



**CHANCELLOR  
STATE COLLEGE**

*The best we can be*

Science Faculty

# **Scientific Report Writing Guidebook**

STUDENT NAME: \_\_\_\_\_



# CHANCELLOR STATE COLLEGE

## NOTES



# CHANCELLOR STATE COLLEGE

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## Chancellor State College Assessment Policy

For all assessment tasks (except exams) students **must** sign the declaration stating that they have read and understood the college assessment policy.

### **Key points to note regarding the Assessment Policy:**

- Students **must** submit a draft – 2 hard copies OR 1 hard copy & email (1 copy will be kept by the teacher the other will be returned to student. Students will receive feedback on an A4 sheet if two copies are not submitted)
- Final submitted in class on due date. The teacher will insist on something handed in.
- An updated final can be submitted through the office before 3pm sharp on the due date.
- E-mails can be used; however, exceptions will not be made for delays or loss of data in transmission. Evidence of a message sent but not received will not be grounds for extension. ***We recommend you do not rely on e-mail for final submission on the due date.***
- Loss of data, inability to print, or failed e-mails are ***unlikely*** to be considered reasonable grounds for extension. **Backup and print regularly.**

### **Below are some specific expectations for the science faculty:**

- 1.5 line spacing
- 11 point (Arial or Calibri font recommended)
- Stapled with no loose leaf
- Task sheet attached to front of final copy

## Word Limit – Quality not Quantity

The QSA word guides are as follows and apply to the introduction and discussion. It does not apply to the abstract, method or results. The QSA recommends only:

**Year 12: 1000-1500 words (maximum 2000 words)**

**Year 11: 800-1000 words (maximum 1500 words)**

Excess word counts detract (not add) from a task and may be penalised as is represented in the exit standards.

### **VHA standard from Chemistry and Physics**

- Discriminating selection, use and presentation of scientific data and ideas to make meaning accessible to intended audiences through innovative use of a range of formats.

Students who significantly exceed the word limit have not demonstrated *discrimination* or made the *meaning accessible*.

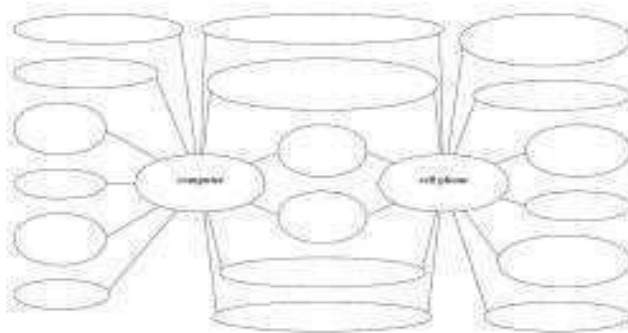
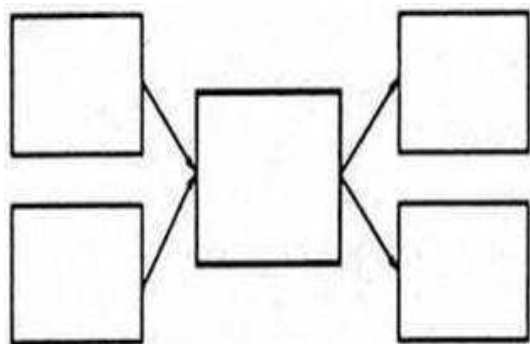
Biology does not have a similar statement however a student that significantly exceeds the word limits uses a scattergun approach with large amounts of information to eventually hit the target criteria. This student failed to *critically analyse and evaluate information* to only include pertinent information. Also, they have not *integrated the information* effectively.

The student communicates by:

- Gathering, critically analysing and evaluating information and data from a variety of valid and reliable sources.
- Integrating the information and data to make justified and responsible decisions.

### Being Concise

Using graphic organisers are also an effective way to reduce word limits whilst demonstrating links, relationships, etc. Here are some examples:



# CHANCELLOR STATE COLLEGE

## Reducing Unnecessary Words and Phrases

Below is an example of a students work. Below the students work is an example of how a teacher has re-stated the exact same information but in a more concise manner. This has improved the response not diminished it!

### **Students work**

One of the important benefits of fire is in forestry, where fires often aid in the regeneration of forests. A proposition was made by Smith *et al* (2009) that indicated that the frequency of brushfires was correlated with the number of melaleuca trees saplings in the area.

These saplings are important as they provide eucalyptus oil which is the second largest horticultural sector in Australia. The eucalyptus oil industry is a significant contributor to the Australian export market.

**78 words**

### **Re-stated**

Forests benefit from the regenerating effects of fire. Smith *et al* (2009) indicated that brushfire frequency was correlated with melaleuca sapling density.

These saplings produce eucalyptus oil. The eucalyptus oil industry is the second largest horticultural sector in Australia and contributes significantly to our export market.

**49 words**

Selecting words carefully and omitting any unnecessary words can eliminate wordiness. Here are some examples of common changes:

<b>WORDY</b>	<b>CONCISE</b>
One of the problems	One problem
In only a very small number of cases	Occasionally, rarely
An additional piece of evidence that helps to support this hypothesis	Further evidence supporting this hypothesis
In spite of the fact that knowledge at this point is far from complete	Although present knowledge is incomplete
It is also worth pointing out that	<b><i>Omit it</i></b>
Before concluding, another point is that	<b><i>Omit it</i></b>
It is interesting to note that	<b><i>Omit it</i></b>

## Guidelines for writing a Scientific Report

An essential part of science is learning to communicate findings from a scientific investigation. Thus, preparation of a laboratory report in the form of a scientific paper is regarded as an important part of your learning. Formal laboratory reports are typically required in the sciences. A formal laboratory report is utilized either for writing up a given laboratory that you performed or for designing and conducting your own laboratory exercise.

These reports are an important mode of assessment and should represent your best work. Follow the content and format provided by your teacher and outlined below.

**A scientific paper must fulfill two objectives.** First, it must accurately describe the procedures that were followed and the results that were obtained. Second, it must place these results in perspective by relating them to the existing state of knowledge and by interpreting their significance for future study.

Scientific papers are written in a standard format with the following sections;

- **Title,**
- **Abstract,**
- **Introduction,**
- **Materials and Methods,**
- **Results and**
- **Discussion.**

References, calculations and raw data are usually included after the discussion. Each section contains specific information about the research being described. In the following document, a description of the information found in each section will be outlined, along with some common mistakes made by students. The best way to get a feel for how a scientific paper is organized is by looking at articles in scientific journals. There are many such journals in the library at the University of the Sunshine Coast or they can be found via the internet using "Google Scholar".

## Title

Each piece of scientific work should include a concise but descriptive title. While it is important to be short and concise (essentially one sentence) you do not want to be vague or incorrect. The title should reflect **exactly** what you did in your study. This is also your first shot at grabbing the reader's attention.

### EXAMPLE

**Less descriptive title:**

Migrating Whales and Electromagnetic Fields

**Preferred title:**

The Effect of Electromagnetic Fields on Migrating Whales

The title is phrased in a similar way to the research question, also known as the operational question. Clearly identify the independent variable (IV) and dependent variable (DV).

