# INTERNAL ASSESSMENT INTRODUCTION

- This project, known as an **internal assessment** (IA) will consist of one investigation or scientific exploration.
- You will spend **10 hours** doing this investigation but it will provide 20% of your overall assessment for your IB biology score.
- The written assignment should be **6–12 pages** in length.
- The variety and range of possible investigations is large, you could choose from:
- Traditional hands-on experimental work.
    - This could involve extending some of the protocols that you undertook as part of the syllabus or you might investigate in a practical way an experiment relevant to some of the concepts you have learned through the course.
- Database investigations.
    - A database is a mass of information that can be searched through the use of query.
    - You may obtain data and process and analyse the information for your investigation.
    - Examples might include GenBank, the Allel Frequency Databse (AlFreD) or the Audubon Christmas bir d count
- Simulations and Models.
    - It may not be feasible to perform some investigations in the classroom, but you may be able to find a computer simulation.
    - The data from a simulation could then be processed and presented in such a way that something new is revealed.
    - For example, the Game of Life simulation allows the exploration of emergent properties.
- Combinations of the above are also possible.
- The subject matter of your investigation is up to you.
- It may be something within the syllabus, something you have or will study, or it can be related to the syllabus or outside the syllabus.

# THE PURPOSE OF INTERNAL ASSESSMENT (IA)

- IA enables you to demonstrate the application of your knowledge and skills.
- Work submitted for IA must be your own personal work.
- Teachers are expected to be/ will be an important source of support during both the planning stage and the period when you are working on the internally assessed work.
- Your must read and be familar with the IB animal experimentation policy and explain the IA criteria by which your work will be judged.

- You are required to discuss the internally assessed work and obtain advice and information through out this process. There will be a series of stages that you must address personally.
- **Teachers are allowed to read and give advice to students on one complete draft of the work.**
- **Teachers can give oral or written advice to you, but cannot edit your draft.**
- **The next draft handed in must be the final version for submission.**
- **Delaying submission of the 1st draft will mean that feedback/advice will not be given and this submission will be considered the final version.**
- All work must be authenticated before finalized approval by the teacher.

## INTERNAL ASSESSMENT CRITERIA

- There are five assessment criteria, ranging in weight from 8-25% of the total possible marks.
- The criteria are the same for SL and HL students.

| Criterion | Points | Weight |
|---|---|---|
| Personal engagement | 0–2 | 8% |
| Exploration | 0–6 | 25% |
| Analysis | 0–6 | 25% |
| Evaluation | 0–6 | 25% |
| Communication | 0–4 | 17% |
| **Total** | **0–24** | **100%** |

- Your teacher will guide you through the procedure and will assess your work according to five criteria.
- If they are too generous or too harsh, the scores may be changed by an external moderator, so you need to make it as clear as possible that you deserve high scores.
- For IA you carry out a scientific investigation and write a **6 – 12 page report** on it.
- The first task is to choose a research question.
- IB regulations allow database investigations and the use of simulations or models, but the guidance given here assumes that you are doing experimental work.

- Humans cause problems in experiments, especially with the control of variables, so it is best if your research question refers to other species.
- The IB has strict ethical rules for animal experiments and although they do not ban using animals, they prohibit procedures that cause suffering to animals.
- Experiments with plants, bacteria and fungi are less likely to raise ethical concerns.

## GUIDANCE ON PERSONAL ENGAGEMENT AND EXPLORATION

- After your teacher introduces the idea of an internal assessment investigation, you will have an opportunity to discuss the topic of your investigation with your teacher.
- In dialogue with your teacher you can then select an appropriate topic, define a workable research question, and begin to do research into what is already known about your topic.
- You will not be penalized for seeking your teacher's advice.
- Your teacher will help you develop a topic, then a research question, and then an appropriate methodology.
- Your teacher will provide guidance as you work and they will read a draft of your report, making general suggestions for improvements or completeness.
- Your teacher will not, however, edit your report or give you a tentative grade for your report until it is finally completed.
- **After this you are not allowed to make any changes.**
- You should choose a question that you are genuinely interested in, but also that is suitable for investigation by doing experiments.
- Your work will be assessed on your ability to provide a focused, purposeful, and personal approach to your investigation.
- Have you found a topic that interests you?
- What is the specific purpose of your investigation?
- Have you written an introduction with references that explains to the reader the importance of the topic and other relevant information that gives context to your investigation?

## ACADEMIC HONESTY

- It is **your responsibility** to appreciate the meaning of academic honesty, especially authenticity and intellectual property.

