# IB Biology (subject-focused) Extended Essay (EE)

## Primary Data Investigations (Student-Collected Data)

*Complete Section-by-Section Guide to score 30/30*

*Based on: IB Extended Essay Guide (first assessment 2027) | EE Support Material | EE Assessment Criteria*

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**HOW TO USE THIS GUIDE**

This guide is organized by essay section, in the order they must appear in your Extended Essay. Each section contains:

- A description of what belongs in each section and why
- Required elements for the top markband
- The IB criterion each section addresses
- Common mistakes to avoid
- Formatting suggestions
- Notes on key differences from the Biology IA (where relevant)

**⚠ AVOID / COMMON MISTAKE**

**AN ESSAY, NOT A LAB REPORT – Read this first!**

The extended essay is an *essay*, not a lab report. It must be presented as continuous prose (subheadings still used). The method should be narrated in text. Your evaluation should be woven into the discussion – not placed in a separate section after the conclusion. The conclusion must come last (before reference list). These structural expectations are fundamentally different from the Biology IA.

Table of Contents

## ASSESSMENT CRITERIA OVERVIEW

The EE is marked out of 30 across five criteria. Examiners use a best-fit approach and mark positively. The top markband does not require a flawless essay.

| Criterion | Strands | Top Band Descriptor |
|---|---|---|
| **A: Framework** (6 marks) | Research question<br>Research methods<br>Structure | RQ is relevant, clear and focused in relation to the scope of the essay.<br>Methods are suitable, explained and applied effectively.<br>Structural conventions effectively support communication of the research. |
| **B: Knowledge** (6 marks) | Knowledge<br>Terminology<br>Concepts | Comprehensive, relevant research materials establish knowledge of subject matter.<br>Terminology is accurate and consistent.<br>Concepts are explained and used effectively to demonstrate understanding. |
| **C: Analysis & Argument** (6 marks) | Analysis<br>Line of argument | Analysis is effective and consistently produces relevant findings.<br>A clear, sustained line of argument links the RQ, research findings and conclusions. |
| **D: Discussion & Evaluation** (8 marks) | Discussion<br><br>Evaluation | A balanced discussion of the significance of the findings is fully supported by appropriate evidence.<br>Strengths and limitations are explained. |
| **E: Reflection** (4 marks) | Evaluative<br>Growth | Consistently evaluative with specific examples.<br>Consistent evidence of the student's growth and transfer of learning. |

## 1. TITLE PAGE

While the title page is not assessed, it sets the professional tone. It is a required structural convention.

### Required elements

- **Research question** – stated in full, exactly as it appears throughout the essay
- **Student code** – no personal name, supervisor name, or school name anywhere in the essay (anonymity is mandatory)
- **Subject: Biology** – clearly stated as the DP subject the essay relates to
- **Word count** – the total word count (max 4,000). If you used explanatory footnotes, state: "The stated word count includes explanatory footnotes."

✅ **FOR TOP MARKS:** A professional, anonymous title page with all four required elements supports readability and demonstrates awareness of structural conventions (Criterion A – Structure strand).

⚠ **AVOID / COMMON MISTAKE**

Do NOT include a separate essay title or topic line. The 2027 guide requires only the four elements above – the research question serves as the title.

## 2. CONTENTS PAGE

Include a clear contents page listing all major sections with accurate page numbers. Not included in the word count. Active readers use the contents page to predict the direction of the essay – a good contents page acts as a signpost for the examiner.

**FORMATTING TIP**

Word can generate an automatic table of contents that automatically updates headings with page numbers with page links

1. Create a table by selecting 'References' > 'Table of Contents'
2. Make larger headings "heading 1", subheading "heading 2", sub-sub heading "heading 3" etc.

** Table should automatically update the headings and page # but if they didn't change, select the table of contents and press fn + F9 "update entire table"*

# 3. INTRODUCTION (Criteria A, B, C)

The introduction tells the reader what to expect: the focus of the essay, the scope of the research, the sources to be used, and an insight into the line of argument. It is advisable to revisit and edit the introduction once the body of the essay is complete, to ensure it accurately introduces the essay as written.

**DIFFERENCE BETWEEN IA AND EE INTRODUCTION**

The core content is the same: IV–DV relationship explained with biological theory, study organism justified, peer-reviewed sources cited, and detailed biological processes described. The format is also the same – structured subsections and figures are fine in both.

The EE background differs from the IA in three ways:

- **Broader literature scope** – the IA focuses narrowly on the IV–DV link; the EE must also survey the wider field (what has been established, what is debated, where your investigation fits) to demonstrate knowledge "in the wider context of the relevant discipline" (Criterion B)
- **Wider context required** – connect the topic to broader biological, ecological, medical, or agricultural significance
- **Line of argument previewed** – the introduction must give "an insight into the line of argument" (Criterion C), which is not required in the IA

*tl;dr EE background = IA background + broader literature review + preview of where the argument is going.*

## 3.1 Context, Background, and Literature Review

This is the foundation of the essay. For a primary-data biology EE, you must demonstrate that you understand both the specific biological processes involved in your investigation and the broader scientific context in which it sits.

