putting it into your own words. What follows are steps to take in writing a summary of a scientific article:

1. Read the entire article. When you have finished, try to state in one or two sentences what the author intended to tell you. If the article has an abstract, it should provide the information about the author's intention in several sentences. Try to restate the abstract in your own words. Write this restatement down. Remember that your audience is someone who is interested in the topic and needs to get the key points quickly.
2. Read each paragraph of the article and determine the main point of each. Write that information next to the paragraph or on a separate piece of paper, in as few words as possible.
3. When you have read and summarized each paragraph, combine the information. Include each of the important elements of the paper. Scientific journal writing is terse and there should be little or no extraneous material; nevertheless, you must reduce the article to a shortened version. You probably will have something from each paragraph included in your summary.
4. Be sure you have included all the key information:
   - The problem or question studied
   - How the study/experiment was carried out (indicate processes but omit details)
   - Results that were observed
   - What the results mean to the problem being examined
5. Write the summary in essay form using your own words. Be accurate but do not try to sound as "scientific" as the writer of the article. Remember that you are writing for an audience of upperclass biology majors, not for your TA or an expert in the field.
6. To help your reader, break the summary into paragraphs at logical places and do not "pad" your paper with excess verbiage to make it longer. A page full of words is an impenetrable forest. Good scientific writing is direct, clear, and succinct.
7. Lead the reader smoothly through the steps of your essay, avoiding gaps and coherence problems. Begin paragraphs with ***topic sentences*** containing key words ("problem," "hypothesis,", etc.), to create ***transitions*** and ***structure*** in your paper.
8. Resist the desire to present the author's words as your own in your paper. Such presentation not only fails to convince the reader that you understand the work, but is actually a form of academic dishonesty called plagiarism. Refer to the information on the course website and to Pechenik (pp.32-37) for examples and suggestions about how to improve your note-taking so that you avoid plagiarism.
9. Read your paper carefully and edit it for clarity, spelling, and grammatical correctness.
10. Watch your verb tenses. The experimenters ***were*** investigating a question that ***exists*** now, and they ***did*** things that they ***report*** in the article. The article itself ***identifies*** a problem, ***presents*** a hypothesis, ***explains*** the methods ***used***, ***reports*** the results that the authors ***found***, and ***arrives at*** certain conclusions. As you can see from this illustration, certain shifts of tense can be logical and appropriate.

HOLISTIC RUBRIC

Indicate your grade and comments for the paper you grade with this rubric in the "Feedback for Summary Paper" table below. Be sure to give both the letter grade and the number of points.

A These papers include a complete but concise summary of an approved primary source. The summary should demonstrate a clear understanding of the original journal paper and its implications. The paper is clearly focused and coherently organized. Thoughts are expressed with superior clarity and precision.

B These papers include an accurate summary but are not as thorough or as effectively organized as an A paper. They may not be as concise as an A paper would be. They show some depth of thought. Organization is coherent and ideas are expressed with clarity.

C These papers include a summary but present only a superficial treatment of the selected primary source. The summary may not make clear all of the important points and may lack depth of thought. However, the reader is left with the impression that the writer understood the basics of the primary source. The writing demonstrates basic fluency, but the language may not effectively communicate the writer's ideas.

D These papers may contain a limited or inaccurate summary of the primary source. It may be extremely simplistic and problems in organization may be evident. The writing may lack fluency and may fail to communicate the writer's ideas.

F These papers may fail to summarize an approved primary source. The summary may be cursory and/or demonstrate an inability to grasp the content of the article. There are marked problems with organization and mechanics that make the language very difficult to follow.