- You are also responsible for initiating your research question with the teacher, seeking help when in doubt, and demonstrating independence of thought and initiative in the design and implementation of your investigation.
- You are also responsible for meeting the deadlines set by your teacher.
- The IA is your responsibility, and it is your work.
- **Plagiarism** and copying others' work is not permissible.
- You must clearly distinguish between your own words and thoughts and those of others by the use of quotation marks (or another method like indentation) followed by an appropriate citation that denotes and entry in the bibliography.

# RESEARCH QUESTION (RQ)

## ADVICE ON WRITING A SUCCESSFUL RESEARCH QUESTION (RQ)

- If you are really stuck and do not know where to start, one formula for a RQ is to ask 'What is the influence of X on Y?', where X and Y are factors or variables that can be measured, controlled, or counted.
- Make sure that anything in your RQ can be measured using materials and techniques available to you in the school..
- Be as precise as possible, even if it means that the RQ is quite long.
- If you are using any living organisms, or products from living organisms, such as seeds from a certain plant, give the most precise name you can and give the scientific name if possible (e.g. *Pisum sativum* for garden peas).
- Think about timing: can your experiment be completed in the amount of time the teacher is giving you?

# VARIABLES

## INDEPENDENT VARIABLE (IV), DEPENDENT VARIABLE (DV) AND CONTROLLED VARIABLES (CV)

- Have you listed the IV and DV, and explained how any other variables (CV) that influence your data collection will be controlled?
- The ***independent variable (IV)*** is whatever is changed on purpose by the investigator to see what effects it will produce.
    - It is what you are testing to find out what happens.
    - It should be the only thing that is different from one part of the experiment to the other.
- The ***dependent variable (DV)*** is whatever you will be measuring as the results of your investigation.
    - It is whatever changes in the experiment because of the manipulations of the experimenter.
    - Some scientists like to think of the dependent variable as 'nature's answer': it is how the natural world's laws respond to your research question.
- For example, in an experiment testing the effect of different amounts of fertilizer on the growth of bean plants, a range of five different concentrations of fertilizer would constitute a variable.
- Everything else must be the same, the type of plant, type of soil, age of plants, light conditions, etc.
- The one thing that you can vary on purpose, each different concentration of fertilizer, is the independent variable.
- The ***controlled variables (CV)*** are the things that are kept the same in all parts of the experiment in order to be sure that the experiment is fair.
- These variables ensure that the independent variable really is solely responsible for any changes recorded, because the independent variable is the only thing different between one test tube and the next.
- There is no need to make an exhaustive list: just be sure to identify the controlled variables that would most dramatically affect the results in an undesirable way.
- **Reminder**: do not confuse 'controlled variables' with 'the control'.
- The control of an experiment is a variant of the experiment that is set up in order to have something to compare the other results with.

## METHODOLOGY

- Will the methodology you are planning result in sufficient numerical data so that techniques of analysis such as standard deviation can be used?

- One of the most important parts of your methodology is to make sure that you will be able to collect as large a sample of data as possible for each range of variable that you have chosen.
- Continuing with our example of fertilizer on bean plants, five plants per concentration of fertilizer would be the minimum amount of data that would be considered sufficient.
- Have you explained how you have modified a standard method and made it your own design?
- Have you considered safety, environmental, and ethical concerns?
- Is your personal approach and engagement with this investigation obvious to the reader?
- When writing your method, take inspiration from other methods or think about a recipe in a cookbook.
- You should be as precise and concise as possible.
- Here are some of the kinds of things to consider.
    - Could your method be read by someone else and fully understood by that person?
    - Have you clearly described how the independent variable is integrated into the steps?
    - The dependent variable?
    - All the controlled variables?
- For glassware such as beakers and flasks, be sure to indicate the volume in millilitres (ml).
- If you just ask for test tubes, the standard size will be given but be aware that there are some with smaller or wider diameters.
- If the glassware is going to be heated, think of what you might need when moving it once it is hot, such as wooden pinchers or metal tongs.
- If the experiment involves cutting something, do not forget to ask for a knife (or scalpel if necessary).
- For chemical solutions, you must be precise about the concentration (in % or in moles per litre) as well as the volume (in ml).
- Think about materials used to transport things: the manipulation of liquids will probably require the use of pipettes or syringes, the manipulation of powdered chemicals will require a spatula, and, if you need to weigh the powder, how will you put it on the balance?
- Did you ask for a balance?
- If you ask for any electronic probes (for temperature, light, humidity, etc.), be sure to ask for an interface for connecting them to the computer, laptop or a data-logging device.

- Thermometers come in three forms: glass thermometers, electronic thermometers, and temperature probes.
    - Be sure to state clearly what kind you need.
- If an experiment needs to be saved overnight from one lesson to the next, did you ask for a tray or a box to keep the samples in?
    - Are they labelled?