### Required elements

- **Specific biological context** – explain the biological system and process(es) directly involved in your investigation with enough depth for the reader to interpret future results
- **IV–DV relationship established** – use biological theory and cited literature to explain WHY changing the IV is expected to affect the DV
- **Broader significance** – connect the topic to a wider biological, ecological, medical, or agricultural context – demonstrate knowledge "in the wider context of the relevant discipline"
- **Literature review** – survey the current state of research on your topic. What has been established? What is uncertain or debated? What gap does your investigation address?
- **Study organism introduced** – name the species (binomial nomenclature, italicised) and briefly explain why it is suitable for this investigation (e.g. availability, relevance to the biological process, ethical considerations, practicality in data collection, etc.)
- **Peer-reviewed sources only** – cite academic journal articles and textbooks throughout. Do NOT use blogs, Wikipedia, or revision websites
- **Key terminology defined** – define technical or subject-specific terms when first used, otherwise it comes across as jargon
- **Figures where helpful** – include a diagram or image (with Figure caption and in-text reference) if it helps explain a process or the experimental system

**FOR TOP MARKS:**

Criterion B (Knowledge) top band: "Comprehensive, relevant research materials are used to establish knowledge of the subject matter."

Criterion B (Concepts) top band: "Relevant concepts are explained and used effectively to demonstrate understanding."

Guidance: "Before you delve into peer-reviewed scientific publications, ensure that you understand fully the theories and concepts associated with your topic."

## 3.2 Research Question

The research question is the central focus of the entire essay. It must be specific, focused, and describes exactly what is being investigated

### Required elements

- **IV stated with full range and units**
- **DV stated with unit, measurement period, and method**
- **Study organism named** – common name (*Species name*)
- **Consistent wording** – copy-paste the RQ; needs to be written *identically* everywhere in the essay

✅ **FOR TOP MARKS:** Criterion A (Research question) top band: "relevant to the topic of investigation, clear and focused in relation to the scope of the essay." Including specific IV values and organism name achieves this focus.

⚠ **AVOID / COMMON MISTAKE**

Do NOT write the RQ as a yes/no question – use sentence starters like 'how does' or 'to what extent'. Do NOT omit the range of IV. Do NOT use vague terms like 'amount' – use proper SI units.

## 3.3 Hypothesis

A hypothesis provides a specific, falsifiable prediction and helps situate the RQ within biological theory.

### Required elements

- **Specific falsifiable prediction** – state how each IV group will affect the DV
- **Biological justification and reasoning** – explain WHY you predict this outcome using theory from the background/past studies
- **Predictive graph (recommended)** – a hand-drawn or simple graph showing the hypothesised line/curve of best fit; label axes with units

## 3.4 Scope and Line of Argument

Brief outline of the experimental approach that will be taken and the direction your argument will follow, so the reader finishes the introduction knowing exactly what the essay will cover and how it will be structured. It's essentially the "roadmap" paragraph

### Required elements

- **Outline the approach** – briefly describe what the essay will investigate and how
- **Preview the argument** – give the reader an insight into the line of argument

# 4. METHODOLOGY (Criterion A)

This section must demonstrate that you designed and conducted the experiment yourself. Present the method as continuous prose (not a numbered list). Long equipment lists belong in an appendix.

**DIFFERENCE BETWEEN IA AND EE METHODOLOGY**

In the IA, the methodology is structured with separate labelled subsections (IV, DV, CVs, materials list, safety table, step-by-step procedure). In the EE, this **information must be presented as continuous essay prose** rather than standalone tables or numbered lists. Standalone equipment/materials lists can be placed in an appendix – but be aware that examiners are not required to read appendices. This means all key apparatus, quantities, concentrations, and measurement precision must still be named within the narrative prose of the method itself (e.g., "Root length was measured daily using a digital calliper (±0.01 mm)"). The methodology must remain "detailed so that the investigation can be replicated" – the replication detail is carried by the narrative, not by a list the examiner may never see.

Summary: the content is the same as the IA – nothing should be lost. Only the format changes (prose instead of tables and numbered steps). If a full materials list is placed in the appendix, reference it in the method (e.g., "A complete list of materials and apparatus is provided in Appendix A"), but ensure all key apparatus and quantities are still named in the prose itself.

## 4.1 Variables

All variables must be clearly identified, defined, and justified within the narrative of the methodology.

### Required elements

- **Independent variable** – named with full SI units, specific values/levels listed, range and increments justified using biological reasoning or pilot data. Identify the control group and why it is an appropriate baseline
- **Dependent variable** – named with SI units, measurement method and instrument specified, measurement period stated
- **Controlled variables** – all significant CVs identified. For each: explain the biological impact on the DV if left uncontrolled, describe how it was controlled (apparatus, values), and justify the chosen constant value
- **SI units throughout** – the International System of Units must be used. Never write "amount" – always use g, mL, mol $L^{-1}$, etc.

✓ **FOR TOP MARKS:** "Variables in the research question must be defined and justified, and allow measurements to be made in the investigation." Criterion A (Research methods) top band: methods are "suitable for the research question" and "applied effectively."

**⚠ AVOID / COMMON MISTAKE**

You must explain the biological relevance of your range limits. Use published literature or pre-trial data to support your choice.Do NOT present variables as standalone tables in the body of the essay. Describe and justify them within the narrative prose.

## 4.2 Pilot Experiment

A pilot experiment (pre-trial) is strongly recommended and demonstrates scientific rigour.

### Required elements

- **Brief description** – what was tested and why
- **Key findings** – what the pilot revealed (e.g., insufficient growth or measurable change within timeframe, optimal concentration identified, rate too fast to detect differences between groups, measurement intervals too widely spaced, chosen measurement technique not sensitive enough to detect differences, etc.)
- **Decisions made** – how the pilot informed the final methodology (range selection, duration, technique modifications, etc.)

