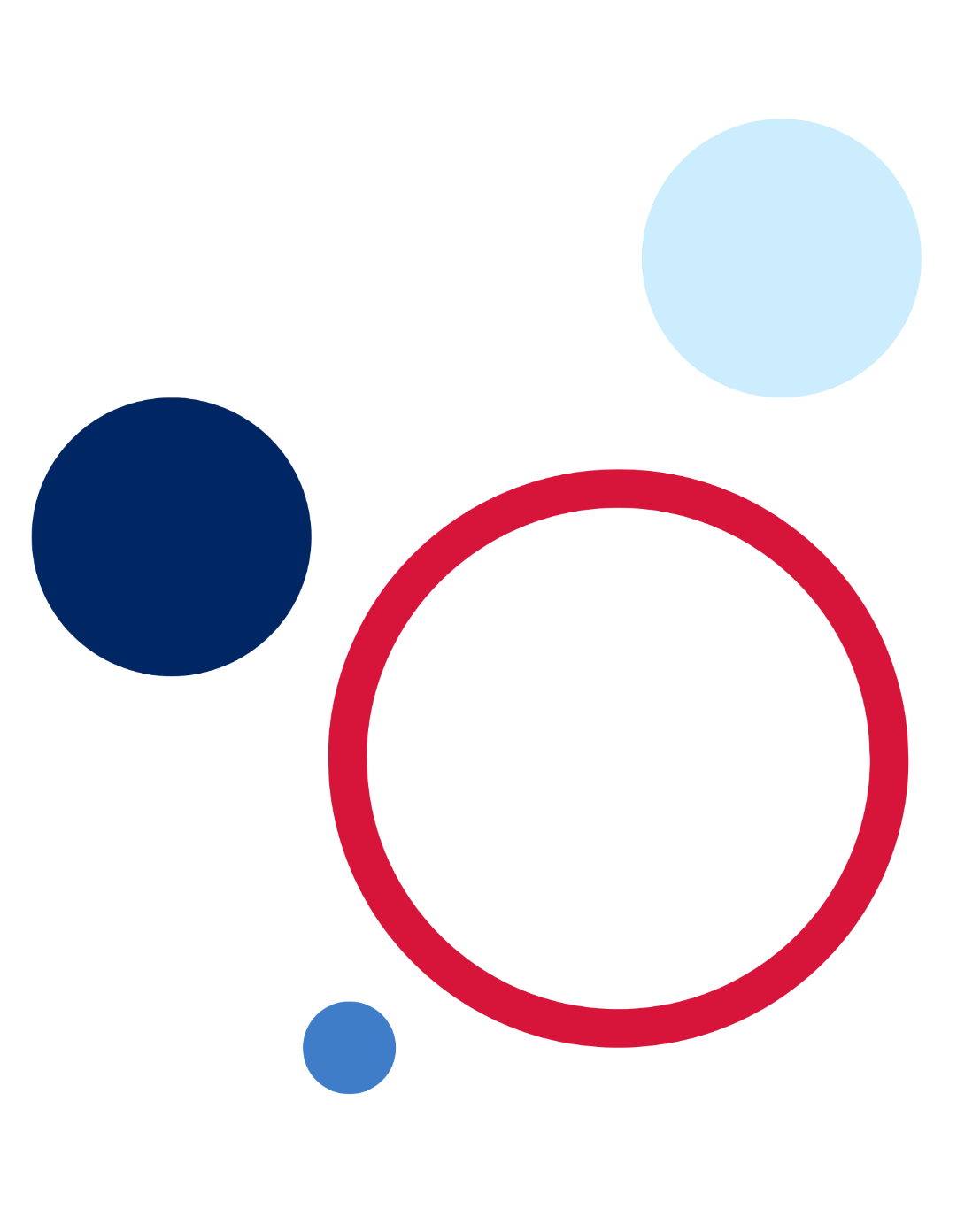
Science Extension Stage 6 – writing the Scientific Research Report



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## Overview

**Stage and Learning Area**: Science Extension Stage 6

**Description**: this resource has been designed to address Module 4: The Research Report and the syllabus's ‘The Scientific Research Report’ component.

This resource supports Science Extension teachers in guiding students in developing their Scientific Research Reports.

**Duration**: not applicable

### Outcomes

A student:

* **SE-1** refines and applies the Working scientifically processes in relation to scientific research
* **SE-2** analyses historic and cultural observations, ethical considerations and philosophical arguments involved in the development of scientific knowledge and scientific methods of inquiry
* **SE-3** interrogates relevant and valid peer-reviewed scientific research to develop a scientific research question, hypothesis, proposal and plan
* **SE-4** uses statistical applications, mathematical processes and/or modelling to gather, process, analyse and represent reliable and valid datasets
* **SE-5** analyses and applies the processes used in reliable and valid scientific research to solve complex scientific problems and inform further research
* **SE-6** analyses and reports on a contemporary issue or an application of science informed by either primary or secondary-sourced data, or both, in relation to relevant publicly available data sets
* **SE-7** communicates analysis of an argument or conclusion incorporating appropriate scientific language and referencing techniques in a scientific report

[Science Extension Stage 6 Syllabus](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/science-extension-syllabus) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2017

**Differentiation consideration**: this resource is designed to support students in constructing high-quality Scientific Research Reports. Teachers may supply capable students with this resource to review and refine their SRP drafts. Teachers may also use this resource as an instructional tool to unpack the different components of the SRP. Such discussions may provide opportunities to address misconceptions and misunderstandings related to formal scientific communications.

## Resource: writing the Scientific Research Report

## Introduction to the resource

The Scientific Research Report (SRR) represents the culmination of many weeks of work that Science Extension students engage in as part of the course. While the Research Portfolio documents cover all aspects of the research journey, the SRR provides evidence of students’ ability to communicate their scientific findings and understanding in the most-recognised form of scientific communication – the peer-reviewed scientific paper.

This resource advises students on the best practices for developing their SRRs. It is based on the instructions in the Science Extension Stage 6 Syllabus but includes suggestions from various resources.

Contrary to popular thinking among many students, the SRR should not be constructed linearly from the title to the appendix. As shown in Figure 1, students should, after completing data collection, focus on preparing the figures and tables that will be used in their SRP. Then, they should develop the Methodology section, which can be written mechanically using the information in their portfolio. This is followed by the Results-Discussion-Conclusion sections. Students should write the Literature review only after constructing those sections (Methodology to Conclusion). This sequence allows students to fine-tune the literature review to the issues directly relevant to their investigation. The abstract and title are the final sections to be developed.

