# Biology IA Checklist

> **These sections should all appear in the IA in the following order and contain the information listed**
> *TL;DR* (Too Long ; Didn't Read) is a short summary of what each section should contain

## Research Question
- ☑ Needs to be specific and focused.
- ☑ Includes: IV (with range), DV (with unit and period of measurement) and *Study species* (common name)
- ☑ RQ is written the same everywhere in the IA

*TL;DR* sentence that describes exactly what you are investigating including all key information

## Background
- ☑ Context provides concise description of the system in which RQ is embedded
- ☑ Detailed biological explanation for the main processes involved in the IA
- ☑ Include figure(s) if it helps explain a process/theory/context
- ☑ Explains and justifies use of study species (written: *Genus species*)
- ☑ Prior peer-reviewed studies conducted in this topic and the gaps the IA will seek to fill

*TL;DR* – theory and context a reader needs to know to understand and follow the investigation

## Hypothesis
- ☑ Specific prediction for how your IV groups will impact your DV(s)
- ☑ Can be supported by a predictive graph showing a hypothesized LOBF of expected relationship
- ☑ Detailed and supported justification for this prediction using biological theory/literature

*TL;DR* – A specific answer to your RQ with justification for this prediction

## Independent Variable
- ☑ State the variable. Provide the range (including units)
- ☑ Describe the IV in terms of how it is being made and used/applied
- ☑ Justify the selection of the IV experimental groups including range and increments. Be sure to indicate which is the control (if there is one) and why it's a control.
  *\* For a typical investigation, 5 experimental groups (4+ control) are the minimum standard*
- ☑ Provide the number of repeats/trials per experimental group. Justify why this amount of data is appropriate and sufficient at answering the RQ. <u>5 repeats/trials per group is the bare minimum – more is recommended</u>

*TL;DR* – explanation of experimental groups you are testing and why were these chosen

## Dependent Variable(s)
- ☑ State DV (including units and time period of measure, if applicable)
- ☑ Describe how it will be measured and over what time period including apparatus.
- ☑ Include diagram/image of how measurement was taken either in this section or in methodology
- ☑ Justify the selection of the DV (why this measurement, quantity, time etc.)

*TL;DR* – explanation of variable you are measuring and why was this chosen

## Control Variables

| Control Variable and Impact | Method of Control |
|---|---|
| ☑ <u>Explain</u> biologically what the potential impact this variable could have on your DV | ☑ <u>Describe</u> how this be controlled / kept constant<br>☑ Include specific apparatus and values<br>☑ Justify these choices |

*TL;DR* – explanation of variables (other than your IV) that could influence your DV and how they will be controlled

# Biology IA Checklist

## Uncontrolled Variables

| Uncontrolled Variable and Impact | Method of Control |
|---|---|
| ☑ <u>Explain</u> biologically what the potential impact this variable could have on your DV | ☑ <u>Describe</u> how this be monitored throughtout the investigation |

*TL;DR* – explanation of variables that could influence your DV that are outside of your control and how they will be monitored so as to determine if they influenced investigation

## Safety Considerations

☑ If none, outline and justify this

| Hazard | Nature of Hazard | Method of Control |
|---|---|---|
| ☑ Name of the hazard (chemical, microorganism, hazardous procedue or apparatus) | ☑ Describe potential harm or risk <br> ☑ Support with references | ☑ How will hazard be controlled so as to minimize/eliminate risk <br> ☑ Support with references |

*TL;DR* – explanation of potential dangers and how harm will be prevented

## Environmental Considerations

☑ Explain and justify how materials/plants/chemicals were properly disposed of following the conclusion of IA
☑ These considerations should be supported with references (past studies, MSDS, etc.)