✓ **FOR TOP MARKS:** "A pilot experiment is recommendable, as well as comparing with published (scientific) concentrations." A pilot demonstrates that the student has thought critically about their methodology before committing to data collection

## 4.3 Procedure

A continuous narrative describing exactly what was done, organised with subheadings for clarity (e.g., "Preparation of solutions", "Experimental setup", "Data collection"). Must be detailed enough for replication.

### Required elements

- **Written as continuous prose with subheadings** – not a numbered list of steps
- **Detailed enough for replication** – a reader should be able to reproduce the investigation using only this section (supplemented by the appendix for full materials lists)
- **Diagrams or photographs** – include annotated diagrams or photos at relevant points; assign figure numbers and reference in text
- **Cross-reference, don't repeat** – refer back to variable information (4.1) and pilot findings (4.2) rather than restating them (e.g: "The five $KNO_3$ concentrations described in Section 4.1 were prepared as follows…")

✅ **FOR TOP MARKS:** Criterion A (Research methods) top band: "Research methods that are suitable for the research question are explained and applied effectively."

A top-scoring procedure reads as a clear, logical narrative that the examiner can follow without confusion. Every key apparatus, quantity, concentration, and measurement precision is named within the prose. The reader understands not just what was done, but why each step matters for producing valid, reliable data.

⚠ **AVOID / COMMON MISTAKE**

Do NOT present the method as a numbered list of steps – this is an essay, not a lab report.
Do NOT forget to include mathematical uncertainties on measurements.
Do NOT write in future tense ("I will…") – write in past tense passive voice ("Solutions were prepared…").

## 4.4 Risk Assessment and Ethical Considerations

Address all safety, ethical, and environmental dimensions of the investigation. While not directly scored as a standalone criterion, omission undermines the credibility of your research and may affect Criterion A (Research methods).

### Required elements

- **Safety precautions** – identify specific hazards (chemical, biological, equipment) and describe mitigation measures (should be supported by references such as MSDS/SDS data sheets)
- **Ethical considerations** – if using animals or human participants, explain how the IB Ethical Guidelines and Sciences Experimentation Guidelines were followed
- **Environmental impact** – address waste disposal, impact of fieldwork on habitats, sustainable use of materials (should be supported by references such as MSDS/SDS data sheets)

# 5. RESULTS AND DATA PROCESSING (Criteria A, C)

Present all data clearly and systematically, then process and analyse it using appropriate quantitative methods.

**DIFFERENCE/SIMILARITIES BETWEEN IA AND EE DATA PRESENTATION**

The data presentation standards (tables, processed data, statistics, graphs) are essentially the same as the IA – same rigour, same formatting expectations. The only structural difference is that in the IA, the interpretation happens in a separate Criterion C section (Analysis → Conclusion). In the EE, the data is presented here (Section 5) and then the interpretation is woven into the Discussion (Section 6).

## 5.1 Qualitative Data

Record all non-numerical observations made during the investigation. Qualitative data supports the discussion, helps explain anomalies, and can distinguish between groups that do not show statistically significant quantitative differences.

### Required elements

- **Observations recorded systematically** – for each IV group, describe visual or sensory observations (colour changes, texture, turbidity, growth patterns, unexpected behaviours, etc.)
- **Images included** – photographs of samples/setup with figure captions (Figure number + description + relevant details) and in-text references
- **Anomalous observations noted** – flag anything unexpected (e.g., unusual colour, precipitate, insect damage, contamination, uneven growth)
- **If no visual differences** – provide a brief justified statement explaining why qualitative data was not meaningfully different across groups

**FOR TOP MARKS:** analysis "must follow standard processes, including qualitative and quantitative approaches." Qualitative data is part of good scientific practice and may be valuable in the discussion when interpreting quantitative results.

## 5.2 Raw Data Presentation

All unmodified, unprocessed numerical data collected during the investigation.

### Required elements

- **Detailed table caption** – format: 'Table X – [what was measured] of [Study species] measured after [time frame] for [IV groups].' Include definitions of any abbreviations used
- **Column headers** – include: variable name, unit, and uncertainty (e.g., Temperature (°C ± 0.5))
- **Consistent decimal places** – match the precision of the measurement apparatus throughout
- **All raw data included** – individual trial values; if dataset is too large, include a representative sample in the main body and the full dataset in an appendix (with a reference statement: "Full raw data available in Appendix A")
- **Anomalies highlighted** – flag outliers visually (e.g., with an asterisk or highlight the cell a different colour) and a note in the caption as to how they were identified (*see Statistical Analyses*).

**EXAMPLE CAPTION FORMAT**

'Table 1 – Root length (mm ± 0.01) of Allium cepa measured after 7 days of exposure to varying $KNO_3$ concentrations (mM ± 0.01). Asterisk (*) denotes an outlier identified using the IQR method in Section 5.4.'

**EXAMPLE TABLE FORMAT**

Present in a table clearly showing all data for each IV group for each trial

e.g. format for data collection once per trial per IV group:

| Independent variable (± unit) | Dependent variable (± unit) | | | | |
|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 |
| IV group A | | | | | |

e.g. format for data collection twice (beginning and end) per trial per IV group:

| Independent variable (± unit) | Dependent variable (± unit) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Trial 1 | | Trial 2 | | Trial 3 | | Trial 4 | | Trial 5 | |
| | Initial | Final | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| IV group A | | | | | | | | | | |

e.g. format for data collection over several time points per trial per IV group:

| Independent variable (± unit) | Trials | Dependent variable (± unit) | | | |
|---|---|---|---|---|---|
| | | Day 1 | Day 2 | Day 3 | Day 4 |
| IV group A | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| | 4 | | | | |
| | 5 | | | | |

## 5.3 Processed Data

Show all calculations performed on the raw data, explain why and how each calculation was done, and present the results in a clearly formatted table.

