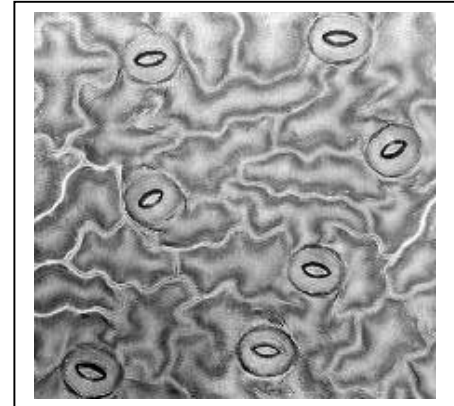<u>**EXPERIMENTS**</u>

Environmental Correlates of Leaf Stomata Density

Bruce W. Grant and Itzick Vatnick
Biology, Widener University, Chester PA, 19013
grant@pop1.science.widener.edu
vatnick@pop1.science.widener.edu

stomata viewed at 400x in nail polish impression from leaf underside © Marc Brodkin, 2000

Appendix 2. Guidelines for Stomata Written Reports

You have not done science until you have presented your data and interpretations in a way that is usable by your colleagues. There is a big leap between the set of activities involved in conducting a research project (collecting and analyzing data) and the actual communication of your findings to a research community of your peers. There are strict rules of conduct to follow in presenting your findings - rules designed not only to make it as easy as possible for you to present your work but also to make it easy for your peers to quickly grasp and understand your work. Your further development as a credible scientist and/or teacher depends upon you ability to master the form, style, and art of scientific writing.

Dozens of books have been written on how to write a research paper, thesis, etc. One of the problems with these books is that many are written by people with lots of writing experience, but little experience as scientists; therefore, these books show little empathy for the problems that many young scientists face in their writing. Although it is true that the style and content of most scientific papers are fairly consistent, it is not true that good scientific writing is dry and dull. Nothing works better at deterring your readers from reading your work than does garbled impenetrable prose. Good writing is catalytic to learning and understanding, and without learning how to write you are lost. No one can actually teach you how to write. You have to do the writing yourself, make mistakes, and do it all over again.

What follows is a format for the scientific paper for this course. This handout is organized into five sections. The first section lists general suggestions and outlines the basic format that you should use. Following these five sections is a brief section addressing how oral reports differ from written reports. You should always compose the written report first, and then distill salient features for your oral presentation.

I. General Suggestions You Should Follow for Each Section.

1) Your report should contain 8 sections: (1) Title Page/Abstract, (2) Introduction, (3) Materials/Methods, (4) Results, (5) Discussion, (6) Literature Cited, (7) Acknowledgements, and (8) Appendices. Each serves a specific function detailed below. Take great care to place the right text in the right section – format matters,
2) Word-process your report, double space, with at least 1" margins along all edges,
3) Be clear, concise and insightful with your prose,
4) Avoid all anthropomorphisms, awkward phrasings, and grammatical illegalities. Proof-read aloud several times,
5) Never create words (e.g. "obtaination," "mobilate") – use a dictionary,
6) 1 datum vs. 2 data,
7) it's = it is, whereas the word its is the possessive form of it,
8) affect is the verb, effect is the noun,
9) PROOFREAD AND SPELLCHECK YOUR WORK,
10) any technical terms you use to communicate your hypothesis, methods, results, etc, need to be briefly defined at FIRST use, and subsequently used correctly,
11) DO NOT waste paper on a title page with only the title on it (see Part II, below), DO NOT insert wasteful blank areas between sections, USE double sided xerox for your copies,
12) Submit a disk-copy of your original data, your PowerPoint presentation, and your document along with your hard copy of the manuscript,
13) Any student research group that produces an outstanding research paper may elect to take a 1-2 credit independent study with me during a subsequent semester, if they agree to present their research results at the Widener University Undergraduate Research Projects Day in April, or off-campus the spring annual meeting of the Delaware Valley Society for Conservation Biology, the Pennsylvania Academy of Sciences, and/or at the National Council on Undergraduate Research. In the past, many student papers for this course have easily been of sufficient caliber to present nationally at NCUR and elsewhere.

