Guide to Writing Genetics Lab Reports: Overview

The instructions provided here are crucial for developing a good Biology lab report. Chemistry or engineering reports are **not** biology reports. High school biology reports are **not** college-level biology reports. The lab reports you will write in this class are based on the format and requirements for publication of research in genetics-related scientific journals. You should learn the correct way to condense protocols into an appropriate Methods section, how to present data effectively, and how to draw conclusions from the data and explain the significance. Here are three websites that provide additional detail on how to construct your lab report:

http://biology.luther.edu/paper.htm
http://ncsu.edu/labwrite/
http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWtoc.html

Your lab report will be graded according to the Genetics lab report rubric available in this lab manual. In brief, you will be graded on completeness (all sections, figures, tables, etc. are present), content (material is appropriate, accurate, referenced as needed, etc), presentation (sub-sections are organized, transitions are clear, figures are properly labeled, etc) and spelling and grammar. Please Proofread: spell-check programs are not designed to catch mistakes in scientific terms. If writing does not come easily to you or English is not your native language, please take advantage of the writing services in the CommLab in Clough Commons (www.communicationcenter.gatech.edu) to improve your written and verbal communication skills.

Some questions to ask while preparing your report:

1. What question was the experiment trying to ask and was the experiment designed to answer that question?
2. What are your controls? Every good genetics experiment needs positive and negative controls to allow you to determine if the experiment truly worked. Some experiments in this lab course may not have controls due to limitations in time or materials; in those cases you should consider what the appropriate control could be.
3. How many samples did you look at? In order to show trends, you can't look at just one sample, you need to look at several. How can you *statistically* represent the patterns you see in your data?
4. What does your data mean? Did your controls work as expected? Does the data answer the question being asked? What else needs to be done? How could you do things better?

Based on the Ecology Guide to Writing Lab Reports by L.E. Green, Z. Marion, L. Lettieri, R. Penczykowski (2010).
Modified for the Genetics Lab curriculum by C. Spencer, S. Stuckey, N. Saini (2011-12)

Guide to Writing Genetics Lab Reports: Lab Report Format

Your lab report should contain the following *labeled* sections:

Title: Construct a phrase that clearly describes the content of the paper/experiment. "DNA Fingerprinting" is too broad; "Comparison of RFLP versus SINE analysis to distinguish crime scene evidence" explains the *what* & *why* of the experiment.

Abstract: The abstract helps the reader to understand the larger document by acting as a summary or "pre-reading" of the key points. The abstract describes the question your experiment is designed to address and its scientific merit. The abstract should be concise yet complete. See the lab report rubric for specifics on what we look for in a good abstract.

Introduction: Provide the context and purpose of the experiment. This is accomplished in three steps:

1. Summarize the broad state of knowledge pertaining to the general topic
2. Identify how the goals of this experiment fit to this knowledge: provide the relevance of the experiment.
3. State the specifics of what was done in the experiment: present your hypothesis and/or objectives.

Background information needs to be cited. Use the introduction to say what you studied in your experiment *and* what broader gaps in general ecological knowledge your experiment addresses. **Example:** "We tested the effects of overexpressing a protein involved in purine catabolism because we wanted to investigate techniques used to correct a disorder associated with toxic buildup of deoxyadenosine." You should take it a step further by trying to convince your reader why they should care. Imagine that you are explaining the experiment and its importance to another biology undergraduate or researcher. Imagine the questions that they might ask you as you are explaining what you did and try to address them in the background. **Example:** "Adenosine deaminase (ADA) deficiency leads to severe combined immunodeficiency (SCID), which is a devastating immunological disorder affecting 1 in 100,000 live births (add citation here), yet the treatment of ADA-SCID through gene therapy techniques to restore the protein has not been widely investigated."

Hypotheses: Be explicit in your comparisons:
"More...than…" "Different…from…" "Difference between ____ and ____"
Examples: "We hypothesized that **more** viable cells would be cultivated after treatment with exogenous adenosine deaminase **than** cells that have not been treated," and "We hypothesized that cells treated with the protein would **differ from** those in which no protein was expressed."