Recall that **the independent variable** (IV) is the part of the experiment that you are changing and the **dependent variable** (DV) is what is being measured as a result of that change.



**HINT: Use this formula to create a scientific title.**

The Effect of \_\_\_\_\_ [IV] on \_\_\_\_\_ [DV]

For example: The Effect of Exercise on Heart Rate

**Example 1** - "Photosynthesis" ***This doesn't tell the reader much about the paper.*** Instead "The effect of differing light wavelengths on the rate of photosynthesis on the common garden pea plant (*Pisum sativum*)" This tells the reader what is in the paper.

**Example 2** - "Studies on a snake", again too brief. What snake, ***where, what kinds of studies?*** Instead "The Thermal Ecology of a Population of the Common Death Adder (*Acanthophis antarcticus*), in Sippy Downs, Queensland"



## Introduction

The principal job of an introduction is to guide the reader from the broad area of your discipline to the particular topic you will be discussing. From a larger perspective on the problem, the introduction typically proceeds through several transitional sentences, leading the reader logically to the specific question you hope to answer with your experiment or topic you intend to discuss in your research paper.

An introduction also gives the reader the **necessary background** to understand *why* you are performing an experiment or writing the paper. In the introduction you should summarize the work done by other researchers in this area. For a paper in a typical class, most teachers would expect at least **3-5 relevant citations** to appear in the introduction (see references). Remember, you should be careful to restrict background material to that which is directly pertinent to the problem at hand. In other words, you should always be able to justify why you included the material in the introduction to your paper.

The following is a list of 3 elements that are needed in the introduction.

1. Orient the person reading your report to the subject using a concise review of relevant background information. **Research** the available scientific information regarding the selected experimental topic.
  - The literature cited may be from a variety of sources, i.e. your class text book, other text books, research articles, articles from the internet, etc.
  - Information must be **unmistakably relevant** to the specific content of the laboratory.
  - Be selective. When extracting information from other sources, identify 3 or 4 main points. Summarize each point in 1 sentence.
2. Include the purpose of your report. Allow the person reading your paper to understand **why** you are performing your experiment.
3. Indicate your expectations of the outcomes of the experiment and what alternatives you might expect. This proposed explanation of the outcomes/phenomenon is known as the **hypothesis**.



**HINT:** Use this formula to write your hypothesis:

If \_\_\_\_\_ [IV] is \_\_\_\_\_ [describe how it was changed], then \_\_\_\_\_ [DV] will \_\_\_\_\_ [describe the expected effect].

For example:

“If the **antibiotic cleaning agent** is placed on a bacterial colony, then **growth of the colony** will be **inhibited**.”

## Materials and Method

Students often start with this section as it is straight-forward. In writing a materials and methods section, you need to describe what you **did** in such a way that a fellow scientist can follow and duplicate your experiment.

The following is a list of 5 elements that are needed in the introduction.

1. Use the third person and past tense.



**HINT:** Use this formula to write your methods.

**Change this sentence from the book.**

- Add 5 drops of 0.1 M copper (II) sulphate solution into one of the test tubes and shake it so that the solution covers the zinc surface.

**To past tense with you doing the action.**

- I added 5 drops of 0.1 M copper (II) sulphate solution into one of the test tubes and shook so that the solution covered the zinc surface.

**Remove all I, We, Me and replace with the equipment used.**

- Five drops of 0.1 M copper (II) sulphate solution was added into one of the test tubes and shook so that the solution covered the zinc surface.

2. When following a procedure from a lab manual or published paper, simply describe how you conducted your experiments (there should be enough detail such that the reader could easily duplicate your experiments – no lists!, write as a paragraph). Common practices like gel electrophoresis do not need to be explained in detail
3. Keep in mind what information is important to the results obtained and for reproducing the experiment. This includes details such as concentrations, temperatures, measurements, units, timing, calculations, etc. Irrelevant details like “A wax pencil was used to label the test tube,” can be left out!!
4. In field studies it is important include the locations and times that data were collected.
5. Explain who you summarized the data (means, standard deviation) and the calculations and statistical analysis you did.

**Incorrect Example:**

"We measured the samples' hardness. Then we put the pieces of metal in the furnace and then waited for one hour. Then we removed them and put them in the hardness tester again. Joe was listening to his iPod while we did this lab.."

**Correct Example:**

"Samples of different hardness were prepared by annealing them in a furnace for various lengths of time and at different temperatures. The hardness was measured before and after annealing, using a Rockwell hardness tester set up for the B scale."

## Results

The Results section describes, in words, your observations (*qualitative data*) and the measured experimental data (*quantitative data*). It also includes the data displayed in tables and/or in graphs. Results describe only what was found or observed, just the facts. **Interpretation and explanation of results is discussed in the discussion section.**

### Figures

Figures include graphs, maps, photos and technical diagrams. Presentation of data in graphs is generally more desirable than tables because they aid the reader in visualizing trends in the data. There are many different types of graphs, but the most common graphs used in scientific writing are line graphs, used for continuous data such as time and temperature (Fig. 1), and vertical bar graphs used for discrete data such as apples vs oranges OR boys vs girls (Fig. 2). Regardless of the type of graph you use, all contain similar elements.

- (1) **Axes.** A graph consists of a horizontal axis and a vertical axis. The independent variable (what's changed) are plotted on the horizontal axis (bottom line) and values of the dependent variable (the effect or the outcome you measured) are plotted on the vertical axis (up and down line).
- (2) **Labels.** Both axes should be clearly labelled and include units of measure.
- (3) **Figure Caption.** There should be a figure caption ***below*** the graph that briefly describes the information in the figure. It should be clear, concise, and informative. The figure caption should be understandable ***without reference*** to the text and answer, if appropriate, the questions "what", "where", "when" and "why". Figures are numbered in order they appear in the text.

### EXAMPLE

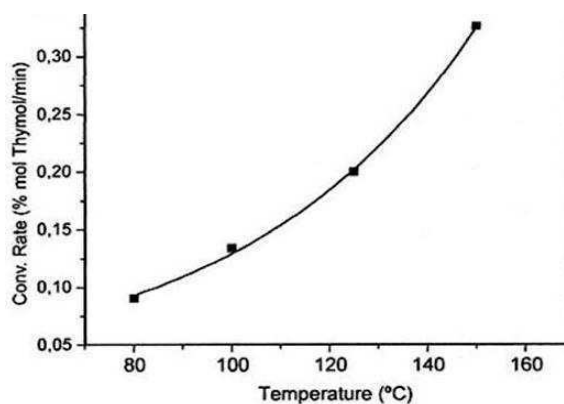


Figure 1. Effect of increasing temperature by 20°C from 80 to 140°C on the conversion of sugar into thymol.

