Suggestions for Writing Lab Papers

The lab report consists of a paper written in *scientific format* and it should include the following sections.

Title: give a title which accurately describes the contents of your paper. Make sure your names and school address appear on this title page.

For example:

Effects of sponge encrustation on the swimming behavior, energetics and morphometry of the scallop *Chlamys hastata*.

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Abstract: explain concisely what you did. Give a synopsis of your results, citing actual data where appropriate but without statistics. Briefly state the significance of your results. *Do not cite references here*.

For example:

Abstract. The effect of sponge encrustation on swimming ability of *Chlamys hastata* was determined by investigating swimming behavior, scallop morphometry, and energy expended during swimming with and without commensal epibionts. Scallops swam significantly longer after sponge encrustation was removed from their shells, but no significant differences were detected in swimming elevation or distance. Scallops with sponge encrustation showed no adductor muscle hypertrophy or changes in shell morphometry compared to scallops without encrustation. However, *C. hastata* did exhibit scaling relationships associated with maximizing swimming efficiency. Specifically, shell width and adductor muscle mass were positively allometric with shell height, while shell mass was negatively allometric with shell height. Scallops increased their energy expenditure (both aerobic and anaerobic) during swimming, but no significant difference was detected between unencrusted (43.0 μmol ATP consumed during a 2 min escape swim) and sponge-encrusted (40.0 μmol ATP) scallops. Scallops in both treatments derived 86% of the energy used for swimming from anaerobic stores. The lack of substantial differences between scallops with and without commensal sponges is partially explained by the observation that even heavy sponge encrustation increases the scallop's immersed weight by only 5%. The presence of a sponge encrustation does not appear to inhibit swimming by this scallop species.

Keywords: come after the abstract and represent all key concepts and name designations contained in your paper in single or paired-word format. It is customary to include genus and species names here and, where appropriate, larger taxon designations either by formal or informal taxonomic name.

For example:
Keywords: *Chlamys hastata*, swimming energetics, epibiotes, scallop-sponge association

Introduction: give some background material to introduce the subject. Explain what others have found in the past. Describe what you are planning to do (but not *how*-this comes later) and what you are expecting to show. Include relevant references, but DO NOT cite my lectures or lab introductions. You have primary literature that covers all the necessary background. Similarly, DO NOT use web sites. They are not peer-reviewed and information on them is suspect.

It is often difficult for students to indicate their expectations for the study; that is, predicting what the results will be, yet, the scientific method requires that you test a hypothesis. You could make the statement, "The hypothesis we are testing is that... and our expectations are that..."

For example:

INTRODUCTION

Scallops are often found associated with encrusting epibionts such as sponges, barnacles, polychaete worms, bryozoans, tunicates, and algae. Of these, the scallop/sponge relationship has received the most attention, perhaps because scallops and sponges form symbiotic relationships worldwide. However, the nature of the relationship is not always clear and the interactions between different species of sponge and scallop seem to vary. In Australia, sponge encrustation inhibits predation of the scallop *Chlamys asperrima* by the predatory seastar *Coscinasterias calamaria* by camouflaging the scallop and also by interfering with tubefoot adhesion (Pitcher & Butler, 1987). Field studies support these conclusions since sponge cover decreases mortality of *C. asperrima* (Chernoff, 1987). In England, the scallop *Chlamys varia* appears to benefit from encrustation of the sponge *Halichondria panicea*. In this case, the sponge interferes with adhesion of seastar tube feet and makes byssal openings in the scallop inaccessible to seastar digestive membranes, thus decreasing susceptibility of the scallops to seastar predation. The sponge also appears to benefit from this association due to an increased supply of nutrients generated from the inhalant current of the scallop (Forester, 1979).

In the Puget Sound, Washington, USA the scallop *Chlamys hastata* Sowerby is often found in association with the sponges *Mycale adhaerens* Lambe and *Myxilla incrustans* Esper. The relationship was characterized as a mutualism by Bloom (1975). He determined that...

