How to read this guide
Bold Headers: refer to suggested sections included in the IA (these are given in the order they would appear in the written report)
- Clarifying points for elements of what should be included in these sections
- **[Codes]** reference the extended marking rubric by Chris Pain found here to justify why these elements should be included

* *Additional notes,* sometimes with examples from past student IAs

Title Page (optional)

- Research Question (RQ) as title
- Personal Code
- Page count (does not include title page or works cited, numbering should start on next page)

Background

- Provide context for your RQ (disturbance, climate change, infections, treatment, etc.) **[E2.2]**
- The reader should understand *why* you are doing this study, why it's important – it should clearly convey personal interest and try to include local issues (if possible) **[P2.2] + [P2.3]**
- Explain any scientific theory/information relevant to your study of which the reader should be made aware. **[E2.4]**
- Explain and justify your *study species* – why is this species being used? Could include picture of species to give more context

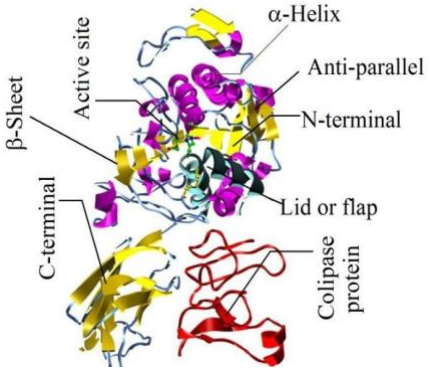


Figure 1 Structure of human pancreatic lipase (HPL) *(Mukherjee, 2014)*

** When pictures are used, include a picture caption. If you didn't take the picture, reference its use **[C4.10]***

- Describe prior studies (if relevant) that have conducted a similar experiment and outline their findings **[E2.1]**

** Search https://scholar.google.com/ using your chosen topic/variables to find and read relevant studies*

- Why is your study novel/different than past investigations? **[P2.1] + [P3.1]** If your study has already been done, explain what new aspect your investigation is bringing to the literature/topic **[P2.4]**

** Entire section should be heavily supported with multiple, different, relevant scientific citations (scientific papers) and cited in a consistent format in-text (scientific, MLA, Oxford, etc.) **[E2.5] + [C1.6]***
** Citations should only be of information relevant to answering your RQ or its context **[C3.3]***

Aim of Investigation

- Provide a brief explanation of what you are going to do in your investigation, i.e. what is your goal?

Research Question

- One-sentence research question. Should be specific and concise and contain the IV and DV and species name (if applicable). The reader should know very clearly what you are investigating **[E1.1] + [E1.2]**

Ex: To what extent does the concentration of ammonium hydroxide (0.1mM, 1mM, 4mM, 7mM, 10mM) affect the ability of aquatic plant *Ludwigia ovalis* to absorb ammonium as measured by the change in pH over time?

- The research question needs be able to be answered by a clear hypothesis **[E1.3]**

Hypotheses

- **Hypothesis:** Provide a clear, concise, measurable hypothesis i.e. what do you think will happen? **[E2.7]** This could be supported with a general sketch graph of what you think the relationship will be (figure 2) **[E2.8]**
- **Justification**: Provide reasons why you think this will occur. This should be supported by scientific papers and prior studies **[E2.7]**

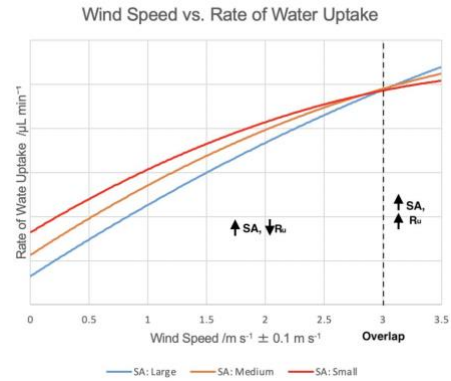


Figure 2 Graphical representation of hypothesis, portraying wind speed against rate of water uptake with different leaf sizes

If statistical tests are used (ANOVA, t-test, chi squared, etc.):

- **Null Hypothesis (H_0):** No significant differences between your independent variables (used in your statistical analyses). The likelihood of this statement being true is tested in order to decide whether to accept or reject your alternative hypotheses **[A2.4]**
- **Alternative Hypothesis (H_a):** A different significant result than your hypothesis. **[A2.4]**