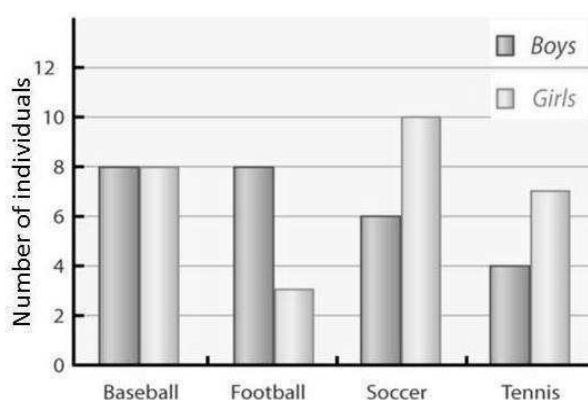


Figure 2. Number of boys and girls at Chancellor State College that participate in the sports of Baseball, Football, Soccer and Tennis

## Tables

In contrast to figures, tables allow precise numerical presentation of data. As with figures, they should be concise and organized such that relations and trends in the data are evident without reference to the text. All tables contain similar elements.

- (1) **Title.** Tables are numbered in order they appear in the text. The title briefly describes the information presented in the table and is presented at the **top** of the table.
- (2) **Column and row headings.** Column headings identify variables or data in each column below the heading. They contain variable names and units of measurements. Row headings identify entries in the rows to the right of the heading. Note that only the initial letter of words or phrases in column and row heading is capitalized.
- (3) **Body.** The body contains the data presented in the table. Data should be presented so that similar elements read down (i.e., in columns). When presenting numbers, give only significant figures; enter numbers in a column under the column heading.
- (4) **Horizontal lines.** Horizontal lines separate the table title from the column headings, the column headings from the subheadings and the column headings from the body

## **EXAMPLE**

Table 1: Changes in the mass of 1cm potato cube over time for the concentrations of salt 0.5% and 1.0%.

% Salt (NaCl)	Initial Mass (g)	Mass at 5 min (g)	Mass at 10 min (g)	Mass at 15 min (g)
0.5%	0.34	0.34	0.35	0.35
1.0%	0.37	0.37	0.38	0.39

## Notes regarding Results

Any statistical analysis done on your data should be included in your appendix. Only sentences stating if differences seen in your means are statistically significant or not should be included in your results. Your teacher will show you how to conduct ANOVAs or lines of regression if they are needed in your report.

The explanation of **why** the trends occurred in your data should be left for your discussion.

## Discussion

The discussion is a challenge to write because it requires **thinking critically about the findings and examining the relationship of the results to other experiments**. Parts of the discussion repeat other elements of your report. This is OK. A reader should be able to understand the entire experiment by reading only the discussion.

1. Start the discussion by restating the purpose and key methods used in the experiment.
2. Make a general statement indicating if the experiment had the predicted outcome.
3. Use your data to discuss relationships or trends (*when things tend to happen together*) and cause and effect (*when one thing causes another to occur*). Refer to specific examples from your results to support these conclusions.
4. Compare your results and conclusions with similar research conducted by other scientists (**RESEARCH**). Tell how your laboratory results are similar or different to results reported by other scientists.
5. Include relevant information from reference books, periodical literature, and other sources to **justify / support** your explanation of how and why the trend is present.
6. Identify any apparent errors or inconsistencies in your results. What caused the results to be inaccurate? Write a paragraph identifying and explaining possible sources of error and how they might have affected your results. Think of ways to improve your experiment. For example, maybe there is another way to carry out the experiment using other environmental conditions. How would this procedure produce different results?
7. Include a brief paragraph discussing how the results from this laboratory experiment relate to everyday or “real world” situations. For example, if you were examining bacterial growth, you could extend your discussion to the issue of sanitation in hospitals or meat factories.

### Discussion Layout Example

The results are not consistent with the research hypothesis. In addition, the results differ from those of my classmates **[describe what difference was, were your values higher or lower, different color, failure to grow, etc.]**.

One explanation for this difference is that \_\_\_\_\_ **[explain what was done differently, or what may have happened, or where your procedures varied]**.

This would have caused \_\_\_\_\_ **[explain how the difference in your procedures may have altered the results]**.

## Abstract

**The abstract appears after the title.** However, in this guidebook we have left this section till last as **it is the last section that you will write because you need to know the results of your experiment and important conclusions first**. The abstract gives a general overview summarizing the purpose, methods, major findings and conclusions. Use concise sentences reflecting the major points from the laboratory.

The following is a list of 5 elements that are needed in the abstract. Write each element in one or two sentences.

1. State the purpose. What was the purpose of the laboratory? That is, why was the experiment done?
2. State the predicted outcome. Was the prediction based on a scientific theory or law? If yes, identify the relevant theory or law. Then, state the researched hypothesis or hypotheses.
3. Summarize the methods, including only the major methods used. If a well known technique is used (e.g., gel electrophoresis), just state the name of the technique. The details about the technique will follow in the materials and method section of the laboratory report.
4. In one or two sentences, highlight the major results. Start with a sentence beginning, "The major findings from this laboratory were..."
  - ❑ Only the key results are included in the abstract. Generally, this means reporting the final results from the calculations.
  - ❑ If an average of the data was calculated, report only the average not individual data points.
  - ❑ If class data are used for comparison, state the average or make a general statement about how they compare to your individual data points. The other data will be discussed in the results and conclusion sections of the report.
5. Summarize your major conclusions. Start with a sentence such as, "From the data, it can be concluded that..."

### Example

Examination of the ability of vegetative propagules (small buds and branched fragments) of the green alga *Codium fragile* ssp. *tomentosoides* to attach and grow on natural substrata was conducted in laboratory and field experiments. In the laboratory, the probability of attachment (on coralline algae, mussel shell, smooth and rough rock) was greater for buds than cut branches (both ~4 cm long) over 10 weeks. Probability of attachment also differed among substrata with attachment to coralline algae being the greatest. In the field experiment, buds were transplanted to three tide pools at different tidal heights on the rocky shore. After eight months the proportion that attached did not differ significantly among pools. These findings indicate that vegetative propagation may contribute to the invasive success of *Codium fragile*.

