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How to Write a Laboratory Report
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Introduction



This booklet has been designed to help you to write a laboratory report in the natural or applied sciences. You may have written laboratory reports as part of your science studies in high school or TAFE. This experience will certainly help you when you come to write laboratory reports at university. However at the university level, you are usually studying different disciplines in science (Chemistry, Biology, Physics, Electrical Engineering, etc.) and each discipline has its own way of constructing knowledge about the world. So the reports you write in Chemistry, for example, will be different from those you will write in Biology, even though these differences may not always be very great. In addition, the kind of report you write and its complexity will vary according to your level in the course, that is, whether you are in the first, second or third year of your undergraduate degree. In this handout, it is impossible to show you all the different ways of writing a laboratory report which are acceptable at university. What we will try to do is to show you some of the general principles of report writing. To do this, we will be using a model report and exercises from the biological sciences. However, remember, your own science lecturers will probably be giving you advice and guidelines for the particular report you will be writing, so refer to these as well as this handout in order to write a successful report.

We wish to acknowledge the advice and feedback given by staff and students of the Department of Biological Sciences, the University of Sydney in the preparation of this booklet. In particular, we would like to thank Dr Charlotte Taylor for her invaluable help.

Objectives

After you have completed this handout, you should be able to:

- understand the overall structure and purpose of the laboratory report
- know what kind of information belongs in the different parts of the report
- be able to structure the information within each section of the report in a logical way
- recognise and improve problem areas in the language of the report

Organisation of this Booklet

The explanations and exercises for each part of the laboratory report are found in the first part of this handout. There is a key at the end of the handout where you can check your answers. You can work through the handout at your own pace and choose your own order. You do not have to work through from beginning to end. You can choose a section that you want to find out about and simply go to that section.

The sections are ordered in the following way:

- | | |
|-------------------------------------|---------------------------------|
| (1) Overall structure of the report | (5) Results |
| (2) Introduction | (6) Discussion (and conclusion) |
| (3) Methods | (7) References (and appendices) |
| (4) Title | (8) Abstract |

(1) The Overall Structure of the Laboratory Report

Let's look at the typical structure of a laboratory report.

Structure of Report	Function of each part
Title	to tell the reader the topic of your report
Abstract	to provide a summary of the whole report
Introduction	to give enough background information to the reader so they will know the context and purpose of your exp.
Methods	to tell the reader what you did, the materials you used, the procedure you followed
Results	to tell the reader what you found
Discussion	to interpret and explain the significance of what you found
Conclusion (optional)	to summarise your findings and interpretations
References	to tell the reader (in alphabetical order by author) the origin of all the references you have cited the text.
Appendix(-ces)(optional)	to give more detailed information

As you can see, a laboratory report has a clear structure and this is very helpful when you come to write your report. The stages in the report and their sequence have developed in this way to accurately re-tell or recount a scientific activity and to interpret the results of this activity. In this way scientific knowledge is developed out of scientific experimentation.

In a first year course, you will probably not be asked to write a complete laboratory report. You may only be asked to write the Results and Discussion section or you may be asked to write your report in a group, in which case you will need to allocate different parts of the report writing to different group members.

A full report will need to communicate the following points:

what you set out to do and why	(INTRODUCTION)
how this was done	(METHODS)
what your findings were	(RESULTS)
what the results mean	(DISCUSSION AND CONCLUSION)
what background references you used	(REFERENCES)

Since the introduction and discussion (and conclusion) are generally the most difficult parts of your laboratory report to write, many students leave these stages until after they have written the methods and the results. If you have to write an abstract, it is usually the last part of the report that you write.

(2) The Introduction

A: THE CONTENT

In general the information or the content in your introduction should answer the following 5 questions:

- (1) What is the subject of your report? What is your experiment about?
- (2) Why is the subject important? (optional in first year)
- (3) What is the theory on this subject? What have other researchers found out about this subject?
- (4) How does your experiment compare with previous experiments done in that area (is it going to confirm a hypothesis already stated, to apply a methodology to other subjects? etc.)
- (5) What is the aim or objective of your experiment or what hypothesis(es) is/are being tested? What are you trying to find out?

The answers to these questions can help to provide guidelines as to what information should be included in the introduction.

Exercise 1

Look at the following introduction to a laboratory experiment. Identify the answers to the above questions. Has the author included information to answer all of the above questions?

Model 1

Introduction

Gibberellic acid is a plant growth substance which is known to have certain, often dramatic, effects on the growth of plants (School of Biological Sciences, 1994). Gibberellins appear to affect almost all plant organs but their most spectacular effect is stem elongation (Low, 1975). Stem elongation occurs when gibberellic acid is applied to plants which are genetic dwarfs and this makes these plants indistinguishable from the normal tall variety (Irvine and Freyre, 1960). However, stem elongation does not usually occur when gibberellic acid is applied to most normally tall plants (Keenton, 1980).

This experiment aimed to establish whether the addition of gibberellic acid had a similar effect on the growth of tall and dwarf pea plants.

B: THE STRUCTURE

The five different types of information typically found in the introduction are usually structured in a particular way:

- Stage 1 State the subject of the report and why it is important
- Stage 2 Summarise what researchers already know about the subject
- Stage 3 State how your experiment compares with previous experiments
- Stage 4 State the aim and/or hypothesis of your experiment

Exercise 2

Read the following introduction and identify what is wrong with its staging and content. Make comparisons with the previous introduction.

Model 2

Introduction

The experiment has been carried out to study the effect of gibberellic acid on dwarf and tall plants. Past research has shown that 'the most dramatic effect of the gibberellins is the transformation of dwarf plants into tall ones by greatly increased stem elongation' (Brian and Hemmings, 1955). Keenton (1980) said that gibberellins only affect those plants that normally undergo little stem elongation but have much less effect on most normally tall plants. Two varieties of pea seeds, dwarf (*Pisum sativum* cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 3 weeks.

C: THE LANGUAGE

There are 3 areas of language which you need to pay attention to, if you are to write a good introduction. They are:

- keeping the focus on the most relevant information (Pay attention to your choice of topic or what you put in your sentence beginnings to develop your introduction),
- the language of certainty and usuality
- the choice of present or past tense

Model 1

Gibberellic acid is a plant growth substance which is known to have certain, *often* dramatic, effects on the growth of plants (School of Biological Sciences, 1994).

Gibberellins *appear* to affect *almost all* plant organs but their most spectacular effect is stem elongation (Low, 1975).

Stem elongation occurs when gibberellic acid is applied to plants which are genetic dwarfs and this makes these plants indistinguishable from the normal tall variety (Irvine and Freyre (1960).

However, stem elongation does not usually occur when gibberellic acid is applied to *most* normally tall plants (Keenton, 1980).

This experiment aimed to establish *whether* the addition of gibberellic acid had a similar effect on the growth of tall and dwarf pea plants.