Numerical Equivalents for Letter Grades using holistic rubric (circle grade and points):

grade	pts		grade	pts		grade	pts		grade	pts
A+	20		B+	17		C+	14		D	10-11
A	19		B	16		C	13		F	<10
A-	18		B-	15		C-	12			

FEEDBACK FOR SUMMARY PAPER*	WEAK	OK	STRONG
Topic is introduced clearly.			
Paper demonstrates ability to paraphrase and and summarize information in own words.			
Paper reflects clarity of thinking.			
Paper is well-organized and shows continuity of thought.			
Paper uses precise and concise language.			
Information in summary reflects scope of material in article.			
Paper ends with appropriate concluding paragraph.			
Writer has revised paper from rough draft and has incorporated major editorial suggestions.	NA	NA	NA
Paper has been proofread for typographical, spelling, punctuation and grammatical errors.			
Comments:			
* teaching material originally prepared by Dr. Sue Schaefer, UCI Learning and Academic Resources Center; modified by Dr. Rudi Berkelhamer for use in Bio Sci 100LW			

NUMERIC RUBRIC

Indicate your score for each of the grading areas below, then put the point total (20 maximum) at the top ("Total ___/20"). The maximum points for a paper aspect is given following the slash (/) in the heading for that paper part. Write comments about the paper at the bottom of this sheet.

Total___/20 The Report

- indicate your overall evaluation of the student paper (circle your choice; no separate points for this) excellent very good okay poor

___/3 Introduction

- too general — too specific
- enough background to introduce main thesis — does not set up the main thesis effectively

___/8 Main body

- main thesis clearly stated — missing or vague
- important methods described — too little or too much detail
- accurate presentation of results — inaccurate or questionable
- clear discussion of importance of results — unclear or missing the importance
- logical development of paper — rambles and lack continuity
- paper presented in adequate in depth — superficial or overly detailed
- original paper paraphrased and summarized — paper plagiarized

___/3 Conclusion

- excellent summation
- too general ↔ too specific
- does not tie together the main report
- misses "what's next"

___/2 Citation

- citation given at beginning of summary
- correct format used for citation (from writing text):
  - Lastname1, A. B., C. D. Lastname2, and E. F. Lastname3. Year. Article title with only the first word capitalized. *J. Title Abbrev.* vol: p-p.
  - Berkelhamer, R., and A. Cordon. 2002. Effective methods of teaching biology laboratory teaching assistants. *Proc. 23rd Workshop/Conf. Assoc. Biol. Lab. Educ. (ABLE)* 23: 325-342.

___/4 Style and mechanics overall (circle): excellent very good ok poor

- audience (i.e., peers): appropriate — too simple/too advanced
- ideas and word choice: concise — repetitive
- use of language: fluent — awkward
- appearance: legible and well laid out — untidy and difficult to read
- grammatically correct: 1-2 mistakes — very poor sentence structure
- correct spelling: 1-2 mistakes — many words are incorrectly spelled
- correct format: minor errors — did not follow prescribed format

Comments on this paper:

GRADING RUBRIC FEEDBACK

Please tear off and turn in before leaving

Initials _____

Paper No.	Rubric Used		Letter Grade (holistic) or Overall Assessment (numeric) – give +/- as needed				Score (out of 20)	Comments
	Holistic	Numeric	A (excel -lent)	B (very good)	C (okay)	D (poor)		
1								
2								
3								
4								

Compare your experience using the two rubrics. Which was easier to use? Which do you think you could explain to students more easily? Which do you think will result in the most consistent grades among TA's? Please be sure to give any comments as to how you think either of the rubrics might be improved. Feel free to use the back of this sheet for additional comments.

Appendix B: Student Paper #1

Williams, T. M., J. E. Haun and W. A. Friedl. 1999. The Diving Physiology of Bottlenose Dolphins (*Tursiops truncatus*). *J. Exp. Bio.* 202: 2739-2748.

Studies have shown that dolphins alter their mode of locomotion on the water surface in order to conserve their energy. However, dives provide a complication with the changes of pressure at increasing depths. While shorter duration dives allow for greater variations in speed and swimming mode due to a need for less oxygen, longer duration dives require more oxygen and it would appear more efficient energy utilization. It has been shown that the energetic cost of swimming in other marine animals is greatly reduced in those that use interrupted patterns of swimming. More efficient swimming potentially leads to more efficient foraging and more food. This study examines the locomotion strategies and physiological impact of long and sort duration dives on the bottlenose dolphin (*Tursiops truncatus).*