## Scientific Report Checklist

<b>TITLE</b>	<input type="checkbox"/> Is it brief? <input type="checkbox"/> Is it specific? <input type="checkbox"/> Does it contain key words such as the independent and dependent variable?
<b>ABSTRACT</b>  <i>Summary</i>	<input type="checkbox"/> Does it state the hypothesis? <input type="checkbox"/> Are the procedures briefly explained? <input type="checkbox"/> Does it include the main results and conclusions?
<b>INTRODUCTION</b>  <i>Why was the study undertaken?</i>  <i>What question was studied?</i>	<input type="checkbox"/> Does it state the problem/issue? <input type="checkbox"/> Does it mention relevant literature and what is already known about the problem? <input type="checkbox"/> Have you cited this literature? <input type="checkbox"/> Does it include the purpose of the experiment? <input type="checkbox"/> Does it state what your expectations of the outcomes are and what alternatives you might expect? (HYPOTHESIS)
<b>MATERIALS &amp; METHODS</b>  <i>How was the problem studied?</i>	<input type="checkbox"/> Is it in 3 <sup>rd</sup> person, past tense? <input type="checkbox"/> Have you stated equipment, facilities, chemicals used? <input type="checkbox"/> Have you given enough information for someone to repeat your study? <input type="checkbox"/> Have you included the statistics, calculations done to the data?
<b>RESULTS</b>  <i>What were the findings?</i>	<input type="checkbox"/> Are ALL of the relevant results included? <input type="checkbox"/> Have you included data in the form of tables, graphs etc? <input type="checkbox"/> Do the tables and graphs have an explanatory caption?
<b>DISCUSSION</b>  <i>What do these findings mean?</i>	<input type="checkbox"/> Have you commented on how the results met with your expectations? <input type="checkbox"/> Have you interpreted the results i.e. Trends, cause and effect? <input type="checkbox"/> Have you explained your interpretation with researched scientific articles? <input type="checkbox"/> Have you cited this literature to support your results? <input type="checkbox"/> Do your own results or the results of others support your interpretation? <input type="checkbox"/> Are there errors in your results? <input type="checkbox"/> What effect do these errors have on your data? <input type="checkbox"/> Have you stated real world applications of your experimental conclusion?

Title is informative.	The Effects of the Fungus <i>Phytophthora infestans</i> on Bean, Pea, and Corn Plants
Write author's name first followed by lab partners' names.	Lynne Waldman, Partner One, Partner Two
Label sections of lab report clearly.	<b>Abstract</b>
Provide background information.	<i>Phytophthora infestans</i> is a fast-spreading, parasitic fungus that caused the infamous potato blight by devastating Ireland's crops in the 1840s. <i>P. infestans</i> also causes late blight in tomato plants, a relative of the potato. In this experiment, the effects of <i>P. infestans</i> on <i>Phaseolus</i> variety long bush bean, <i>Zea mays</i> (corn), and <i>Pisum sativum</i> (pea) were studied. The soil surrounding the roots of 18-day old plants was injected with <i>P. infestans</i> cultured in an L-broth medium. Plant height, number of leaves, and leaf angle were measured for each plant during the next 8 days. Chlorophyll assays were performed prior to exposure, and on the eighth day after exposure to the fungus. The plants were also examined for black or brown leaf spots characteristic of late blight infections. The results showed that <i>P. infestans</i> had no apparent effect on the bean, corn, and pea plants. One reason for this may be that there were no fungus zoospores in the L-broth medium. More probably, however, <i>P. infestans</i> may be a species-specific pathogen that cannot infect bean, corn, or pea plants.
Do not cite sources in Abstract.	
State purpose of current experiment.	
Briefly describe methods.	
Describe results. Do not refer to any figures.	
Briefly explain the results or state your conclusions.	
Limit Abstract to a maximum of 250 words.	
Italicize Latin names.	<b>Introduction</b>
Provide background information.	Originating in Peruvian-Bolivian Andes, the potato ( <i>Solanum tuberosum</i> ) is one of the world's four most important food crops (along with wheat, rice, and corn). Cultivation of potatoes began in South America over 1,800 years ago, and through the Spanish conquistadors, the tuber was introduced into Europe in the second half of the 1600s. By the beginning of the 18 <sup>th</sup> century, the potato was widely grown in Ireland, and the country's economy heavily relied on the potato crop. In the middle of the 19 <sup>th</sup> century, Ireland's potato crop suffered wide-



spread late blight disease caused by *Phytophthora infestans*, a species of pathogenic plant fungus. Failure of the potato crop because of late blight resulted in the Irish potato famine. The famine led to widespread starvation and the death of about a million Irish.

The potato continues to be one of the world's main food crops. However, *P. infestans* has reemerged in a chemical-resistant form in the United States, Canada, Mexico, and Europe (McElreath, 1994). Late blight caused by the new strains is costing growers worldwide about \$3 billion annually. The need to apply chemical fungicides eight to ten times a season further increases the cost to the grower (Stanley, 1994 and Stanley, 1997). *P. infestans* is thus an economically important pathogen.

*P. infestans*, which can destroy a potato crop in the field or in storage, thrives in warm, damp weather. The parasitic fungus causes black or purple lesions on a potato plant's stem and leaves. As a result of infection by this fungus, the plant is unable to photosynthesize, develops a slimy rot, and dies. *P. infestans* similarly infects the tomato plant (*Lycopersicon esculentum*) (Brave New Potato, 1994).

The purpose of the present experiment was to determine the effects of *P. infestans* on plant height, number of leaves, leaf angle, and chlorophyll content of three agriculturally important plants: *Phaseolus* variety long bush beans, *Zea mays* (corn), and *Pisum sativum* (peas). Symptoms of fungal infection were assumed to be similar to that in potatoes.

## Materials and Methods

*Phaseolus* variety long bush bean, *Zea mays* (corn) and *Pisum sativum* (pea) seeds were soaked overnight in tap water. Fifteen randomly chosen seeds of each species were planted 1 cm beneath the surface in three separate trays containing 10 cm of potting soil. Another set of trays, which was to be the control group, was prepared in the same fashion. All

Use proper citation format (e.g., Name-Year system).

Do not use direct quotations. Paraphrase source text and cite the source in parentheses.

Use an abbreviated title when no author is given.

State purpose of experiment clearly.

Write M&M in past tense.

Provide sufficient detail to allow the reader to repeat the experiment.

the experimental plants were placed in one fume hood, and all the control plants were placed in relative positions in another fume hood in the same room. The plants were exposed to the ambient light intensity in the hood (153 fc) and air current 24 hrs a day, and were watered lightly daily. The plants were allowed to germinate and grow for 18 days.

*Phytophthora infestans* on potato dextrose agar was obtained from Carolina Biological Supply House. At day 10 of the plant growth regime, pieces of agar on which the fungus was growing were transferred to L-broth. L-broth consisted of 5 g yeast extract, 10 g tryptone, 1 g dextrose, and 10 g NaCl dissolved in distilled water, and adjusted to pH 7.1, to make 1 L of medium. The medium was sterilized before adding the fungal culture. After 4 days in L-broth, 6 mL of the fungal culture was injected into the soil around the roots of each 18-day old plant. 6 mL of L-broth without *P. infestans* was injected into the soil of the control plants. All plants were then allowed to grow for another 8 days.

Every other day after treatment with *P. infestans*, plant height and number of leaves were measured for both the control and the experimental plants. Plant height was measured from the soil to the apical meristem of the plant. Leaf angle (as shown in Figure 1) of the largest, lowest leaf on each plant was measured three times, once prior to injection, once 4 days after injection, and once 8 days after injection. Leaf angle was measured in order to

Include figures in M&M section if they help clarify the methodology.