Independent Variable

- Describe what it is (including units if applicable)

Ex: concentration (mol/L), pH, temperature (°C), reaction time(s), surface area (cm^2), ratio x:y…

- Justify why these (range, quantity, increments) were chosen. Can be adapted from prior studies **[E3.1]**
- How will this be manipulated? **[E3.6]**

Dependent Variable

- Describe what it is (including units) **[E3.2]**

Ex: pH, change in temperature (°C)/ mass (g)/ height (cm), gas produced (mL), absorbance (Au), yield (g), conductivity (Amp), voltage (V), heart/respiratory rate (BPM), area of growth (mm^2), concentration (mol/mL)…

- How it will be measured **[E3.2]**
- Justify why this was chosen (why this measurement, quantity, etc.). Can be adapted from prior studies.

** Strong justifications for your variables provide the reader with confidence as to the methodological design.*

Control Variables

- Include this as a table: **[E3.3]**

Variable	Impact	Method of Control
Name of the variable	*What is the potential/likely impact this could have on results, i.e. why is it important to control? You should provide reference if appropriate* ***[E3.4] + [E3.5]***	*How will this be controlled / kept constant. Should include specific apparatus and values [****E3.9****]*

Risk Management

- Describe what the potential risks/hazards are in your method and how you will prevent these. Good references: CLEAPSS, chemicalsafety Can be presented as a table: **[E4.1]**

Hazard	Nature of the Hazard	Control
Name of the hazard. Can be chemical, microorganism, hazardous procedure or equipment	The potential harm or risk this hazard poses to the investigator	How will this be controlled so as to minimize/eliminate risk?

Ethical/Environmental Considerations

- Describe how your investigation may cause ethical (if living subjects are involved) or environmental (such as disposal or disturbance) concerns and how these were minimized/mitigated or prevented (if possible) **[E4.2/4.3]**

***** *Even if you think you don't have any health/safety/ethical/environmental considerations, you still need to discuss this and justify why*

Materials and Apparatus

- Each material should be followed by an amount (with units) and quantity (if relevant) **[E3.8]**
- Each apparatus/measuring instrument should be followed by the unit in which it measures and an uncertainty (examples: 30cm ruler ± 0.1 cm, 2x 100mL glass beakers ±5mL, electronic balance (to nearest 0.01g ± 0.005 g) **[E3.8]**

**A measure of the accuracy of an instrument is given by its uncertainty. As a good rule of thumb, the uncertainty of a measuring device is 50% of the smallest division.*

- Include a diagram of the experimental setup **[E3.8]**

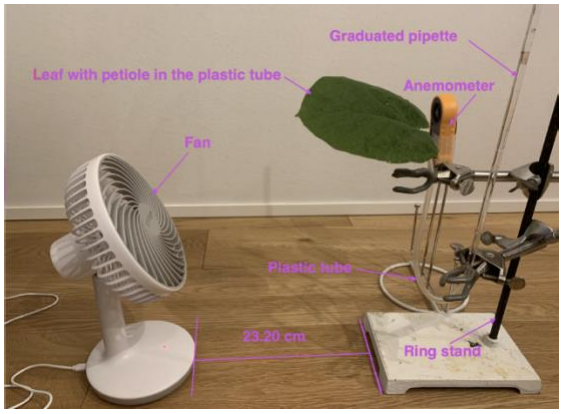


Figure 3 Experimental setup

Method

- Step by step. Every single step should be included, including how data is collected–the more detailed the better–as the goal is to write a clear enough method that it is easily repeatable. **[E3.11]**
- Include how you will keep controls constant [**E3.9]**
- Your method should include how data is collected, potentially including diagrams or pictures of how data is collected (this makes it more personal and can even provide evidence) **[E3.7]**

Counting bacterial growth as squares covered:

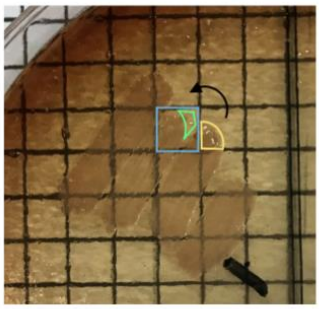


Figure 9. example of how to organize and count number of bacteria filled squares

1.Using a ruler, create a grid with squares of 0.5×0.5cm, making sure that the grid is large enough to cover the petri dish (refer to figure 8)
2.draw the outline of the petri dish and how the quarters will be placed so they are kept constant between dishes
3.Count the squares that the bacteria are covering for each sample, some rounding will be needed. As an example referring to figure 9, when a square is not completely filled (blue), use bacteria in other square (yellow) to fill in the missing surface (green).

