**IB HL Biology Lab Report Outline (INMAN)**

Cover Sheet with Title (Includes detailed title, name, date, class)

I. **Title**: Needs to clearly describe the lab and include the IV and DV.

II. **Design**:

 **Background**: Give a brief, but thorough introduction to the content behind what you are investigating, IN THIRD PERSON (NO “I”, “You,”, or “We”). This background needs to include the detailed SCIENCE/BIOLOGY behind your investigation. You can also include the reasons behind choosing this topic to investigate…just keep it in third person! Introduce and state your general research question/aim here. If you use a source, CITE IT PROPERLY IN MLA FORMAT. However, don’t use a source for knowledge we learn in class that you should really already know (common knowledge?). Citing a dictionary is just silly!

 **Hypothesis**: Now that you’ve introduced the reader to the content, state your hypothesis. The general format is “If…(IV), then…(DV), because…(scientific logic/reasons for the prediction). **YOU MUST HAVE SCIENTIFIC JUSTIFICATION FOR THE HYPOTHESIS**.

 To really solidify your hypothesis, don’t just say that an “increase” or “decrease” in the DV is expected, but discuss HOW/IN WHAT WAY the DV will change (ie; discuss rate, shape of the curve, leveling off/stabilizing…when will this happen and why).

 YOU ARE **NOT** DEVELOPING THEORIES!

 **Sketch Graph**: This should be done electronically, not hand-written. The axes should be labeled just like they will be in the DCP section and there should be a detailed title on the sketch graph. A general trend line is fine. Just make sure this sketch graph matches what your hypothesis says!

 **Identify variables**:

 **Independent variable**: Identify what this is (ex: *Amount of fertilizer*) and the different levels that were used (ex: *5.0g, 10.0g, 15.0g, 20.0g*), along with the reason for using these different levels and the uncertainty in measuring these levels

 (ex: *+/- 0.1g*).

 **Control group**: Do you have a group that did not receive the IV? Or one that represented the naturally-occurring variation (ex: *seeds with 0.0g fertilizer*).

 **Dependent variable**: Identify how you measured the effect of the independent variable (ex: *plant growth in height*) and uncertainty/units (ex: *+/- 0.5mm*). Remember that you must use a metric form of measurement.

 **Controlled variables**: A great way to organize this is by using a table (see Table 1). Be VERY specific on the WHY and HOW. Don’t forget to title this table!

**Table 1: Controlled Variables for Effect of Fertilizer Concentration on**

**Height of *Brassica rapa***

|  |  |  |
| --- | --- | --- |
| **Variable to be Controlled** | **Why the Variable is Controlled** | **How the Variable is Controlled** |
| **GOOD** Ex: *Species of Seed/Plant*☺ | **GOOD** Ex: *Different species of plant can exhibit different rates of growth and have varying nutritional and environmental needs.* | **GOOD** Ex: *Only Brassica rapa (mustard) seeds will be used.* |
| **BAD** Ex: *Plant*☹ | **BAD** Ex: *The plant needs to be kept the same because different plants can give different results.* | **BAD** Ex: *The seed type will be kept the same.* |

 **Method**: This is how the experiment was completed!

 **Materials**: A materials list is not always necessary, but it helps organize your method. A table is often nice for this, too (see Table 2).

**Table 2: Equipment for** **Effect of Fertilizer Concentration on Height of *Brassica rapa***

|  |  |  |
| --- | --- | --- |
| **Equipment** | **Quantity** | **Uncertainty** |
| **GOOD** Ex: *100mL Graduated Cylinder*☺ | **GOOD** Ex:*1* | **GOOD** Ex:*+/- 0.5mL* |
| **BAD** Ex: *Graduated Cylinder*☹ | **BAD** Ex: *1* | **BAD** Ex: *10mL* |

 ***YOU DON’T NEED TO INCLUDE***: (*isn’t it a bit elementary?*)

 *Step 1: Gather materials.*

 **Procedure**: Starting with SAFETY guidelines, give a detailed (perhaps broken into steps) procedure that another person could replicate EXACTLY. A good experiment is REPRODUCABLE so that other scientists can verify results (test and retest). If you do not include an essential step/part of what was done in the lab, and another person could not reproduce your experiment exactly, then you may score a “0” on Aspect 3 of the Design!! Labeled pictures/diagrams of the setup are nice in this section.