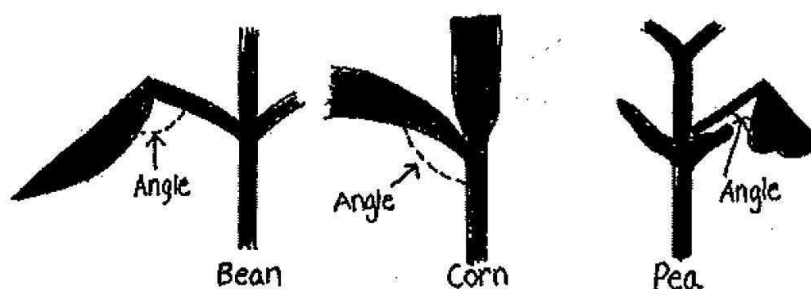


Figure 1 Leaf angle as measured in bean, corn, and pea plants

determine if *P. infestans* causes wilting in the three plant species. In addition, the plant was examined visually for the presence of any leaf spots.

Chlorophyll assays were performed on one plant from each tray prior to injection and on the eighth day after injection. For each chlorophyll assay, the leaves of the plant were removed from the stem. For each 0.1 g of leaves, 6.0 mL of 100% methanol were used. The leaves were thoroughly ground in half of the methanol with a pestle in a mortar. The leaves were ground again after the rest of the methanol was added. Extraction of the chlorophyll was allowed to proceed for 45 min at room temperature. Then the suspension was gravity filtered through filter paper to remove the leaf parts. The absorbance of the filtrate was measured with a Spectronic 20 spectrophotometer at 652 nm and 665.2 nm. The absorbance values were converted to relative chlorophyll units using the following equation derived by Porra and colleagues (1989):

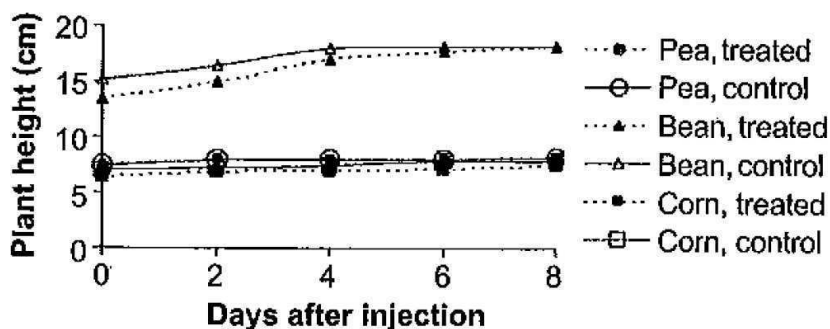
$$\text{Total chlorophyll (a and b)} = \text{Dilution factor} \times [22.12 A_{652 \text{ nm}} + 2.71 A_{665.2 \text{ nm}} (\text{mg/L})] \times \text{Volume of solvent (L)} / \text{Weight of leaves (mg)}$$

Make proper subscripts.

## Results

*P. infestans*-treated plants and the control plants had similar growth patterns (Figure 2). Both the experimental and control pea and corn plants grew at a

Include a text in the Results section. Describe the important results shown in each figure and table.



Refer to each figure and table in parentheses.

Make text in legend and in axis titles large enough to read easily.

Figure 2 Average height of control and experimental plants in the period after injection with *P. infestans*

Make sure intervals on axes have correct spacing.

Make points and lines black and background white for best contrast.

In the axis titles, write the variable followed by the units in parentheses (where applicable).

Position the figure caption below the figure.

Make the figure title descriptive. Do not use "y-axis title vs. x-axis title."

Check that figures are numbered in sequence.

Describe the figures in order.

Insert symbols such as ° using word processing software.

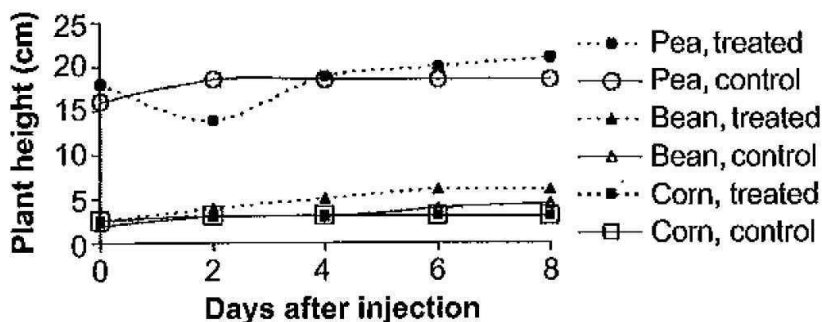


Figure 3 Average number of leaves of control and experimental plants in the period after injection with *P. infestans*

constant, but very slow rate over the eight day test period. The control bean plants were taller on average than the experimental bean plants throughout most of the experiment. Both groups showed the same growth pattern, however, with rapid growth occurring from day 18 to 24 (0 to 4 days after injection), followed by slower growth to the end of the experiment.

As plant height increased, the average number of leaves on all of the plants also increased over the measurement period (Figure 3). There is an uncharacteristic decrease in the number of leaves of pea plants treated with *P. infestans* from day 18 to 20 (0 to 2 days after injection), but this is probably due to counting error.

There was a general decline in average leaf angle of all the plants over the first four days after injection with *P. infestans* (Figure 4). The plants did not follow this pattern over the second half of the experiment, however. The leaf angle of the experimental bean group increased by 28°, while that of the control bean group only increased by about 3°. The leaf angle of the control pea plants increased significantly (33°), while that of the experimental pea plants decreased 4°. The leaf angle of the corn control group decreased 0.5°, while that of the corn experimental group showed a much sharper decline of 24°.

There was also no difference between the experimental and control groups with regard to chloro-

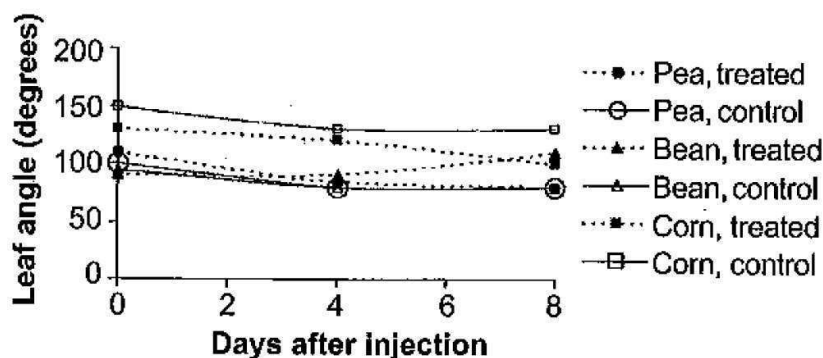


Figure 4 Average leaf angle of control and experimental plants in the period after injection with *P. infestans*

phyll content. There was a slight increase in chlorophyll content from day 18 to 26 (0 to 8 days after injection) in the corn plants (Table 1). For the bean group, there was a large decrease in chlorophyll content, 0.1 relative chlorophyll units, which did not seem to agree with the general appearance of the plants. There may have been some error when this assay was carried out. There was little change in chlorophyll content for the pea group.

Finally, there was no evidence of any brown or black leaf spots symptomatic of *P. infestans* infection.