Although the SRR is a highly structured and formal means of communicating science, a well-written SRR can still convey the excitement of scientific research. The Literature review and Discussion sections allow students to display flair and creativity in communicating their scientific understanding. They do this by applying critical and analytical thinking, reasoning, and developing informed judgements to their own research and information in the literature. From a learner’s perspective, scientific inquiries also explore students’ intellectual expanse. Science Extension students experience the pleasure of finding things out and contributing to scientific knowledge generation.

Figure 1 – a flowchart depicting the sequence of development of the different sections of the SRR

A flowchart depicting the sequence of development of the different sections of the Scientific Research Report.
Sections are:
Figures and tables
Methodology
Results
Discussion
Conclusion
Literature Review
Abstract 
Title, Acknowledgements, References

The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. He to whom the emotion is a stranger, who can no longer pause to wonder and stand wrapped in awe, is as good as dead — his eyes are closed.[[1]](#footnote-2)

Scientific principles and laws do not lie on the surface of nature. They are hidden, and must be wrested from nature by an active and elaborate technique of inquiry.”[[2]](#footnote-3)

## Title

**The title**

A title is a stand-alone statement that is specific, precise and informative, and provides the aim of the investigation. It is not a restatement of the scientific research question or the hypothesis. The title should appear on the cover page.

**Science Extension Stage 6 Syllabus (2017)[[3]](#footnote-4)**

### What to include in a title

Include essential information to inform your reader that they should keep reading:

* key information about the study design
* kmportant keywords
* what you discovered.

Here are some guidelines for developing good-quality titles for your SRR:

1. Be concise[[4]](#footnote-5). Use as few words as possible to convey the main idea of your research. Also, a wider audience will better understand plain-language titles[[5]](#footnote-6). However, important scientific terms (keywords) related to your research must be included.
2. Use a declarative or descriptive title whenever possible. A declarative title states the study's findings, while a descriptive title describes the research topic and design. Here are examples of each:

* **Declarative title**: Initial Upper Palaeolithic humans in Europe had recent Neanderthal ancestry[[6]](#footnote-7)
* **Descriptive title**: quantifying the effect of delaying the second COVID-19 vaccine dose in England: a mathematical modelling study.[[7]](#footnote-8)

1. It is best to avoid interrogative titles. Interrogative titles are questions. While they may heighten curiosity, interrogative titles do not convey the main ideas of your research.

* **Interrogative title**: [Can a robotic arm be controlled by the brain?](https://www.sciencejournalforkids.org/articles/can-a-robotic-arm-be-controlled-by-the-brain/)

1. Do not use abbreviations except those commonly used (such as DNA) in your title. Readers unfamiliar with the jargon and abbreviations used in your field of research may not understand the thrust of your report.
2. Avoid using phrases such as ‘A report on’, ‘A study of’, ‘Results of’, or ‘An experimental investigation of’. They are uninformative.

The following table shows the most cited scientific papers in the Thomson ISI Index. Note that all these papers have simple titles that are easily understood by readers who may not be experts in the field of biochemistry.

Table 1 – most cited scientific papers in the Thomson ISI Index[[8]](#footnote-9).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Rank | Citations | Title | Year | Journal |
| 1 | 305,148 | Protein measurement with the folin phenol reagent. | 1951 | J. Biol. Chem. |
| 2 | 213,005 | Cleavage of structural proteins during the assembly of the head of bacteriophage T4. | 1970 | Nature |
| 3 | 155,530 | A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. | 1976 | Anal. Biochem. |
| 4 | 65,335 | DNA sequencing with chain-terminating inhibitors. | 1977 | Proc. Natl Acad. Sci. USA |
| 5 | 60,397 | Single-step method of RNA isolation by acid guanidinium thiocyanate-phenol-chloroform extraction. | 1987 | Anal. Biochem. |

## Abstract

**The abstract**

The abstract is a one paragraph (approximately 100–200 words) summary of the scientific research investigation. It contains the question, the methods, key results and conclusions. It should be accurate and precise. Referencing is not needed in the abstract.

**Science Extension Stage 6 Syllabus (2017)**

After the title, the abstract is the second-most-read part of your article. Therefore, a good abstract is an important tool for readers to find and evaluate your work. In addition, readers will use it to decide whether to read the rest of your article. Therefore, it should be a concise standalone piece that accurately represents your research.

The following structure provides a scaffold for constructing a good abstract. However, the abstract should be written as a single paragraph without headings.

**Background or introduction** – what is currently known?

* Start with a brief, 2- or 3-sentence introduction to the research area.
* Indicate the objectives or aims – what is the study, and why did you do it?
* Clearly state the research question you are trying to answer.

**Methods** – what did you do?

* Explain what you did and how you did it. Include important information about your methods but avoid the details.

**Results** – what did you find?

* Briefly describe the key findings of your study. Include essential data (including confidence intervals or p values) where possible.

**Conclusions** – what did you conclude?

* Tell the reader why your findings matter and what this could mean for the ‘bigger picture’ of this area of research.

## Literature review

**Literature review**

This section (approximately 750–1000 words) is designed to inform the reader of the relevance of the scientific research and includes background information enabling the reader to understand the key areas involved. It is usual to start the review with a broad scope and become more specific. Sources used are to be current and, where possible, original articles referenced rather than reviews of the articles.

**Science Extension Stage 6 Syllabus (2017)**

The Literature review section clarifies the motivation for the work presented.

A good literature review should answer the following questions:

* What is the issue you are addressing?
* What is already known about the issue in the literature?
* What are the gaps in the literature?
* What do you hope to achieve?

Initially, provide some general information about the field of research to create a broad context for a knowledgeable reader outside of the field. Then, narrow the scope until you reach the specific question you are trying to answer. The Literature review should only include material directly relevant to your research; it does not need to contain the entire history of the field of interest.

Cite some critical publications in the field of research. Provide some context to those articles. For example:

* Do they suggest multiple ideas relating to the issue you are addressing?
* Do those ideas represent alternate or conflicting models in your field of research?
* What is the strength of the evidence provided in those articles?

