HIGHER LEVEL

INTERNAL ASSESSMENT

PEARSON BACCALAUREATE

HIGHER LEVEL

Biology

2nd Edition

ALAN DAMON • RANDY McGONEGAL • PATRICIA TOSTO • WILLIAM WARD

Supporting every learner across the IB continuum

ALWAYS LEARNING

PEARSON

Internal assessment for Biology

The internal assessment (IA) task for biology will consist of one investigation/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 task, otherwise known as the Individual Investigation or II, can be:

- hands-on practical work
- using a spreadsheet for analysis and modelling
- extracting data from a database and analysing it graphically
- a combination of spreadsheet/database work and traditional hands-on investigation.

The purpose of internal assessment

IA enables you to demonstrate the application of your knowledge and skills. Work submitted for IA must be your own personal work. Your instructor 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 instructor will inform you of the IB animal experimentation policy and explain the IA criteria by which your work will be judged.

You are encouraged to discuss the internally assessed work with your instructor and obtain advice and information. Instructors are allowed to read and give advice to students on one draft of the work. Your instructor can give oral or written advice to you, but the instructor cannot edit your draft. The next draft handed to the instructor must be the final version for submission. Your instructor must authenticate this work.

Internal assessment criteria

The following is a list of the five criteria used to assess the report of the individual investigation you will perform, and the weighting given to each criterion.

- Personal engagement, 2 marks, 8%.
- Exploration, 6 marks, 25%.
- Analysis, 6 marks, 25%.
- Evaluation, 6 marks, 25%.
- Communication, 4 marks, 17%.

Total 24 marks = 100%.

Guidance on personal engagement and exploration

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?

NATURE OF SCIENCE: ADVICE ON WRITING A SUCCESSFUL RESEARCH QUESTION (RQ)

- If you are really stuck and do not know where to start, one formula for a research question (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's lab.
- 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).
- Even if your RQ is the title of your investigation, be sure to restate it clearly in the Introduction or Aim of your report.
- Think about timing: can your experiment be completed in the amount of time the teacher is giving you?

- Have you listed the dependent and independent variables, and explained how any other variables that influence your data collection will be controlled?

NATURE OF SCIENCE: TYPES OF VARIABLES TO CONSIDER

- The *dependent variable* 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.
- The *independent variable* 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. 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* 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.

- 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?

NATURE OF SCIENCE: WRITING A STEP-BY-STEP METHOD

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 or a data-logging device that does not require a laptop.
- 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?

Assess yourself on personal engagement

Check which descriptor fits your work best.

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

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.

Assess yourself on exploration

Use a best-fit 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.

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**	☐

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?

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.

For their Individual Investigations students can use data-logging devices such as this one to measure such things as temperature, pH, dissolved oxygen, and more. Ask your teacher what kind of probes are available in your school's lab.

Guidance on analysis

This criterion asks to what extent your report provides evidence that you have selected, processed, analysed, and interpreted the data in such a way that the conclusions reached are in line with the proposed research question.

- Have you selected and recorded raw data, including the uncertainties and appropriate qualitative data?
- Have you selected an appropriate method for analysing the data?

NATURE OF SCIENCE: SETTING UP EFFECTIVE TABLES OF RAW DATA

- Give the table a number and a title (e.g. Table 2: Pea seed characteristics).
- 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.

NATURE OF SCIENCE: 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.