### Required elements

- **Description and justification of each calculation** – for each measure (mean, standard deviation, coefficient of variation, rate, % change, etc.), explain WHAT it shows and WHY it was performed
- **Method stated** – specify software and version (e.g., 'Data were analysed using Microsoft Excel for Mac (Version 16.107)') OR show a sample calculation with correct formula and working
- **Instrument uncertainty** – state the instrument uncertainties relating to the IV and DV (*note: propagation of uncertainties is optional and not required in Biology)*
- **Processed data table** – with detailed caption; columns for IV group (± uncertainty), mean DV (± unit), standard deviation, and coefficient of variation (if relevant)

✓ **FOR TOP MARKS:** "Results must be presented in a standardized format… clearly labelled with appropriate headings, units and numbering." "Examples of calculations should include mathematical uncertainties on the measurements collected." This contributes to Criterion A (Structure). Criterion C (Analysis) top band: "Analysis in the essay is effective and consistently produces relevant findings." The sciences guidance: analysis "must follow standard processes, including qualitative and quantitative approaches and statistical methods where appropriate, and may include mathematical transformation."

**EXAMPLE CAPTION FORMAT**

Example caption: 'Table 3 – Mean, standard deviation, and coefficient of variation (CV) for germination success (%) of *Lactuca sativa* after 96 hours in groups imbibed with varying concentrations of GA3 solutions'

**EXAMPLE TABLE FORMAT**

e.g. format:

| Independent variable (± unit) | Dependent variable (unit) | | |
|---|---|---|---|
| | Mean | Standard Deviation | Coefficient of Variation |
| | | | |

## 5.4 Statistical Analyses

Select and apply statistical tests that are appropriate for your data type and sample size. Justify every test choice. Present results clearly.

**LINKED RESOURCE**

Consult STATS FLOWCHART – RAW DATA to help chose appropriate test and links to online calculators

### Required elements

- **Outlier test** – check for statistical outliers in the raw data using $Q_1$, $Q_3$ and IQR. Do not remove outliers – flag them in the raw data table and consider presenting results both with and without the outlier(s)
- **Normality test** – Shapiro-Wilk test to check normality of each IV group's data (prerequisite for parametric tests)
- **Homogeneity of variance** – Levene's test (prerequisite for ANOVA)
- **Choice of main test justified** – based on normality and variance results: if both passed → one-way ANOVA; if either failed → Kruskal-Wallis
- **Main test applied** – one-way ANOVA or Kruskal-Wallis; present results showing $H_o$, $H_a$, p-value, and inference
- **Post-hoc test if $p < \alpha$** – Tukey's HSD (following ANOVA) or Dunn's test (following Kruskal-Wallis); present pairwise comparisons
- **Correlation test** – if IV is continuous: Pearson's (parametric) or Spearman's (non-parametric); include $H_o$, $H_a$, r, $R^2$, p-value, and inference
- **Null and alternative hypotheses stated** – for each statistical test
- **Online calculator acknowledged** – if used, state the calculator name/URL; this does not replace justification of the test choice

**EXAMPLE TABLE FORMAT**

e.g. format for statistical tests (also include table caption with additional information and selected α)

| | Hypotheses | *p-value* | Inferences |
|---|---|---|---|
| Test name | $H_0$ -<br>$H_a$ - | | |

**FOR TOP MARKS:** A top-scoring statistical analysis demonstrates a logical chain: outlier check → normality check → variance check → appropriate main test → post-hoc (if significant) → correlation (if IV is continuous). Every test choice is justified based on the results of the preceding test.

**⚠ AVOID / COMMON MISTAKE**

Use SD for $n \leq 30$. SEM is more appropriate for $n > 30$. ANOVA without a post-hoc test when $p < \alpha$ is incomplete. Correlation coefficient must be accompanied by a significance test – $r^2/r_s$ alone is not sufficient. Outlier(s) must NOT be simply removed without justification – could present results both with and without the outlier(s).

## 5.5 Graphs

Graphs must plot **processed data** (means, NOT raw trial data). Choose the graph type that matches your IV type. Quality over quantity – include only the graph(s) essential to answering the RQ.

### Graph caption – required elements

- **Graph number and title**
- **Study species (*Genus species*)**
- **What is being measured and over what time period**
- **Source of error bars** (e.g., 'Vertical error bars show ±1 standard deviation')
- **Statistical information** – $r^2$, $R^2$, *p-value* from correlation test; or letters indicating post-hoc significance (if applicable)