Indicate the knowledge gaps that exist in your field of research. A knowledge gap refers to a deficit in knowledge or data in an area or topic in a scientific discipline. The knowledge gap you are addressing is a small component of a larger area of research. Explicitly state how your work addresses that knowledge gap. In addition, that knowledge gap will drive your scientific research question, scientific hypothesis, and the design of your experiment.

## Scientific research question

**Scientific research question**

The Scientific research question addresses a single independent variable but may be broken down into subparts if multiple aspects are involved and are directly related. The Scientific Research Project should have a single major focus and subsequently only one main scientific research question. The question should be clear, precise and specific; written in scientific language, and be developed from the review of the literature.

**Science Extension Stage 6 Syllabus (2017)**

Develop the research question based on the information presented in the literature review. A high-quality research question relates the gaps in the literature to the variables that will be investigated in your research. It must also be specific and concise but contain sufficient information so the reader understands the inquiry. Example[[9]](#footnote-10):

**Observation**: Brown-headed cowbird nestlings refrain from ejecting host offspring from the nest even though those offspring compete for limited parental resources.

**Research question**: Why do nestling cowbirds tolerate the presence of host offspring in the nest?

## Scientific hypothesis

**Scientific hypothesis**

Once the Scientific research question has been chosen, a hypothesis is then formulated. A hypothesis is a statement that relates an independent variable to a dependent variable in a causal relationship that can be tested.

**Science Extension Stage 6 Syllabus (2017)**

Not all research investigations are hypothesis-driven. For example, observational and pilot studies may not contain hypotheses. When a hypothesis is tested in an investigation, it must possess the following qualities:

* **Testability** (the hypothesis can be investigated in a controlled experiment)
* **Predictability** (a prediction of observed outcomes)
* **Explanatory** (the hypothesis is derived from one or more theories/concepts in the field of research).

A hypothesis is a testable explanation of an observation. Thus, hypothesis-driven investigations test whether the collected evidence supports the prediction in the hypothesis. Although ‘hypothesis’ and ‘prediction’ are often incorrectly used interchangeably, they refer to different but complementary concepts. **A hypothesis attempts to explain the mechanism behind a phenomenon, while a prediction states the expected results.**

Hypotheses are never proven but can be disproved. Thus, if the evidence from an investigation does not support the hypothesis, it is rejected. Conversely, if the evidence supports the prediction, we say the **hypothesis cannot be rejected**. Furthermore, if the hypothesis cannot be rejected, we conclude that the scientific theory on which it is based is probably valid. For example9:

**Observation**: Brown-headed cowbird nestlings refrain from ejecting host offspring from the nest even though those offspring compete for limited parental resources.

**Research question**: Why do nestling cowbirds tolerate the presence of host offspring in the nest?

**Prediction**: Cowbird nestlings will grow at a faster rate in nests that contain host offspring.

**Scientific theory/concept**: The presence of host offspring causes parents to bring more food to the nest.

### The null and alternate hypotheses

The null and alternate hypotheses are used in inferential statistical tests of datasets. The null hypothesis is derived from the research hypothesis. In the hypothetico-deductive approach to scientific investigation, the research hypothesis predicts a relationship or pattern of behaviour between variables based on scientific theory. The null hypothesis assumes that such a relationship or pattern of behaviour does not exist or occurs only by chance. The alternate hypothesis counters the null hypothesis by assuming that the null hypothesis is not supported.

In statistical tests, only the null hypothesis is tested. The statistical test determines if the null hypothesis is supported. If the null hypothesis is not supported, it will be rejected, and the alternative hypothesis will be accepted. Thus, the scientific hypothesis is statistically significant. On the other hand, if the null hypothesis is supported, it cannot be rejected. Thus, the scientific hypothesis is not statistically significant.

**The null and alternate hypotheses should only be provided if a statistical test forms part of the data analysis. It cannot be substituted for the research hypothesis.**

## Methodology

**Methodology**

The Methodology is usually written first and is refined as the scientific research progresses. The methodology should be written in passive voice, simple past tense and contain enough specific and detailed information so that it can be repeated by another scientist to obtain the same results.

**Science Extension Stage 6 Syllabus (2017)**

The information in this section ensures understanding, reproducibility, and replicability. A well-written methods section enhances readers’ understanding of the research and is the backbone of transparency and replicability.

Information commonly described in this section:

* step-by-step procedures in paragraph form
* for field studies, a description of the field site or site where the experiment was performed
* the details of sample preparations
* information about the study organisms used
* the variables and experimental controls in the investigation
* the equipment used, including model numbers and year
* important equipment settings (for example, the temperature of incubation, speed of centrifuge)
* the amounts of reagents used, including units
* all specific measurements taken, including units
* any software used
* the procedures used to process and analyse data
* the details of any statistical analyses conducted (for example, ANOVA, linear regression).

The Methodology section should not be provided as a numbered list. Instead, each procedure should be written as a separate paragraph with subheadings. For example:[[10]](#footnote-11)

**Strains and growth conditions**

Strains and plasmids are listed in S3 Table, and primers are listed in S4 Table. Unless otherwise stated, P. fluorescens SBW25 were grown at 28°C and E. coli strains at 37°C in Lysogeny broth (LB) [82] solidified with 1.5% agar where appropriate. Liquid cultures were grown in 10 mL microcosms at 28°C for P. fluorescens and 37°C for E. coli at 250 rpm unless otherwise stated. Minimal media was made using M9 salts supplemented with 2 mM MgSO4 and 0.1 mM CaCl2 and each carbon source present at 0.4%. For motility assays, plates were solidified with 0.5% agar. Gentamicin (Gent) was used at 25 mg ml−1, Streptomycin (Strep) at 250 mg ml−1, Kanamycin (Kan) at 50 mg ml−1, Carbenicillin (Carb) at 100 mg ml−1, Tetracycline (Tet) at 12.5 mg ml−1, IPTG at 1 mM, and X-gal at 40 mg ml−1.

**Molecular biology procedures**

Cloning was carried out in accordance with standard molecular biology techniques. All pTS1 plasmid inserts were synthesised and cloned into pTS1 by Twist Bioscience. The ORF of rsmQ was amplified by PCR with primers RsmQ\_EcoRI\_F and RsmQ\_XhoI\_R and ligated between the EcoRI and XhoI sites of pME6032. The ORF of rsmQ with a TEV cleavage site and a hexahistidine tag at the C-terminus was synthesised by Twist Bioscience. The ORFs of each Rsm protein were amplified by PCR using the primers indicated in S3 Table. The fragment in each case was cloned between the NdeI and XhoI sites of pET28a. Bacterial-2-hybrid plasmids were made by Gibson assembly (RsmE/I) and restriction cloning (RsmA/Q) into the BamHI and EcoRI sites of pKNT25 and pUT18C.