And note that "If…,then…" statements make lousy hypotheses.

Make sure that your introduction follows a logical train of thought. No big transitions. Go from giving background on the state of the field to background on the particular aspect of interest (e.g. insect pollination, odors) to finally background on YOUR system (e.g. the species you are studying). End with a sentence describing your main objectives, the explicit hypothesis you are going to test, and a BRIEF sentence or two on how you tested it. **Example:** "We describe here an experiment to test the hypothesis that treatment of adenosine deaminase-deficient cells with the missing protein will lead to a greater number of viable cells over a period of time than untreated cells. We expressed the protein

following transfection with an engineered plasmid and then monitored for cell viability over a period of time."

Methods: This provides all necessary information so that another scientist could repeat your experiment. What did you do, how did you do it. Be specific and use scientific terms for the materials or equipment used. Do not provide a "shopping list" of the materials needed. We do not need to know you used a black sharpie to label your sample tube, but we do need to know it was a 1.5 ml microfuge tube. Try to avoid using brand names for items unless the brand used is essential for someone repeating your experiment. For a genetics lab, 1.5 ml microfuge tube is preferable to Eppendorf tube.

Explain why you used the control that you used. **Example:** "Because the protein was expressed from a plasmid, we used an empty vector without the gene of interest to account for effects of the plasmid alone."

Try to think of the questions that a reader will have about how you did your experiment and make it as clear as possible, without including extraneous details. Your methods should not read like a short story. Avoid including details like how many times you pipette a sample after adding a reagent and whether you stood while you added the solution as opposed to sitting. Some of that information can be useful, but instead of writing a literary story, be direct and state the reaction conditions, temperature settings or chemical information that you think is important. **Example:** "The study was conducted at room temperature in a laminar flow hood in a biosafety level 3 laboratory." Other pertinent details are size of sample area, how many replicates and what constituted an independent replicate, the statistical tests you used, etc…

If you used statistical methods to analyze your data, the names of these tests should be given, as well as a description of the input data for each test, at the end of your methods section.

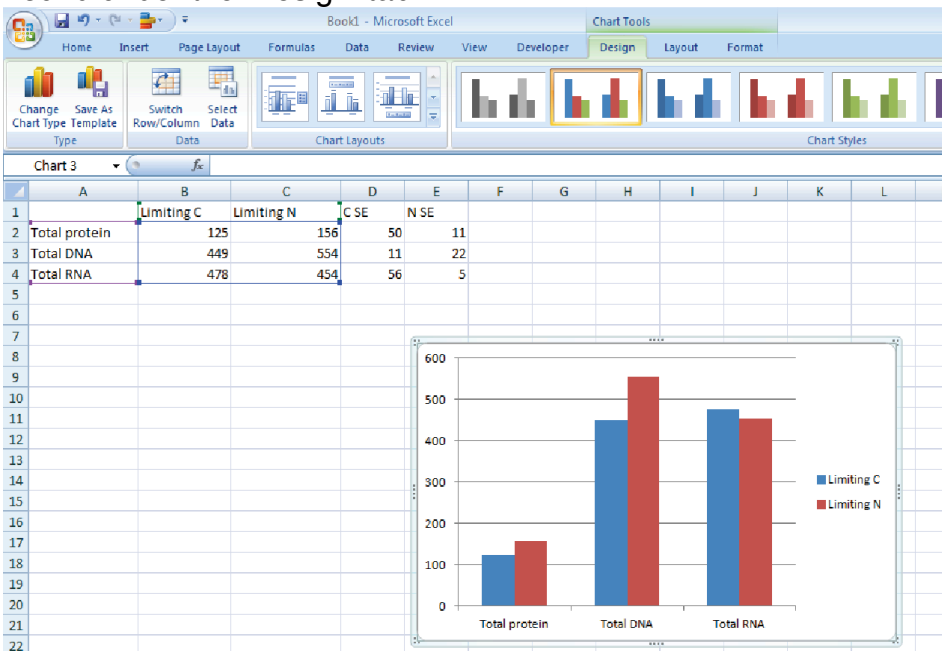
Results: Describe what you found in a paragraph(s) of text – figures alone do not make a complete Results section! Your results are the take-home message of what your data say. Use figures or tables to represent important trends or results of your analyses, and be sure these are cited in the textual description. The tables and figures should be placed at the end of the entire document, numbered, in order. Results should be a summary of data and observations; you should not include raw data. The text should summarize what you found, giving means ± SE or SD. Tell what happened clearly and concisely without interpretation. Use figures to highlight the main point(s). *Use statistics to make your point, but don't make the statistics your point.* Instead of saying: "We got a p-value of 0.001 meaning our results were significant," say instead " The treatment had significantly more growth than the control, according to a two-tailed t-test ($t = 0.87$, $df = 1$, $p = 0.001$)." Explain exactly what the statistical test was testing. Don't just report a Chi-square value and expect the reader to know what you were testing.