## GUIDANCE ON PERSONAL ENGAGEMENT (8%)

- This criterion assesses the extent to which you engage with the investigation and make it your own.
- Personal engagement may be recognized in different attributes and skills.
- These include thinking independently or creatively, addressing personal interests, and presenting scientific ideas in your own way.
- For maximum marks under the personal engagement, criterion, you must provide clear evidence that you have contributed significant thinking, initative, or insight to your investigation.
- You research question could be based upon something covered in class or an extension of your own interest.
- For example, you may have a *green thumb* and you enjoyed the practicals that you did with plants in class.
- You could turn your botany talents to growing a number of plants for your study.
- Personal significance, interest, and curiosity are expressed here.
- You may also demonstrate personal engagement by showing personal input and initiative in the design, implementation, or presentation of the investigation.
- Perhaps you design, and improved method for measuring the rate of an enzyme controlled reaction or devised and interesting method for the analysis of data.
- You are not to simply perform a cookbook-like experiment or repeat and experiment that is commonly carried out in most practical work programmes without any modification.
- The **key** here is to be involved in your investigation, to contribute something that makes it your own.
- Show that you have specific reasons for being interested in the research question.
- Show that your investigation involved as many of your own ideas as possible and the research question, experimental design and presentation of results are not all copied from elsewhere without modification.

**EXAMPLE:** A personal approach to design

- A student is interested in diving and wants to investigate the slowing of the heart when a diver holds their breath underwater (bradycardia).

- She takes her pulse on the surface and the after holding her breath for 30 s at the bottom of a swimming pool.
- There is a reduction in the pulse rate.
- She takes her pulse using the simple method of feeling her radial artery and couting for 30 s.
- The student wants to find out how rapidly the pulse falls, whether it falls suddenly or gradually and whether it stabilizes at a lower rate.
- She needs to monitor the heart rate continuously for one minute or more underwater.
- For this she needs an electronic probe, but the equipment that her teacher offers her has to be kept dry.
- If the student designs her own method for this, she will certainly have demonstrated a personal approach.

**ASSESS YOURSELF ON PERSONAL ENGAGEMENT (8%)**

| Descriptor | Check box |
|---|---|
| Shows personal significance, interest, or curiosity | ☐ |
| Shows personal input or initiative | ☐ |
| Shows personal engagement with independent thinking and insight | ☐ |

- Check which descriptors your work best.
- The marks that can be awarded are a 0, 1, or 2, depending on how you have engaged with the investigation and made it your own.
- Evidence of engagement could be personal interest, creativity in designing the experiment, or initiative in its implementation. 0 means none of the descriptors is fulfilled; 1 means one or two have been fulfilled; and if all three have been fulfilled, then it's a score of 2.
- Remember that you are not comparing yourself with just the other students in your school: you are comparing yourself with IB students all over the world.
- Use a best approach to grading yourself using these criteria.
- Tick the boxes in the Check list columns that are the most appropriate for what you have achieved, and determine your mark.
- This exercise can give you a chance to improve your work because you are grading yourself.

| Mark | Descriptor |
|---|---|
| 0 | The student's report does not reach a standard described by the descriptors below. |
| 1 | **The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or creativity.**<br>The justification given for choosing the research question and/or the topic under investigation does not demonstrate **personal significance, interest or curiosity**.<br>There is little evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation. |
| 2 | **The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or creativity.**<br>The justification given for choosing the research question and/or the topic under investigation demonstrates **personal significance, interest or curiosity**.<br>There is evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation. |

## GUIDANCE ON EXPLORATION (25%)

Describe the biology relating to your investigation so that it is clear why you want to ask your research question.

- State the research question clearly.
    - It should be focused rather than broad, so you can obtain enough experimental evidence to develop convincing conclusions.
- Background information about your investigation must be appropriate and relevant.
- Explain how you designed and developed your experimental procedures, including preliminary trials, how you will ensure that the date is reliable and that there is enough to provide strong evidence relevant to the research question.
- Include a risk assessment of the experimental methods used and an audit or environmental and ethical considerations.
- The **key** here is your ability to select, develop, and apply appropriate methodology and produce a scientific work.