*TL;DR* – after your IA is done, how will you deal with materials and study species appropriately

## Ethical Considerations

☑ If none don't need to include.
☑ If animals were used: follow the IB guidelines and explain how appropriate measures were done
☑ If data is collected from participants or secondary data used:  explain how permission/consent was obtained and how data will be used during and after the investigation, including anonymity

*TL;DR* – explanation of how IA is minimizing any negative impacts to living things involved

## Materials

☑ items have quantity (x1) and or amount (g, mL)
☑ chemicals have concentrations and volume (mL) /amount (g)
☑ containers have dimensions/sizes

## Apparatus

☑ units and precision (±)
☑ brand/model of apparatus if known

*TL;DR* – everything investigator needs to conduct investigation to as much detail as possible

## Methodology

☑ Use subheadings to separate method into parts
☑ Use diagrams/pictures of the experimental setup and specific steps. Cite these in relevant steps
☑ Each step should be detailed including the name of apparatus used
☑ Control table can be referenced when referring to how variables were controlled/maintained
☑ Ensure elements including time period, trials, repeats are clear
\* Ensure you are not repeating information. If relevant information was written elsewhere in IA, reference it

*TL;DR* – detailed step-by-step explanation which would allow any reader to easier replicate investigation

# Biology IA Checklist

Qualitative Data

| IV group (trial) | Obervations | Image |
|---|---|---|
|  | ☑ Provide descriptive non-numerical obervarions (colour, shape, smell, etc.) | ☑ Include image of observation |

*TL;DR* – any non-numerical data which can help elucidate differences among trials and experimental groups

Raw Quantitative Data

- ☑ Raw Data
- ☑ Formatting reminders:
    - o Detailed table caption, including any shortforms used in the table for clarity
    - o Column headers (IV and DV) contain units and uncertainties (where applicable)
    - o All data presented to the same decimal place which matches the listed uncertainty of apparatus
    - o Anomalies highlighted where applicable
    - \* If there is so much raw data that it cannot fit in this section, provide a sample and the rest in appendix

*Example table caption format:*

Table 1 – [raw data collected] of [*Study species*] measured after [time frame] for [IV groups].

Table 1 – Length of plant (root to tip) of *A. schoenoprasum* measured after 30 days in groups exposed to varying concentrations of auxin hormone.

*Example table formats:*

*Data collection entails collecting data once per trial per IV group*

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

*Data collection entails collecting data twice (beginning and end) per trial per IV group*

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

*Data collection entails collecting data over several time points once per trial per IV group*

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

*TL;DR* – all unmodified numerical data collected

**Biology IA Checklist**

<span style="color:#2E74B5">Processed Data</span>
- ☑ For each calculation (ex: mean, st dev, rate, etc.):
  - ○ Description of what this calculation is and justification for why it was done
  - ○ Description of how it was conducted (excel, online calculator, etc.)
- ☑ Description of measurement uncertainties. Explain how the uncertainties of your IV and DV were determined/calculated
- ☑ Processed Data Table (with mean, st dev, etc.)

*Example table format:*

| Independent variable (unit ± uncertainty) | Mean Dependent variable (unit) | Standard Deviation |
|---|---|---|
|  |  |  |

<span style="color:#2E74B5">Statistical Analyses</span>
- ☑ Description and explanation for choice of statistical test conducted
- ☑ Description of how it was conducted (excel, online calculator, etc.) including screenshot if applicable
- ☑ Null and alternative hypotheses
- ☑ Full results of the statistical tests presented as a tables

*\* Consult the following flowchart to help determine what test(s) to run:* <span style="color:#2E74B5">*Stats flowchart*</span>

<span style="color:#2E74B5">Graph(s)</span>
- ☑ Large and not blurry (copy/paste from excel; DO NOT screenshot)
- ☑ Graph caption contains information regarding study species, what is being measured, over what time period, source of error bars, and information of statistics included (ex: as $r^2$, *p* value)
- ☑ letters above data points can be used to indicate statistical difference (if post-hoc test conducted)
- 2 graph options:
  1. scatter plot: IV <u>and</u> DV are continuous
     - ☑ y and x axis labels have name and units
     - ☑ LOBF is solid line, has $r^2$ and *p value* (from stats test such as Pearson, ANOVA, etc.)
     - ☑ Vertical error bars from Standard Deviation or Standard error
     - ☑ Horizontal error bars for the uncertainty in IV values