Number tables independently of figures.

Table 1 Chlorophyll content of corn, bean, and pea plants prior to infection and 8 days after infection

Plant	Relative chlorophyll units		Change in chlorophyll content (relative units)
	Day 0	Day 8	
Corn, treated	$9.036 \times 10^{-4}$	$9.383 \times 10^{-4}$	$+3.45 \times 10^{-5}$
Corn, control	$9.270 \times 10^{-4}$	$8.963 \times 10^{-4}$	$+3.34 \times 10^{-5}$
Bean, treated	$1.034 \times 10^{-1}$	$1.2 \times 10^{-3}$	$-1.022 \times 10^{-1}$
Bean, control	$1.7 \times 10^{-3}$	$1.6 \times 10^{-3}$	$-1 \times 10^{-4}$
Pea, treated	$1.3 \times 10^{-3}$	$1.7 \times 10^{-3}$	$+4 \times 10^{-4}$
Pea, control	$1.2 \times 10^{-3}$	$1.2 \times 10^{-3}$	0.0000

Position the table caption above the table.

Use scientific notation correctly.

Do not split small tables across two pages.

Briefly restate the results in the Discussion section.

Give possible explanations for the results.

Support explanations with references to published sources.

Offer possible ways to test whether explanation is valid.

Whenever possible, use primary references (journal articles, conference proceedings, collections of primary articles in a book). Avoid textbooks (secondary references) and websites (may be unreliable).

## Discussion

*P. infestans* did not affect the plant height, leaf angle, number of leaves, and chlorophyll content of *Zea mays*, *Pisum sativum*, or *Phaseolus*.

Symptoms of infection are the presence of brown or black spots (areas of dead tissue) on leaves and stems, and, as the infection spreads, the entire plant becomes covered with a cottony film (Stanley, 1994). None of the experimental plants exhibited these symptoms.

There may be several reasons why *P. infestans* did not affect the plants in this study. One reason is that the L-broth culture of *P. infestans* may not have contained zoospores of the fungus. Zoospores are motile spores that can penetrate the host plant through the leaves and soft shoots, or through the roots (Stanley, 1994). Zoospores are usually produced in wet, warm weather conditions (Ingold and Hudson, 1993). If the L-broth culture did not contain any zoospores, or if the soil around the plants was not sufficiently saturated to stimulate production of zoospores, then these conditions may have prevented *P. infestans* from attacking the roots and shoots of the plants.

In order to determine if the problem was lack of zoospores, first the L-broth culture could be examined microscopically for presence of zoospores. Second, the *P. infestans* plants could be watered with different quantities of water to determine if the fungus requires wetter soil for zoospore production and motility.

Another reason why *P. infestans* may not have affected the plants is that this species of fungus may be specific to potato (*Solanum tuberosum*) and tomato (*Lycopersicon esculentum*) plants (Stanley, 1994), which both belong to the nightshade family (Solanaceae). In contrast, corn belongs to the grass family (Gramineae), and peas and beans are legumes (Leguminosae). It may be that these plant families are not susceptible to *P. infestans*, which has a very limited host range (Stanley, 1994). Non-

susceptible plants have been shown to have defense mechanisms that prevent *P. infestans* from infecting them (Gallegly, 1995).

Further research is required to determine if *P. infestans* really cannot infect corn, pea, and bean plants. Goth and Keane (1997) developed a test to measure resistance of potato and tomato varieties to original and new strains of *P. infestans*. Their experiments involved exposing the experimental plants' leaves directly to the fungus, and this method could perhaps be tested on corn, pea, and bean leaves as well.

## References

- Brave New Potato. 1994. *Discover* 15(10): 18-20.
- Gallegly ME. 1995. New criteria for classifying *Phytophthora* and critique of existing approaches. In: Erwin DC, Bartnicki-Garcia S, Tsao PH, editors. *Phytophthora: Its Biology, Taxonomy, Ecology, and Pathology* St. Paul: The American Phytopathological Society. pp. 167–172.
- Goth RW, Keane J. 1997. A detached-leaf method to evaluate late blight resistance in potato and tomato. *American Potato Journal* 74(5): 347–352.
- Ingold CT, Hudson HJ. 1993. *The Biology of Fungi*, 6th ed. London: Chapman and Hall.
- McElreath, Linda R. 1994. One potato, two potato. *Agricultural Research* 42(5): 2–3.
- Porra RJ., Thompson WA, Kriedemann PE. 1989. Determination of accurate extinction coefficients and simultaneous equations for assaying chlorophylls a and b extracted with four different solvents: verification of the concentration of chlorophyll standards by atomic absorption spectroscopy. *Biochimica et Biophysica Acta* 975: 384–394.
- Stanley D. 1994. What was around comes around. *Agricultural Research* 42(5): 4–8.
- Stanley D. 1997. Potatoes. *Agricultural Research* 45(5): 10–14.

In Name-Year end reference format, list authors alphabetically by first author's last name.

Substitute the title when no author is given.

Use mostly primary journal articles or articles in a book.

List all authors (up to 10; then list first 10 followed by "et al." or "and others.")

See the tabbed pages in Chapter 4 for examples of how to reference printed and electronic sources.

Give inclusive page numbers, not just the page(s) you extracted information from.

Make sure all in-text citations have a corresponding end reference.

Make sure all end references have a corresponding in-text citation.

## The Extended Response Task

*These notes were written by Dr Richard Walding, Griffith University*

The Extended Response Task (ERT) requires you to respond to a science question, statement, circumstance or issue. It is essentially non-experimental, but will require research and use of secondary (someone else's) data – although you may have to draw on primary (your own) experimental data. In Senior Science, the evidence will consist mainly of science principles, concepts, facts, ideas and data.

There are 2 phases to preparing your ERT:

### 1. RESEARCH PHASE

The following flow chart and schematics give a suggested approach to the completion of the task.

**Read the stimulus (background information) in the task sheet**  
and search for and collect information to help you understand the science involved.  
Transfer this information to your note/log book.



**Develop a Research Question based on the task stimulus.**  
(unless you've already been given one).



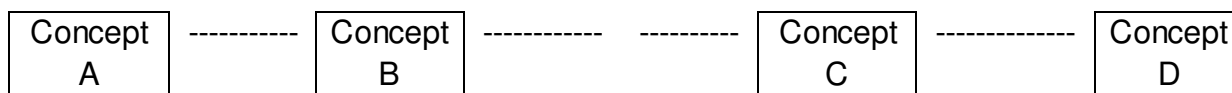
**Conduct a literature/internet search to analyse the Research Question.**  
(you may need to make some assumptions about quantities or do calculations).



**Develop a position (thesis) statement based on your Research Question.**  
Ensure that it is significant (not trivial), that it is about a real-world issue in the stimulus, that it has a narrow focus, that it allows you to bring scientific evidence (facts, concepts and data) to make your argument. Discuss this with your teacher.



**Deconstruct the focus area and the thesis.**  
Read more narrowly to identify, interpret and analyse underlying science concepts/ideas.