## ASSESS YOURSELF ON EXPLORATION (25%)

| Descriptor | Check list | | | | | |
|---|---|---|---|---|---|---|
| RQ is | **Not focused** | ☐ | **Not fully** focused | ☐ | **Fully focused** | ☐ |
| Background information is | **Superficial** or of limited relevance | ☐ | **Mainly** appropriate | ☐ | **Entirely** appropriate and relevant | ☐ |
| Methodology to answer the RQ is | Very **limited** | ☐ | **Mainly** appropriate | ☐ | **Highly** appropriate | ☐ |
| Methodology | **Limitedly** considers relevance of the data to the RQ | ☐ | **Somewhat** considers relevance of the data to the RQ | ☐ | **Completely** considers relevance of the data to the RQ | ☐ |
| Methodology | **Limitedly** considers factors that influence reliability and sufficiency of the data for the RQ | ☐ | **Somewhat** considers factors that influence reliability and sufficiency of the data for the RQ | ☐ | **Completely** considers factors that influence reliability and sufficiency of the data for the RQ | ☐ |
| Awareness of the safety, ethical, or environmental issues | **Limited** | ☐ | **Some** | ☐ | **Full** | ☐ |

- If most of your ticks are in the left-hand column, you cannot give yourself more than 2 marks for this criterion.
- If most of your ticks are in the middle column, you can give yourself a 3 or a 4.
- If most of your ticks are in the right-hand column, you can give yourself a 5 or a 6 for the Exploration criterion.
- How have you done so far for exploration?
- Do you need to use more references for background information?
- Do you need to improve your methodology and collect more data?

| Mark | Descriptor |
|---|---|
| 0 | The student's report does not reach a standard described by the descriptors below. |
| 1–2 | The topic of the investigation is identified and a research question of some relevance is **stated but it is not focused**.<br>The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation.<br>The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.<br>The report shows evidence of limited awareness of the significant **safety**, ethical or environmental issues that are **relevant to the methodology of the investigation***. |
| 3–4 | The topic of the investigation is identified and a relevant but not fully focused research question is described.<br>The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation.<br>The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.<br>The report shows evidence of some awareness of the significant **safety**, ethical or environmental issues that are **relevant to the methodology of the investigation***. |
| 5–6 | The topic of the investigation is identified and a relevant and fully focused research question is clearly described.<br>The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation.<br>The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.<br>The report shows evidence of full awareness of the significant **safety**, ethical or environmental issues that are **relevant to the methodology of the investigation***. |

## GUIDANCE ON ANALYSIS (25%)

- This criterion assesses the extent to which your report provides evidence that you have selected, processed, analysed, and interpreted the data in ways that are relevant to the research question and can support a conclusion.
- For maximum marks under the analysis criterion, your investigation must include sufficient raw data to support a detailed and valid conclusion to your research question.
- Your processing of data must be carried out with sufficient accuracy.
- Moreover, your report must show evidence of full and appropriate consideration of the impact of measurement uncertainty on yoru analysis.
- Finally, for maximum marks, you must correctly interpret your data, so that completely valid and detailed conclusions to the research questions can be deduced.
- The **key** here is to make an appropriate and justified analysis of your data that is focused on your research question.