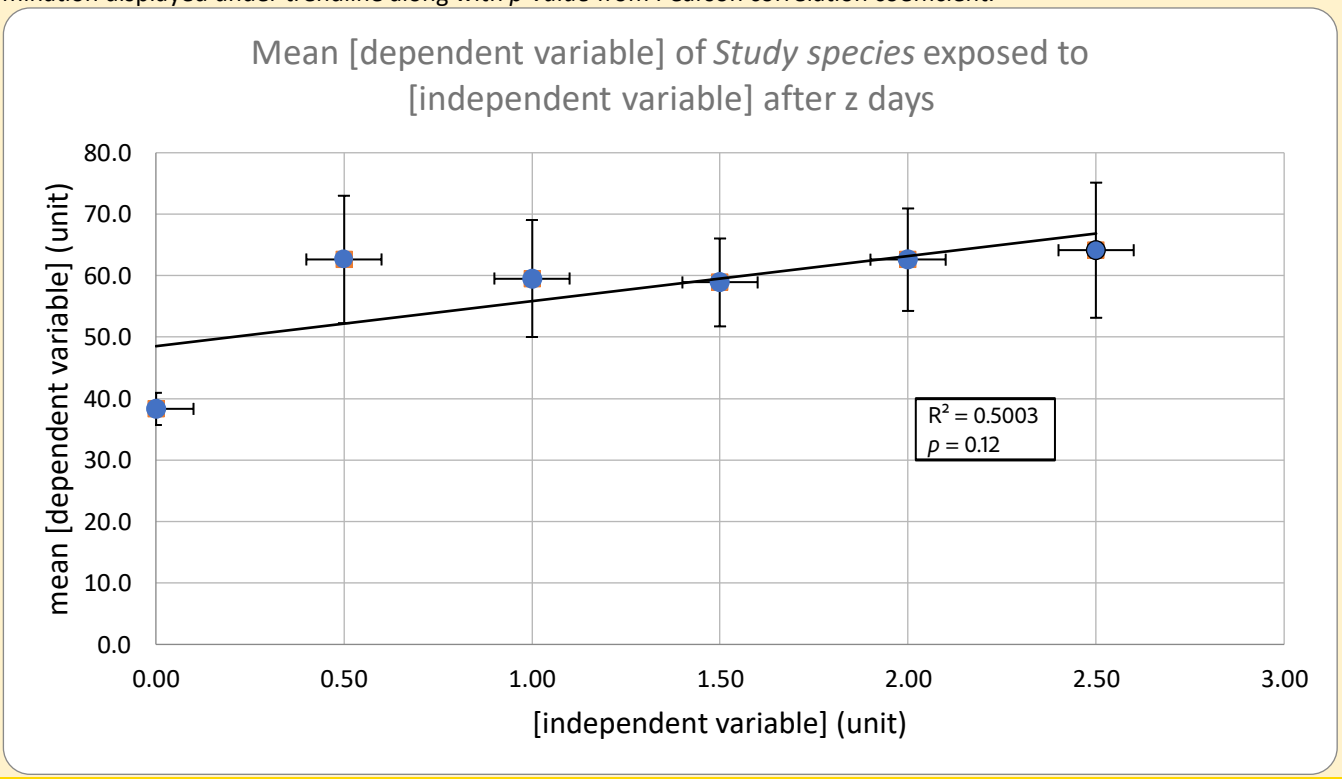
| Scatter plot (continuous IV) | Bar chart (categorical/discontinuous IV) |
|---|---|
| • X axis: IV with name and units<br>• Y axis: Mean DV with name and units<br>• LOBF: solid line; display $r^2$ / $r_s$ and *p-value* from test<br>• Vertical error bars: ±1 SD (SEM if n > 30)<br>• Horizontal error bars: ±1 IV uncertainty | • X axis: IV group descriptor (no units needed)<br>• Y axis: Mean DV with name and units<br>• Vertical error bars: ±1 SD (SEM if n > 30)<br>• Letters above bars: indicate post-hoc significance groupings (e.g., Tukey p < 0.05) |

**⚠ AVOID / COMMON MISTAKE**

Do NOT include any graphic not referenced in the body text.
Do NOT screenshot graphs from software – copy and paste as high-resolution images.
Do NOT plot raw trial data on graphs – the Y axis should show mean DV values.
Make graphs large and easy to read. Font size on axis labels should be at least 12pt.