If you followed a procedure from another paper, cite its source and provide an overview of the method. There is no need to reiterate the details unless you deviate from the source and change some steps in your procedure. However, it is important to provide enough information so the reader can follow your methods without referring to the original source. Here is an example[[11]](#footnote-12):

**Systematic literature search**

We extracted female Bateman gradients from a previous meta-analysis [3] and expanded this database by adding studies that have since been published. Specifically, we ran a systematic literature search using the ISI Web of Knowledge (ISI Web of Science Core Collection database; Clarivate Analytics) with the “topic” search terms defined as (“Bateman\*” OR “opportunit\* for selection” OR “opportunit\* for sexual selection” OR “selection gradient\*” OR (“mating success” AND “female\*”)) on the 31st of March 2022.

Provide sufficient information in the Methodology section so readers can understand the results. On the other hand, detailed information should be provided in the Appendix. For example, if a computer program was developed as part of the research project, then present the code in the Appendix, but highlight its essential features in the Methodology section. Likewise, if a survey was conducted during the research, the instrument should be presented in the Appendix.

### Visual representations

Consider including a visual representation of your methods to help your readers understand your research methodology. Visual representations may include flowcharts, decision trees, or checklists.

### Ethical Considerations

Information on ethical considerations that apply to your research should be provided in the Methodology section of your SRR. This could include relevant ethics permits and specific procedures and protocols, such as the care and disposal of animals or working with genetically modified organisms.

## Results

**Results**

The Results are based upon the facts. This section describes what was observed, calculated or the trends discovered. It is not an explanation of the results. The order of the results can either follow the order of the methodology or, maybe, in order of most important to least important. Results may include tables, graphs and/or other visual representations to highlight important features. It may be relevant to comment on the degree of uncertainty stated for each set of data collected. All visual displays should be labelled with a number, concise name and a stand-alone description of how the result was obtained. It is useful to integrate visual displays with text so that the reader is guided through the research.

**Science Extension Stage 6 Syllabus (2017)**

The Results section is the place in the SRR where your key findings are presented objectively. It lays the foundation for the Discussion section, where those data are interpreted. If the procedures described in the Methodology section were followed faithfully, and the data collected and analysed as per those procedures, then the results are valid. The results of a well-conducted investigation are real. However, unlike the results, the interpretations of the data (in the Discussion) may be contested or changed.

### Processing data

Raw data should not be reported in the Results section of the SRR. Instead, they should be presented in the Appendix. In addition, raw data should be processed before analysis. Some examples of data processing include:

* removing erroneous measurements
* removing ‘noise’ from measurements
* identifying and possibly removing outliers in datasets.

You must explain all data processing you undertake in your research. Removing data points from datasets without valid reasons and explanations may be construed as scientific malpractice.

**Note: you must not exclude data simply because they violate a trend that would otherwise be apparent, or because the data contradict a favoured hypothesis (Pechenik, 1993).**

### Tables and figures (graphs)

Figures and tables are the most used forms of data visualisation. Here is a definition of these terms:

A **table** presents lists of numbers or text in columns, and should be used to illustrate differences, but not to represent relationships.

A **figure** is any visual presentation of results or illustration of concepts/methods, including photographs, graphs, diagrams of set-ups, drawings, maps, and flowcharts.

Tables and graphs help organise data to reveal trends and patterns in them. Those trends and patterns may form the evidence for the scientific narrative you describe in your SRR. Before writing the Results section, prepare the data you will include in your report. Synthesise reportable or summary data from the raw data. For example, if multiple measurements of the dependent variable are made, only report the average of those measurements in the Results section (the raw measurement data are provided in the appendix).

#### Tables

The tables in the Results section of the SRR should not contain all the data obtained in the experiment. Table 2 shows an example of such a table. Instead, the important information in this table should be summarised so that the reader’s attention is drawn to the key finding (Table 3).

Table 2 – example of a table used to record data in an experiment. In this experiment, the student measured the effect of three fertilisers on plant growth.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fertiliser | Initial height (cm) | Final height (cm) | Change in height (cm) | The average change in height (cm) |
| A | 5.1 | 10.3 | 5.2 | 5.3 |
| A | 3.8 | 9.2 | 5.4 |  |
| B | 3.5 | 7.8 | 4.3 | 4.1 |
| B | 4.3 | 8.2 | 3.9 |  |
| C | 5.2 | 10.3 | 5.1 | 5.1 |
| C | 4.7 | 9.8 | 5.1 |  |

Table 3 – this table summarises the information in Table 2. The phrase n=2 indicates that the data are the averages of two measurements.

|  |  |
| --- | --- |
| Fertiliser | The average change in height (cm). n=2 |
| A | 5.3 |
| B | 4.1 |
| C | 5.1 |

The raw measurements, such as the initial and final heights, should be presented in the Appendix.

Tables can also include relevant statistical information about the data (Table 4).

Table 4 – results of a study to measure the effect of physical activity on urine production. E1: Vigorous outdoor exercise for 20 mins; E2: Outdoors & sedentary; C: Indoors & sedentary. The data in the table represents the average volume of urine produced by ten individuals in each group. The descriptive statistic is the standard deviation of the mean (indicated as ± …).

|  |  |
| --- | --- |
| Treatment | Average volume of urine produced (mL). n=10 |
| E1 | 29.4 ± 4.47 |
| E2 | 30.5 ± 4.24 |
| C | 50.3 ± 5.34 |

#### Graphs

Do not assume that you must plot graphs of your data. Often, data can be meaningfully displayed in tables. However, graphs are useful for displaying patterns and trends in your data.

When data is presented as graphs, keep them as simple as possible. When constructing graphs, pay attention to the following (the acronym, SALT, may be used to remember these features of graphs):

* **S**cale – ensure that the scales for all axes are appropriate and consistent.
* **A**xis – the independent variable is plotted on the x-axis, and the dependent variable on the y-axis.
* **L**abels – label the axes with the independent and dependent variables, including their units (as appropriate).
* **T**itle – an informative title that indicates the examined variables.