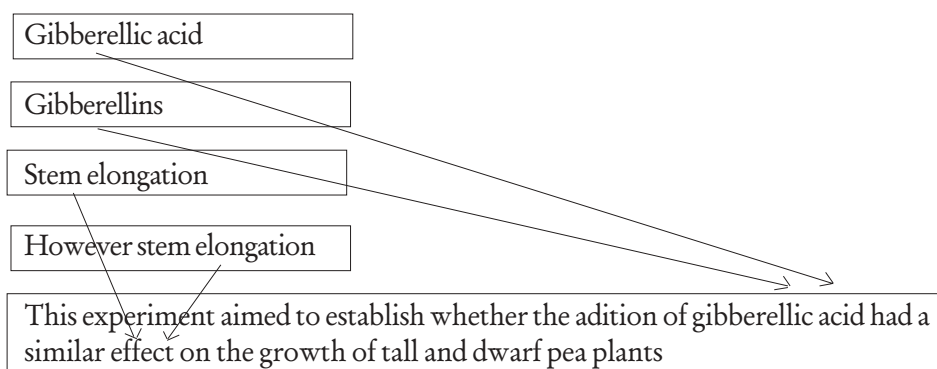
- (1) The beginnings of the sentences (the topics) have been highlighted in bold type. The focus in the first 2 sentences is on gibberellic acid or gibberellins as the writer introduces us to this substance. However, the focus shifts to stem elongation in the third sentence because this is what the experiment will investigate. Notice how the idea of stem elongation has been introduced in the last part of the second sentence:

Gibberellins appear to affect almost all plant organs but their most spectacular effect is stem elongation (Low, 1975).

The idea of stem elongation is then taken up at the beginning of the next sentence and developed further:

Stem elongation occurs when gibberellic acid is applied to plants which are genetic dwarfs and this makes these plants indistinguishable from the normal tall variety plants (Irvine and Freyre, 1960)

In this way the ideas are linked together and the text is developed. In the last sentence of the introduction, the focus shifts to the experiment itself and its aims. The language choices in each sentence beginning build up to the statement of aims.



- (2) Scientists are always careful about **how certain and how usual** their results are and when you summarise previous research you also have to accurately summarise the certainty of previous findings. The language in italics is what you use to talk about how certain or how usual a finding or result is. For example, *often* indicates a high degree of frequency for the dramatic effects of gibberellic acid.
- (3) Some of the verbs have been underlined. Notice how they are in the PRESENT TENSE because they tell us what is generally known about gibberellic acid. However the statement of the aim of the experiment is in the PAST TENSE because it tells us about this particular experiment.

Model 2

The experiment has been carried out to study the effect of gibberellic acid on dwarf and tall plants.

Past research has shown that ‘the most dramatic effect of the gibberellins is the transformation of dwarf plants into tall ones by greatly increased stem elongation’ (Brian and Hemmings, 1955).

Keenton (1980) said that gibberellins *only* affect those plants that normally undergo little stem elongation but have *much less effect* on most normally tall plants.

Two varieties of pea seeds, dwarf (Pisum sativum cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 3 weeks.

- (1) The focus in the first sentence, the experiment and its aim, is too general and does not give the reader any background information about why the experiment is being carried out.
- (2) The focus in sentences 2 and 3 is on the research or the person responsible for the research rather than on the ideas in the research itself. This makes it hard for the reader to see the relationships between the actual content of the research findings. It also suggests that the writer does not understand those relationships.
- (3) The focus in the last sentence is on the actual plants used in the experiment which suggests that this sentence should not be in the Introduction but in the Methods section. Also, notice the use of the past tense and the PASSIVE VOICE of action or ‘doing’ verbs (were planted, was monitored) which also indicates the Methods stage.

D: WRITING YOUR OWN INTRODUCTION

Now you are ready to apply what you have learnt about writing the introduction to your own experiment. If you have been keeping good laboratory notes you will already have kept a record of your aims and, if appropriate, your hypothesis(es). In other words, you will already have enough information to write stage 4 of your introduction.

In your laboratory records, you have probably written your aim as an instruction:

To establish whether the addition of gibberellic acid promotes stem elongation in both tall and dwarf pea plants.

For your laboratory report, you need to write out your aim as a complete sentence.

The aim of this experiment was to establish whether the addition of gibberellic acid promotes stem elongation in both tall and dwarf pea plants.

You can also write out your aim as a hypothesis(es). A hypothesis is a good guess or prediction about the experimental outcome, in other words, the result of your experiment. Sometimes you will need to write an introduction which contains both an aim and a hypothesis.

The hypothesis is that the addition of gibberellic acid will promote stem elongation in both tall and dwarf pea plants.

Stages 1, 2 and 3 of the introduction provide the reader with background information about your experiment. You will have to read your laboratory notes and your text books and in some cases, other sources such as journal articles to find this information. You do not need to write everything that is known about the topic. Two paragraphs is usually enough. Also be careful not to copy your laboratory notes and textbooks. It is also a good idea to avoid quotations. Your lecturer wants to see that you understand the topic, so try to use **your own words** combined with the technical language of your field. When you write your own introduction, remember that you will probably have to draft and re-draft it a number of times. You may even leave the final draft until you have written up the rest of your report and you have a clearer understanding of how your results and your interpretation of your results relate to your aim and your introduction as a whole.

Exercise 3

Write out 2 other possible hypotheses for this experiment.

(3) The Methods



Writing the methods stage is probably the most straightforward part of the laboratory report. However students still have problems in deciding -

- what content or information to put in and how much to put in
- how to structure this content

A: THE CONTENT

The information you provide should typically answer the following questions -

- (1) What materials did you use?
- (2) What methods did you use?

The methods should give enough detail so that someone else can duplicate your experiment. However they should not be as detailed as the instructions in your laboratory notes. Remember not to comment on your observations or measurements in the methods stage. You should do this in the results stage.

B: THE STRUCTURE

The structure of the methods is determined by the sequence or order of what you used and what you did in the laboratory. In other words you tell or recount to the reader what happened in the laboratory, step by step.

Stage 1: State what you did and used first

Stage 2: State what you did and used second etc

It is usual to integrate your description of the materials with your recount of the methods. However, in some experiments, you may need to describe your materials separately.

Exercise 1

Read the following methods sections for the experiment on gibberellic acid. Make comparisons between the 2 models and decide which version is appropriate for the laboratory report. Find reasons for your decision.

Model 1

Methods

Materials:

- (i) seeds of tall (ver. Telephone) and dwarf (ver. Greenfeast) peas.
- (ii) 8 flower pots
- (iii) sand and vermiculite (mix approximately equal portions)
- (iv) 70% ethanol content solution
- (v) gibberellic acid in 70% ethanol (0.4mg of solution)
- (vi) a mm ruler for measurement

Firstly, cover the holes in each pot with a thin layer of cotton, then carefully half fill the pots with sand mixture, tamp the soil down by pressing it with the palm of the hand. Secondly, ... In the second week, all the seedlings were examined and measured. The dwarf peas which had been treated with gibberellic acid had grown almost twice as much as the control plants.