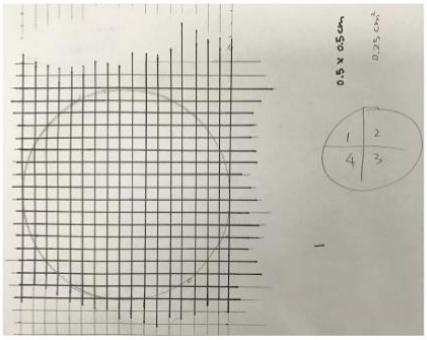


Figure 8. Grid on paper

- In your method, when you mention measuring tools, include how data should be collected and the units and uncertainties of those tools **[E3.11]**
- If your method is based on an established protocol (like preparing agar), cite this **[E3.12]**. If your method of collecting is an already-known protocol, adapt it for your needs **[P3.2]**

***** *If your method involves multiple parts, these can be separated into separate sections for clarity*

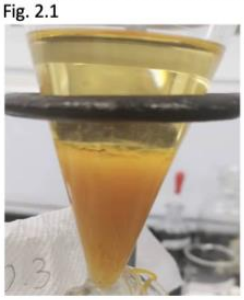
Data Presentation and Analysis

- Short introduction on what was collected in order to answer RQ and how it is presented **[A1.1]**
- Justification of data manipulation and statistical tests carried out **[A1.1]**

Raw Data, Qualitative

- Observations should be briefly included (perhaps in a table form if it is observational data over time) **[A1.4]**
- Should be accompanied by pictures

1.75wt%
Solid formation in separatory funnel
Fig. 2.1



A half solid material sedimented in 2/3 of the trials. This material melts with body temperature and is of a golden opaque color. The one trial that formed glycerin (clear) also had a layer of solid forming between the glycerin and crude biodiesel (Fig. 2.1).

Raw Data, Quantitative

- Tables of raw collected data.

Format:

Table 1 – short description of table

Independent variable (unit & uncertainty)	Dependent variable (unit & uncertainty)				
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
	5				

X = anomaly

** Tables need to include title, caption, units and uncertainties in headings, and do not span multiple pages*

[A1.5] + [C2.2] + [C2.3] + [C2.4] + [C2.5] + [C4.6]

** Raw data should not include calculated values (mean, st. dev, etc.)*

Processed Data

- Include a short description of what tests were conducted
- Tables of processed data (data that has been calculated), such as mean/average, St.Dev. (Standard Deviation), S.E. (Standard error), *p value*, df (degrees of freedom) **[A2.1] + [A2.2] + [C4.6]**
- For each type of calculation, you may include a formula and a worked example (not necessary) **[A2.6]**
- Ensure decimal points are consistent (mean same decimal place as raw data) **[C4.4]**

*** Data requirements for valid analysis and statistical analyses:*

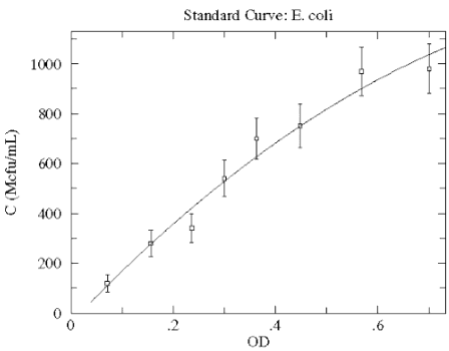
- *IV: min. 5 increments over a suitable range **[A1.2]***
- *DV: min. 5 repeats/samples (if less than 5 you cannot calculate St.Dev. and must use range) **[A1.3]***

Notes about Statistics:

