Bishop Anstey High School East

"Selflessly Serving Our Community"

Trinity College East

"Selflessly Serving Our Community"

CAPE BIOLOGY LABORATORY MANUAL

TABLE OF CONTENTS

LABORATORY RULES

1. Lab coats must be worn and properly fastened during ALL laboratory sessions.
2. Wear **safety goggles** to protect your eyes when heating substances, dissecting, etc.
3. Absolutely no eating or drinking in the lab.
4. Report all accidents, injuries, and breakage of glass or equipment to teacher or Laboratory Technician immediately.
5. Keep pathways clear by placing extra items (books, bags, etc.) on the shelves or under the work tables. If under the tables, make sure that these items cannot be stepped on.
6. Long hair (chin-length or longer) must be tied back to avoid catching fire.
7. Work quietly — know what you are doing by **reading** the assigned experiment **before** you start to work. Pay close attention to any **cautions** described in the laboratory exercises.
8. Do not taste or smell chemicals.
9. Do not attempt to change the position of glass tubing in a stopper.
10. **Never** point a test tube being heated at another student or yourself. Never look into a test tube while you are heating it.
11. Unauthorized experiments or procedures **must not** be attempted.
12. Keep solids out of the sink.
13. Leave your workstation clean and in good order before leaving the laboratory.
14. Do not lean, hang over or sit on the laboratory tables.
15. Do not leave your assigned laboratory station without permission of the teacher.

16. Learn the location of the fire extinguisher, eyewash station, first aid kit and safety shower.
17. Fooling around or "horseplay" in the laboratory is absolutely forbidden. Students found in violation of this safety rule will be barred from participating in future labs and could result in suspension.
18. Anyone wearing acrylic nails will not be allowed to work with matches, lighted splints, Bunsen burners, etc.
19. Do not lift any solutions, glassware or other types of apparatus above eye level.
20. Follow all instructions given by your teacher.
21. Learn how to transport all materials and equipment safely.
22. **ALL** drawing laboratory reports must be completed within the allotted practical session.
23. **ALL** written laboratory reports must be submitted by 9:00am of the morning following the practical session unless indicated otherwise.
24. There is a zero tolerance for Plagiarism so ensure that all reports are a reflection of your individual work and not your partner's or a published report.
25. Students must present an excuse signed and written by parents in order to pursue any missed laboratory exercise or report.
26. Use of cell phones is prohibited unless it use is directly related to the laboratory practical at hand.

I____ have read and understood the laboratory rules of Bishop Anstey and Trinity College East Sixth Form. I acknowledge that failure to adhere to these rules can lead to my child(ren) being barred from further experiments or a penalty in accordance with the school's code of conduct.

_________________________ ____________________

Parent’s Signature **Date**

GUIDELINES FOR DRAWING LABORATORY REPORTS

Scientific drawings are an important part of the science of biology and all biologists must be able to produce good quality scientific drawings regardless of your artistic ability. Drawings not only allow you to record an image of the specimen observed, but more importantly, they help you to remember the specimen as well as the important features of the specimen.

All drawings done for this course must adhere to standard rules of scientific illustration. The following are some **guidelines** that you are to use when illustrating specimens:

1) Look at the specimen carefully and examine the significant features that will be included in the drawing.

2) DRAW ONLY WHAT YOU SEE!! Do not include what you think you should see. Hence, your drawing must reflect a faithful representation of the specimen observed.

3) All drawings must be done in pencil ONLY.

4) Drawings must be large and clear (with smooth continuous lines) so that features can be easily distinguished.

5) 6) Always use distinct, single lines when drawing.

7) All drawings must have the following:

- Title (gives a full, clear and concise explanation of what is being illustrated) must be printed below the drawing in capital letters and include the view and magnification, the title must be underlined.

- Magnification indicated next to the title with calculations at the back of the drawing (indicate the magnification at which the specimen was observed). Remember!!!!! Magnification = size of object / size of specimen

- Labels written in upper case **OR** lower case. Always include labels of the important features of the specimen. Each label line must be straight and should not overlap with other label lines. Labels must be printed next to label lines and must include annotations which should give information about the specimen that cannot be seen on the diagram.

8) Be sure to underline scientific names. All scientific names must be written as follows: Genus (beginning with a capital letter) species (beginning with a common letter) e.g. *Amoeba proteus*.