Model 2

Methods

Two varieties of pea seeds, dwarf (*Pisum sativum* cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 4 weeks. Two sets of dwarf seeds (an experimental and a control) and 2 sets of tall seeds were planted in separate pots. After the seeds had germinated (at the beginning of the second week), the experimental seedlings were treated with gibberellic acid in 70% ethanol (0.4 mg per ml of solution) and the controls were treated with 70% ethanol alone. Each seedling received one drop of the solution applied to the top leaf (growing tip). At the end of each week, the height of each seedling was recorded in cms.

C: THE LANGUAGE

Model 2

Methods

Two varieties of pea seeds, dwarf (*Pisum sativum* cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 4 weeks. **Two sets of dwarf seeds (an experimental and a control) and 2 sets of tall seeds were planted in separate pots. *After* the seeds had germinated (*at the beginning of the second week*), the experimental seedlings were treated with gibberellic acid in 70% ethanol (0.4 mg per ml of solution) and the controls were treated with 70% ethanol alone. Each seedling received one drop of the solution applied to the top leaf (growing tip). *At the end of each week*, the height of each seedling was recorded in cms.**

- (1) Some sentence beginnings have been highlighted in bold to show how the focus is not on the person carrying out the experiment (the reader already knows that you are doing the experiment, so this information is not very useful) but on the things that you are using in your experiment.
- (2) Some verbs are underlined. They are ‘action’ verbs like plant, measure, etc. because they describe your activities in the laboratory, what you did and what you used. They are in the PAST TENSE because the methods tells the reader what you did in the laboratory when you carried out this particular experiment. They are also written so that the sentence beginnings are about the things you are using in the experiment and not about you. This type of focus requires a special structure of the verb which we call the PASSIVE VOICE.

ACTIVE **I planted** two varieties of pea seeds

PASSIVE *Two varieties of pea seeds were planted*

- (3) Time phrases (in italics) are used to order the sequence of events.

Exercise 2

Re-write the following extract from Model 1 in the passive.

Firstly, cover the holes in each pot with a thin layer of cotton, then carefully half fill the pots with sand mixture, tamp the soil down by pressing it with the palm of the hand.

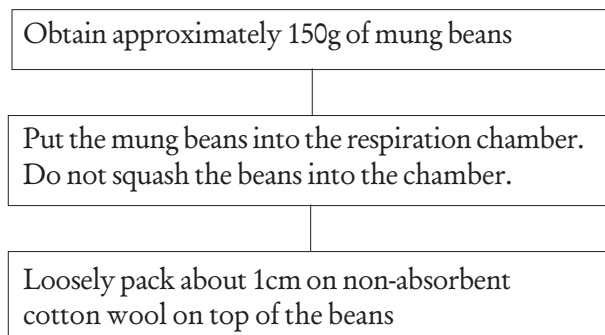
D: WRITING YOUR OWN METHODS

In first year, you may be given a list of instructions for carrying out your experiment in your laboratory notes.

For example:

- Obtain approximately 150g of mung beans.
- Put the mung beans into the respiration chamber.
- Do not squash the beans into the chamber. ...

The procedure for the experiment can also be laid out in a flow chart.



In 2nd or 3rd year, you will be expected to construct your own instructions or flow chart and write out the procedure for your experiments yourself in your workbook.

Although the instructions or flow chart can help you to write up the methods stage, they are usually too detailed for what you will eventually write in your methods section. So don't just copy the list of instructions in your laboratory notes and simply change the language structures. You will have to decide what the key information is for carrying out the methods and use this in writing up your methods stage.

(4) The Title

A good title is short and to the point. It tells the reader the purpose of your experiment or what you found.

Exercise 1

Examine the following titles for the experimental models we have been looking at in the introduction and methods stages. Which one do you think is more appropriate and why?

Model 1

The Influence of Gibberellins on Plant Growth

Model 2

The Effect of Gibberellic Acid on the Growth of Tall and Dwarf Pea Seedlings

THE LANGUAGE

Typically, a title is made up of a long and complex noun group. A noun group is a group of words that has the same function as a noun, that is, it names or identifies a person, place or thing. Within a noun group, one word is usually central to the meaning of the group and this is called the **HEAD**. Other words can occur before and after the head to add to its meaning.

For example:

Article	Adjective	HEAD	Prepositional phrases (ie. preposition + noun)
The	Dramatic	Influence	of Gibberellins on Plant Growth

Usually, the noun group for the title is formed from the aim of your experiment.

Model 1

Aim: **noun** **verb** **noun**
how gibberellins influence plant growth

Title: head noun preposition + noun preposition + noun
The Influence of Gibberellins on Plant Growth

Notice how the noun group is formed:

The verb **influence** in the aim changes to the noun **influence** in the title
The nouns **gibberellins** and **plant growth** in the aim change to prepositional phrases in the title and these add meaning to or modify the head noun **influence**. The choice of preposition tells us what **influences** what.

how gibberellins influence plant growth

The Influence of Gibberellins on Plant Growth

The Title

Model 2

Aim: how gibberellic acid affects the growth of tall and dwarf pea seedlings

Title: The Effect of Gibberellic Acid on the Growth of Tall and Dwarf Pea Seedlings

SPELLING NOTE: when you write the noun 'effect' you begin the word with 'e' but when you write the verb 'affect' you begin the word with 'a'. Both the verb 'affect' and the noun 'effect' have a similar meaning ie, influence but note that the verb 'effect' (= carry out) has a different meaning to the verb 'affect.'

(5) The Results

A: THE CONTENT

Your results section provides information to answer the following question:

- (1) What did you find (your precise measurements) and/or what did you observe?

If your experiment generated a set of results, it is common practice to display your results in detail in the form of a table or graph. However, you have to use language to introduce your table or graph and give it a title. You are also expected to write a short summary of your results, which identifies the most important results in terms of the aims of your experiment (this summary is usually only a few sentences long because the detailed results are given in the tables or graphs).

B: THE STRUCTURE

Your results section usually has 3 main stages:

Stage 1: introduce the results section and tables and/or graphs (optional)

Stage 2: present table(s) and/or graph(s)

Stage 3: summarise the results

You may have a series of results to report and in this case, the structure of the results section will be repeated, and you will need to consider the relationships between different sets of results when you are deciding on the sequence in which you will present your results.

Let's see what a results section looks like:

Exercise 1

Examine the 2 models of a results section and decide which is the more appropriate model in terms of its content and structure. Find reasons for your answer. Examine the tables in model 1 and 2 and decide which table is appropriate and why.

Model 1

RESULTS

Measurement of plants

Pot	Number of internodes	Total height	Length of internode
1 and 2	5	8	1.75
3 and 4	5	13	3.45
5 and 6	6	22	4.6
7 and 8	5	25	4.95

The Results

Dwarf plants treated with gibberellic acid appear to have grown at a greater rate than those not treated with gibberellic acid. The average height of the dwarf plants treated with gibberellic acid was 13 cm, the average number of their internodes was 5 and the length of their internodes was 3.45cm. For dwarf plants which were not treated with gibberellic acid the measurements were 8cm, 5 internodes and an internode length of 1.75cm. Tall plants which were treated with gibberellic acid grew more than those which were not treated. It appears that the addition of gibberellic acid to dwarf plants causes them to grow.