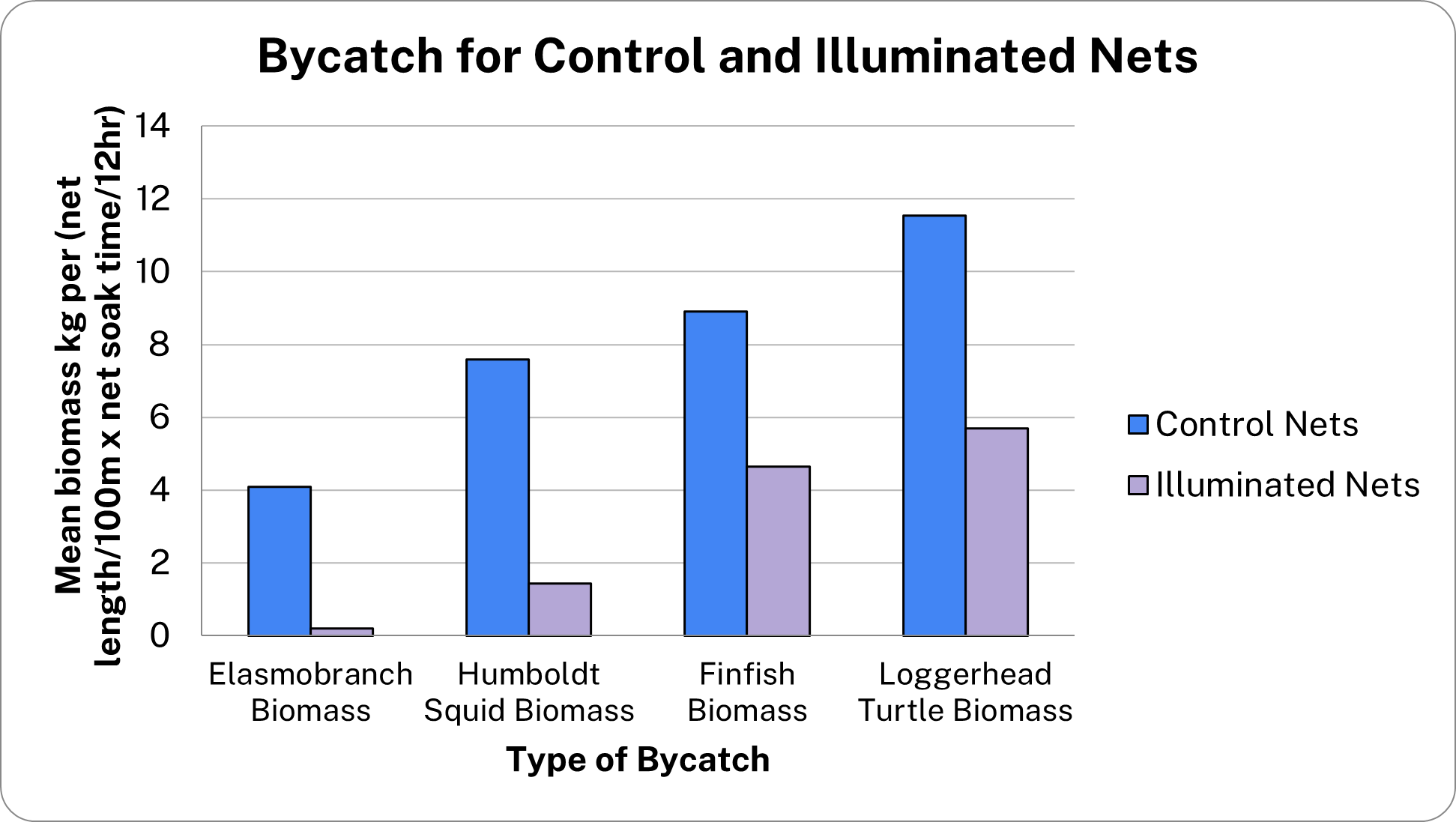
If multiple graphs are plotted on the same axes, then include a:

* **K**ey – the different graphs (data points) should be indicated using clearly distinguishable colours, patterns, or shapes.

Note that with complex graphs, the acronym SALT may be changed to TALKS.

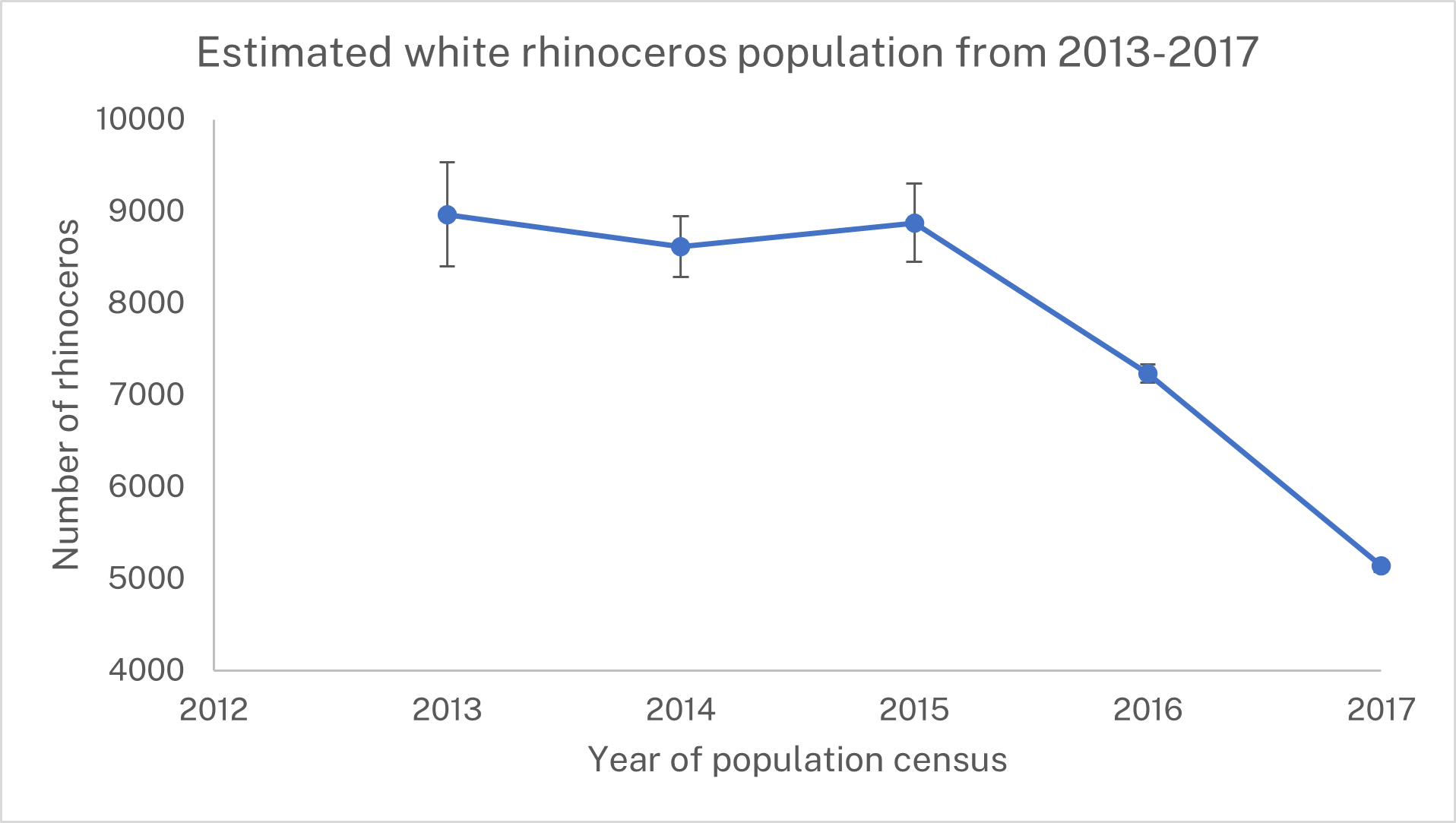
Figure 2 shows an example of a graph that satisfies the criteria for good-quality graphs.