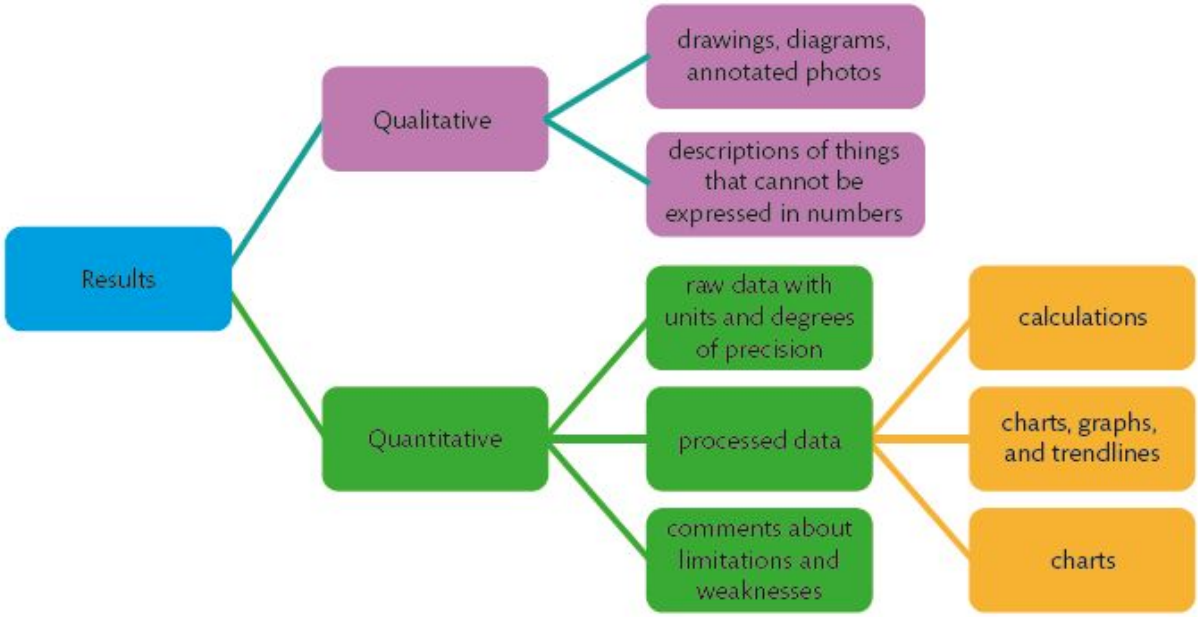

**Figure 1** Accuracy is how close an investigator gets to measuring the accepted true value that is reliable and verifiable. Precision is how close the data points are to each other. Precise measuring instruments do not give different values each time the same thing is measured.
It is possible to measure something very precisely (getting the same results each time) but be very inaccurate, as seen in the first illustration of the target. This might happen if a balance was not set to zero after placing a recipient on it, giving the mass of the substance being weighed but also including in that number the mass of the container, thus falsifying the measurement.

## SETTING UP EFFECTIVE TABLES OF RAW DATA

- Present all the raw data generated in your experiments in properly constructed results tables.
- Include a full title to explain what data is shown in each table.
    - (e.g. Table 2: Pea seed characteristics).
- The left hand column should show the different levels of the independent variable.
- The other columns are for the results for the dependent variable.
- All rows and columns should have headings.
    - Units should be with the headings, not with the numbers in the body of the table.
    - Use correct SI units.
- Set up the rows and columns in a neat and orderly way to facilitate interpretation, e.g. values that have been measured using the same tool, such as a thermometer, should be aligned in the same column.
- In the headings of each column, put three things: the name of what was measured, the appropriate units, and the degree of precision.
    - As a rule of thumb, the degree of precision is half of the smallest unit that the apparatus can measure.
        - For example, if a ruler has a 1 mm scale the precision can be expressed as ±0.5 mm.
        - The degree of precision may also be found on the measuring device itself or in documentation.
- Put only numbers in each box (cell) of the table, no units, and be sure to have only one value in each box of the table.
    - For example, do not include symbols such as ± or in the cells with the raw data.
    - One exception is a negative sign: this is allowed with the raw data.
- The number of decimal places after the decimal point should be in accordance with the degree of precision, e.g. if a thermometer is precise to ±0.5°C, then all the numbers in the column should end in .0 or .5 and not have any more or any fewer decimal places after the decimal point (even for 0.0).
- Align the decimals, even when there are negative signs in front of some of the numbers.

## TYPES OF DATA TO CONSIDER, QUANTITATIVE AND QUALITATIVE/RAW AND PROCESSED

- The diagram below shows qualitative data in purple.
- Such data cannot be expressed in numbers.
- Raw quantitative data are shown in green, and processed quantitative data are shown in orange.