The study was divided into two parts; passive breath holding on the water surface and open water dives. Blood samples and heart rate were assessed in each part and compared to results from stationary exercise experiments. Post-dive lactate production and respiratory rates were measured. Surface breath-holding duration and dive duration was also examined. The surface breath-holding tests were conducted to determine the effects of apnea alone on bottlenose dolphins. Open water diving tests assessed the combined effects of exercise and breath holding. The first 25m of decent and last 25m of ascent were video recorded to observe swimming mode. Percentage of time gliding defined as forward movement with out motion of the fins, and stroke frequency were also assessed. For the surface breath holding test, bottlenose dolphins were trained for voluntary breath holds to avoid a forced dive response. For the diving experiments the dolphins were put into harnesses, which carried instruments to record time/depth and heart rate.

Average heart rate decreased with dive depth and was lower after a dive than the resting pre-dive rate. The mean respiratory rate increased by more than double after dives when compared with the value for the dolphin at rest. Average descent rates were slower than predicted to be the most energetically cost effective and ascent were faster than predicted. Videotape and observation displayed the dolphin's use of interrupted patterns of swimming, especially in deeper dives. While those swimming close to the water surface incorporate a lot of stroking, diving dolphins underwent long periods of gliding with interrupted periods of stroking to gain momentum. The lack of muscular movement associated with gliding probably contributed to the longer dive duration. Previous studies have found that swimming vertically at depths also requires less energy than swimming horizontally, most likely due to buoyant forces.

Using the data collected in this experiment with data previously available for swimming bottlenose dolphins, the effects of apnea can be analyzed and the capacity of the dolphins to maintain aerobic metabolism can be estimated. Final bradycardia, unusually low heart rate, occurred faster for shallow diving bottlenose dolphins, than for those diving to high depths and for those holding their breathe on the waters surface. Stationary breath holding resulted in immediate changes in blood gases and slower insignificant change in lactate levels. Plasma lactate counts increased significantly in deep diving dolphins as opposed to those passively holding their breath or shallow diving, increasing with duration of apnea. Surprisingly, the highest post dive lactate concentration recorded was only 57% of the absolute maximum reported for bottlenose dolphins. Thus leading to a conclusion that anaerobic pathways were not engaged for a significant period. The onset of post dive lactate accumulation can be predicted by the aerobic dive limit (ADL). The ADL is the maximum time for a breath hold than can be supported by oxygen reserves before plasma lactate levels rise. The values found for stationary dolphins holding their breath correlate well with predicted values. However values for deep diving bottlenose dolphins were a bit unclear. Changes in lactate level for deep diving bottlenose dolphins occurred later than expected and the dolphins remained under water longer than expected.

There is a complicated relationship between the body's responses to exercise and diving in bottlenose dolphins. In this study the bottle nose dolphins performed dives, requiring them to be submerged for along period of time. Calculations indicate that the oxygen store would have been exceeded during this period. However, the dolphins did not experience substantial anaerobic response to compensate for the energy shortfall. Rather they altered their mode of swimming. Bottlenose dolphins incorporate altered swimming patterns with long periods of gliding to compensate for the depleting oxygen stores. The bottlenose dolphins also take advantage of changes in pressure and buoyancy to further maximize their efficiency in swimming patterns.

Appendix C: Student Paper #2

Withers, P. C. and S. S. Hillman. 2001. Allometric and ecological relationships of ventricle and liver mass in anuran amphibians. *Functional Ecology.* 15: 60-69.

Past studies have shown that amphibians lose water at a rate equivalent to that of evaporation from a free surface area. Thus living on dry land presents a challenge to which amphibians have adapted in two main ways: either by developing a high tolerance to dehydration, or by burrowing underground to avoid high temperature and low surface humidity. In the case of high dehydration tolerance it has been shown that ventricle mass plays a substantial role; the lack of water strains the cardiovascular system, whose cardiac output is largely determined by stroke volume (the amount of blood pumped by the left ventricle each time the heart contracts). In the case of burrowing, the liver has been shown to play a vital role; it provides energy storage for the fasting required and can supply protein for the construction of cocoons. The authors of this article determined the allometry of amphibian ventricle and liver mass, expressing each as a power function of total body mass. They then analyzed the relationship of these important organs to their ecological roles, hypothesizing that dehydration-tolerant species will have a larger ventricle mass and burrowing species will have a larger liver mass.