  2. bar chart: IV discontinuous/categorical (ex: different types of fertilizers)
     - ☑ y has name and units, x has descriptor
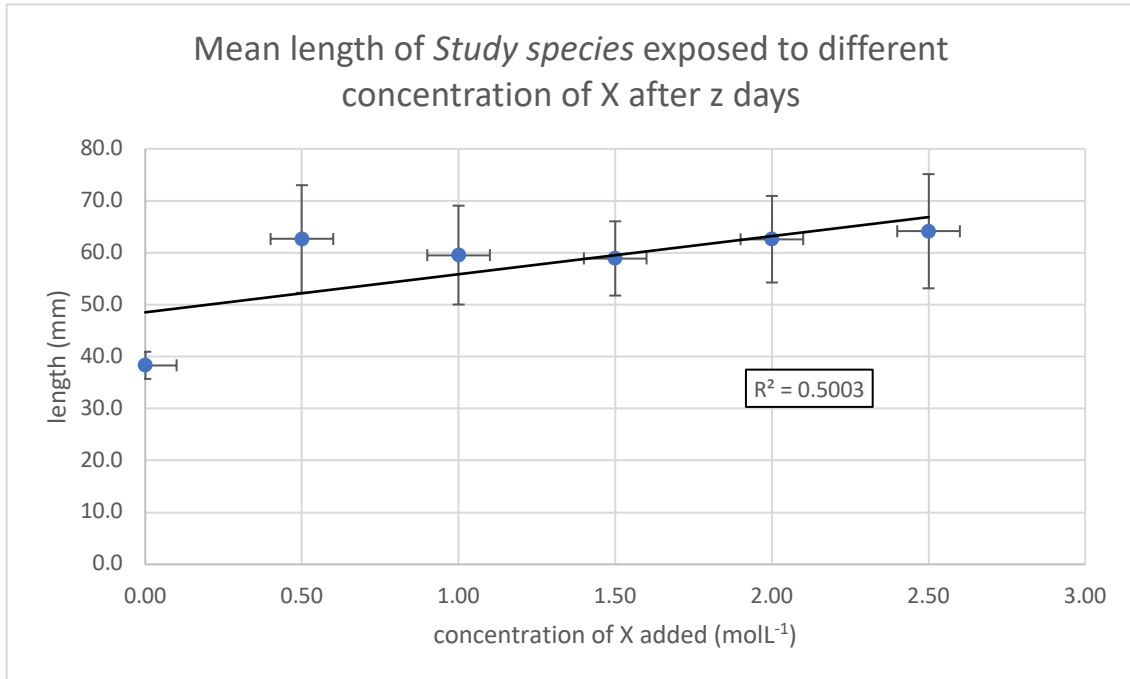     - ☑ Vertical error bars from Standard Deviation or Standard error

\* Graphs only ever plot processed data (no trials), thus y axis is "mean of DV"
\*\* The fewer the better: only include multiple graphs if *absolutely* necessary to the RQ

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*Example graph formats:*

Graph 1 – Scatter plot of length of plant (root to tip) of *Study species* measured after 30 days in groups exposed to varying concentrations of chemical X. 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.



Mean length of *Study species* exposed to different concentration of X after z days

$R^2 = 0.5003$

length (mm) / concentration of X added (molL$^{-1}$)

Graph 2 – Bar chart of germination success of *Study species* in groups planted in different soil treatments. Error bars show ±1 Standard deviation. Groups which do not share letters denote significant difference (*post-hoc* Tukey *p < 0.05*).



Mean germination success of *Study species* across different soil treatments

germination success (%) / Soil treatment
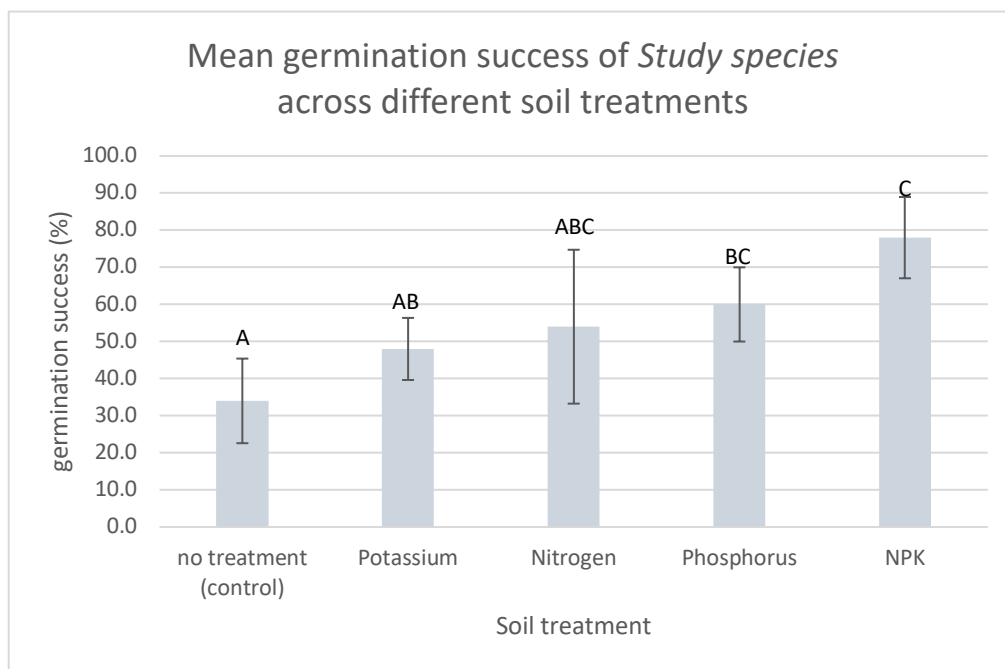
*TL;DR* – visual representation of processed data which helps elucidate differences between and within groups