II. Specific Suggestions for the Title Page (Title, Names, and Abstract).

1) The title page contains your title, your names and your abstract on ONE page,
2) The title should clearly relate to your project. The title should be clear, concise, and appropriate,
3) Following the title, list your names in alphabetical order,
4) Following your names, write "(Biology 301, Fall 2001)",
5) The Abstract for your paper comes next:
a). The Abstract contains a short summary of every section in your report. Cover the main points only without dwelling on details of your methods or results. In reality, the Abstract will be the only part of your paper that will be read by the majority of those who get past the title; therefore, tailor the prose for maximum speed, simplicity and impact,
b). Summarize your Introduction, Methods, Results (including key numerical results and stats), and Discussion sections separately in a couple of tight sentences devoted to each. Fell free to lift good sentences from these sections to build your Abstract,
c). length = 250 – 300 words, single space the Abstract,
d). Write clearly, use good English, proofread, spell check, explain all terms you use or don't use them, correctly use all terms you do include, and make sure all text belongs here,
e). All of the suggestions from Part I, above, apply except that it is not as necessary in the abstract to define all technical terms – readers are welcome to find these definitions in the paper.

III. Specific Suggestions for the Introduction (length = 1-2 pages).

1) Introduce the general topic of the report. Work especially hard at getting a good opening sentence. Why is the general topic of the report of any interest to you and to the reader? Your job is to MOTIVATE INTEREST in the reader,
2) State the specific question that is the subject of the report. You may use a sentence such as "We investigated the effects of   ...... {describe the environmental difference} on ....{describe what you will look at},
3) Briefly explain the hypothesis(es) that may offer an answer to your question. Be thorough, yet concise in explaining your hypotheses. A common oversight is to state an hypothesis and presume that a reader will immediately see why you have stated it. DO NOT MAKE THAT MISTAKE! Why do you think you might find what you hypothesize?
4) There may be alternate hypotheses that may answer the same question. If so, they should be mentioned and your studies must be designed to distinguish among competing hypotheses, if possible. If not, save these issues for your Discussion Section under "Future Directions",
5) If there are other questions that you address, then repeat steps (2)-(4) for each one,
6) For this course, I am not requiring extensive use of the literature since there simply isn't time for a detailed literature review. However, if we discussed the use of specific materials during our conferences, you should weave these materials into your introduction. Ask me about the details of this that pertain to your project. Note that if you decide to follow up on your project in a subsequent independent study, your first task will be to perform a thorough literature review,
7) Many feel compelled to offer an overview of the kinds of data they will collect as a set-up for the Methods section, but I consider this to be optional,
8) All of the suggestions from Part I apply, especially - write clearly, use good English, proofread, spell check, explain all terms you use or don't use them, correctly use all terms you do include, and make sure all text belongs here,

IV. Specific Suggestions for the Materials and Methods (length = 1-2 pages)

1) This section describes the procedure you used to address your research question, and you are encourages to use sub-headings to subdivide this section (e.g. "Site Descriptions", "Field Sampling", "Lab Sampling", "Data Analyses", etc.),
2) Briefly describe the habitats of the study sites for your field collections. Give the reader an idea of the basic ecology of the sites,
3) Provide a detailed set of figures containing xeroxes or downloads of maps showing the general location of your sites as well as a very detailed map (which may be sketched by hand) that would **allow a reader to find your exact sampling locations within 50 feet**. The most detailed maps can easily be put into an Appendix, if you choose,
4) Include all of the necessary and sufficient detail for the reader to be able to duplicate your field and lab methods exactly. Distinguish between essential detail and extraneous detail (e. g., studies were carried out on Earth by *Homo sapiens*) and omit the latter. For every experimental design there are important implicit assumptions. Be sure to address the critical ones. Comment on the accuracy of your measurement techniques, when relevant. E.g., to how many significant digits did you measure things (e.g. ± 0.001 gm or ± 5 mm)?
5) Clearly document the archival process of sample identification and storage. How did you identify your samples, and how are they archived for permanent storage?