 **Don’t forget**: You need to make clear the number of TRIALS here.

 Be very clear as to what data was collected (**quantitative** AND **qualitative**)

 You can discuss how data will be analyzed after collected, but do so briefly, as this will be evident when one reads the DCP section. The biggest concern here is that YOU think about how you will analyze your data BEFORE you collect it…and make a data table(s).

III. **Data Collection and Processing**

 **Raw Data**: This is the table comprised of the raw numbers (quantitative data) you collect on the day of your experiment. Be sure that you give a VERY detailed title and uncertainties.

EXAMPLE:

**Table 3: Height (+/-0.5mm) of *Brassica rapa* at fertilizer concentrations of 5.0g-20.0g after 14 days of growth.**

|  |  |
| --- | --- |
|  | **Height (+/- 0.5mm) After 14 Days of Growth** |
| **Grams of Fertilizer****(+/- 0.1g)** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** | **Trial 5** |
| 0.0 | 27.5 | 20.5 | 28.0 | 30.0 | 26.5 |
| 5.0 | 32.5 | 30.0 | 30.0 | 35.0 | 33.5 |
| 10.0 | 34.5 | 35.0 | 38.0 | 32.5 | 36.5 |
| 15.0 | 38.0 | 39.5 | 42.5 | 40.5 | 44.5 |
| 20.0 | 50.0 | 48.5 | 46.5 | 45.0 | 40.0 |

Or…

**Table 4: Height (+/-0.5mm) of *Brassica rapa* at fertilizer concentrations of 5.0g-20.0g after 7 and 14 days of growth.**

|  |  |
| --- | --- |
|  | **Height (+/- 0.5mm) After 14 Days of Growth** |
| **Grams of Fertilizer****(+/- 0.1g)** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** | **Trial 5** |
| **Day 7** | **Day 14** | **Day 7** | **Day 14** | **Day 7** | **Day 14** | **Day 7** | **Day 14** | **Day 7** | **Day 14** |
| 0.0 |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |
| 10.0 |  |  |  |  |  |  |  |  |  |  |
| 15.0 |  |  |  |  |  |  |  |  |  |  |
| 20.0 |  |  |  |  |  |  |  |  |  |  |

There are bunches of ways to organize your data, even beyond these two! This is where you can let your creativity out!

Now don’t forget qualitative data! You can organize this in different ways. To collect the data, it’s nice to have a table. But also summarize in a little paragraph.

**Table 5: Qualitative Observations of *Brassica rapa* at fertilizer concentrations of 5.0g-20.0g after 14 days of growth.**

|  |  |
| --- | --- |
|  | **Qualitative Observations**  |
| **Grams of Fertilizer****(+/- 0.1g)** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** | **Trial 5** |
| 0.0 | pale green leavesand white stem;  | pale green leaves; yellow spots;pale green stem | greener than the others at 0.0, but pale in comparison to experimental groups | Pale green leaves, green stem | Pale green leaves; yellow spots, white stem |
| 5.0 |  |  |  |  |  |
| 10.0 |  |  |  |  |  |
| 15.0 |  |  |  |  |  |
| 20.0 |  |  |  |  |  |

Or…

**Table 6: Qualitative Observations of *Brassica rapa* at fertilizer concentrations of 5.0g-20.0g after 14 days of growth.**

|  |  |
| --- | --- |
|  | **Qualitative Observations of Leaf Color and** **Stem Color (DG = dark green, G = green, P = pale green, Y = yellow, W = White)** |
| **Grams of Fertilizer****(+/- 0.1g)** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** | **Trial 5** |
| **LEAF** | **STEM** | **LEAF** | **STEM** | **LEAF** | **STEM** | **LEAF** | **STEM** | **LEAF** | **STEM** |
| 0.0 | PG | W | PG,Y | PG | PG | G | PG | G | PG, Y | W |
| 5.0 |  |  |  |  |  |  |  |  |  |  |
| 10.0 |  |  |  |  |  |  |  |  |  |  |
| 15.0 |  |  |  |  |  |  |  |  |  |  |
| 20.0 |  |  |  |  |  |  |  |  |  |  |

But always have a little paragraph that summarizes your qualitative findings:

EXAMPLE: Plants that did not receive fertilizer showed the palest leaves, sometimes even having yellow spots, as well as white stems. Etcetera, etcetera…

 **Processed Data**: Most labs involve at least averaging and calculating standard deviation of your raw data. You can include this information in your raw data table (which would no longer make it a “raw” data table only, and that’s ok! You’d never label your table “raw data” anyways, right? If it will fit on the page, this is probably the most efficient way to go because a reader can see all the data, raw and processed, right there together.