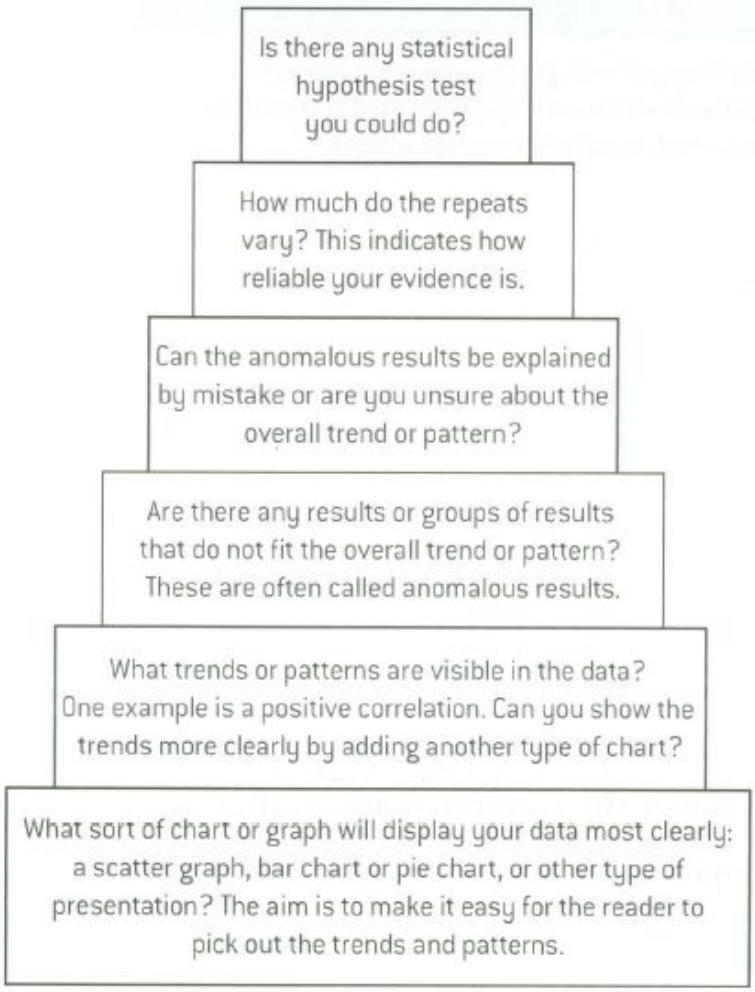

- Have you successfully analysed the data?
- Is the analysis accompanied by consideration of the uncertainties?
- Can the investigation be taken further?
- Ensure that you have enough raw data to provide evidence for any statistical tests and for detailed and valid conclusions to your research question.
- Analyse your data by calculating mean results and a measure of the variation in the repeats, such as a standard deviation.
- If possible, carry out a statistical hypothesis test, so you know the significance level of differences in the data.
- The test must be appropriate for your data so check carefully the conditions under which the test you intend to use is valid.
- Make it clear what the effect of measurement uncertainty is on your analysis.
- Plot graphs to display the data.
- Include an informative title.
- Plot means results with your measure of variation (e.g. standard deviation).
- Join means with straight lines and do not extrapolate with a line beyond the first or last data points.
- Aim to include a few large graphs rather than many tiny ones.

## ASSESS YOURSELF ON ANALYSIS (25%)

| Descriptor | Check list | | | | | |
|---|---|---|---|---|---|---|
| Raw data | **Insufficient relevant** raw data have been collected to support a conclusion | ☐ | **Incomplete** relevant raw data have been collected to support a conclusion | ☐ | **Sufficient** relevant raw data have been collected to support a detailed and valid conclusion | ☐ |
| Data processing | Inaccurate or **insufficient** data processing has been carried out to support a conclusion | ☐ | **Significant** inaccuracies and inconsistencies are present in the data processing that has been carried out to support a conclusion | ☐ | **Sufficient** accuracy is present and sufficient data processing has been carried out so that a conclusion can be draw that is consistent with the experimental data | ☐ |
| … consideration has been given to the impact of measurement uncertainty on data analysis | **Little** | ☐ | **Some** | ☐ | **Full and appropriate** | ☐ |
| Interpretation of processed data | **Insufficiently** or incorrectly interpreted processed data invalidate the conclusion or render it very incomplete | ☐ | Interpretation of processed data leads to broadly valid but incomplete or **limited** conclusions to the RQ | ☐ | Interpretation of processed data is correct and leads to a **valid** and detailed conclusion to the research question | ☐ |

- If most of your ticks are in the left-hand column, you cannot give yourself more than 2 marks for this criterion.
- If most of your ticks are in the middle column, you can give yourself a 3 or a 4.
- If most of your ticks are in the right-hand column, you can give yourself a 5 or a 6 for the Analysis criterion.
- How have you done so far for analysis?
- Do you need to tweak your investigation and collect more data so that you have enough data to do sufficient data processing?
- Remember that data processing includes both mathematical and graphical work as necessary to support a valid conclusion fully.
- (**Hint**: graphing raw data is not considered to be data processing.)

| Mark | Descriptor |
|---|---|
| 0 | The student's report does not reach a standard described by the descriptors below. |
| 1–2 | The report includes **insufficient relevant** raw data to support a valid conclusion to the research question.<br>Some **basic** data processing is carried out but is either too **inaccurate or too insufficient to lead to a valid** conclusion.<br>The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis.<br>The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete. |
| 3–4 | The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question.<br>Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing.<br>The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis.<br>The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced. |
| 5–6 | The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question.<br>Appropriate and sufficient data processing is carried out with **the accuracy** required to enable a conclusion to the research question to be drawn that is fully **consistent** with the experimental data.<br>The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis.<br>The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced. |



**EXAMPLE**: OBSERVATIONS AND QUESTIONS

- Two gerbils were being kept in a biology laboratory and the person who cleaned the laboratory started giving them a peanut each when she cleaned the lab each morning.
- After a few weeks, she noticed that when she entered the lab the gerbils came over to the front of the cage, stood on their back legs and waited for their peanut.
- When other people came into the lab at other times they did not do this.
- This observation suggests some interesting questions.
    - Were the gerbils able to recognize the cleaner and if they were, what were the recognition features?
    - If clothes of different colour, but the same design were worn, was she still recognizable?
    - Was the time of day critical to recognizing the cleaner?
    - Could the gerbils predict the arrival of the cleaner before she actually came into the lab?
    - Could sight, sound or smell be used for recognition?
- A simple observation can lead to interesting and worthwhile questions.