The purpose of this study was to investigate different aspects of scallop swimming as a function of sponge encrustation. We looked at the effects of encrustation on swimming behavior, energy expended by the scallop while swimming, and scallop morphometry. We expected that sponge encrustation would decrease the ability of scallops to swim while increasing the amount of energy expended.

Materials and Methods: describe how you did your experiments, in a logical order. Keep details concise. Explain what statistical tests were used, but don't belabor the statistics. Stats are used to verify that your data are or aren't different, they are not the reason for doing the experiment.

For example:

MATERIALS AND METHODS

Swimming behavior

Scallops were videotaped during escape swimming to determine the time, distance, and elevation of swimming bouts with and without sponge encrustation. Sponge-encrusted scallops (*N*=28) were placed individually in a 2.5 m diameter outdoor tank filled with seawater to a depth of 85 cm. The bottom of the tank was marked with black tape to form a grid of sections measuring 30 cm on each side. A video camera was suspended from a scaffold over the tank so the entire bottom of the tank was in view. Individual scallops were placed in the middle of the tank. After an acclimation period (at least 10 min) a seastar (*Pycnopodia helianthoides*) was placed next to the scallop. The swimming response that ensued was videotaped. The elevation in the water column that the scallop attained was determined by an observer watching through a port in the side of the tank. Each scallop was induced to swim three times with ten minutes of rest between each bout. After the scallop had swam three times with sponge encrustation, all sponge was gently removed from the scallop and placed in a weigh boat. The scallop was then weighed and returned to the holding tank. The sponge was rinsed with fresh water and dried to constant mass. After 24 hours recovery time [a period that has been used to allow scallops to recover after swimming in other studies (e.g., Thomas & Gruffydd, 1971)], the clean scallop was again placed in the large tank with a *P. helianthoides* and induced to swim three more times, again with 10 minute rest periods between swimming bouts.

Each videotaped swimming bout was played on a video screen and the path traveled by the scallop was traced on an acetate sheet. The trace was then scanned and the 2-dimensional length of the path was measured with Optimus image analysis software. The time of swimming was determined with a stopwatch.

Mean swimming time, elevation, distance and speed were determined for each individual with sponge encrustation and after the sponge had been removed. Paired t-tests were used to determine any differences between the treatments.

Results: this section describes your results to the reader, with references to Tables and Figures. Explain what is in each Table and Figure and point out what is important. Your references to tabulated data should deal with *means*, while you should describe *trends* in your graphs. Your Results section should present your data *in order* as given in your Materials and Methods section. Guide the reader through your Results section with careful attention to all relevant points. *Assume the reader is naive*. Whenever you make a statement about statistical relevance, the statement must be followed by your statistics (in parentheses). Tables and figures can be inserted in your paper following their first mention.

For example:

Swimming behavior

There was no evidence that scallops tired during the three spaced swimming bouts as there was no drop in swimming ability or decreased reaction to the predator over the course of the trials.

Average sponge dry mass for the 28 scallops tested was 0.63 ± 0.08 g (all values are means ± SE), with a range of 0.1 to 2.2 g. Scallops swam significantly longer after encrusting sponge had been removed (Table 1), spending an average of 0.7 sec longer in the water column. There were no significant differences in swimming distance, elevation or speed the scallops swam. Despite good replication (N=28) and a powerful test (a paired t-test), calculated power was low for these analyses, indicating that effect sizes were very small.

Raw data*: your data will most often be presented as means ± some indication of variance (usually standard deviation or standard error). *You will rarely, if ever, present raw data.*

* note that *data* is plural; *datum* singular.

Tables: Number each table and refer to this number in the text of your report (e.g. "As shown in Table 2..."). Give a *legend* to indicate what is contained in the table. Make the legends as informative as possible, but keep to a sentence or two.