Model 2

RESULTS

The final measurements recorded at the end of the fourth week are shown in Table 1.

Table 1: The average height of seedlings(cm), their number of internodes and the average length of internodes(cm) for each treatment after 4 weeks.

Treatment	average height of seedlings (cm)	average number of internodes	average length of internodes (cm)
Dwarf control	8	5	1.75
Dwarf + GA	13	5	3.45
Tall control	22	6	4.6
Tall + GA	25	5	4.95

The results in Table 1 show that dwarf plants which were treated with gibberellic acid (GA) grew to almost twice the height of the controls (untreated dwarf plants). Their internode length almost doubled. When the Wilcoxon test was applied, these differences were statistically significant. However treated dwarf plants did not grow to the height of normal tall plants. The application of gibberellic acid to tall plants did not cause any significant differences in their growth.

C: THE LANGUAGE

Model 2

The results in Table 1 show that dwarf plants which were treated with gibberellic acid (GA) grew to almost twice the height of the controls (untreated dwarf plants). Their internode length almost doubled. When the Wilcoxon test was applied, these differences were statistically significant. However treated dwarf plants did not grow to the height of normal tall plants. The application of gibberellic acid to tall plants did not cause any significant differences in their growth.

- (1) Some verbs in model 2 have been underlined. Most of them are similar kinds of verbs to those used in the methods stage (action verbs) because they tell the reader what happened in your experiment. Notice that they are also in the **PAST** tense because they tell the reader what you found in this particular experiment.
- (2) The results in model 2 are stated with certainty, eg. grew This is what the researchers found. In model 1, the results are not stated with certainty, eg. appear to have grown. This is incorrect.

Dwarf plants treated with gibberellic acid appear to have grown at a greater rate than those not treated with gibberellic acid.

- (3) The first verb in model 2, ‘show’ (in italics), is in the simple present tense, a ‘timeless’ tense. It tells us what the results in the table show and this does not change with time. The results will always show the same things.
- (4) Table 1 is referred to in the text (in bold). Other ways of referring to Table 1 are: **Table 1** shows

The results show that dwarf plants which were treated with gibberellic acid (GA) grew to almost twice the height of the controls (untreated dwarf plants) (**Table 1**).

D: WRITING YOUR OWN RESULTS

Look at your own results. You will probably have recorded them in the form of tables or graphs. When you transfer your tables and graphs to your written report, you must number them and give them a title. Graphs (and other diagrams, etc.) are called **figures** in your report. When you number your tables and figures, you must number them in separate sequences. You should also put the title of your figure **under** the figure and the title of your table **above** the table.

When writing about your results, introduce them in a general way at the beginning of the results section. Don’t forget to refer to your tables and figures while you are summarising the results.

The following questions will help you to summarise the results:

- If you drew a graph, what did the curve show about the relationship between your variables?
- How did the rate of reaction vary?
- What did the controls show?
- What did the replicates show?

6. The Discussion (and Conclusion)

The discussion section is probably the most difficult and challenging to write because you have to think carefully about the specific results you obtained in your experiment and interpret them and generalise from them. In this way you relate your own results to the store of scientific knowledge. The information you put in the discussion should answer the following questions:

A: THE CONTENT

- (1) Have you fulfilled the aims of your experiment? (Can you accept or reject your hypothesis?)
- (2) How do your results compare with those of previous researchers?
- (3) Why did you get the results you got? You may have to explain inconsistent or unexpected results.
- (4) What problems did you encounter in carrying out the experiment and how could you overcome these in future investigations?
- (5) What is significant or important about your results? What are the implications of your results?
- (6) What further areas of investigation, if any, can you suggest.

Exercise 1

Look at the following discussion stage and identify the answers to the above questions. Has the writer included information to answer all the above questions?

Model 1

Discussion

The results show that gibberellic acid has a marked effect on the growth of dwarf pea plants but little effect on the growth of tall pea plants. This is largely consistent with previous research findings (Low, 1975, Keenton, 1980). However, the dwarf plants in this experiment did not grow into normal 'tall' plants (Irvine and Freyre, 1960), although they underwent significant stem elongation compared to untreated dwarf plants. This may be accounted for by the fact that all treated dwarf replicates did not show the same degree of stem elongation, some growing far more than others. This suggests that some experimental error was involved and it is possible that differences in the concentration of gibberellic acid added may have caused these variations. More care needs to be taken in the preparation and administration of treatment solutions in future experiments as well as greater accuracy in measurements.

Since gibberellic acid appears to stimulate growth in dwarf plants and have little or no effect on the growth of tall plants, it is possible to conclude that the absence of gibberellic acid in dwarf plants may be responsible for their dwarfism. Further investigation needs to be carried out into why dwarf plants are unable to produce gibberellic acid naturally.

B: THE STRUCTURE

Unlike the introduction, the staging of the discussion is not so straightforward and the order in which you sequence the information depends on the aim of the experiment and the kind of results you obtained. In the example above, the information provided in the discussion is ordered in the same sequence as the questions. Although this is a good guideline for staging the discussion, remember it is only a guideline and you need to adapt it to each experiment you carry out.

STAGE 1 Relate your results to the aims of the experiment

The results show that gibberellic acid has a marked effect on the growth of dwarf pea plants but little effect on the growth of tall plants.

STAGE 2 Explain how your results compare to those of previous researchers

This is largely consistent with previous research findings (Low, 1975, Keenton, 1980). However, the dwarf plants in this experiment did not grow into normal 'tall' plants (Irvine and Freyre, 1960), although they underwent significant stem elongation compared to untreated dwarf plants.

STAGE 3 Explain why you got your results

This may be accounted for by the fact that all treated dwarf replicates did not show the same degree of stem elongation, some growing far more than others.

STAGE 4 Identify problems in experimental technique and suggest improvements

This suggests that some experimental error was involved and it is possible that differences in the concentration of gibberellic acid added may have caused these variations. More care needs to be taken in the preparation and administration of treatment solutions in future experiments as well as greater accuracy in measurements.

STAGE 5 State the significance or implications of your experimental findings and areas of future research

Since gibberellic acid appears to stimulate growth in dwarf plants and have little or no affect on the growth of tall plants, it is possible to conclude that the absence of gibberellic acid in dwarf plants may be responsible for their dwarfism. Further investigation needs to be carried out into why dwarf plants are unable to produce gibberellic acid naturally.

Exercise 2

Read the following discussion for the same laboratory experiment and try to identify the problems in its content and staging. Use the questions below to help you.

Model 2

Discussion

Gibberellins appear to affect almost all plant organs but their most spectacular effect is stem elongation (Low, 1975). Table 1 shows that dwarf plants which were treated with gibberellic acid grew to almost twice the size of untreated plants. A major fault in the experiment was that the concentration of gibberellic acid varied between replicates. This meant that, for example, in week 2 there were differences in length among the 5 replicates when they should have been similar. The number of people involved in the experiment should be minimised to reduce experimental error.