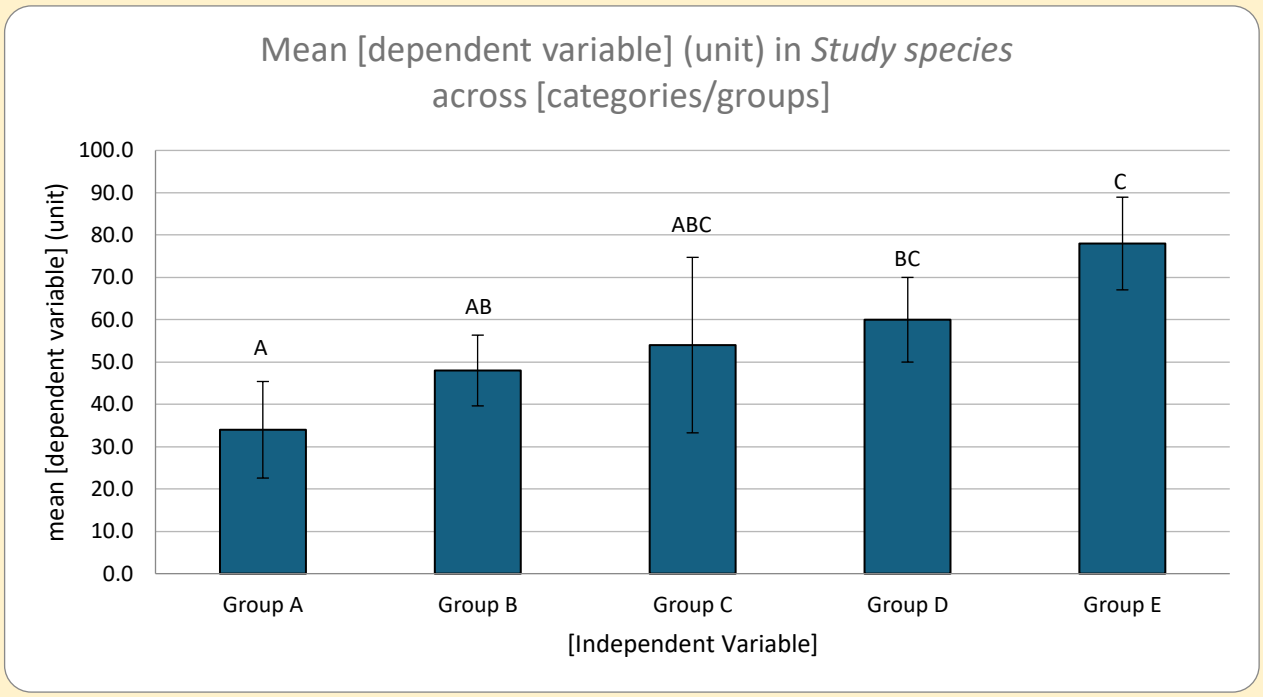
**EXAMPLE GRAPH FORMAT (SCATTER PLOT)**

Graph 1 – Scatter plot of [dependent variable] (unit) of *Study species* measured after z days in [independent variable]. Vertical error bars show ±1 Standard deviation, horizontal error bars show ±1 calculated uncertainty (see "Analysis" section). Coefficient of determination displayed under trendline along with *p-value* from Pearson correlation coefficient.



**EXAMPLE GRAPH FORMAT (BAR CHART)**

Graph 2 – Bar chart of [dependent variable] (unit) of *Study species* across 5 [categories/conditions]. Error bars show ±1 Standard deviation. Groups which do not share letters denote significant difference (*post-hoc* Tukey $p < 0.05$).




**FOR TOP MARKS:** Every graph and figure must be referred to in the body text at the point where it supports your argument. "When it comes to writing the essay, include only graphics, tables and other information that support the points you are making. Be sure to refer to the graphic in the text. If you do not refer to the graphic, then it is not supporting your points and it should not be used."

## 6. DISCUSSION (Criteria B, C, D)

The discussion is where you (1) interpret your results, (2) explain them biologically, (3) compare them with published literature, and (4) evaluate your methodology. This is where the highest marks are earned across Criteria C and D. Every paragraph must be analytical, not descriptive. Analytical writing explores the why, how, and so what – descriptive writing merely states what happened.

**DIFFERENCE BETWEEN IA AND EE ANALYSIS AND DISCUSSION**

In the IA, Criterion C separates Analysis from Conclusion, and Criterion D is a standalone evaluation table placed after the conclusion. In the EE, all of these elements are handled within the Discussion section. Evaluation must appear before the conclusion – not after it. Literature comparison happens throughout the discussion, not saved for the conclusion.

The content and reasoning from the IA transfer directly – only the placement and format change. Also note: unlike the current IA criteria, the EE Criterion D explicitly assesses both strengths AND limitations.

**ANALYTICAL WRITING TIP – PEEL TECHNIQUE**

Use PEEL to structure each paragraph in your discussion:

P – State the Point you are making

E – Provide Evidence (data, citation) to support it

E – Explain how the evidence supports the point

L – Link the point to your research question and the next point in your argument

### Recommended Structure:

Use "Discussion" as the overall section heading. Within it, use subheadings that reflect the content of YOUR investigation – name your specific variables, trends, and themes.

### Subheading 1: The main relationship between IV and DV

Name the specific variables in the subheading. This is the "big picture" – what does the data show overall?

- **Overall trend described with data** – describe the relationship between IV and DV with reference to specific mean values from your processed data table and graph
- **Variability within groups** – discuss SD values and error bar size – what they tell you about how consistent results were within each IV group
- **Differences between groups** – interpret error bar overlap between adjacent IV groups and what this means for whether differences are meaningful
- **Statistical results interpreted** – interpret the main test (ANOVA/Kruskal-Wallis p-value, or correlation $r^2$ and p-value) and post-hoc groupings – explain what the results mean for your conclusion, not just the numbers
- **Biological explanation** – explain WHY this overall trend occurred using mechanisms, pathways, or processes from published literature

### Subheading 2: Key features, anomalies, and qualitative observations

Zoom into anything that deviates from, or adds nuance to, the main trend described above:

- **Optima, thresholds, plateaus, or rate changes** – if your data shows a peak, a decline beyond a certain value, a levelling off, or a change in rate – describe the pattern and explain the biological mechanism
- **Outliers** – discuss any outliers identified in Section 5.4 (IQR test). Explain whether they affect the overall trend. Do NOT simply dismiss them – consider whether they represent genuine biological variation or a methodological issue
- **Anomalous groups** – if one IV group does not fit the overall pattern, explain possible reasons (biological, methodological, or both)
- **Qualitative data** – use observations from Section 5.1 to explain or contextualise quantitative patterns. For example: "Root tip necrosis was visible at 0.5 mM (Figure X), which may explain the decline in mean growth rate at this concentration"
- **Evaluation woven in** – if a methodological limitation explains a feature or anomaly (e.g., narrow range prevented identification of a true optimum, insufficient repeats explain large SD in one group), discuss it here with a specific improvement