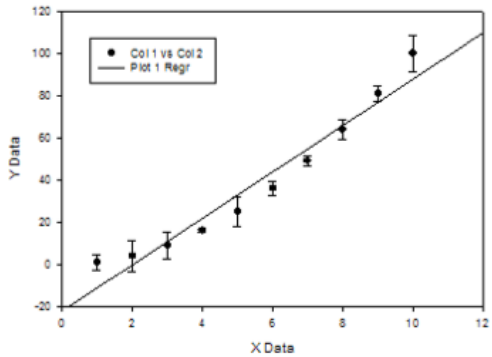
- The main purpose of data processing is to elucidate variation and reliability of the data (which will be a determining factor for your conclusion and discussed in analysis and evaluation)
- If you are unsure what statistical tests to use, consult the following flow diagram: here
- Suggested tests:
  - Mean – allows you to find a clear pattern from your trials
  - Standard Deviation/error – displays variation surrounding your mean (plotted as error bars). If error bars overlap, groups are *likely* not different from one another – still need to conduct stats test
  - T-Test (2 groups) / ANOVA (>2 groups) – allows you to see if there is a significant difference among your experimental groups. The calculated *p* value is compared to a critical value (based on df) and your null hypothesis is either accepted (no significant difference) or rejected (significant difference). Note: To see which groups differ specifically, a *post-hoc* test needs to be done. Guide ANOVA
    *in order to do an ANOVA and Tukey *post-hoc* you need to test for: normalcy and variance

Graphs

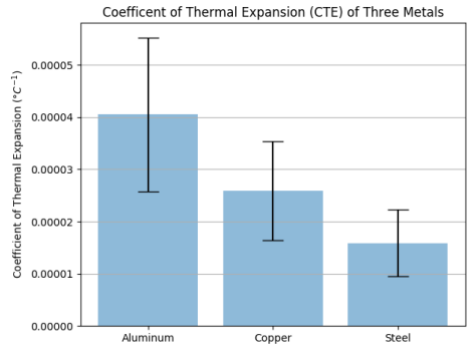
- Graphs clearly and effectively represent data – need to be legible and neat and be the correct type; this will depend on whether your data is continuous or discontinuous **[C4.7]**



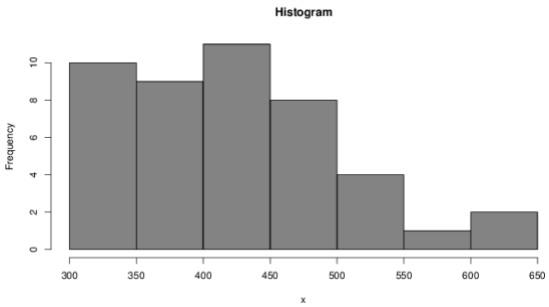
Line graph – change over time



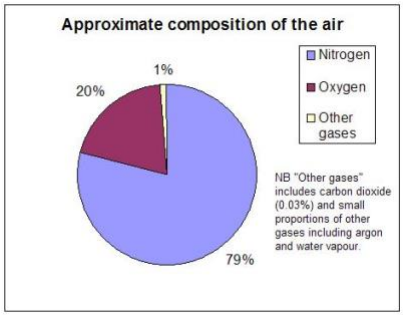
Scatter plot – correlation of variables (independent x, dep. y)



Bar chart – comparing groups



Histogram – distribution of data



Pie chart – parts of a whole

** Graphs need to include title, caption, axis labels (with units), legend (if applicable), error bars (from SD or SE) , trendline (if applicable) and be scaled appropriately* **[A3.4] + [A3.5] + [C2.2] + [C2.6] + [C4.8] + [C4.9]**

For a guide on how to use excel to create graphs like a scatter plot, go here and add error bars, go here

Analysis

- Interpret the patterns and trends in the data, refer to tables and graphs when reporting numbers/trends **[A4.1]**. Compare groups and trials/repeats. Be specific. **[A4.4]**
- Discuss the variation (SD) in the data (error bars) and possible anomalies/outliers **[A4.2] + [A4.3]**
- Discuss the uncertainty of your data (*p value*, critical value for stats tests → do you accept or reject null/alternative hypothesis?). **[A3.3]** Do you need to remove data, and if so, does this impact your findings? **[A3.1]**
- Discuss qualitative data **[EV1.1]**