**Draw a concept map explain relationships between underlying physics concepts/ideas**

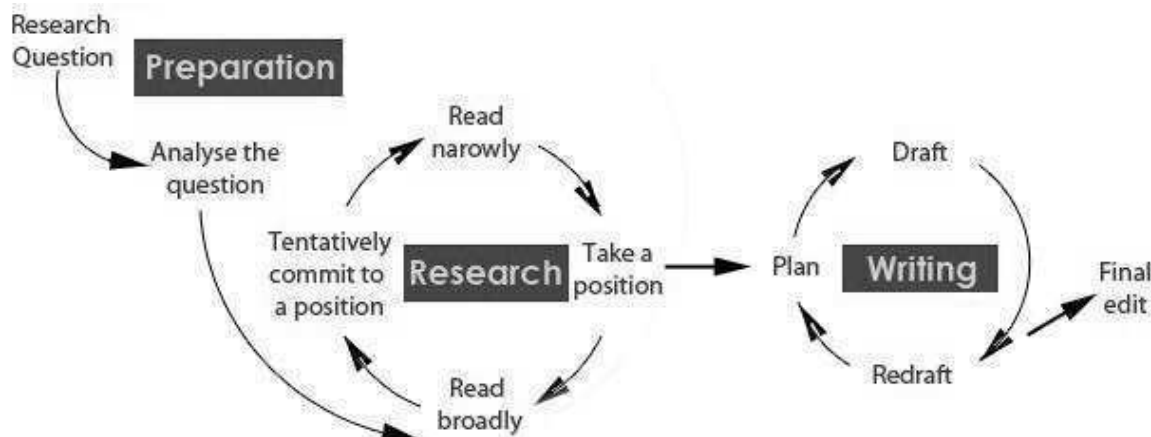
(rank from general to specific; organise logically, link with arrows and use linking words).



### **Plan your arguments.**

State how the identified scientific concepts/ideas are linked to your thesis statement and to each other. You need to be a little discriminating in deciding how, and to what extent, the identified concepts tie into your thesis.





## 2. WRITING PHASE – PLAN, DRAFT & EDIT YOUR ESSAY

### Introductory paragraph (1-2 pages; 200 – 250 words)

The introductory paragraphs should include a topic sentence which includes the thesis or a specific purpose statement, followed by a brief overview of the essay. This is where you establish the intention of your writing and inform the reader of what the paper is about. You should state why the issue is personally relevant to you, and say why it is relevant to society. Next, you should present definitions of the words and terms that may not be familiar to your audience. You should briefly present the arguments you will be using. The last sentence of this paragraph should also include a transitional sentence that moves the reader to the first paragraph of the body of the essay. In summary, the introduction should contain:

- Thesis (topic, focus) statement and overview
- Personal relevance
- Social relevance
- Definitions (of words, and technical terms)
- Scientific explanations (valid and accurate)
- Closing statement and link to next section

### Body paragraphs (3-5 pages; 600 – 800 words)

These should consist of the arguments; and the limitations or counter-arguments. Arguments and support should be logically linked and sequenced in a way that makes it easy and interesting to follow the author's train of thought.

### Argument 1 – the first idea that supports the argument for your thesis.

This paragraph should clearly set out the first and most important argument (premise).

- The first sentence should contain a link to the transitional sentence from the previous paragraph.
- Use only one idea/concept per paragraph. If you change ideas, start a new paragraph.

- It should then include the data (facts, statistics, principles, examples, real-life experiences) and the relevant theory (concepts, laws, formulas, quantities, units) that support the premise. All of the evidence (data and theory) should be specific, relevant and explanations are given that show how each piece of evidence supports and convinces of the author's position. Be careful that if you cite scientific theories or mathematical calculations in support of your thesis, you must explain why and how they relate.
- It should then draw a clear connection to the thesis statement; and most importantly – it should be plausible.
- The closing sentence ideally should not only sum up the paragraph, but also provide a link to the next argument, in order to provide fluency of expression and cohesion in the argument.

### **Argument 2 – the second idea that supports the argument for your thesis.**

Same structure as Argument 1 but with further evidence supporting your thesis.

### **Argument 3 – the third idea that supports the argument for your thesis.**

Same structure as Argument 1 but with the final evidence supporting your thesis.

### **Counter-arguments**

Here you can qualify the limitations of your arguments in terms of the quality of the data you used, the supporting formulas or theory, and the logical process you have adopted. You can lump them all together in a “Counter-arguments” or “Limitations” section or you can address them in each of your three arguments.

You could examine the background material presented to you in the stimulus or that you have located elsewhere. You could examine the *authority* on which the claims in the evidence have been made. Not all of the following will apply:

- Is the theory presented correctly without mistakes?
- Are the formulas, units, quantities, and symbols correct and appropriate?
- Have scientific terms been used in an everyday sense to change the meaning?
- Does the theory apply to a limited range of situations or is it able to be generalised more broadly?
- If you are quoting or responding to the claim of a scientist, is it in the scientist's field of expertise?
- Is the cited expert really an expert?
- How recent is the source?
- How authoritative is the expert? Are they recognised by colleagues as an outstanding expert?
- If several scientists disagree on the topic, have you consulted several experts as well?
- Is supporting evidence available, and is the statement by the scientist in accordance with this evidence?
- Is the expert's statement clear and intelligible, and correctly interpreted?

- Does the scientist have a vested interest in the research? That is, does the scientist work for a company or institution with a financial interest in the research; if so, you may have to question the scientist's personal reliability (is he/she honest, unbiased, and conscientious?). This has been a problem in the asbestos, cigarette, swine flu, mobile phone, vaccination, nuclear and oil industries.

## **Concluding paragraph/s** (1 page; up to 200 words)

These paragraphs are the summary paragraphs. Each sentence should sum up the main idea or point of the individual paragraphs in the essay. The conclusion should be very strong and clear and follow logically from information collected and judgments made and must not introduce new information. Ideally, it would contain four critical points:

1. A restatement of the thesis statement, using some of the original language or language that "echoes" the original language. (The restatement, however, need not be a duplicate of the thesis statement.)
2. A summary of the main points from the body of the essay and how they link to this thesis.
3. A statement about the limitations of the arguments.
4. A final statement that signals the discussion has come to an end. This final statement may state the implications of the thesis. It is sometimes where you can offer a solution to the reader. Your last few sentences should leave a lasting and strong impression on the reader.

## **Documentation**

You will need to present a Reference List and a Bibliography.