- (1) Is the information in the first sentence related to the results of this experiment?
- (2) Look at the second sentence. What kind of information is it telling us? Is this appropriate for a discussion section?
- (3) Is the second sentence connected to the third sentence? Do the ideas flow from one to the other in a logical way?
- (4) What does the last sentence recommend? Do we know why this recommendation is being made?
- (5) What other kinds of information should the writer have included?

C. THE LANGUAGE

Model 1

The results show that gibberellic acid has a marked effect on the growth of dwarf pea plants but little effect on the growth of tall pea plants. **THIS is largely** consistent with previous research findings (Low, 1975, Keenton, 1980). **However**, the dwarf plants in this experiment did not grow into normal 'tall' plants (Irvine and Freyre, 1960), although they underwent significant stem elongation compared to untreated dwarf plants. **THIS may** be accounted for by the fact that all treated dwarf replicates did not show the same degree of stem elongation, some growing far more than others. **THIS suggests** that *some* experimental *error* was involved and it *is possible* that differences in the concentration of gibberellic acid added *may* have caused these variations. **More care needs to be taken** in the preparation and administration of treatment solutions in future experiments as well as **greater accuracy** in measurements.

SINCE gibberellic acid *appears* to stimulate growth in dwarf plants and have little or no effect on the growth of tall plants, it *is possible* to conclude that the absence of gibberellic acid in dwarf plants *may* be responsible for their dwarfism. **Further investigation needs to be carried out** into why dwarf plants are unable to produce gibberellic acid naturally.

- (1) Notice the number of linking words that have been put into CAPITAL letters and bold type (eg: conjunctions like ‘however’ and reference words like ‘this’). These are important for connecting the ideas and information in different sentences to each other. In this way, the writer develops the text in a logical way.
- (2) Some of the verbs have been underlined. These verbs are in the PRESENT tense because they allow the writer to make general statements or generalisations about the results. Notice, however, that the verbs which refer to the results of this particular experiment are still in the PAST tense.

However, the dwarf plants in this experiment did not grow into normal ‘tall’ plants (Irvine and Freyre, 1960), although they underwent significant stem elongation compared to untreated dwarf plants.

- (3) The language in italics allows the writer to make evaluations or judgements about the experimental techniques, the results and the interpretation of those results. The writer is careful about giving reasons for unexpected results and explaining the importance or significance of the results. This is because s/he cannot be certain about this information.

This *may* be accounted for by the fact that all treated dwarf replicates did not show the same degree of stem elongation, some growing far more than others. This suggests that some experimental error was involved and it is *possible* that differences in the concentration of gibberellic acid added *may* have caused these variations.

- (4) The language in bold (lower case) allows the writer to make general recommendations about future experimental techniques or future research.

Exercise 3

Read the following student draft (Model 3) for the discussion stage of the experiment. There are a number of problems with this draft. Firstly, identify the content or stages that are missing or that need to be extended. Then, re-draft the discussion correcting any problems in grammar and academic style.

Model 3

Discussion

By looking at the measurement tables, the experiment has again proven the significance of gibberellic acid’s role on the dwarf plant. It coincides with many experiments and theory which were given. Although the experiment’s result was quite good still there was some minor aspect need to be adjusted, since the experiment was carried out by a group therefore there was a lot of individual opinion or way of doing thing eg: By preparing treatment solutions without looking carefully at the measurements and mixing up the labels and the solutions. It should be minimised the number of people do the experiment as the more mistakes the more experimental error involved.

D: WRITING YOUR OWN DISCUSSION

Refer to your own laboratory notes when you are writing your discussion. Hopefully, you will have recorded any unexpected results and their possible explanations, as well as possible interpretations of your other results. You will also have to compare your results with previous research. Think carefully about how you will sequence the information so that you develop a logical discussion. Use the questions at the beginning of this section to help you. Remember that not all of the questions or the stages will be relevant to every experiment. Write a number of draft discussions until you are satisfied with your writing.

(7) References

This is the last section of the report. It is standard academic practice to provide details of all the references you mentioned (cited) in your report at the end of the report (not the ones you may have read but didn't mention). References are listed in alphabetical order. For each reference give the author's name, the year of publication, the full title of the book or article and the publication details. The model below will help you in writing your list of references. However, since there are a number of different conventions associated with giving references, **always make sure that you follow the guidelines for referencing given by your individual lecturers, and be aware that these will vary.** There is also a Learning Assistance Centre handout on referencing which deals with this area in more detail.

References

Irvine, J.E. and Freyre, R.H. (1960) Reversal of genetic dwarfism in *Trephrosia vogelii* by gibberellins. *Nature*. 185: 11.

Keenton, W.T. (1980) *Biological Science*. Norton and Co., New York.

Low, V.H.K. (1975) Role of gibberellins in root and shoot growth in *Gibberellins and Plant Growth*. ed. H.N. Krishnamoorthy. Wiley Eastern Ltd., New Delhi.

School of Biological Sciences (1994) *Biology 1 Laboratory Notes*. The University of Sydney, Sydney.

Exercise 1

The following references were mentioned in a student report:

Mauseth, (1995)
Salisbury and Ross, (1992)
Keenton, (1980)
Low, (1975)
Campbell, (1990)

At the end of the report, the student compiled the following reference list. Can you correct it?

References

F.B Salisbury C.W. Ross, (1992) 'Plant Physiology. *Fourth edition*'. Wadsworth Publishing Co California

Bidwell RGS (1979) Plant physiology Collier Macmillan

Low VHK Role of gibberellins in root and shoot growth (1975) (from *Gibberellins and plants growth* ed.HN KRISHNAMOORTHY, Willey. Eastern Ltd New Delhi

NEIL A. CAMPBELL 1990 "BIOLOGY" 2ND Ed THE BENJAMIN/ CUMMINGS PUBLISHING CO. SYDNEY

Mauseth J *Botany Second edition* Saunders College Publishing, Sydney.

Keenton, (1980) *Biological Science*.

APPENDICES

Appendices are only used to put in specific details of your experiment which are not necessary for understanding the main purpose and outcomes of your experiment eg: raw data, more detailed descriptions of your methods or equipment, formulae and calculations, more detailed results. Your main results should go in the results section and readers should not be forced to go to an appendix to find your results. However, you should refer to the appendices in your report eg: A more detailed description of the method used is given in Appendix 1.

(8) The Abstract

Although the abstract is the first section of the report, it is usually the last section that is written. This is because it is a summary or an overview of the whole report and it is easier to write after you have finished the whole report.

(A) THE CONTENT AND STRUCTURE

The information in the abstract typically answers the following questions and is ordered in the following sequence:

- (1) What is the experiment about and why was it done? (introduction)
- (2) How was the experiment done? (methods)
- (3) What were the main results? (results)
- (4) What were the main conclusions? (discussion and conclusion)

As you can see, the sequence of the questions follows the same order as the structure of the report as a whole.

Exercise 1

Compare the abstracts in Model 1 and Model 2 and decide which is the more appropriate abstract. Find reasons for your decision.