Forty-two species of anuran amphibians -- that group consisting of frogs, toads, and tree toads -- were studied. This diversity, however, was achieved by using preserved specimens obtained from two major Australian museums. Thus the experimenters' first task was to determine if these preserved specimens were representative of fresh specimens in terms of relative masses. Five species of fresh frogs were collected for comparative purposes. While no significant differences were found in percentage ventricle mass of fresh frogs and museum-preserved frogs, museum frogs tended to have a significantly larger percent liver mass. However, since liver masses are known to fluctuate seasonally and all data fell within the range of known variation, the authors attributed the differences to the fact that their fresh samples were all collected at the same time of year. Thus the liver masses of museum species were determined representative.

This potential obstacle being settled, the researchers continued their experiment. Data was collected for eight male specimens of each of the forty-two species. Specimens were drained and blotted of excess fluids, their ventricle and liver removed and weighed. Total mass was calculated by remaining body mass plus the weight of the organs removed. Other variables included habitat (arboreal, terrestrial, or burrowing as determined from published sources) and dehydration tolerance (these numbers were borrowed from a prior published work in which they were measured as percentage mass loss at critical activity point or death). The data collected was then subjected to several methods of statistical analysis. Graphs of ventricle and liver masses were plotted logarithmically against total body mass. Stepwise multiple regression techniques and ANOVAs (Analysis of Variance) were then used to determine the relationship of two variables, filtering out the remaining variables.

It was found that there is an isometric relationship for allometry of both ventricle mass and liver mass versus total body mass, meaning the power of the exponential function relating the two is not significantly different from one. Statistical analysis concurred that there is a strong relationship for ventricle mass with dehydration tolerance, but not with habitat. For liver mass it was found that there is a strong correlation with habitat but not dehydration tolerance. These results neatly support the authors' hypothesis. It was concluded that relative ventricle and liver masses are appropriate morphological measures of dehydration and burrowing adaptation of amphibians to land.

Appendix D: Student Paper # 3

Golding, Y. C., M. Edmunds. 2000. Behavioral mimicry of honeybees (*Apis mellifera*) by droneflies (Diptera: Syrphidae: *Eristalis* spp.). *Proceedings of the Royal Society Biological Sciences* 267(1446): 903-909.

For many years, researchers and entomologists have been conscious of a possible Batesian mimicry between droneflies (*Eristalis* species) and honeybees (*Apis mellifera*). Batesian mimicry is the imitation of an unpalatable or dangerous species by a palatable or harmless species. As previously observed, droneflies are comparable to the honeybee in size, shape and coloration, but an astute eye or a predatory bird can easily differentiate between the two. Therefore, the authors hypothesize that for the droneflies' mimicry of the honeybee to be effective, it must also behave in a manner similar to that of the honeybee when foraging. This article tests this mimicry in a field study by comparing the average time spent foraging on each flower and the average time spent flying between flowers of both the honeybee and the dronefly.

The experiment was carried out on five distinct patches measuring 2 m by 1 m, with different flowers that attracted both the honeybee and at least three different species of mimics (*E. tenax, E. perinea* and *E. arbustorum*). To show that the dronefly mimics the honeybee and not just bees in general, the researchers named the honeybee as their model and used the bumble-bee (several species of black and yellow *Bombus*) as their control. Researchers also had to demonstrate that the dronefly was dissimilar to other dipterans, so they named the dronefly as the model and all other flies the control. Observations of flight time and feeding time were recorded via video camera during sunny periods and later calculated for each species of insect on each species of flower.