For example:

Table 1. *Swimming behavior of scallops with sponge encrustation and after the sponge had been removed. Numbers represent grand means ± SE of three trials for each of 28 scallops.*

	with sponge	without sponge	Paired t-test (2-tailed)	Power
Time (sec)	8.6 ± 0.2	9.3 ± 0.3	t = 2.74; p = 0.01	
Elevation (cm)	71.6 ± 3.0	72.7 ± 3.3	t = 0.36; p = 0.72	0.09
Distance (cm)	150.4 ± 5.4	155.3 ± 4.7	t = 0.95; p = 0.35	0.23
Horizontal speed (m sec^{-1})	0.18 ± 0.01	0.17 ± 0.01	t = 0.68; p = 0.51	0.26

Figures: include graphs, histograms, illustrations, and so on. Number each and again provide a descriptive legend. In "cause and effect" relationships, always plot graphs with the *dependent* variable (Y axis) over the independent variable (X axis). In "cause and effect" relationships, changes in one parameter cause changes or effects in another. For example, temperature change (independent variable) causes heart rate (dependent variable) to change. In "correlation" relationships, however, where no cause and effect is implied, the position of each variable on the axes is unimportant. Thus, spawning in sea urchins may be correlated with time of phytoplankton bloom, yet no causality may be involved. When you have produced a graph with regression type data, don't forget to include the regression equation and the coefficient of determination (r^2).

Significant vs. biologically realistic numbers: these may not be competing, but often are. For example, a value of 14,236.7 may be mathematically significant, but it may obscure the point that something measures about 14,000, which is most important. The mean of 1.2, 2.1, and 3.1 can be reported as 2.3333333, which is neither significant nor biologically realistic. Presenting and comparing values of 4.2197 and 8.4362 (instead of 4.2 and 8.4) obscures the point that one value is twice the size of the other. These concepts cannot be easily explained, but think of the impact that you wish your data to give.

Discussion: now discuss your results and, whenever possible, show how they fit in with previously published material (i.e. cite references). Don't hesitate to refer to actual values taken from your results or the results of others, to make a point, but you don't need to include statistics. Your discussion should focus on explaining your results in terms of the biology of the organism. Sometimes students feel compelled at the end of a Discussion to include everything that was bad about the experiment: fellow-worker incompetence, temperature variations, cosmic rays, and so on. This is not recommended, especially if it is unnecessarily expansive or where it could otherwise weaken a strong ending. Sometimes, a good ending can include suggestions for improvement, but be careful that this is not overdone to the extent that it comprises a significant portion of the "discussion."

References Cited: use references in the body of the text; e.g. "Smith (1969) reported that..." or "...this phenomenon has been well documented (Smith, 1969)." Then give the complete reference in the **References, References Cited,** or **Literature Cited** section at the end of the paper. An example of the format is:

REFERENCES

Baldwin, J., and Morris, G.M., 1983. Re-examination of the contributions of aerobic and anaerobic energy production during swimming in the bivalve mollusc *Limaria fragilis* (Family Limidae). *Aust. J. Mar. Freshw. Res.* **34**: 909-914.

Bloom, S.A., 1975. The motile escape response of a sessile prey: a sponge-scallop mutualism. *J. Exp. Mar. Biol. Ecol.* **179**: 311-321.

Carefoot, T.H., 1987. Gastropoda. In *Animal Energetics,* vol. 2. (ed. T.J. Pandian & F. J. Vernberg), pp. 89-172. New York: Academic Press.

Carsen, A.E., Hatcher, B.G. and Scheibing, R.E., 1996. Effect of flow velocity and body size on swimming trajectories of sea scallops, *Placopecten magellanicus* (Gmelin): a comparison of laboratory and field measurements. *J. Exp. Mar. Biol. Ecol.* **203**, 223-243.

Do not entitle this section on references a Bibliography. This is a term which is used for general readings not necessarily cited in the text. **DO NOT cite references which you have not read**. Not only does this lead to padding of the Reference section but, in addition, it can be misleading. Scientists are not exempt from taking things out of context or from misinterpreting other people's work. If you must cite a reference that you've found in another paper, an acceptable format is "Smith (1960, as cited in Jones, 1980) reported that..." but be sure to include **both** references in the "References Cited" section of your report.

Where their are two authors, cite both in the text: Smith and Jones (1992) found that...; where there are three or more authors, cite in text as Jones *et al.* (1993). "*et al*" is short for *et alii* which means "and others." It is usually in italics and always has the period.