Model 1

The results in Table 1 show that the effect of gibberellic acid on the growth of tall (*cv. Telephone*) and dwarf (*Pisum sativum cv. Greenfeast*) plants differs. Gibberellic acid promoted stem elongation only in dwarf plants. Although stem length increased three times, the number of internodes remained the same. Tall plants remained unaffected. Therefore, gibberellic acid played an important role in stimulating stem growth in dwarf plants but it had no effect on tall plants. Dwarf plants grew taller through stem elongation but tall plants remained the same.

Model 2

The influence of gibberellic acid on the growth and development of two varieties of pea seedlings, dwarf (*Pisum sativum cv. Greenfeast*) and tall (*cv. Telephone*) was investigated. Weekly measurements of plant height and internode length and number showed that gibberellic acid promoted significant stem elongation in the dwarf plants, although the number of internodes remained unaffected. No change was recorded in tall pea plants. This suggests that gibberellic acid is necessary for the growth of tall pea plants and its absence may account for dwarfism in peas.

B: THE LANGUAGE

Model 2

The influence of gibberellic acid on the growth and development of two varieties of pea seedlings, dwarf (*Pisum sativum cv. Greenfeast*) and tall (*cv. Telephone*) was investigated. Weekly measurements of plant height and internode length and number showed that gibberellic acid promoted significant stem elongation in the dwarf plants, although the number of internodes remained unaffected. No change was recorded in tall pea plants. This *suggests* that gibberellic acid *is* necessary for the growth of tall pea plants and its absence *may account for* dwarfism in peas.

- (1) The abstract contains a number of noun groups (**in bold**) because the information has to be condensed in such a short summary and these noun groups are able to pack in a lot of information.
- (2) The verbs in the abstract (underlined) are mainly in the past tense because they summarise what was done and found in this particular experiment.
- (3) Some of the verbs are in the present tense (*in italics*). This tense is appropriate when you are interpreting the significance of your results and stating your conclusions. Notice that two of these verbs also contain tentative meanings (**suggests, may account for**) because the writer cannot be certain of his/her conclusions.

Answer Key for Exercises

(1) THE OVERALL STRUCTURE OF THE LABORATORY REPORT

No exercises.

(2) THE INTRODUCTION

Exercise 1

- (1) What is the subject of your report? What is your experiment about?
Gibberellic acid
- (2) Why is the subject important? (optional in first year)
is a plant growth substance which is known to have certain, often dramatic, effects on the growth of plants (School of Biological Sciences, 1994).
- (3) What is the theory about this subject? What have other researchers found out about this subject?
Gibberellins appear to affect almost all plant organs but their most spectacular effect is stem elongation (Low, 1975). Stem elongation occurs when gibberellic acid is applied to plants which are genetic dwarfs and this makes these plants indistinguishable from the normal tall variety (Irvine and Freyre (1960). However stem elongation does not usually occur when gibberellic acid is applied to most normally tall plants (Keenton, 1980).
- (4) How does your experiment compare with previous experiments done in that area (is it going to confirm a hypothesis already stated, to apply a methodology to other subjects? etc.)
This experiment aimed to establish whether the addition of gibberellic acid had a similar effect on the growth of tall and dwarf pea plants.
- (5) What was the aim or objective of your experiment or what hypothesis was being tested? What were you trying to find out?
This experiment aimed to establish whether the addition of gibberellic acid had a similar effect on the growth of tall and dwarf pea plants.

Exercise 2

- Stage 1 State the subject of the report and why it is important
This stage is not present in model 2
- Stage 2 Summarise what researchers already know about the subject
Past research has shown that ‘the most dramatic effect of the gibberellins is the transformation of dwarf plants into tall ones by greatly increased stem elongation’(Brian and Hemmings, 1955). Keenan (1980) said that gibberellins only affect those plants that normally undergo little stem elongation but have much less effect on most normally tall plants.

- Stage 3 State how your experiment compares with previous experiments
This stage is not present in model 2
- Stage 4 State the aim and/or hypothesis of your experiment
The experiment has been carried out to study the effect of gibberellic acid on dwarf and tall plants.
 This aim is too general.
- Inappropriate stage: this stage should be in the Methods
Two varieties of pea seeds, dwarf (*Pisum sativum* cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 3 weeks.

A COMPARISON OF THE STRUCTURES OF THE INTRODUCTIONS IN MODELS 1 AND 2

Structure in Model 1

<p>Gibberellic acid is a plant growth substance which is known to have certain, often dramatic, effects on the growth of plants (School of Biological Sciences, 1994).</p> <p>Gibberellins appear to affect almost all plant organs but their most spectacular effect is stem elongation (Low, 1975). Stem elongation occurs when gibberellic acid is applied to plants which are genetic dwarfs and this makes these plants indistinguishable from the normal tall variety (Irvine and Freyre (1960). However, stem elongation does not usually occur when gibberellic acid is applied to most normally tall plants (Keenton, 1980).</p> <p>This experiment aimed to establish whether the addition of gibberellic acid had a similar effect on the growth of tall and dwarf pea plants.</p>	<p>Introductory sentence: tells us the subject of the report and why it is important.</p> <p>Summary of previous research. Relationships between different research findings are made clear.</p> <p>Relationship between this experiment and past research is made clear.</p>
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Structure in Model 2

<p>The experiment has been carried out to study the effect of gibberellic acid on dwarf and tall plants.</p> <p>Past research has shown that the 'most dramatic effect of the gibberellins is the transformation of dwarf plants into tall ones by greatly increased stem elongation' (Brian and Hemmings, 1955). Keenton (1980) said that gibberellins only affect those plants that normally undergo little stem elongation but have much less effect on most normally tall plants.</p> <p>Two varieties of pea seeds, dwarf (<i>Pisum sativum</i> cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 3 weeks.</p>	<p>No general introductory sentence which tells us what gibberellic acid is and what it does.</p> <p>Research findings simply listed. Relationships between findings not shown. Findings not related to present experiment.</p> <p>This information tells the reader about how you carried out the experiment and so it should go in the methods stage.</p>
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Exercise 3

Write out 2 other possible hypotheses for this experiment.

The hypothesis is that the addition of gibberellic acid will only affect the growth of dwarf pea plants.

or

The hypothesis is that the addition of gibberellic acid will promote growth in both tall and dwarf pea plants.

or

The null hypothesis is that gibberellic acid has no effect on the growth of either tall or dwarf pea seedlings.

As we know from the results, the first hypothesis would be accepted but the second and third would be rejected and you would state this in the discussion stage.

(3) THE METHODS

Exercise 1

Read the following methods sections for the experiment on gibberellic acid. Make comparisons between the 2 models and decide which version is appropriate for the laboratory report. Find reasons for your decision.

Model 2 is appropriate for the methods section of the laboratory report. Model 1 contains a list of materials and a list of instructions, which have probably been copied from the laboratory notes. These kinds of directions on how to carry out the experiment are usually given in your laboratory notes. Model 1 also contains a stage that should be in the Results section.