IV. Specific Suggestions for the Materials and Methods (continued...)

6) Specifically address the issue of sample replication. How did you replicate your samples for the purposes of finding statistics (averages, 1 SD, etc.)? Always replicate your measurements. How confident you are in your conclusions depends upon the amount of "experimental error" you have been able to avoid. There are two sources of error (excluding mistakes!). One source is measurement error, which corresponds to the resolution of your equipment (e.g., did you measure distance with a tape measure or micrometer?). But, the second source of error is due to "inherent variation" in whatever you are measuring. For example, if you were measuring the diameters of 10 trees that were all 5 yrs old, you would expect differences among them. Always design your experiments so that measurement error is much less than this inherent variation. The best way to estimate "experimental error" is to replicate a given treatment as many times as possible. We will discuss the appropriate means to estimate variation for your project,
7) There are specific means by which experimental error, statistical confidence, and hypotheses testing are to be worked into the design of your project, depending on your particular question. We will discuss specific methods of statistical analyses appropriate to your project beginning with the labs before you collect any data and continuing throughout the semester.
8) All of the suggestions from Part I apply, especially - write clearly, use good English, proofread, spell check, explain all terms you use or don't use them, correctly use all terms you do include, and make sure all text belongs here.

V. Specific Suggestions for the Results (length of text = 1-2 pages, not including Tables and Figures).

1) This section contains all of the results of the experiments and other measurements you made, and is usually the SHORTEST section,
2) Present the results from each of the sets of data you said you would collect in the Methods Section in the same order as in the Methods,
3) Avoid text redundancy,
4) Any statistical tests are reported in your Results; however, this section contains NO interpretations of your results. Simply state the results and the statistics to back up your statements (which may be placed in parentheses). Only use the word "significance" when discussing a statistical test. Do not say "our results were significant" in any other context,
5) For every data set there exists an optimum format for presentation. This format may be a combination of tables and figures (e.g. scatterplots, bar graphs, etc.) that are (a) well documented and easy to read, (b) illustrate the data with a minimum of redundancy, and (c) enable the reader to **quickly perceive** the results. Poorly conceived graphs will obscure the data and leave readers unconvinced. Combine figures if needed,
6) All Tables and Figures should be numbered in order (i.e., Table 1, Table 2, etc.) and referred to by number in the text,
7) For each Table and Figure, include a legend at the top or bottom. The legend should briefly state using complete sentences what the Table or Figure shows, what the units of the axes are (if appropriate), what the error bars represent (if appropriate), and other information to enable that Table or Figure to STAND ALONE. A reader should be able to look at any Table or Figure in your ms and be able to understand what's in it without consulting the text of the ms. Thus, you are encouraged to duplicate text in the legend and ms to facilitate clarity. A typical legend should be about 3-5 sentences,
8) Clearly explain every Table and Figure in the Results using text very similar if not identical to text in each Table or Figure legend,

V. Specific Suggestions for the Results (con.).

9) Clearly indicate whenever possible the variation in any average you present (graphically on each figure or numerically on each table). Specifically explain replication as needed to explain any measures of sample variation you present (e.g., error bars on your figures, $\pm$ SD in tables, etc.),

10) Place all raw original data in an Appendix. A reader should be able to duplicate your results figures exactly from your original data,

11) All of the suggestions from Part I apply, especially - write clearly, use good English, proofread, spell check, explain all terms you use or don't use them, correctly use all terms you do include, and make sure all text belongs here.

VI. Specific Suggestions for the Discussion (length = 1-2 pages).

1) Re-introduce the general topic of the report. Work especially hard at getting a good opening sentence. Why is the general topic of the report of any interest to you and to the reader? Your job is to MOTIVATE INTEREST in the reader, but keep it brief (1-2 sentences) unlike in the Introduction (where 1 paragraph was needed),

2) This section contains your interpretation of your results. Discuss your hypotheses. Re-connect to the themes of your paper that you laid out in your Introduction (re-use any literature you cited). Do your data support your hypothesis(es)? How "confident" are you in your findings? However, note that YOU CAN NEVER PROVE AN HYPOTHESIS BY EXPERIMENTS. All you can do is accept or reject hypotheses with a finite, numerical degree of "confidence" (e.g. 95% or 99%). No scientist can ever be 100% sure,

3) Following an opening paragraph, discuss all of your results in turn in the same order as in the Results section. Explain to the reader what the Tables and Figures show. Avoid recitation of previous detail, but cite Tables and Figures to support your statements. Never over-extend yourself beyond your database. Abstain from speculations that your data do not specifically support. Feel free to suggest new hypotheses for future work, but do not present new data. Be conservative in your assessments, but **do not make excuses**.