## GUIDANCE ON EVALUATION (25%)

This criterion assesses the extent to which your report provides evidence of evaluation of the investigation and results with regard to the research question and the wider world.

- For maximum marks under the evaluation criterion, you must state a detailed conclusion that is described and justified, that is entirely relevant to the research question, and fully supported by the data presented.
    - Use the expressions ‘confirmed by the data’ or ‘refuted by the data’ rather than ‘right’ or ‘wrong’.
- Have you demonstrated that you understand the implications of your conclusion?
- You should make a comparison to the accepted scientific context if relevant.
    - Compare your conclusions with published research or with the general scientific consensus among biologists about your research question.
    - Do your conclusions conform to the consensus or are they unexpected?
    - In your research for this, you do not need to find the exact same investigation with the exact same results.
    - It is possible to compare your findings with another investigation that is different but with results the either confirm or refute what you have found.
        - When possible, compare your first-hand data with literature values (secondary sources).

    - Describe any unexpected results: were there any outliers in the data, or any surprises?
- Have you discussed the reliability of your data?
    - This is where you can usually connect the theory from class with your lab work.
- The strengths and weaknesses of your investigation, such as the limitation of data and sources of uncertainty, must be discussed and you must provide evidence of a clear understanding of the methodological issues involved in establishing your conclusion.
    - Assess the strengths and weaknesses of all aspects of your investigation, especially all the possible sources of error in your data and the reliability of the experimental methods used.
    - This means not only identifying limitations, but also discussing the implications and consequences of these limitations.
- Have you discussed the limitations and/or likely sources of error in your method?
- Have you suggested relevant and feasible modications to your method?
- Finally, to earn maximum marks for evaluation, you must discuss realistic and relevant improvements and possible extensions to your investigations.
- The **key** here is different than the previous criterion for analysis.
- The focus of evaluation is to incorporate the methodology and to set the results within a genuine scientific context while making reference to your research topic.

| *Your evidence is strong if you answer "yes" to these questions* | *Your evidence is weak if you answer "yes" to these questions* |
|---|---|
| Are your results consistent enough to give you reliable evidence to use to answer the research question? | Are your results variable or are there many anomalous results that can't easily be explained? |
| Was the design of your experiment successful so that only it gave precise and accurate results? | Were there faults in the experimental design which limited the precision or the accuracy? |
| Were all the variables controlled satisfactorily so that only the independent variable was varied? | Were there uncontrolled variables, which introduced uncertainties into your interpretation of the results? |
| Is there only one explanation that fits all the evidence and answers the research question? | Are there alternative explanations that would also fit the evidence and which you cannot refute? |
| Can you support each part of your answer to the research question with experimental evidence or by reference to other published data? | Are there parts of your answer to the research question which are unsubstantiated or uncertain and which need further investigation? |

## ASSESS YOURSELF ON EVALUATION (25%)

| Descriptor | Check list | | | | | |
|---|---|---|---|---|---|---|
| Conclusion is … | **Outlined** and **not relevant** to the RQ | ☐ | **Described** and **relevant** to the RQ and supported by the data | ☐ | **Described**, **justified**, and **entirely relevant** to the RQ and **fully** supported by the data | ☐ |
| Comparison | Comparison with the scientific context is **superficial** | ☐ | Comparison with the scientific context is **somewhat** relevant | ☐ | Conclusion is correctly **described and justified** by relevant comparison with the scientific context | ☐ |
| Strengths and weaknesses | Strengths and weaknesses are only compared with the **practical and procedural** issues faced | ☐ | **Some** awareness of strengths and weaknesses, such as limitations of data, sources of error, and methodological issues as they affect the conclusion | ☐ | **Complete discussion*** and understanding of the limitations of the data, sources of error, and methodological issues as they affect the conclusion | ☐ |
| Relevant and realistic suggestions for improvement and extensions of the investigation | **Few** relevant and realistic suggestions for improvement and extensions of the investigation are **outlined** | ☐ | **Some** relevant and realistic suggestions for improvement and extensions of the investigation are **described** | ☐ | **Discussion*** of relevant and realistic suggestions for improvement and extensions of the investigation | ☐ |

- If most of your ticks are in the left-hand column, you cannot give yourself more than 2 marks for this criterion.
- If most of your ticks are in the middle column, you can give yourself a 3 or a 4.
- If most of your ticks are in the right-hand column, you can give yourself a 5 or a 6 for the Evaluation criterion.
- **Discuss** is a command term.
    - A command term tells you how to structure your writing.
    - This command term tells you to present a detailed account showing a range of possibilities.
    - Discuss a wide range of improvements that could be made to your investigation.
    - Also discuss a wide range of extensions of your investigation.
- How have you done so far on your evaluation?
- It is important to restate the data that you are using to justify your conclusion.