A COMPARISON OF THE STRUCTURES IN MODELS 1 AND 2

Structure in Model 1

METHODS	
Materials:	
i) seeds of tall (ver. Telephone) and dwarf (ver. Greenfeast) peas.	Materials are separated from methods.
ii) 8 flower pots	Materials are listed.
iii) sand and vermiculite (mix approximately equal portions)	
iv) 70% ethanol content solution	
v) gibberellic acid in 70% ethanol (0.4mg of solution)	
vi) a mm ruler for measurement	
Firstly, cover the holes in each pot with a thin layer of cotton, then carefully half fill the pots with sand mixture, tamp the soil down by pressing it with the palm of the hand.	Methods are written as instructions. Too much detail is given.
Secondly, ...	
In the second week, all the seedlings were examined and measured. The dwarf peas which had been treated with gibberellic acid had grown almost twice as much as the control plants.	Results are given in the wrong part of the laboratory report.

Structure in Model 2

<p>METHODS</p> <p>Two varieties of pea seeds, dwarf (<i>Pisum sativum</i> cv. Greenfeast) and tall (cv. Telephone) were planted and their growth was monitored over a period of 4 weeks. Two sets of dwarf seeds (an experimental and a control) and 2 sets of tall seeds were planted in separate pots. After the seeds had germinated (at the beginning of the second week), the experimental seedlings were treated with gibberellic acid in 70% ethanol (0.4 mg per ml of solution) and the controls were treated with 70% ethanol alone. Each seedling received one drop of the solution applied to the top leaf (growing tip). At the end of each week, the height of each seedling was recorded in cms.</p>	<p>Recount of materials used and first activity.</p> <p>Recount of total time period of experiment.</p> <p>Second event.</p> <p>Time phrases used to order the sequence of events.</p>
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Exercise 2

Re-write the following extracts from Model 1 in the passive.

Firstly, cover the holes in each pot with a thin layer of cotton, then carefully half fill the pots with sand mixture, tamp the soil down by pressing it with the palm of the hand.

Firstly, the holes in each pot were covered with a thin layer of cotton. Then, the pots were carefully half filled with sand mixture and the soil was tamped down by pressing it with the palm of the hand.

(4) THE TITLE

Exercise 1

Model 2 is more appropriate. Model 1 is too general. It does not give us enough information about the purpose of the experiment.

Both Model 1 and Model 2 tell the reader the purpose of the experiment or what we are trying to find out about gibberellins and plant growth. They do not tell us what we actually found. We can also write the title so that it tells us what we found. Then we would write a title like the following:

Model 3

Gibberellic Acid Affects the Growth of Dwarf Pea Seedlings but not Tall Seedlings

(5) THE RESULTS

Exercise 1

Examine the 2 models of a results section and decide which is the more appropriate model in terms of its content and structure. Find reasons for your answer. Examine the tables in model 1 and 2 and decide which table is appropriate and why.

Model 2 is more appropriate. The results section and the table are introduced. The title of the table and its content is appropriate (see above). The content and structure in the summary of the results is appropriate. Model 1 is inappropriate for the following reasons. The results section is not introduced. The table has no number and its title is too general. The different treatments are not identified - we do not know what the numbering of the pots means. The type of measurement is not identified - is it an average? or a median? Is the height in cm or mm? There are also problems with the summary of the results in Model I (see above).

A COMPARISON OF THE STRUCTURES OF THE SUMMARIES OF THE RESULTS IN MODELS 1 AND 2

Model 1

<p>Dwarf plants treated with gibberellic acid appear to have grown at a greater rate than those not treated with gibberellic acid. The average height of the dwarf plants treated with gibberellic acid was 13 cm, the average number of their internodes was 5 and the length of their internodes was 3.45cm. For dwarf plants which were not treated with gibberellic acid the measurements were 8cm, 5 internodes and an internode length of 1.75cm.</p>	<p>Results not summarised</p>
<p>Tall plants which were treated with gibberellic acid grew more than those which were not treated.</p>	<p>Content of table repeated</p> <p>No comparison made between results for treated and untreated dwarf plants. Results simply listed. Most important result not highlighted.</p>
<p>It appears that the addition of gibberellic acid to dwarf plants causes them to grow.</p>	<p>Difference between results for dwarf plant and results for tall plants not made explicit.</p> <p>Results are generalised and interpreted not summarised. Interpretation of results should be done in the discussion stage.</p>

Model 2

<p>The results in Table 1 show that dwarf plants which were treated with gibberellic acid (GA) grew to almost twice the height of the controls (untreated dwarf plants). Their internode length almost doubled.</p> <p>When the Wilcoxon test was applied, these differences were statistically significant. However treated dwarf plants did not grow to the height of normal tall plants.</p> <p>The application of gibberellic acid to tall plants did not cause any significant differences in their growth.</p>	<p>Table is referred to in the writing. Abbreviation (GA) used in table is explained. Results for dwarf plants Summarised and compared. Most important result highlighted.</p> <p>Significance of results stated. Unexpected result identified.</p> <p>Results for dwarf and tall plants summarised and compared.</p>
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(6) THE DISCUSSION

Exercise 1

Look at the following discussion stage and identify the answers to the above questions. Has the writer included information to answer all the above questions?

- (1) Have you fulfilled the aims of your experiment? (Can you accept or reject your hypothesis)
The results show that gibberellic acid has a marked effect on the growth of dwarf pea plants but little effect on the growth of tall pea plants.
- (2) How do your results compare with those of previous researchers?
This is largely consistent with previous research findings (Low, 1975, Keenton, 1980). However, the dwarf plants in this experiment did not grow into normal 'tall' plants (Irvine and Freyre,1960),
- (3) Why did you get the results you got? You may have to explain inconsistent or unexpected results.
However, the dwarf plants in this experiment did not grow into normal 'tall' plants (Irvine and Freyre,1960), although they underwent significant stem elongation compared to untreated dwarf plants. This may be accounted for by the fact that all treated dwarf replicates did not show the same degree of stem elongation, some growing far more than others.
- (4) What problems did you encounter in carrying out the experiment and how could you overcome these in future investigations?
This suggests that some experimental error was involved and it is possible that differences in the concentration of gibberellic acid added may have caused these

variations. More care needs to be taken in the preparation and administration of treatment solutions in future experiments as well as greater accuracy in measurements.

- (5) What is significant or important about your results? What are the implications of your results?
Since gibberellic acid appears to stimulate growth in dwarf plants and have little or no effect on the growth of tall plants, it is possible to conclude that the absence of gibberellic acid in dwarf plants may be responsible for their dwarfism.
- (6) What further areas of investigation, if any, can you suggest.
Further investigation needs to be carried out into why dwarf plants are unable to produce gibberellic acid naturally.

Exercise 2

Read the following discussion for the same laboratory experiment and try to identify the problems in its content and staging. Use the questions below to help you.

- (1) Is the information in the first sentence related to the results of this experiment?
No, the information is general information about gibberellins.
- (2) Look at the second sentence. What kind of information is it telling us? Is this appropriate for a discussion section?
Sentence 2 is telling us the results and should go in the results section.
- (3) Is the second sentence connected to the third sentence? Do the ideas flow from one to the other in a logical way?
There is no relationship between the ideas in sentence 2 and those in sentence 3.
- (4) What does the last sentence recommend? Do we know why this recommendation is being made?
Minimising the number of people involved in the experiment. This recommendation is made to reduce experimental error but we do not know how the number of people affected experimental error. This information is not linked to the major fault of the experiment.
- (5) What other kinds of information should the writer have included?
The actual results of the experiment are not interpreted in any way. They are not compared with previous results. The significance and implications of the results are not discussed.