Figure 2 – a column graph showing the effect of illuminated fishing nets on Bycatch[[12]](#footnote-13)



As with tables, graphs may include statistical information. Figure 3 shows an example of such a graph.

Figure 3 – a graph showing the population of white rhinoceros at a protected reserve from 2013–2017. The error bars indicate ± Standard Error of the Mean (SEM). This figure is adapted from the original[[13]](#footnote-14)



### Constructing the Results section of the SRR

Construct the section, one result at a time. Here is a suggested strategy:

1. Identify which figures and tables are necessary for telling your story.
2. Order the data so that they construct a narrative that you will convey to your readers. That narrative should consist of a logical flow of ideas. Often the sequence of the data presented will differ from the sequence of the activities in your investigation.
3. Once you have settled on the sequence and layout of your data, construct your Results section.
4. Number the figures, tables, and graphs. All figures and tables are numbered sequentially: Figure 1, Figure 2, Figure 3, Table 1, Table 2, Table 3, and so on. They should be numbered in the order they are referred to in the text of the Results sections (for example, Figure 9 should not be referenced before Figure 1). Then, write a caption for each piece of data. The caption should convey all the information needed for a reader to understand the figure without referring to the report.
5. Present the main ideas for each piece of data. Describe fully what is indicated in the figures and tables. Do not expect your readers to interpret or understand the information in the data visualisations.
6. Ensure that you refer to all figures and tables in your text. Also, never represent the same data in tables and graphs.

The information provided in the figure or table captions should make them self-explanatory. When writing your results, summarise only the most important information displayed in the figures and tables. Importantly, let the reader know what your data means. Table 5 provides examples indicating how data should be reported so that the reader’s attention is drawn to the key messages you are developing.

Table 5 – illustrations of best practices to write the results section of your SRR. For each example, low-quality and revised high-quality descriptions are provided.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Poor quality | | | High quality | | |
| Example | **Initial description** | **Comment** | | **Revised description** | **Comment** | |
| 1 | At 20oC, the seedlings showed negligible growth for the first 8 days of the study. However, between days 8 and 16, the average seedling grew 5 mm, from 8 mm to about 13 mm. Growth continued over the next 16 days, with the seedlings reaching an average height of 24 mm by day 24 and 30 mm by day 32. | Too much detailed information is provided. It is expected that knowledgeable readers can make sense of the information provided in figures and tables.  The key finding of the investigation (the effect of temperature on growth rate) is lost in the detail. | Temperature had a pronounced effect on seedling growth rates (Figure XX). Seedlings at 25oC (average growth of 0.8 mm/day) consistently grew more rapidly than those at 20oC (average growth of 0.3 mm/day). | | | The author makes a specific reference to the figure displaying the data. Furthermore, the readers’ attention is brought to the important finding that higher growth temperatures resulted in higher growth rates. |
| 2 | Although individual specimens of Littorina littorea varied considerably in shell length at each tidal height (Figure XX), there was a significant (t=26.3; df=47; p<0.05) distributional effect of shore position on mean size (Table XX) | The reader is left to figure out what is important in the data. For example, the phrase “significant distributional effect” is an interpretation of the data not directly evident from the information provided. Such interpretations should be described in the Discussion section of the SRR. | Although individual specimens of Littorina littorea varied in shell length at each tidal height (Figure XX), the mean shell length was significantly greater (t=26.3; df=47; p<0.05) for snails collected higher up in the intertidal zone (Table XX); high shoreline animals were, on average, 26% larger than low-shore animals. | | | The reader is directed to specific data, and their meanings are provided. The reader can associate observations with specific data. |

The following example5indicates how figures and tables are referred to in the Results sections of scientific papers:

Moreover, Bateman gradients showed substantial variability across studies (Fig 2 and Table 1).

In the next example[[14]](#footnote-15), the authors refer to data presented in Figure 1, and in Supplementary Data S1[[15]](#footnote-16):

Given prior trends (Figs 1 and S1), OSD should become more negative as attitudinal position becomes more negative.

### Reporting statistics

Statistical tests should only be conducted if they are suitable for data analysis. Most statistical tests possess various assumptions about the data being analysed. If those assumptions are not satisfied, then the outputs of the statistical tests are meaningless. For example, a Student’s t-test assumes that the compared samples are normally distributed and possess equal variances. The following examples indicate how statistical outputs are reported in the Results section of the SRR.

No statistics

* The height varied significantly between children aged 5–7, 8–10, and 11–13. The means were 115.3, 133.5, and 149.1 cm, respectively.

