Checklist for Internal Assessment

**Exploration - approximately 4 pages**

**Title:**
- an experimental study on….
- include both the independent variable (what’s being changed) and the dependent variable (what’s being measured)
- example: An experimental study on the rate of reaction of rennin on different percentage concentrations of full cream milk

**Research Question:**
- one line statement on what the experiment is about
- outline to what extent the independent variable is being changed and what the dependent variable is being measured in
- if a living organism is used, identify it by common and scientific name
- example: What effect will the percentage concentration of full cream milk (measured from 60% to 100% concentration in 10% intervals) have on the rate of reaction of rennin and milk (measured in time taken in seconds to form clots) at a temperature of 35°C?

**Background Information:**
- use scientific theory to describe and explain how the chosen IV affects changes in the organism/biological material being dealt with, and why the chosen DV is a good measure of this change
- include figures to illustrate concepts more clearly - numbered, titled, and referred to in text
- include an explanation of personal engagement (what led you to this particular question?)
- sources are cited appropriately

**Hypothesis:**
- should be in the form of if… then… because… (prediction is explained using scientific theory)
- should be quantitative when possible
- sources are cited appropriately

**Variables:**
- columns, on the left, the variable, and on the right the important information
- IV correctly identified with units and precision - discuss method to manipulate IV, specific reasoning for range and increments
- control group (comparative trial) built into your experiment to ensure that your dependent variable is being produced or affected by the independent one is identified if applicable
- DV correctly identified with units - discuss method to record/measure DV, determine uncertainty, and any calculations that need to be done
- 5+ controlled variables (factors that could impact results if not kept the same throughout the experiment) clearly identified - discuss why these variable might impact the data collected, how these variables will be kept constant, and if necessary how they will be monitored
Checklist for Internal Assessment

<table>
<thead>
<tr>
<th>Variable</th>
<th>How Manipulated/Measured/Recorded/Kept Constant</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independant:</td>
<td></td>
<td></td>
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<tr>
<td>Temperature (units w. uncertainty)</td>
<td>State temps used</td>
<td></td>
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<tr>
<td>Dependant:</td>
<td></td>
<td></td>
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<tr>
<td>Rate of O₂ production (units)</td>
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<td></td>
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<tr>
<td>Control:</td>
<td></td>
<td></td>
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<tr>
<td>State variable</td>
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Materials:
- detailed list of materials - including quantities, concentrations, volumes, masses etc
- detailed list of equipment - including (in brackets) the uncertainty
- annotated photo of experimental set-up with a clear description - make sure to show how control group(s) differ from experimental group(s)

Procedure:
- step-wise format that can be repeated by others - third person and past tense
- describe how to manipulate the IV, including specific details of range/increments
- state the method for recording results, including units and uncertainty of tools
- each variable identified in the variables table should be addressed in the procedure
- clearly communicates the reasons why each step is appropriate and necessary
- minimum 5 trials over a suitable range of 5 independent variable “intervals” (unless comparing populations)
- if the procedure is based on or adapted from a published protocol then the original protocol must be cited

Safety, Ethical, or Environmental Issues:
- columns - on the left, the issue, on the right, how the issue was addressed
- comment on possible hazards, environmental, ethical and social impacts of the investigation, and how they were dealt with to minimize the impact
- discuss use of chemicals in terms of handling and disposal
- if using human subjects, refer to IB Animal Experimental Policy

<table>
<thead>
<tr>
<th>Issue</th>
<th>How Issue Addressed</th>
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Analysis - approximately 4 pages

Raw Data:
- raw data clearly distinguished from processed data (separate table)
- raw data collected is sufficient to support a detailed & valid conclusion
- one table that includes each of the 5 IV “intervals” - not 5 separate tables, no breaks in table
- table title is specific, including IV and DV
- units of IV and DV present and correct in table heading
- uncertainty indicated (with units) in heading - same decimal places as recorded data
- all data recorded is correct and honest (matches the group data if applicable)
- decimal places in a column correspond (and match uncertainty)
- include detailed qualitative observations in paragraph form after raw data table - mention anything noticed that might affect results, such as variation within the organism/biological material being dealt with
- example: Table 1: Table showing the time taken (in seconds) for different percentage concentrations of milk (60%- 100% in 10% increments) to react with the enzyme rennin at 35°C

Sample Calculations:
- include a short paragraph section that gives an overview of how and why you decided to process and present the data in the form that shows up in the processed data - why do SD/POE over using uncertainty of measuring device
- show a sample calculation (all stages to the final result) for each type of calculation done. For standard deviation, include a written explanation of how excel was used to calculate it. Explain it in a way that someone who doesn’t know how to use excel would understand.
- mathematics applied correctly (carry decimals through calculations, final answer in significant figures (should match raw data), uncertainty in final answer has same decimal places as recorded data)