 If you have to use a separate table, that’s ok! Just be sure to put a very detailed title on it!

 Sample calculations should be included wherever you have your processed data (like underneath the data table). Try your hardest to get these typed and not hand-written. Use actual data from you lab (duh?) and tell the reader which data you are using.

 EXAMPLE:

 Sample calculation of average height (+/- 0.5mm) of *Brassica rapa* trials 1-5

 at 0.0g (+/-0.1g):

 (27.5mm + 20.5mm + 28.0mm + 30.0mm + 26.5mm) / 5 = 26.5mm

 If you are graphing your data, don’t forget that you probably want to get the equation of any best fit line or curve you find. Include that equation somewhere in your processed data as well.

 **Presenting Data**: Now it’s time for your graph(s)! Be sure to use very detailed titles on these, too (pretty much the same ones on your processed data tables). Make sure you have:

 - uncertainties on your axes and in the title

 - made your graph large enough so it is clearly visible

 - not made your points/dots/markers too large

 - added a trend line/curve and equation

 - NOT CONNECTED THE DOTS (in most cases)

 - added error bars and told what they represent IN THE TITLE

 - NO GRAPHED RAW DATA

 - included a legend if there are multiple lines (and make sure you either print in color or make the line styles different to be ascertained in black and white print)

IV. Conclusion and Evaluation

 **Conclusion**:

 Going back to your hypothesis, state your conclusion based on the data collected.

 - Do NOT say the hypothesis was…

 ☹- PROVEN, DISPROVEN, CORRECT, INCORRECT, WRONG, RIGHT

 -DO use words like…

 ☺- SUPPORTED, NOT SUPPORTED

 You must then go back to the scientific reasoning that was used to explain your original hypothesis…and revisit this ***scientific justification***, explaining how the results jive with the justification or not. If the experiment/data made some other relationship evident, give a detailed scientific explanation for why what happened may have happened.

 Be sure to discuss any equations fit to lines.

 Don’t assume the reader knows…DON’T USE PHRASES LIKE:

 *“It is evident,” “As you can see,” “Obviously,” “It is very visible,” etc.*

 Revisit the rubric CHECKLIST for other important discussions that should be included in your conclusion.

 **Evaluating Procedures:**

Revisit rubric CHECKLIST.

 Time management and human error are not valid scientific errors. Your procedure should have been designed with the given time limit as a consideration. You should also develop your procedure to decrease the human error as best as you can (ie; using a Vernier probe to collect data versus you manually recording data).

 Make sure you know the meanings of these words if you are going to use them:

 ***ACCURATE/ACCURACY PRECISE/PRECISION CONSISTENT***

 ***VALID RELIABLE SKEWED***

 ***ANOMOLOUS***

 **Improving the investigation**:

 Revisit rubric CHECKLIST.

 Tying into “Evaluating Procedure,” a table is nice.

**Table 7: Weaknesses/limitations of the experiment “*Effect of Fertilizer Concentration (5.0g-20.0g) on Stem Growth of Brassica rapa over 14 days*” and suggested areas for improvement**

|  |  |  |
| --- | --- | --- |
| **Weakness/Limitation** | **How it may have affected the data** | **How it could be improved** |
| *Ex: Seed size variation*☺ | *Ex: Due to the fact that some seeds were larger than others (despite all being the same species, Brassica rapa), this may have caused some plants to grow larger than others due to genetics/size of the seed.* | *Ex: Seeds used in the experiment could be screened to make sure they are all the same size (1mm in diameter) in order to control for this variable.* |
| *Ex: Time limitation*☹ | *Ex: Due to the fact that the experiment had to be conducted in one hour, only 3 plants were used in the experimental trials. This limited the amount of data that could be collected.* | *Ex: An unlimited amount of time would be granted for working on this experiment.* |