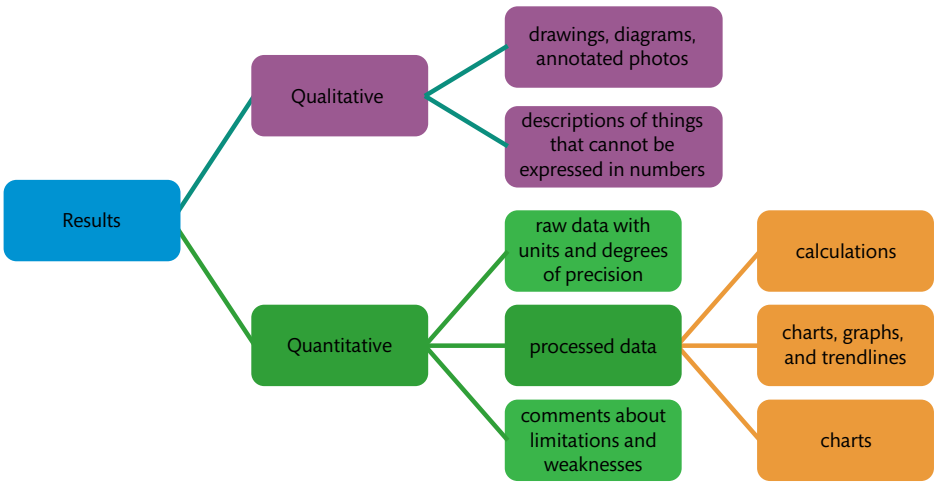

Figure 2

- Have you successfully analysed the data?
- Is the analysis accompanied by consideration of the uncertainties?
- Can the investigation be taken further?

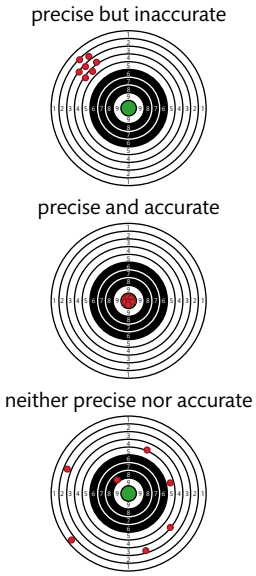

Figure 1 Accuracy is how close an investigator gets to measuring the accepted true value that is reliable and verifiable. Precision is how close the data points are to each other. Precise measuring instruments do not give different values each time the same thing is measured. It is possible to measure 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.

See Section 1 of the Maths and ICT chapter for more information about data analysis.

Assess yourself on analysis

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.

Guidance on evaluation

Your work will be assessed on your ability to provide evidence that you have selected, processed, analysed, and interpreted the data in a manner that supports your conclusion. You will also need to show that the conclusion(s) is entirely in line with the RQ and has been described fully. In addition, the conclusion must be justified by the data you have collected, and justified through relevant comparison with the accepted scientific context. Students are encouraged to do research to find similar investigations and see how their results and conclusions compare with those of other scientists. Such comparisons do not necessarily have to be quantitative but full citations of any sources used are required. If a comparison with a similar investigation is not possible, there could at least be a comparison with the current scientific understanding of the theories or laws governing the phenomenon being investigated.

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.)

- Have you interpreted the analysis to form a conclusion?
- Is your conclusion relevant to the purpose of your investigation?
- Have you compared your conclusion to accepted scientific theory and given references? 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.

NATURE OF SCIENCE : SOME THINGS TO CONSIDER WHEN WRITING A CONCLUSION

- Explain how the data that were collected in this lab investigation answered the RQ stated earlier in the report.
- Explain how the results either *confirmed* the hypothesis or *refuted* the hypothesis. Use the expressions 'confirmed by the data' or 'refuted by the data' rather than 'right' or 'wrong'. The latter two terms should be reserved for ethical arguments in science.
- Describe any unexpected results: were there any outliers in the data, or any surprises?
- If you have not already done so, explain what can be learned from the results. This is where you can usually connect the theory from class with your lab work. When possible, compare your first-hand data with literature values (secondary sources).

- Have you discussed the limitations and/or likely sources of error in your method?
- Have you discussed the reliability of your data?
- Have you suggested relevant and feasible modifications to your method?
- Have you demonstrated that you understand the implications of your conclusion?
- Have you suggested relevant and feasible extensions to your investigation?

Assess yourself on evaluation

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.

Guidance on communication

You will be judged on how clear your communication is to the reader of your report. Have you communicated the focus, process, and outcomes of your investigation clearly?

Your work will be assessed on your ability to communicate effectively to your reader.

- Have you written your report on the investigation in a concise, clear, and logical format?
- Does your written method enable this investigation to be repeated successfully by others?
- Can your written explanation of data analysis be easily followed?
- Are your graphs, tables, and images unambiguous? 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.
- Have you used subject-specific terminology throughout?

NATURE OF SCIENCE : WRITING STYLE, USING THE IMPERSONAL STYLE IN SCIENCE WRITING

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 ...'

- Is subject-specific notation used throughout?
- Are the correct conventions for significant figures, decimals places, and uncertainties used throughout?

Assess yourself on communication

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.