Processed Data:
- table title is specific, including IV and DV
- columns clearly labelled (uncertainty with units in heading)
- use appropriate measure of uncertainty. Calculate standard deviation when 5x5 (if propagation of error isn’t necessary). If propagation of error is necessary, use standard deviation in calculation.
- calculations or statistical test appropriate to investigation and address RQ (SD/POE needs to be done for each data point (ie. 5 times for a 5x5 experiment). Mean and standard deviations recorded in the same units and the same uncertainty, if present, as the data they are calculated from
- use appropriate decimal places within column (consistent with precision of recorded data)
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Results:
- descriptive title for graph, including IV and DV (no uncertainty)
- appropriate choice of graph - default choice should be a scatter plot. If comparing means, i.e. the data is in the 2 IV values x 20 repeats format, then a histogram is appropriate
- axes labelled clearly, including units (no uncertainty) - numbers should be to same number of decimal places as the data they are based on
- axes scaled appropriately
- graph at least 3/4 a page
- standard deviation used for error bars if no propagation of error was necessary
- If propagation of error was done, then it is used for error bars for each data point
- trend line included, as well as the equation of the line and $r^2$ (significant figures) if 5x5
- mean and standard deviation included if 2x20
- include caption stating any other important information - ex: error bars on y axis too small to be plotted, number found in the equation that tells the reader the slope of the line - $m$, error bar source (i.e. SD/POE), mean, standard deviation, justification for including trend line

Evaluation - approximately 4 pages

Discussing Strengths and Weaknesses:
- clearly describe a minimum of 3 weaknesses/limitations due to random biological variation, measurement/instrument errors, systematic error (problems with the method)
- in table format - in the left column, the weakness/limitation, on the right, an explanation of why and how it contributed to the reliability, accuracy, and overall quality of the data
- include at least one strength in the table as well
- identify anomalous data points and any methodology that may have led to them
- make reference to error bars (or standard deviation) with regard to variability of results

Suggestions for Improvement and Extension:
- in table format - in the left column, what you could have improved, on the right, an explanation as to how you could improve this in the future - specific and practical
- provide enough detail so that it could actually be implemented in this course
- suggest next steps and extensions based upon the conclusion: If the level of support is strong look to extend the investigation - possibly look at different independent variables. If the level of support is weak look to repeat the investigation - possibly modify the method, change the way the dependent variable is measured or collect more data, carry out more repeats
- sources are cited appropriately
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Conclusion:
☐ - clearly state the conclusion (as it relates to the hypothesis) - what do the results indicate in terms of the IV and DV? How does the DV link to and help answer, the research question?
☐ - appropriate language used “supports the hypothesis” (not “proves” or “is correct”)
☐ - support the conclusion with specific numerical reference to your data
☐ - if looking for trend/correlation, i.e. the data is in the 5 IV values x 5 repeats format: Is there a pattern to the data? Positive/negative correlation, straight line, bell shaped curve, u-shaped, s-shaped, does it plateau? How large are the error bars? The smaller they are the stronger the correlation is. Are there any anomalies in the raw data that explain abnormal large error bars. Do the size of the error bars make a valid conclusion difficult to reach?
☐ - if comparing means, i.e. the data is in the 2 IV values x 20 repeats format: is one bar on the chart/mean value higher than the other? Is there an overlap of error bars? The larger the overlap the less likely the means are to be significantly different from each other. Does a t-test confirm the observations made in the previous point? Are the error bars similarly sized? If different does this indicate possible errors or simply natural variation? Are there any anomalies in the raw data that explain abnormal large error bars?
☐ - discuss qualitative data - does the qualitative data indicate a possible reason for the natural variation seen in the data?
☐ - justify the conclusion by describing the theoretical mechanism
☐ - compare results with published data and theoretical texts - does the data support accepted theory?
☐ - sources are cited appropriately

Works Cited:
☐ - minimum 3 reliable sources
☐ - statements of fact are cited appropriately
☐ - MLA or APA format

These are also evaluated on the Rubric - do not need to have a separate written section in your report

Communication
☐ - clear presentation of investigation - tables/graphs don’t break across pages
☐ - structure - effective use of space, graphs clear, colouring appropriate
☐ - relevant information included and appropriate terminology used

Personal Engagement
☐ - evidence of personal engagement - independent thinking, initiative, creativity
☐ - justification for choosing research question - personal significance, interest, curiosity
☐ - evidence of personal input and initiative in the designing, implementation, presentation