If the results can be described in a graph, these are generally easier to interpret than a table. You should not present the same data in several ways; choose the one best way. Given a choice between table and graph, go for the more visual of the two, e.g. if your table is just going to report means ± standard errors (SE), report it graphically. Please note: if you can calculate a mean, then you can calculate the SE. You should always add SE bars to your graph in this case. The default SE bar in Excel is a standard distance away from the mean; this is incorrect, and you will need to enter the correct values. Seek help from your TA if you have never added SE bars to a graph. Figures and tables should be labeled Figure 1 or Table 1 in the order in which they are referred to in the text. Each

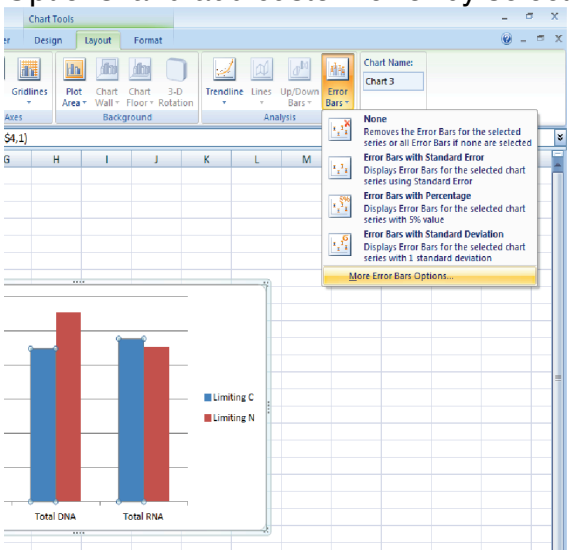
visual aid should have a descriptive caption (1-2 sentences) explaining what they represent. Captions belong *below* a figure, or *above* a table. Figures and tables can be inserted within the body of the text.

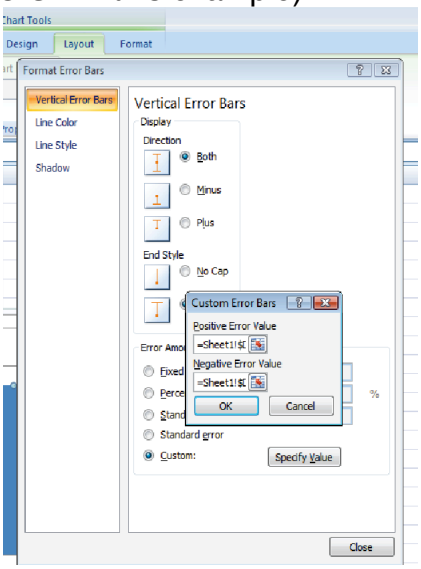
Refer to the following for help creating graphs in Microsoft Excel.

1. Select the data to be graphed and choose the type of graph you wish to use. The graph options can be found under the 'Design' tab.