### Subheading 3: Comparison with published findings

Compare your results with the studies cited in your introduction:

- **Agreements** – where your findings align with published studies – explain why this consistency strengthens the conclusion
- **Discrepancies** – where your findings differ – explain possible reasons (different species, conditions, methodology)
- **Significance** – what your results add to or clarify about existing knowledge

### Subheading 4: Strengths, limitations, and improvements

Evaluate the methodology and sources. The EE support material states: "You should weave your evaluation into the text of the essay itself, evaluating your sources and your methods and results at appropriate points in the discussion." This subheading keeps evaluation within the body, before the conclusion:

- **Strengths** – identify specific methodological strengths and explain WHY each matters for the validity of conclusions
- **Limitations** – identify specific, relevant limitations. For each: explain HOW it affected data quality, what error it introduces (random or systematic), and HOW it affects conclusions
- **Improvements** – for each limitation, propose a realistic, specific improvement and explain WHY it would address the issue

- **Sources evaluated** – assess the quality and relevance of the published literature used (e.g. peer-review status, journal impact factor, number of citations, funding, etc.)
- **Unresolved issues** – identify what remains unanswered and suggest directions for future research

**SUBHEADINGS TIPS**

Name your specific variables in the subheadings – **do not use generic labels**. You may combine or split these subheadings depending on complexity. For example, if there is no clear threshold or optimum, subheadings 1 and 2 can be merged.

Every paragraph under every subheading must contribute to answering the RQ. If it does not advance the argument, remove it.

✓ **FOR TOP MARKS:** Criterion C (Analysis) top band: "Analysis in the essay is effective and consistently produces relevant findings." Criterion C (Line of argument) top band: "A clear, sustained line of argument links the research question, research findings and conclusions." Criterion D (Discussion) top band (7–8): "A balanced discussion of the significance of the findings is fully supported by appropriate evidence." Criterion D (Evaluation) top band (7–8): "An evaluation of the effectiveness of the essay is present, with relevant strengths and limitations EXPLAINED."

**⚠ AVOID / COMMON MISTAKE**

Do NOT place evaluation after the conclusion (it is part of the discussion). The conclusion must be the final written section of the essay. Do NOT use generic evaluation points ("more trials", "human error", "better equipment") without specifying what, why, and how.

## 7. CONCLUSION (Criteria C, D)

The conclusion is the final written section of the essay. It must directly address the research question and synthesise the findings. It should NOT repeat the discussion – it should draw the threads of the argument together into a clear, concise answer

### Recommended Structure:

Write the conclusion as continuous prose. The following elements should appear in approximately this order:

### 1. Direct answer to the research question

- **State the conclusion explicitly** – open with a clear, unambiguous statement that directly answers the RQ
- **Restate the RQ** – remind the reader of the exact research question (copy-paste – same wording as everywhere else)
- **Supported by data** – refer to key statistical results (e.g., ANOVA p-value, correlation $r^2$) that justify the conclusion – do not re-describe trends, just reference them briefly

### 2. Evaluation of the hypothesis

- **Supported, partially supported, or refuted** – state which, explicitly
- **Explain why** – briefly explain which aspects of the data support or contradict the prediction, referencing specific findings from the discussion

### 3. Synthesis in scientific context

- **Synthesise, don't repeat** – provide a "supported, well-explained synthesis" of results – not a repetition of data trends or a re-description of the discussion
- **Broader significance** – briefly state what your findings mean in the wider biological context (implications for the field, connection to real-world applications)
- **Consistency with literature** – one or two sentences summarising whether your overall conclusion aligns with or challenges published studies cited in your introduction

### 4. Remaining uncertainties and future directions

- **Unresolved issues** – if the RQ was not fully answered, state this clearly and explain why
- **Future research** – suggest specific, realistic directions that would address unresolved issues

**⚠ AVOID / COMMON MISTAKE**

Do NOT introduce new data, new processing, or new sources in the conclusion. Do NOT simply restate trends already described in the discussion – synthesise them into a coherent answer.
**Negative results are valid** – "negative" results are just as valid as "positive" results – do not force conclusions the data does not support.
**No definitive answer is acceptable** – the EE guide states: "You might not be able to give a definitive answer to the question. Not having a definitive answer should not compromise your capacity to perform well, as determined by the assessment criteria: as long as your discussion and argumentation are strong."

## 8. REFERENCE LIST (Criterion B)

### Required elements

- **APA format throughout** – all references formatted correctly and consistently → Citation generator
- **Alphabetical order** – by first author's surname
- **Every in-text citation has a corresponding entry** – and vice versa; no orphan citations or unused references
- **Retrieval dates for online sources** – required for traceability
- **Appropriate sources only** – peer-reviewed journal articles, academic textbooks, and trusted institutional websites; NOT Wikipedia, revision sites, or general web pages

✓ **FOR TOP MARKS:** Criterion B (Knowledge) top band: "Comprehensive, relevant research materials are used to establish knowledge of the subject matter." Grade A descriptor: "There is effective engagement with relevant research areas, methods and sources."

**⚠ AVOID / COMMON MISTAKE**

Any IA that lacks references and a reference list will be submitted as 'no grade' due to doubts of authenticity

## 9. APPENDICES

This section is optional. Include only supplementary evidence that supports the transparency and reproducibility of the investigation but is not assessed.