With descriptive statistics

* The average sample height was 136.4 cm (SD = 15.1 cm).
* The height of the initial sample was low (m = 125.9 cm, SD = 16.6 cm).

With inferential statistics

* Scores improved between the pre-test and post-test (p < 0.001).
* Significant differences in test scores were recorded (F = 4.67, p = 0.003).
* A Chi-square test of independence revealed a significant association between gender and product preference (Χ2 = 19.7 df =8, p = 0.012).
* The reaction times were significantly faster for mice in the experimental group (t = 5.94, p < 0.001).

You should report all your results, even if the statistical analyses suggest that the comparisons are statistically insignificant. Describe the trends and patterns evident in your data. Remember that statistical significance only indicates that the observed relationship between the variance does not occur randomly (by chance). On the other hand, the relationship between the variables is established through data analysis (not statistical analysis) and modelling.

Therefore, the Results section of the SRR focuses on presenting the data.

Avoid interpreting the results in this section so that the reader can evaluate your findings objectively. Thus,

* Do
* draw your readers’ attention to key observations, trends, and patterns in your data.
* Do not
* describe how or why the experiment was performed.
* indicate whether the results were expected, unexpected or interesting.

## Discussion

**Discussion**

The discussion (approximately 700–1200 words) forms the argument and provides an explanation of the phenomenon that was investigated. Other peer-reviewed scientific research should be used and referenced to discuss findings and to form an academic argument. The discussion includes an evaluation of the data-analysis and an explanation of the results, why they occurred, key limitations and further implications with suggestions for future directions of scientific research.

**Science Extension Stage 6 Syllabus (2017)**

In the Discussion section of the SRR, you will interpret the results of your investigation and describe their implications for the broader scientific community. The Discussion should not restate the results but provide arguments for making sense of the results. Broadly, you will interpret the results:

* to draw conclusions about the hypothesis
* to discuss whether the results make sense in light of what else we know about the system under study.

There are generally 2 ways that the discussion should be framed:

1. If your findings agree with other discoveries in your field of research, then you have added to the relevant body of knowledge. When multiple studies provide results that lead to similar conclusions, scientists broaden or deepen their understanding of the phenomenon.
2. If your findings do not agree with other discoveries, you must inspect whether you have adhered to the accepted methods of the scientific process (validity). Assuming that your investigation design is valid, your findings may represent a new discovery in your field of research.

Thus, the Discussion should be a narrative of your scientific explorations. Your scientific ideas must be well articulated to contribute to the broader conversations in your field of research. A good discussion requires strong reasoning and argumentation skills. The Claims-Evidence-Reasoning scaffold is a robust framework for developing a high-quality discussion.

* **Claim:** an inference or an answer to a question.
* **Evidence:** evidence is scientific data (quantitative or qualitative) that supports the claim.
* **Reasoning:** a justification that connects the evidence to the claim (usually, this is the scientific theories and principles that connect the evidence to the claim).

Here is a suggested strategy for planning the Discussion section of your SRR:

**State the claims evident in your data**

* For each claim, indicate the evidence and your reasoning (Note that you may have to use multiple lines of evidence to support a claim).
* If there are multiple interpretations of a result, clearly lay out each competing explanation.

**Indicate the relevance of the claims to your inquiry question or hypothesis**

* Do the claims provide sufficient evidence to answer your research question or support your hypothesis?
* What can be learned from the results if your research question cannot be answered or your hypothesis is not supported?

**Comment on the strength of the evidence**

* Explore the quality of the data collected (for example, data accuracy, precision, reliability, the validity of the investigation, and the errors and uncertainties of measurement).
* How can the investigation be improved (for example, by increasing sample sizes, the number and range of measurements, or improved instrumentation)?

**Compare your findings with those discovered by other researchers**

* Are your results consistent or inconsistent with those of similar studies? (Refer to publications in the literature).
* If they are inconsistent, discuss why this might be the case (inconsistencies may arise from using different experimental systems, investigation designs, datasets, or analytical methods).

**Discuss your findings in the context of the field of research**

* For example, do your findings reshape or add to the field’s knowledge base?
* Do they add further evidence to a scientific consensus or disprove prior studies?
* Have your findings contributed to narrowing the knowledge gaps identified in your literature review?

**Outline how future research could build on these observations**

* Can you suggest some key experiments that must be done (these could be based on the alternative explanations you have identified in your research)?

### Discussing unexpected results

Do not worry if your results do not support your hypothesis or answer your inquiry question. Students are often concerned about ‘negative results’ and assume they indicate a failed inquiry. On the contrary, unexpected results or data unsupportive of your hypothesis may be informative – they may highlight some aspect of your research that was not evident at the start of your inquiry.

Discuss your results objectively and explain what the data may indicate. The following examples illustrate how unexpected results may be discussed (modified from Pechenik 1993):

The data indicate that food choice was not related to the food on which the caterpillars were reared. These data run counter to the hypothesis that …

Contrary to the prediction in the hypothesis, the results suggest that Manduca sexta caterpillars showed no dietary preference, even for the food they were reared on.

Then, consider possible reasons for the unexpected result. Speculating plausible explanations for the unexpected result in your research is acceptable. You may propose variations to the design of your experiment to determine if the unexpected result represents a genuine outcome. For example (modified from Pechenik 1993):

In this experiment, the caterpillars were reared on the original diet for only four days before being exposed to the new diet. This length of time may be insufficient for the caterpillars to develop dietary preferences. In their work, Orians and Starks (2003) reared their caterpillars for 5–10 days before introducing the animals to new conditions. This possibility may be tested by varying how long the caterpillars are reared on their original diet before introducing them to their new diets.

Another example (modified from Pechenik 1993):

The lack of statistical significance between the treatment and control groups may be due to methodological difficulties. The large variation observed between the three replicate populations suggests that sampling error may be high. This could be due to errors in counting cells, especially at high cell densities. Sampling error may be minimised by increasing the number of replicate populations, for example, increasing the number of replicates from 3 to 5. Also, using a cell stain to distinguish cells from other material in the cell suspensions will enhance the measurement precision.

### Structuring your discussion

Present your discussion in about three paragraphs. Here is a model of a three-paragraph discussion that addresses all the findings and implications of the research:

**First paragraph**

* Provide the essential interpretations of the data.
* Include the main piece of supporting evidence.