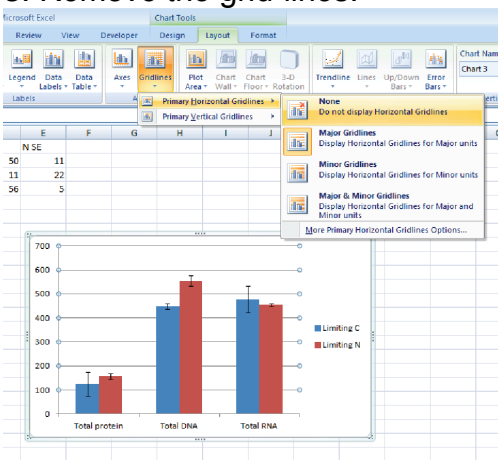


2. Addition of error bars – The option to add error bars can be found under the 'Layout' tab. You can click and select the data series you wish to add the error bars to. On the other hand, you can click on the 'Error Bars' tab and it will ask you to select the data series you wish to add the error bars to. In this example, error bars are being added to the 'Limiting C' data series. Click on the 'More Error Bar Options' and add custom error by selecting the data (C SE in this example).

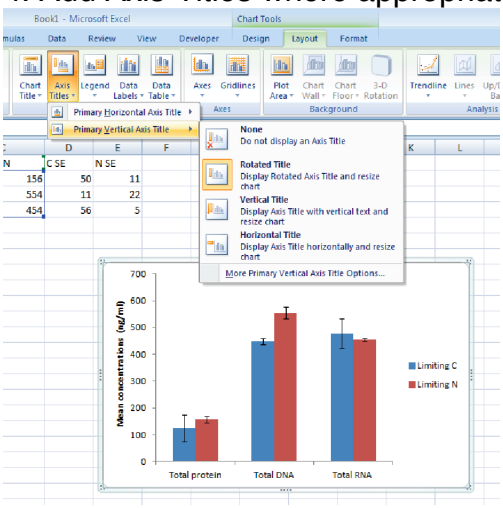




3. Remove the grid-lines.



4. Add Axis-Titles where appropriate



Discussion: Describe how the data relates back to your initial hypothesis/objective. Provide logical arguments explaining what the results mean and how your data relates to the hypothesis you laid out in the Introduction section. If the results of your statistical test cannot be stated in terms of your hypothesis, you need to re-assess the statistical test you used (or use a more testable hypothesis in future experiments). You should compare how your results agree or contrast with your expectations and previously published experiments that relate to your goals. Address any errors in your protocol. Based on your results (and not necessarily the errors of your experiment), suggest logical and interesting experiments for future researchers.

Again, think about your reader and imagine the conversation that a reader might have as they read your report. What questions would they have? How would you use information from the literature to talk about what your results may have meant or what needs to be done next? Only include relevant information, and explain the connection to your results. If information doesn't pertain to your experiment, don't include it (don't just ramble on and on about the general topic or "things that could have affected your results").

Beginning researchers are pretty good at discussing to excess what they might have done wrong to skew or confound their experiments. This is fine, but not the best way to sell your work. Instead, pick the most likely explanations for why you rejected your main hypothesis or hypotheses, and back them up with background literature. Instead of saying "perhaps the protein expression didn't make a difference in cells lacking a native protein," take a stand and confidently talk about your interpretations.

Bad: "Another factor that could have affected our results was the temperature" (followed by no explanation of how temperature would influence our data/results).

Good: "We conducted the experiment in standard laboratory conditions at room temperature. However, true physiological conditions would require an adjustment to 37°C to mimic the natural context in which this protein would be expressed in the human body (add citation here). Thus, the lack of viable cells following expression of the protein was possibly due to improper folding of the protein or low levels of expression."

Literature Cited*: This contains the items specifically referred to within the text in alphabetical order. Items you read but did not specifically cite in the text of your paper should not be included. Format your literature cited according to the style of the journal Genetics (http://www.genetics.org/site/misc/ifora.xhtml#REFERENCES). Notice that there is no example of how to cite a website; websites generally are not appropriate to cite in scientific writing.