A COMPARISON OF THE STRUCTURES OF MODELS 1 AND 2

Model 1

<p>The results show that gibberellic acid has a marked effect on the growth of dwarf pea plants but little effect on the growth of tall pea plants.</p> <p>This is largely consistent with previous research findings previous research. (Low, 1975, Keenton, 1980). However, the dwarf plants in this experiment did not grow into normal 'tall' plants (Irvine and Freyre, 1960), although they underwent significant stem elongation compared to untreated dwarf plants.</p> <p>This may be accounted for by the fact that all treated dwarf replicates did not show the same degree of stem elongation, some growing far more than others.</p> <p>This suggests that some experimental error was involved and it is possible that differences in the concentration of gibberellic acid added may have caused these variations.</p> <p>More care needs to be taken in the preparation and administration of treatment solutions in future experiments as well as greater accuracy in measurements.</p> <p>Since gibberellic acid appears to stimulate growth in dwarf plants and have little or no effect on the growth of tall plants, it is possible to conclude that the absence of gibberellic acid in dwarf plants may be responsible for their dwarfism.</p> <p>Further investigation needs to be carried out into why dwarf plants are unable to produce gibberellic acid naturally.</p>	<p>Specific results of this experiment are generalised and related to the aims.</p> <p>Comparisons are made with previous research.</p> <p>Unexpected results explained and linked with previous sentence.</p> <p>Reason for unexpected result given.</p> <p>Recommendation linked with unexpected result.</p> <p>Importance of generalised result explained.</p> <p>Recommendation for future research linked with importance of result.</p>
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Model 2

<p>Gibberellins appear to affect almost all plant organs but their most spectacular effect is stem elongation (Low, 1975).</p>	<p>This information doesn't relate back to the results section or to the aims. Since it tells us about previous research, it is more appropriate to put it in the introduction section.</p>
<p>Table 1 shows that dwarf plants which were treated with gibberellic acid grew to almost twice the size of untreated plants.</p>	<p>No comparison is made between previous research and the results of this experiment.</p>
<p>A major fault in the experiment was that the concentration of gibberellic acid varied between replicates.</p>	<p>This sentence summarises the results and should go in the results section.</p>
<p>This meant that, for example, in week 2 there were differences in length among the 5 replicates when they should have been similar.</p>	<p>No relationship between this sentence and the previous one. Problems with experimental method not linked with results.</p>
<p>The number of people involved in the experiment should be minimised to reduce experimental error.</p>	<p>Example of problems with experimental method too specific. Improvements in technique not linked with problems in experimental method.</p>

Exercise 3

Read the following student draft (Model 3) for the discussion stage of the experiment. There are a number of problems with this draft. Firstly, identify the content or stages that are missing or that need to be extended. Then, re-draft the discussion correcting any problems in grammar and academic style.

- Stage 1: Have you fulfilled the aims of your experiment? (Can you accept or reject your hypothesis?)
The writer states that the role of gibberellic acid on dwarf plants is significant but does not say what this is.
- Stage 2: How do your results compare with those of previous researchers?
Comparison with previous research is made but is too vague and general.
- Stage 3: Why did you get the results you got? You may have to explain inconsistent or unexpected results.
No reasons given.
- Stage 4: What problems did you encounter in carrying out the experiment and how could you overcome these in future investigations?
Problems in technique are identified and improvements in technique are suggested but they are given in too much detail.

Stage 5: What further areas of investigation, if any, can you suggest. What is significant or important about your results? What are the implications of your results?

The writer simply states that the role of gibberellic acid on the dwarf plant is significant but does not say why. No implications are discussed.

Model 3 (possible re-draft)

DISCUSSION

The results show the significant effect of gibberellic acid on dwarf plants. This is largely in agreement with previous research findings. Although the experimental results were generally valid, some minor variations occurred. This experimental error may be due to the different methods adopted by group members when carrying out the experiment. Reducing the size of the group could improve the accuracy of the results.

(7) REFERENCES

Exercise 1

The following references were mentioned in a student report:

Mauseth, (1995)
Salisbury and Ross, (1992)
Keenton, (1980)
Low, (1975)
Campbell, (1990)

At the end of the report, the student compiled the following reference list. Can you correct it? (**corrections in bold**)

Bidwell, R.G.S. (1979) *Plant Physiology*. Collier Macmillan
(Place of publication is missing. This reference should be removed from the reference list as it is not mentioned in the report)

Campbell, N. (1990) *Biology*. Second edition. The Benjamin/Cummings Publishing Co., Sydney.

Keenton, W.T. (1980) *Biological Science*. Norton and Co., New York.

Low, V.H.K. (1975) Role of gibberellins in root and shoot growth in *Gibberellins and Plant Growth*. ed. H.N. Krishnamoorthy. Wiley Eastern Ltd, New Delhi.

Mauseth, J. (1995) *Botany*. Second edition. Saunders College Publishing, Sydney.

Salisbury, F.B. & Ross, C.W. (1992) *Plant Physiology*. Fourth edition. Wadsworth Publishing Co., California.

(8) THE ABSTRACT

Exercise 1

Compare the abstracts in Model 1 and Model 2 and decide which is the more appropriate abstract. Find reasons for your decision.

Model 2 is more appropriate. See over for the reasons.

A COMPARISON OF THE STRUCTURES OF MODELS 1 AND 2

Model 1

<p>The results in Table 1 show that the effect of gibberellic acid on the growth of tall (<i>cv. Telephone</i>) and dwarf (<i>Pisum sativum cv. Greenfeast</i>) plants differs. Gibberellic acid promoted stem elongation only in dwarf plants. Although stem length increased three times, the number of internodes remained the same. Tall plants remained unaffected. Therefore, gibberellic acid played an important role in stimulating stem growth in dwarf plants but it had no effect on tall plants. Dwarf plants grew taller through stem elongation but tall plants remained the same.</p>	<p>No summary of aims or methods. Only the results are summarised. The Table should not be referred to in the abstract.</p> <p>No conclusions given. Summary of results repeated.</p>
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Model 2

<p>The influence of gibberellic acid on the growth and development of two varieties of pea seedlings, dwarf (<i>Pisum sativum cv. Greenfeast</i>) and tall (<i>cv. Telephone</i>) was investigated. Weekly measurements of plant height and internode length and number showed that gibberellic acid promoted significant stem elongation in the dwarf plants, although the number of internodes remained unaffected. No change was recorded in tall pea plants. This suggests that gibberellic acid is necessary for the growth of tall pea plants and its absence may account for dwarfism in peas.</p>	<p>Summary of aims</p> <p>Summary of methods</p> <p>Summary of results</p> <p>Summary of conclusions</p>
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