More Than Meets the Eye: Lab Write-up Guide for IB

Always include the following unless told it's not necessary. All labs need to be typed but all rough data need to be attached to the back (when applicable). The basic objective in writing laboratory reports is to communicate your methods and conclusions as clearly as possible. All labs should be written in the ***third person****.* ***Do NOT use I.*** *Do not personalize labs. Each person's lab should be unique. No two sentences in any two lab books should be identical, even lab partners. Make 2 copies, one for my file and one for your file. Be sure to include a cover page on* ***top of your lab reports with your first and last names, class, date, and investigative question.***

Investigative Question:
This will be a question that includes both the *independent* and *dependent* variables. The hypothesis is a possible answer to this question, and the actual answer should be in your conclusion.

Background:
Many of the investigative procedures you do involve complicated concepts. Include here any *information* that helps the reader understand what you wanted to accomplish, and why. Research is needed to do a good job but put all information in your own words (read, take brief notes, put texts away, write it up). Use citations for anything you didn't already know. If appropriate include other experiments and their results done on this subject. Here would also be an appropriate place to state your general aim. You **MUST reference** all material with citations in this section. *Refer to the SIGNIFICANCE portion of the Habits of Mind if you have trouble starting this section of the lab report.*

Hypothesis:
Predict an outcome based upon the background information. Whether you are right or wrong has no effect on your grade. The quality of the hypothesis however, is crucial. Whatever you decide to try to prove, you must be sure that it has a relevant biological focus that matches the experiment. **The independent and dependent variables should be identified in the hypothesis as well as the problem question.** The usual format is ***ÏF …***something is done and it affects the object, ***THEN…..*** Include a rationale or reason for your hypothesis which ties into your background. You will need to include a null hypothesis when you are using statistics (t-test, chi^2) to analyze the data.

Variables Description:
A valuable way to make sure you include all your variables appropriately is to make up a table like this before you do the experiment.

Independent Variable (what you are changing)	**Dependent Variable (what you are measuring)**	**Controlled Variables (those factors that need to be held the same in each trial to ensure a fair test)**

A **control** is a comparative trial built into your experiment to ensure that your dependent variable is being produced or effected by the independent one. Very different than controlled variables (a.k.a constants)!

Materials:
All materials used in the lab should be listed including sizes and quantities of each (ie. 4 100-ml beakers, NOT beakers). Remember to include everything needed, such as subjects, field, forest, computer, sensor type, etc. Diagrams of apparatus are appropriate; do not include pictures of individual pieces of equipment.

Methods:
In point numbered format, summarize step-by-step what you will be doing to carry out the lab. These should be in your own words, and should include ALL details as these are your lab directions. Include reasons behind relevant steps. The steps should be clear enough for anyone else to follow. If you use a specialized apparatus, include a labeled diagram. You may also include a table of how your trials will be set up if it makes your procedure more clear. If you are working with organisms (living or preserved), explain briefly how you designed the lab on an ethical level. **If the activity is a planning lab, the procedure will be done individually and in class. The original procedure and grade will be turned in at the end of the lab, although you may retype to show modifications. Use citations if you get ideas or help from sources other than our class.**

Results or Data:
IB needs to see your rough data in the table you originally used. Make sure to have your data table or original observations attached to the back of the lab. If you redo it in the process of manipulating your data, adding

calculations, reformatting it, etc. – that reworking becomes part of your Data Interpretation section. **You still need to include the original data table (initialed by me to show it was original and completed before the experiment was performed).** Make sure tables contain a title, units for each column, columns for any calculations you will have to do (if you forget some, you can add them to the final data table) and the appropriate number of significant digits.

Sometimes there are obvious systematic or random errors that decrease your data's value. Describe simply any such errors just under the data table or after the data interpretation section. Include the uncertainty of the data (or margin of error: MOE) at the top of each column of measurements. MOE is usually ½ the unit of measurement but could be more or less dependent up on preciseness of data collection. This MUST be included to obtain highest marks for Data Collection.

Figure out your percentage error **if possible**. In biology it rarely is used. The equation for this is:

$$\frac{\text{True value} - \text{Observed value}}{\text{True Value}} \times 100 =$$

Drawings are raw data – make sure you follow standard conventions in making them. Labeling is a way of processing that data. All drawings should be on blank paper.