In-Text citations*: In the text of your paper, do not use footnotes or quotes. Instead, where you have included relevant information from the literature *in your own words,* acknowledge the source using the author and date format as shown in the following examples:

> As discussed by Friesen *et al*. (2004), invasion experiments show that the two ecomorphs of bacteria co-exist through frequency-dependent selection.
> Wet monarchs are significantly more susceptible to rapid freezing than dry monarchs (Larsen & Lee 1994).

If there are *more* than two authors of a source, cite the reference by the first author name and *et al*. along with the date. For example:

> Leafhopper behavior is affected by … (Larsen *et al*. 1992).
> Larsen et al. (1992) observed new behaviors in leafhoppers…

*From http://biology.luther.edu/paper.htm.

Tables and Figures: The tables and figures should be placed at the end of the entire document, numbered, in order. Each table should have a title above it and an explanation or key to symbols below, if needed. Each figure should have a complete caption below it that restates the key finding of the figure.

General writing style:

Use **active voice** to make your sentences clear and concise. (If you don't know the difference between "active voice" and "passive voice," please ask your TAs or look it up.)

Use **past tense** throughout your paper, with some exceptions in the Introduction and Discussion. When you are providing background information or describing current unknown questions in science, it is okay to use present tense. But your text describing the hypotheses (typically the last paragraph of the Intro and the first paragraph of the Discussion) should be in past tense. See the **good** example above in the Discussion section.

In this class, we encourage you to use 1st person ("I" or "we"), past tense, but don't use first names when referring to yourself or your lab partner. Appropriate ways to address individuals in the report are limited: first initial first name and last name (G. Burdell) or last name only (Burdell).
Bad: "The plasmid that the experimenters decided to use was obtained from the Jordan laboratory."
Good: "We obtained the plasmid from the Jordan laboratory."
Note: You may find yourself in situations (e.g., other classes, other fields of study, or other countries) where you are encouraged to write in 3rd person. As long as you are **consistent** in your writing style and do not resort to excessive wordiness, we will not penalize you for writing in 3rd person.

Citing sources: Find the information you need, put it in your **own** words (don't quote!), and cite the source. Consider that in a Literature class, *how* something is said is as important as *who* said it ("To be, or not to be: that is the question" W. Shakespeare); in science, we are not concerned with how something was said, only *who* said it. So you should summarize another scientist's ideas/results and then provide their information. Any ideas/information that did not originate in your brain must be cited. Consult a writing reference or published papers (e.g. in the journal *Genetics*) for proper citation format.

Appropriate Verbs:

- Test (the hypothesis)
- Develop
- Determine
- Provide
- Isolate
- Characterize
- Identify
- Restore
- Implement
- Generate
- Facilitate

Some words/things to avoid:

- Starting sentences with This/That/It (it usually isn't clear to what you are referring)
- Appears
- Believe
- Think
- Obviously/clearly (this makes assumptions on what the reader is thinking)
- Very
- Excessive commas (look up the basic comma rules if you don't know them)
- Making statements about absolutes e.g. "X never happens" or "X always happens"
- **Prove or disprove** – Biology is stochastic. There is always the opportunity for chance to change the expected outcome. Thus, we cannot prove or disprove anything.
- Using words in their "common" sense (i.e., their definition outside of science) if those words also have specific scientific or statistical definitions.
  Examples: significant, correlate, normal, sample, isolate, extract

Genetics Lab Report Rubric (for exploratory science or hypothesis-driven research) **Modified 9/6/2015**