**Second paragraph**

* Compare and contrast to previous studies.
* Highlight the strengths and limitations of the study.
* Discuss any unexpected findings.

**Last paragraph**

* Summarise the hypothesis and purpose of the study.
* Highlight the significance of the study.
* Discuss unanswered questions and potential future research.

## Conclusion

**Conclusion**

The conclusion (approximately 250–500 words) is a summary of the scientific research findings and is usually one or two paragraphs in length and should not introduce new information.

**Science Extension Stage 6 Syllabus (2017)**

In the Conclusion, you should summarise your study’s outcomes instead of merely restating your main findings. Present the new insights or intriguing questions that arose from your research. Broaden your perspective. You want your take-home sentences to focus on your accomplishments and the broader implications of your study. End on a strong note.

## Reference

**Reference list**

All sources of information and data that are used to inform the scientific research should be cited using an appropriate footnoting and referencing style.

**Science Extension Stage 6 Syllabus (2017)**

For the Science Extension Report, you should use in-text citations of references, followed by a reference list at the end of the report (before the Appendix). The references in the SRR should be from peer-reviewed sources. Textbooks and non-peer-reviewed sources should not be used.

A consistent referencing style, such as the Harvard Reference Style, should be used consistently throughout the report. Using reference manager software can automate the process of generating in-text citations and the reference list.

## Appendix

**Appendices**

Appendices are not essential, but are used to include relevant documents that are either too large or that detract from the flow of the report. They are to be numbered and referred to in the text.

**Science Extension Stage 6 Syllabus (2017)**

Appendices are additional or supplementary information not essential to understanding the SRR. Thus, your report should be understood without the information in the appendix. For the Science Extension SRR, the appendix contains data (usually raw experimental data) that form the basis of the figures and tables in the Results section. By placing the raw data in the Appendix, the SRR’s Results section becomes smaller and easier to read. Materials that may be included in the Appendix include[[16]](#footnote-17):

* additional figures and tables
* big datasets or raw data
* questionnaires and surveys
* transcripts of interviews
* additional methodology details
* additional documents.

If only one Appendix is used, it can be called ‘Appendix’. However, if more than one is included, all appendices should be clearly labelled in the order they are mentioned in the main text. Appendices may contain letters or numbers (for example, ‘Appendix A’ or ‘Appendix 1’). They may also contain topic-specific headings (for example, ‘Appendix A: Spectroscopic measurements’).

## How to edit your work

You must review your SRR a few times before submitting it for assessment. Your teacher may provide feedback on your draft, which you should incorporate. Also, ask your friends and family members to proofread your SRR draft. Before getting them to read your SRR, provide a summary and context of your research. Then, indicate what type of feedback you would like. For example, if the reviewer has a background in science, they may provide specific feedback on the scientific content of your report. Those who lack a scientific background may provide feedback on the structure, layout, and typographical errors. Also, ask your reviewers to provide their feedback within a specified timeframe so that you can incorporate the suggestions and submit your SRR in time for assessment.

When you assemble your SRR, you may find it difficult to identify errors more difficult. It is best to leave your draft aside for a few days before reviewing and editing the document. Reading your manuscript aloud helps to ensure each sentence makes sense and avoid skimming over mistakes. Try reading your manuscript in reverse order, one sentence at a time, for a radically new perspective. This trick forces you to focus on the sense and structure of each passage.

The most important aspect of reviewing your draft SRR is ensuring there are no scientific inconsistencies in it. If you are in a rush to finish the document to submit it before the deadline, then focus on the scientific content of your SRR. Ensure the accuracy of your information and the fluency of the ideas presented in your SRR.

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## Support and alignment

**Resource evaluation and support**: all curriculum resources are prepared through a rigorous process. Resources are periodically reviewed as part of our ongoing evaluation plan to ensure currency, relevance and effectiveness. For additional support or advice, or to provide feedback, contact the Science Curriculum team by emailing [Science7-12@det.nsw.edu.au](mailto:Science7-12@det.nsw.edu.au).

**Differentiation:** further advice to support Aboriginal and Torres Strait Islander students, EALD students, students with a disability and/or additional needs and High Potential and gifted students can be found on the [Planning, programming and assessing 7-12](https://education.nsw.gov.au/teaching-and-learning/curriculum/planning-programming-and-assessing-k-12/planning-programming-and-assessing-7-12) webpage.

**Assessment**: further advice to support formative assessment is available on the [Planning, programming and assessing 7-12](https://education.nsw.gov.au/teaching-and-learning/curriculum/planning-programming-and-assessing-k-12/planning-programming-and-assessing-7-12) webpage.

**Professional learning**: relevant professional learning is available on the [Science statewide staffroom](https://education.nsw.gov.au/teaching-and-learning/curriculum/statewide-staffrooms), and [HSC Professional Learning](https://education.nsw.gov.au/teaching-and-learning/professional-learning/hsc-pl). [Stage 6 Literacy in context](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy/teaching-and-learning-resources/literacy/stage-6-literacy-in-context-writing/science) provides further advice to teachers to improve student writing.

**Related resources**: further resources to support Stage 6 Investigating Science can be found on the [HSC hub](https://www.hschub.nsw.edu.au/) and the [Science Curriculum page](https://education.nsw.gov.au/teaching-and-learning/curriculum/science).

**Consulted with**: Multicultural Education and subject matter experts.

**Alignment to system priorities and/or needs**: [School Excellence Policy](https://education.nsw.gov.au/policy-library/policies/pd-2016-0468), [School Success Model](https://education.nsw.gov.au/public-schools/school-success-model/school-success-model-explained).

**Alignment to the School Excellence Framework**: this resource supports the [School Excellence Framework](https://education.nsw.gov.au/policy-library/policies/pd-2016-0468) elements of curriculum (curriculum provision) and effective classroom practice (lesson planning, explicit teaching).

**Alignment to Australian Professional Teaching Standards**: this resource supports teachers to address [Australian Professional Teaching Standards](https://educationstandards.nsw.edu.au/wps/portal/nesa/teacher-accreditation/meeting-requirements/the-standards/proficient-teacher) 1.5.2, 2.5.2

**Author**: Science 7-12 Curriculum Team

**Resource**: Classroom resource

**Creation date:** 20 Apr 23.

## References

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### Further reading

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