Researchers first looked at the differences between the three different species of mimics. They found that on knapweed there was no significant differences in either their flying time or their feeding time, however on goldilocks, they found that there was significant difference in their feeding times. Next, they compared the average feeding and flying times of the mimics to the average feeding and flying times of the honeybee. When calculated, there was no significant difference found between the droneflies and the honeybee, therefore supporting their hypothesis that the droneflies mimic honeybee behavior. Then to ensure that the dronefly, and not just flies in general, mimic the honeybee, they compared the feeding and flying times of the dronefly to its control, other dipterans. They found that the average times spent by the dronefly feeding on and in between each flower was more similar to that of the honeybee than to other dipterans. Finally, to check their other control, the feeding and flight times were recorded for the bumblebee and then compared to the mimics. They found significant differences between the mimics and controls, suggesting that the mimic has characteristics more closely related to its model rather than to other bees and that they are essentially Batesian mimics of the honeybee.

Appendix E: Student Paper # 4

Koyana, Sachiko, Shinji kamimura. 2000. Influence of Social Dominance and Female Odor on the Sperm Activity of Male Mice. *Physiology and Behavior.* 71:415-422.

It is said that each male mammal produces different amounts of sperm counts due to their environmental influences. In theory if they have more sperms, it means they have a more likely chance to fertilize and reproduce. However, having a lot of sperms does not mean that they will have a higher chance of fertility, rather, it is the motility or activeness of the sperm that increases the chance of it. Like sperm density, sperm motility is also influenced by the environment of that of the male species. In Koyama's and Kamimura last study, they tested one environmental factor, which is social dominance. In that experiment, they concluded that social dominance does affect the sperm motility because dominant mice have higher rates of sperm motility and subordinate mice have a lower rate of sperm motility. This experiment expands on the previous one. In this experiment, they wanted to test if both social dominance and female odor increases the sperm motility in male mice. Their hypothesis is that the female odor and social dominance should increase the sperm motility of male mice.

In order to test their hypothesis, they used 118 male mice and 37 females to test for 15 weeks. First, the male mice were put into pairs in each cage. After the pairing, they had to test the two mice for social dominance by conducting an intruder's test. The intruder's test is basically having a third mouse (an intruder) in the cage to see if the pair of mice would attack or be aggressive towards it. For each act of aggressiveness, each mouse was assigned points. The more points each got, the more he was labeled socially dominant. When it was clear who were dominant and who were subordinate, they then pair the mice up again according to their type. For each type of mice, they wanted to test the female odor influence on motility. Therefore, each type had 3 groups in which they will be testing for significance of female odor. The first group, which experimental group 1, had a setup where a female mice's cage with the female mice in it on top of the pair of male mice's cage all the time so that the male mice had direct sense of smell from them. The second experimental group had a cage with the bedding for the female mice on top of the male mice, but the cage did not contain the female mice. The bedding consisted of the female urine and the food they ate just to give off some female odor. The control group did not have any contact with the female mice nor did they smell anything that contained female odor. Thus, the dominant and subordinate type mice were split into three groups that were classified above. After 15 weeks of the odor test, the authors took a blood sample from each of the mouse to measure the testosterone and coticosterone levels, which they further analyzed by radioimmunoassay. Sperm was also collected from each mouse and screened for motility by methods of what the authors call VTR images. The images also showed the density of the sperms collected. They also had an extra intruder's test after the 15 weeks to see if the female odor had any influence on the mice's aggression.

The results showed that sperm motility and density was higher in the dominant species than that of the subordinate species. For the subordinate mice, the female odor did not play a significant role to increase their sperm motility because it was constant throughout the three groups. However, their sperm density and testosterone level did increase when they could smell the female mice more. The levels of testosterone were higher in the dominant male mice than the subordinate ones. This means that testosterones level correlates to the sperm motility. When they did their second aggression test, it showed that the dominant mice who more aggressive (overaggressive) had a lower sperm motility. This contradicts what they hypothesized.

In this experiment, the authors concluded that social dominance affected sperm motility, which supports their hypothesis and that female odor does not, which refutes their hypothesis. They also found out that if the mice were overaggressive, it reduces their motility rate due to stress. Since some of their results were contradicting, they will perform another experiment in the future to explain those results.