Criteria	Specific Objectives	Level of Achievement			
	Each specific objective is worth 2 or 3 points for excellent work, 1 point for needs work, and 0 points if absent.	Excellent	Acceptable	Needs work	Absent
(1) Title of lab report (2 points)	(a) Title is specific and clearly conveys a summary of the lab report findings.				
(2) *Abstract: (12 points)* The abstract helps the reader to understand the larger document by acting as a summary or "pre-reading" of the key points. The abstract describes the question your experiment is designed to address and its scientific merit. The abstract is concise yet complete: ≤ 300 word paragraph summary. 1-2 well-developed sentences articulate each objective listed.	(a) Links purpose or motivation for experiment to concepts and "big picture." (b) States particular question/objective or (alternative) hypothesis addressed in experiment. (c) Briefly summarizes experimental approach. (d) Describes major findings and interpretations. (e) Findings are linked back to question or hypothesis. (f) Describes importance & significant implications of experiment.				
(3) Introduction: (12 points) What does the reader need to know to understand your questions? Background might include a review of the general genetics topic under study and/or why the study system is appropriate to address your question.	(a) Provides background specific to your question. (b) Links purpose or motivation for experiment to concepts and "big picture." (c) Ends with a statement of hypothesis or goals.				
(4) *Methods(10 points)* How will you address your question? What data will you collect and how? How will you analyze and interpret this data? What do you expect to find and what evidence would be needed to support your hypothesis?	(a) Begins with 1-2 sentences describing the overall experimental design, including the purpose of the experiment. (b) Describes specific data collection with appropriate detail so the experiment could be replicated, noting any changes to published protocols. (c) Describes analysis and interpretation procedures, e.g., statistical test, appropriate for the data & question. (d) Describes evidence needed to address question or support/reject hypothesis (e) Includes appropriate controls.				
(5) *Results: (9 points)* What did you find?	(a) Begins with 1-2 sentences describing the overall findings of the lab. (b) Reports only findings from the data analysis, without making explanations or conclusions about the data. (c) Findings correspond to data and reported results in lab notebook.				

Continued …

(6) *Discussion: (10 points)* What do your findings mean? Interpret your results with regard to your hypothesis.	(a) Begins with a statement relating the overall results to the question or hypothesis. (b) Uses specific data as evidence to decide how the question is addressed or whether hypothesis is supported. (c) Uses scientific concepts accurately and convincingly to explain how the question is addressed or whether the data support the hypothesis. (d) Connects back to ideas in the introduction. (e) Describes importance & significant implications of experiment. *Addresses other issues as appropriate, e.g., problems that occurred; sources of uncertainty in the lab procedure or findings; comparison of findings to others' findings and explanation for differences; improvements or extensions of the experiment.*				
(7) *Figures & tables: (10 points)* Graphs; drawings, diagrams, tables.	(a) Appropriate visuals for the type of data. (b) Uses correct format (axis labels, graph components such as legend). (c) Caption describes the result in sentence form below figure or as title above table. (d) Discusses and clearly references visuals in text (e) Displays visuals at the end of the report.				
(8) Literature Cited: (10 points) List of all published literature cited in the lab report, formatted in the style of the journal Genetics.	(a) Cites at least two appropriate peer-reviewed scientific papers in addition to all other resources necessary to the writing (4 points) (b) Avoids citing websites unless appropriate for this particular subject. (c) Formats in-text and literature cited (at end) in the style of the journal *Genetics*. (d) Includes in-text citations with the concept they reference, not shuffled to the end of a paragraph.				
(9) Writing and ideas: (15 points) Grammar; spelling; clarity and conciseness of sentences; flow of ideas; use of technical terminology.	(a) Avoids grammatical and spelling errors. (b) Sentences are clear and to the point. (c) Flow of ideas is cohesive and logical. (d) Use of technical terminology is appropriate (e) Words are abbreviated or italicized consistently and as appropriate (e.g. species names, gene and allele names)				
(10) Format of report: (10 points) Organization; page formatting; font style	(a) No separate title page or page breaks between sections (b) Report is written entirely in sentences organized as paragraphs (not bulleted list), with appropriate paragraph breaks between ideas. (c) Abstract limited to 300 words (d) Report is organized into sections (i.e., abstract, methods, etc.) with headings that are bold. (e) Page format: Times New Roman 12 pt font (even for headings); 1 inch margins; single-spaced; pages are numbered as needed.				