Conclusion

- Provide a conclusion based on your data and analysis. Was your hypothesis correct? Does it answer your RQ? (re-address RQ here and answer it) **[EV1.2]**
- Do the trends/patterns have problems making it difficult to be certain (St.Dev., p value, t-test)? **[EV3.1]**
- Is this conclusion strong – why or why not? **[EV1.3]**
- What scientific explanation are there for your observed results? **[EV2.1]** How do your results compare to those of previously conducted investigations/research data? **[EV2.3]**
- What does this mean for your context? **[EV2.4]**

Evaluation of Method

- *Strengths*: Details about your method and how it helped to provide reliable data to answer your research question. Can discuss how your method was novel or unique. Can mention strong data (low St. Dev, low p values leading to reliability in results). Potential applicability of results.
- *Weaknesses and limitations:* Be honest here!

Factors to consider:

  - Was your method appropriate/adequate at obtaining a valid conclusion to your RQ (was there enough range of IV) (was there is enough repeats of DV)? **[EV3.2] [EV3.3]**
  - Were control variables adequately controlled? **[EV3.4]**
  - Limitations (things you could have done but didn't) i.e. lack of time, equipment, space, etc.
  - Appropriateness of measuring apparatus
  - Potential sources of error in your study (this can link to outliers) **[EV4.4]**

** Note: Errors discussed should be limited to systematic errors, not random/human errors*

- *Suggestions for Improvement:* Discuss clear, specific improvements/suggestions to how this method could be improved in order to better answer RQ **[EV4.1] + [EV4.2].**
- Be specific in terms of materials and apparatus you would use

** While written for social sciences, this guide can give you more information*

- Suggestions should be reasonable to a high school student context

  ** Every suggestion should address a previously-mentioned weakness and improve data*
- Can include this as a table for ease and clarity:

Weaknesses/limitations	Improvement

Future Directions/Extension

- Provide future directions for the context of the study: What should be looked at further to better tackle this problem? **[EV4.5]**
- Connect the research study to possible real-world applications

Bibliography

- Include all referenced material in a consistent format (MLA/APA/Scientific/Oxford) and in alphabetical order. Use a citation maker like: calvin.edu or citethisforme.com to help you create one.
- References should be from various reputable sources (not from the same few)

**Note: Keep track of your resources as you write the IA (save URLs in a document)—don't wait until the end!*

Example:

Mukherjee, A. K. (2014). Hydrophobic-hydrophilic interaction in lipase catalytic triad and possibility of a cofactor mediated catalysis. *International Journal of Agricultural and Food Science*, 84-89.

Appendices

- Not necessary, avoid if possible
- Include any supporting material (like stats) or images that do not need to be in the main body of the report but can be referred to. These should be annotated as well. **[C4.10]**

Reminders:

- Page length: 6-12 pages **[C3.5]**
  **Note: Does not include title page, bibliography, or appendices (if included)*
- Try to write in third person/passive voice whenever possible
- Double-check all spelling and grammar throughout the report. If complex scientific, content-specific language needs to be used, ensure you understand its meaning and outline it in the report for the reader **[C4.11] + [C4.12] + [C4.13]**
- Double-check formatting: headings, subheadings, page numbers, margins, tables, captions, etc.
- Double-check you have included all in-text citations where appropriate
- Double-check your IA with rubric to ensure it meets **all the criteria**

Disclaimer:

I wrote this guide as a DP biology teacher both for my students as well as my colleagues, as the IA rubric and expectations are sometimes unclear. While I studied biology at the graduate level and took an IB PD on the IA, I am not an IA examiner and this guide does not necessarily reflect the views of the IB. Not everything I suggest is required for a successful IA, but I included elements that I felt are important in the writing of a strong science academic paper. I synthesized elements from other teachers, guides, and free online resources.

This guide was largely inspired by Chris Pain's IA marking rubric as I wanted a way for students to make sense of all the required elements. It is worth noting that this is not the official rubric, but for me, it is more comprehensive and easier to understand (and grade). The official IA guide from IB can be found here.

For further information see these other useful IA guides from eycawat, biology for life, mrGscience, IAcreator