1) Make large clear diagrams in pencil only. **Do NOT colour biological diagrams!**
2) Draw accurately what you see.
3) Draw individual parts of a specimen in strict proportion to each other.
4) Have appropriate **headings** and state **magnification** when necessary.
5) Use **straight lines** to label a diagram. Use a ruler, and do not label on the drawing.
6) **Do not cross label lines**. Labeling should occur at the end of the straight line. All labels should be written horizontally.
7) Microscope diagrams may need to be done at different magnifications; magnifications must be included.

Data Interpretation and Manipulation:
You will manipulate your data through various calculations or graphing activities in most labs. Indicate how you did calculations by including at least one sample for each type. **Graphs must include descriptive titles, units, be in proper scale and should be either hand drawn or be from a graphing program as I indicate ahead of time.** Usually the independent variable goes on the X axis. Only specific types of computer graphs are allowed and I will let you know when they are appropriate. If you don't know – DO ANY GRAPHS BY HAND ON PAPER!!! Use curved lines to show uncertainty in the graph and you may indicated error bars by including SE or standard deviation where applicable.

Include statistical analysis in the form of std deviation/variance/boxplots (denotes the reliability of your data), correlation graphing/use of t-test (determining relationship between 2 variables), and/or use of chi-squared test to see if the outcome was within range of what was expected.

Discussion: Consists of 2 parts.

a. Conclusion: Explain what the results tell you. What is the answer to your problem? Restate the hypothesis and compare your conclusion to it. How reliable are your results? Do the data follow current scientific trends, or were there errors that leaves your conclusion questionable? Evaluate and explain your results, which lead straight into the evaluation, if you encountered many difficulties. Use citations if you read other sources and included their ideas.

b. Evaluation: What errors did you find or perform during the experiment? How reliable and true are your data? Are they accurate (close to the true values) and precise (measurements taken to the proper significant digit)? Discuss any difficulties. Impact of errors and suggestions for improvement should also be included. How could you have performed this lab better?

Evaluation Cont-

What use is doing this lab and how might the data be used? Are there further experiments that can be performed or did the data suggest other avenues to explore? What anomalies were there and where were the errors? How did those affect the data? Use the following table to help you describe those errors and how to fix them:

The error or problem encountered	How that error affected the data	A suggestion for improvement
Thermometer was held upside down when taking the temperature of the H2O2	The temperature values were outside the accepted values for the H2O2 temp	Hold the thermometer the other way (right side up).

Note: do not say "Measurements could have been more accurate…" or "there was error in measurement." Or "we could have worked harder/paid more attention." Those are not valid evaluation statements and you are just wasting paper.

Some things to avoid:

1. Having hypothesis, procedure, & conclusion be about different things. These 3 parts should be consistent
2. Not recording data: if in doubt – record it. You should not include those values that are outliers.
3. Taking too small a number of samples or trials. The more, the better.
4. Recording data that did not occur. DISHONEST!!!!
5. Beginning to work on the lab procedure and data table or the write-up the day before it is due. What happens if you have questions? Or electricity goes out? Or you get sick?
6. Working too closely with your lab group. Even if there is a suspicion of copying or use of same material, you will both noted has having committed **malpractice** and **administration** will be informed.

A checklist to make sure you have everything:

- ☐ Are the independent and dependent variables clearly and correctly identified?
- ☐ Is the hypothesis testable? Is it suggesting an answer to the aim or question of the activity? Is it supported by scientific knowledge?
- ☐ Are there appropriate strategies to control other variables that might affect your results?
- ☐ Is there a clear easy-to-follow, step-by-step procedure/method outlined that someone else could follow?
- ☐ Does the experiment actually test whether the hypothesis is supported or disproved?
- ☐ Have you got title and column units in your data table? Included MOE in each column?
- ☐ Did you show how you did any calculations? Included units in all equations and work?
- ☐ Did you use an appropriate system of data analysis (right sort of graph)?
- ☐ Did you look at uncertainties by calculating STD deviation and/or SE? (in your data and any instrument you used)
- ☐ Have you used consistent significant figures?
- ☐ Do your graphs have descriptive titles and units on the axis? Curves included or error bars?
- ☐ Does the conclusion accurately reflect the data?
- ☐ Are your procedural modifications fully and accurately discussed?
- ☐ Have you noted sources of error and how to fix those problems?
- ☐ Are anomalous results identified and explained in a reasonable manner?
- ☐ Suggests things, which might be done in the future to improve the design?
- ☐ Include all raw data at the back of the lab?
- ☐ Include all rough drafts at the back of the data?