4) Work at making the text in the Discussion flow effortlessly,

5) Conclude your Discussion with a "Future Directions" sub-section in which you should comment about what would be the next thing you would do for this project. In what direction would your future research take you after this project? Lay out the future directions for your project that hopefully an interested Biology 301 student research group will read, become excited about, and pick up where you left off,

6) All of the suggestions from Part I apply, especially - write clearly, use good English, proofread, spell check, explain all terms you use or don't use them, correctly use all terms you do include, and make sure all text belongs here.

VII. Specific Suggestions for the Literature Cited and Acknowledgements Sections.

1) The Literature Cited section should contain the reference to works you cite somewhere in your paper, (e.g. if you used previously published methods or build on previous work).

2) Each print citation should have: Author(s). Year. Title of paper. Journal. Volume: Pages.

3) Each web citation should have: Author of Page. Date Posted or Last Updated. Title of Page. Name of Organization Hosting This Page (if different from author). Exact http address. Date of your download.

4) Acknowledge in a short paragraph your thanks to all people who consulted with you, or assisted with equipment, logistics, or funding for your project. Also, your final paper should no doubt also acknowledge helpful comments by your anonymous reviewers.

We have used a variety of grading schemes for these reports including Scoring Rubrics (see "Appendix 3: Scoring Rubrics") or a detailed point total breakdown below:

	names…	pts
title	clarity	1
	appropriate for the study	0.5
	title, authors format	0.5
abstract	length	1
	summarized intro	2
	summarized methods	2
	summarized results	2
	summarized discussion	2
	clarity of prose	2
	grammar	2
	spellcheck	0.5
	all terms used are explained	0.5
	tech terms correctly used	0.5
	all text belongs here	1
	total	**17.0**
	pct	100%
intro.	length	1
	good opening sentence	2
	intro motivates interest	2
	state specific question	2
	state hypothesis(es)	2
	explain/justify hypothesis(es)	2
	used appropriate literature	1
	clarity of prose	2
	grammar	2
	spellcheck	0.5
	all terms used are explained	0.5
	tech terms correctly used	0.5
	all text belongs here	1
	total	**18.5**
	pct	100%
methods	length	1
	site descriptions	1
	site maps (50' rule?)	2
	field sample collection M&M	2
	replication explained	1
	lab sample ID & other M&M	1
	statistics explained (eg. Shannon, ANOVA, K-S test)	1
	can study be duplicated?	1
	clarity of prose	2
	grammar	2
	spellcheck	0.5
	all terms used are explained	0.5
	tech terms correctly used	0.5
	all text belongs here	1
	total	**16.5**
	pct	100%

	names…	pts
results	length	1
	results from all methods told	1
	results order same as methods	1
	text redundancy avoided	1
	statistics appropriate	1
	results clearly illustrated	2
	graphics synthesis	2
	figures well documented	2
	tables well documented	2
	all fig./tables explained in text	2
	replication explained in text	1
	replication adequately shown	1
	appendix of original data	1
	clarity of prose	2
	grammar	2
	spellcheck	0.5
	all terms used are explained	0.5
	tech terms correctly used	0.5
	all text belongs here	1
	total	**24.5**
	pct	100%
discus.	length	1
	good opening sentence	1
	discussed hypothesis(es)	2
	reconnected to intro themes	2
	used appropriate literature	1
	discussed all results	1
	discussion flows effortlessly	1
	future directions clear	2
	clarity of prose	2
	grammar	2
	spellcheck	0.5
	all terms used are explained	0.5
	tech terms correctly used	0.5
	all text belongs here	1
	total	**17.5**
	pct	100%
specials	appendices clearly labeled	1
	acknowledgments	1
	literature cited	1
	significance correctly used	1
	confidence correctly used	1
	"prove" correctly avoided	1
	bonus points (TBA each term)	.
	total	**6.0**
	pct	100%
	big total	**100**