## **REFERENCES**

References are used to acknowledge the source of comments, quotations, diagrams, photos and so on. Sources should be listed alphabetically according to the referencing style advised in the task sheet. You should use consistent, accepted conventions of in-text citations and referencing. **Use about seven references for a 1500 word assignment.**

## Words that Work in Science

### **Words to help say what things are made of:**

Consists of	Is composed of	Is made up of
Is comprised of	Is constructed of (with)	

### **Words to help compare things:**

Less/more	The same as	On the other hand
The least	Whereas	The same number as
The most	Unlike	In contrast
Like/ likewise	Dissimilar	However
Similarly	Although	The equivalent of
Equally /equal to	Alternatively	Identical
Matching	Different	parallel

### **Words and ways to help talk about cause and effect (or actions and results):**

Because (of)	Produces/ is produced	Accounts for
As a result (of)	Forms. Is formed	On account of
Consequently	Creates/ is created	Due to
Leads to	Results in	Owing to
Causes	Brings about	When
Makes	Gives rise to	

### **Words to help talk about unexpected outcomes:**

Even though	However	But
Yet	Despite	Although
Nevertheless	In spite of	On the contrary

## Harvard Referencing

	Reference List or Bibliography	In-Text
<b>BOOKS</b>		
Single Author	Walker, J. 2003, <i>Atmosphere in Danger</i> , Aladdin Books, London.	"As a result, there could be large scale crop failures, grain shortages and famine." (Walker 2003, p.12).
2 Authors	Alexander, D. & Rouen, M. 2003, <i>Heinemann SOSE for Queensland Book 1</i> , Heinemann, Sydney.	Walker (2003, p.12) claims that "there could be large scale crop failures, grain shortages and famine." OR "Many gender roles are perpetuated or weakened by media portrayals." (Alexander & Rouen 2003, p.54).
3-5 or more authors	Cameron, K. Lawless, J. & Young, C. 2000, <i>Investigating Australia's 20<sup>th</sup> Century History</i> , Thomson Nelson, Victoria.	Alexander & Rouen (2003 p.54) claim that the media is responsible for perpetuating or weakening many gender roles. Cameron et al (2000, p.185) state.....
Editor	Knauer, K. (ed.) 2001, <i>Time: Great Discoveries</i> , Time Books, New York.	Names of all authors must be given in the List of References. (Knauer 2001, p.59)
No Author or Editor	<i>The CCH Macquarie Dictionary of Business</i> 1993, CCH Australia, North Ryde, NSW.	<i>The CCH Macquarie Dictionary of Business</i> (1993) defines the term as ..... Do not use Anon or Anonymous.
Book with corporate authorship	CSIRO, 2004 <i>Laboratory Handbook</i> , CSIRO Publishing, Collingwood, VIC.	(CSIRO 2004, p.43)
Encyclopedia	<i>World Book Encyclopedia</i> , 2003, 4th edn, Oxford University Press, Melbourne	<i>World Book Encyclopedia</i> (2003, p.212)
<b>PERIODICALS</b> Newspaper/ Journal Article (Print)		
Article	Piper, W. 2005, 'Plants for People', <i>ECOS – Towards a Sustainable Future</i> , ECOS, 123 Jan – March 2005, p.22.	As described by Piper (2005)..... OR ".....to build successful business enterprises." (Piper 2005, p.22).
Journal Article, multiple authors	Gibberd, R. Snow, PT, Rice, PG, & Patel, NB. 1991, 'Nuclear Power at what price?', <i>The Bulletin</i> , Vol.113, June 4, pp 51-5.	Gibberd et al (1991, p. 52) state .....

Article (no author)	<i>ATSIC News</i> 2002, 'Aboriginal identity and the loss of certainty', Vol. 12, No.3, pp50-2.	"The contemporary aborigine ....."( <i>ATSIC News</i> 2002, p. 46. ).
<b>Electronic Newspaper/ Journal Article</b>		
With author	Cotton, K. 2002, 'Virtual Violence', <i>The Bulletin</i> , 28 May, p.62, Retrieved 1 July, 2005 from Australia and New Zealand Reference Centre..	Homework is ruining the eyesight of American children (Howser1999).
No author	Virtual Violence 2002 <i>The Bulletin</i> , 28 May, p.62. Retrieved 1 July, 2005 from Australia/New Zealand Reference Centre.	(Homework Should Be Banned 1999).
<b>INTERNET SOURCES</b>		
Document on World Wide Web An organisation/company can also be an author	Dawson, J. & Johnson K.2002, <i>Referencing made easy</i> (Online) Available at <a href="http://studyguide.unsw.edu.au/">http://studyguide.unsw.edu.au/</a> (Accessed 20 April 2004).	"It is essential you learn how to reference properly", (Dawson & Johnson 2002).
Document on World Wide Web – no author	<i>Plagiarism</i> .2001 Available at <a href="http://www.researching/writing.qld.edu.au">http://www.researching/writing.qld.edu.au</a> (Accessed 10 November, 2005).	("Plagiarism" 2001) Inverted commas used if NOT needing to shorten title.
Whole web site : Personal author	Mendel, S. 2004, SparkNotes on King Lear (Online), Spark notes. Available: <a href="http://www.sparknotes.com/shakespeare/lear">http://www.sparknotes.com/shakespeare/lear</a> (Accessed 20 April 2004)	Mendel (2004)
Whole web site: organization or group as authoring body	The Melanoma Foundation 1997, <i>Melanoma Facts</i> (Online). University of Sydney, Sydney. Available: <a href="http://www.med.usyd.edu.au/medicine/melanoma.htm">http://www.med.usyd.edu.au/medicine/melanoma.htm</a> (Accessed 15 May 2003)	The Melanoma Foundation (1997)
Document from an Electronic Database	Set out as above but cite database used (Ebscohost or Electric Library) after word 'Available'. E.g. Available in Electric Library Australasia <a href="http://elibrary.com.au/education">http://elibrary.com.au/education</a>	Author or Title (if no author) (2001)

Online images (pictures, maps, cartoons and so forth)	The Lunar Interior, 2000 (Online Image). Available at <a href="http://www.planet.jpg">http://www.planet.jpg</a> (Accessed 28 November 2000)	
Email	Saville, A. 2001 email, 24April, <asaville@rockets.com.au >	Saville (2001)
<b>OTHER ELECTRONIC SOURCES</b>		
CD Rom	"Snakes", 1994, <i>Habitats of Reptiles</i> (CD ROM), Crunch Media, N.Y.	Habitats of Reptiles, (1994)
Databases	AGRIS database, United Nations Food and Agriculture Organisation, SilverPlatter (vendor), annual updating	Agris .....
<b>AUDIO VISUAL SOURCES</b>		
Sound Recordings - CD or Tape Cassette	Hopkins, S. 1994 <i>Reclaiming the Spirit</i> , (Sound Recording) Red Hill, Qld.: New World Productions	Hopkins, (1994)
DVD or Video Motion Picture	<i>South American Wetland</i> 1982, (Video Recording) BBC, London	South American Wetland, (1982)
TV Broadcast Radio Broadcast	<i>Upon this Rock</i> . 1999 (TV Broadcast) ABC. May 31	Upon this Rock, (1999)
<b>OTHER SOURCES OF INFORMATION</b>		
Interviews	Berger, P. Aug 2004, <i>Teaching in Australia</i> . Interviewed by M. Brown (Transcript of Interview) Melbourne Conference Centre.	Berger, (2004)

# HIGHER ORDER THINKING



# LOWER ORDER THINKING