| Mark | Descriptor |
|---|---|
| 0 | The student's report does not reach a standard described by the descriptors below. |
| 1–2 | A conclusion is **outlined** which is not relevant to the research question or is not supported by the data presented.<br>The conclusion makes superficial comparison to the accepted scientific context.<br>Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an **account** of **the practical** or **procedural issues** faced.<br>The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation. |
| 3–4 | A conclusion is **described** which is relevant to the research question and supported by the data presented.<br>A conclusion is described which makes some relevant comparison to the accepted scientific context.<br>Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **described** and provide evidence of some awareness of the **methodological issues*** involved in establishing the conclusion.<br>The student has **described** some realistic and relevant suggestions for the improvement and extension of the investigation. |
| 5–6 | A detailed conclusion is **described and justified** which is entirely relevant to the research question and fully supported by the data presented.<br>A conclusion is correctly **described and justified** through relevant comparison to the accepted scientific context.<br>Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **discussed** and provide evidence of a clear understanding of the **methodological issues*** involved in establishing the conclusion.<br>The student has **discussed** realistic and relevant suggestions for the improvement and extension of the investigation. |

# GUIDANCE ON COMMUNICATION

- This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes of the investigation.
- For maximum marks under the communication criterion, your report must be clear and easy to follow.
- Although your writing does not have to be perfect, any mistakes or errors should not hamper the reader's understanding of the focus, process, and outcomes of your investigation.
- Your report must be well structured and focused on the necessary information, the process and outcomes must be presented in a logical and coherent way.
    - Divide the report up into sections with suitable headings.
- Your text must be relevant without wandering off onto tangential issues.
- Your use of specific biology terminology and conventions must be appropriate and correct.
- Lab reports should be written using an impersonal style.
    - This means that words such as 'I', 'we', 'my', and 'us' should be avoided.
    - For example, instead of saying 'Next, I added soap to the Petri dish', you should write 'Next, soap was added to the Petri dish'.
    - The phrase 'my hypothesis' should be rewritten as 'the hypothesis'.
    - We know that it is yours because your name is at the top of the lab report.
    - To avoid using 'I', say things like 'it was noticed that …' instead of 'I noticed that …'.
    - Likewise, 'It is my personal opinion that …' should be written as 'It is the investigator's personal opinion that …'
- Does your written method enable this investigation to be repeated successfully by others?
- Are the correct conventions for significant figures, decimals places, and uncertainties used throughout?
- Graphs, tables, and images must all be appropriately presented.
    - Photos should be annotated, have a legend describing what should be observed, and cite the source.
    - If it is your own photo, put 'author's photo' or 'investigator's photo' as the citation.
- Can your written explanation of data analysis be easily followed?
- Your lab report should be 6 – 12 pages long.
- Excessive length (beyond 12 pages) will be penalized under the communication criterion.

- The **key** here is to demonstrate a concise, logical, and articulate report, one that is easy to follow and is written in a scientific context.

## ASSESS YOURSELF ON COMMUNICATION (17%)

| Descriptor | Check box |
|---|---|
| Focus, process, and outcomes are difficult to understand | ☐ |
| Necessary information about focus, process, and outcomes is missing or difficult to understand | ☐ |
| Inappropriate or irrelevant information detracts from the focus, process, and outcomes | ☐ |
| Many errors in terminology of the subject and conventions of the subject | ☐ |

- These descriptors are for a mark of 1 or 2.
- If your investigation does not fit these criteria go on to the next descriptors.

| Descriptor | Check box |
|---|---|
| Focus, process, and outcomes are clearly stated | ☐ |
| Coherent information is presented about focus, process, and outcomes | ☐ |
| Relevant and concise information facilitates understanding of the focus, process, and outcomes | ☐ |
| Terminology of the subject and conventions are correct | ☐ |

- These descriptors are for a mark of 3 or 4.
- Four is the highest mark for communication.
- Use the above self-grading exercise to improve the work that you have done on your investigation.
- As this investigation is worth 20% of your IB biology exam grade, put in the time and energy it takes to do the best work you possibly can.

| Mark | Descriptor |
|---|---|
| 0 | The student's report does not reach a standard described by the descriptors below. |
| 1–2 | **The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.**<br>The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way.<br>The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information.<br>There are many errors in the use of subject-specific terminology and conventions*. |
| 3–4 | **The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes**.<br>The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way.<br>The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation.<br>The use of subject-specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding. |

*For example, incorrect/missing labelling of graphs, tables, images; use of units, decimal places. For issues of referencing and citations refer to the "Academic honesty" section in the guide.