### Included elements

- **Full materials/apparatus list** – this should be referenced in the methodology
- **Large raw datasets** – If a very large amount of data was collected (e.g. daily measurements for each trial over many weeks) a representative sample or summary belongs in the main body (Section 14), and the full dataset can go in the appendix with a clear statement like "Full raw data available in Appendix A".
- **Additional qualitative data** – additional supplementary photographs can be included if many were taken
- **Full pre-trial methodology** – detailed step-by-step method for the pre-trial can be included and referenced in the main body
- **Raw statistical output** – screenshots of raw output data tables produced by online calculators

**⚠ AVOID / COMMON MISTAKE**

Appendix is NOT assessed by examiners – anything the student wants the examiner to read and credit should NOT go in this section. It is NOT to be used as a word-count overflow section. **Reference each appendix in the main body** (e.g. "see Appendix A")

## 10. REFLECTIVE STATEMENT (Criterion E on RPF)

The 500-word reflective statement is written at the end of the EE process and recorded on the Reflection and Progress Form (RPF), which is uploaded as a separate file (NOT part of the essay PDF). Comprises (1) Evaluative strand – evaluate what was LEARNED, WHY it mattered, and HOW it changed your thinking and (2) Growth and Transfer – how you developed as a learner and HOW this is connected to other contexts

**Recommended structure:**

- **Opening (~50 words)** – state the most significant thing you learned from the EE. The examiner should immediately see you are *evaluating*, not describing
- **Body (~350 words)** – develop 2–3 evaluative points. For each: (1) a specific moment or challenge from your EE process, (2) what you learned from it, (3) where you have applied or will apply this learning. Depth over breadth – develop a few points in detail rather than listing many
- **Closing (~100 words)** – reflect on how the EE experience shaped your thinking overall. What would you do differently, and why?

**WRITING TIPS**

For every sentence, ask: does this tell the examiner what I DID, or what I LEARNED? If it only tells them what you did, rewrite it to explain the learning, the insight, or the change in perspective. Possible topics to evaluate:

- **Experimental skills** – what did you learn about experimental design and data collection?
- **Navigating contradictory literature** – how did you learn to evaluate source quality?
- **Learning a new statistical test** – how did this change how you interpret data?
- **Narrowing or changing your RQ** – what did this teach you about research focus?
- **Managing time and workload** – what strategies did you develop and where could they apply?
- **Understanding correlation vs causation** – how did this affect your conclusions?
- **Writing in academic register** – what did you learn about communicating science?

**FOR TOP MARKS:** Evaluative: "Reflection is consistently evaluative and includes specific examples." Growth: "Reflection consistently shows evidence of the student's growth and transfer of learning."

Key words: consistently, evaluative, specific examples, growth, transfer.

**⚠ AVOID / COMMON MISTAKE**

Do NOT describe your process – evaluate your learning. Do NOT write general statements – give specific examples.
Do NOT forget transfer – explicitly connect learning to another context.
Do NOT exceed 500 words. Do NOT include the reflective statement in the essay – it goes on the RPF (separate upload).

# 11. FORMATTING AND WORD COUNT

## Word count

- **4,000 words MAXIMUM** – following are excluded from the word count: contents page, diagrams, graphs, data tables, equations, calculations, in-text citations, reference list, headers, appendix, figure/table captions, RPF

**⚠ AVOID / COMMON MISTAKE**

Any content that goes beyond 4000 words is NOT READ and therefore NOT COUNTED in the grading. While data tables are not included, tables that include descriptive text are (e.g. controls, qualitative data, evaluation).

## Layout

- **1.5x line spacing throughout**
- **Font size 12 minimum** for ALL text – including figure captions, graph axis labels, and table text
- **Page numbers on every page** – beginning with the first page after the contents page
- **Tables do not break across pages**
- **Headings/captions are not separated from their related content**

## Figures and tables

- **Each figure has a name** (Fig.1, Fig.2…) AND a detailed caption (using APA guidelines)
- **Each figure referenced in text** – e.g., '(see Fig.1)' before or immediately after the figure
- **Figures placed near their in-text reference** – not on a separate page far from the citation
- **Images are not blurry** and stay within normal margins
- **Species names correctly formatted** – *Genus species* (italicised; Genus capitalised, species lowercase)

## Writing style

- **Third-person passive throughout** – recommended to avoid all personal pronouns (I, we, my, our)
- **In-text citations** – every biological or scientific claim must be supported by an in-text citation (APA format)
- **Technical terms defined** – define complex/subject-specific terms clearly when first used; avoid jargon

## Digital file

- **Save as PDF** – check the final PDF version for correct page numbers, image placement, consistent fonts, line spacing, and no widows/orphans before submission
- **File size under 10 MB** – optimise embedded images if needed. The RPF is uploaded separately

## APA citation

- **In-text citations** – mainly parenthetical style (although narrative can be used when refering to a specific study/investigator). Direct quotations should be avoided or used very sparingly (note: they are included in word count)
- **Reference list** – alphabetical order. *Note: this is called a 'Reference List' NOT 'Works Cited' or 'Bibliography*

**LINKED RESOURCE**

Consult APA CITATION GUIDE for full details on in-text citations and reference list entries

**⚠ ACADEMIC INTEGRITY AND AI USE**

"Using artificial intelligence (AI) to write an essay that is then presented as your own is dishonest." Additionally, AI-generated material can be "considered as one of your resources… always acknowledged and cited appropriately."
Generally speaking, AI use should be avoided but if it used it must be declared and validated against other sources.