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# Biology IA Checklist

## Analysis
- ☑ Discuss qualitative data
- ☑ Discuss quantitative data
    - ○ Overall trends and differences among your groups.
    - ○ Variability *within* your groups (st dev, anomalies/outliers, measurement uncertainty)
    - ○ Variability *between* your groups (error bar overlap, measurement uncertainty, *p* values from stats)

*TL;DR* – Detailed description of collected and processed data.

## Conclusion
- ☑ Overall conclusion based on your analysis
- ☑ Answer RQ
- ☑ Does this support your hypothesis or not? Justify
- ☑ Explanation for your findings using scientific theory and comparison to prior/similar studies
- ☑ Re-address your context

*TL;DR* – Detailed explanation of collection and processed data using scientific theory

## Evaluation

| Weaknesses/Limitations | Suggestions for Improvement |
|---|---|
| ☑ Discuss quality, reliability and limitations of data collected and sources of error<br>☑ Methodological only (relating to approach of investigation to RQ or procedural steps)<br>☑ Weaknesses could include issues relating to:<br> ○ control of variables<br> ○ measurement apparatus precision<br> ○ data variability<br>☑ Limitations could include issues relating to:<br> ○ IV increments/range<br> ○ Length of data collection period<br> ○ Number of repeats/trials per experimental group<br> ○ Confines of the system of study | ☑ For EACH weakness/limitation provided: explain clear, specific improvements/suggestions to how this method could be improved in order to better answer RQ<br>☑ Be specific in terms of values/quantities, materials and apparatus you would use<br>☑ Suggestions should be justified<br>☑ Suggestions should be realistic in the context of a high school student |

*TL;DR* – Detailed explanation of how the investigation was lacking and how it can be improved if it were repeated

## Reference List
- ☑ Consistent, correct format, alphabetical order (use APA guidelines)
- ☑ Sources are all appropriate and are either from peer-reviewed journals, textbooks, and/or trusted websites

# Biology IA Checklist

**Formatting**

- ☑ **3000 words maximum** (excluding charts, diagrams, graphs, data tables, equations, calculations, references, works cited, headers)
- ☑ Page number included on each page
- ☑ Margins normal (moderate at most)
- ☑ Font 12 minimum throughout entire IA (including figure captions, graphs, tables)
- ☑ Tables do not break pages
- ☑ Headings/captions are not separated from their related text
- ☑ Pictures/diagrams:
    - o have a figure name (Figure 1) and caption (use APA guidelines)
    - o referenced in text (see Figure 1)
    - o placed directly near where they are referenced in text (not on a different page)
    - o not blurry and stay within the normal margins
- ☑ All entries in reference list are referenced in-text in the IA (use APA guidelines)
- ☑ Written in third-person passive (avoid all use of personal pronouns if possible)
- ☑ Every time biological/scientific explanations are provided or justifications are given an in-text citation is used as support.
- ☑ Complex/subject-specific terms are defined/explained clearly (avoid use of jargon)

*\* Any IA that lacks references and a work cited will be submitted as "no grade" due to doubts of authenticity*
*\*\* the IA will be run through Turnitin and Chat GPT checkers. Any issue in this regarded will be treated as plagiarism and the IA will be submitted as "no grade" and may result in potential removal from IB and Biology*

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