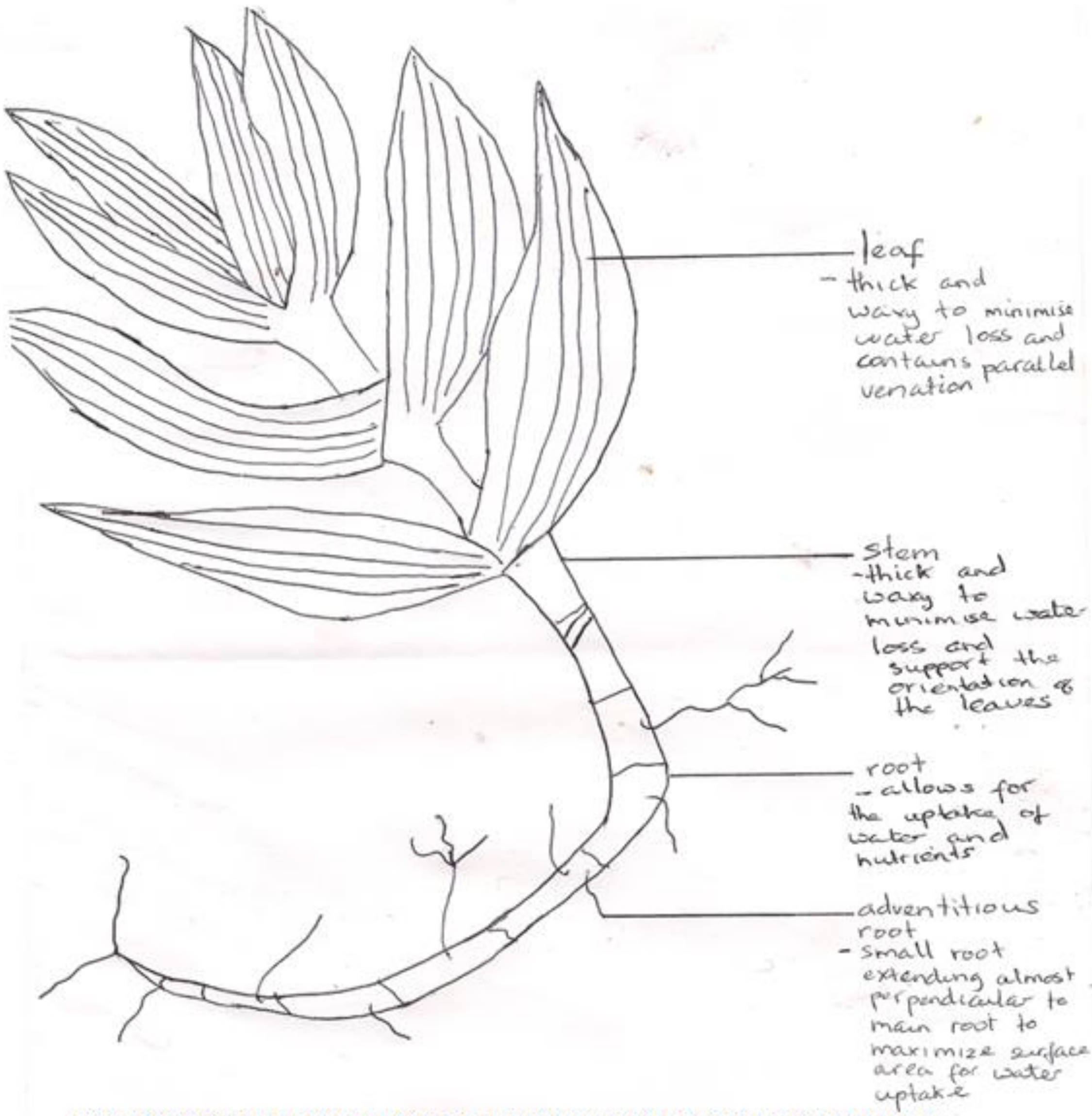
9) There are three main types of drawings:

- Habit "sketches": these drawings are used to illustrate an entire organism and shows all the basic features that can be seen when looking at the organism in its entirety. ***See figure 1.***

- Low power plan drawings: these drawings show the basic plan of sections of specimens. For example, you may want to examine the cross section or longitudinal section of a dicotyledonous stem. There are several cells seen in a cross section of a stem, and these cells are grouped into tissue types (e.g. epidermis, pith, xylem, and phloem). A low plan drawing shows the position of the tissue types, without showing the cells. ***See figure 2.*** Cell types are illustrated in a high power diagram.

- High power detailed drawings: these drawings are used to show detailed cells within a section of a specimen (e.g. cells within the section of a leaf). ***See figure 3.*** These drawings can also be used to show the details of microscopic or unicellular organisms (e.g. Amoeba - a protozoan),

Figure 1: Illustrated example of a habitat "sketch"



DRAWING OF THE ANATOMY OF THE MONOCOTYLEDONOUS ORNAMENTAL PLANT CALLISIA (MAG X0.4)

Figure 2: Illustrated example of a low power plan drawing.

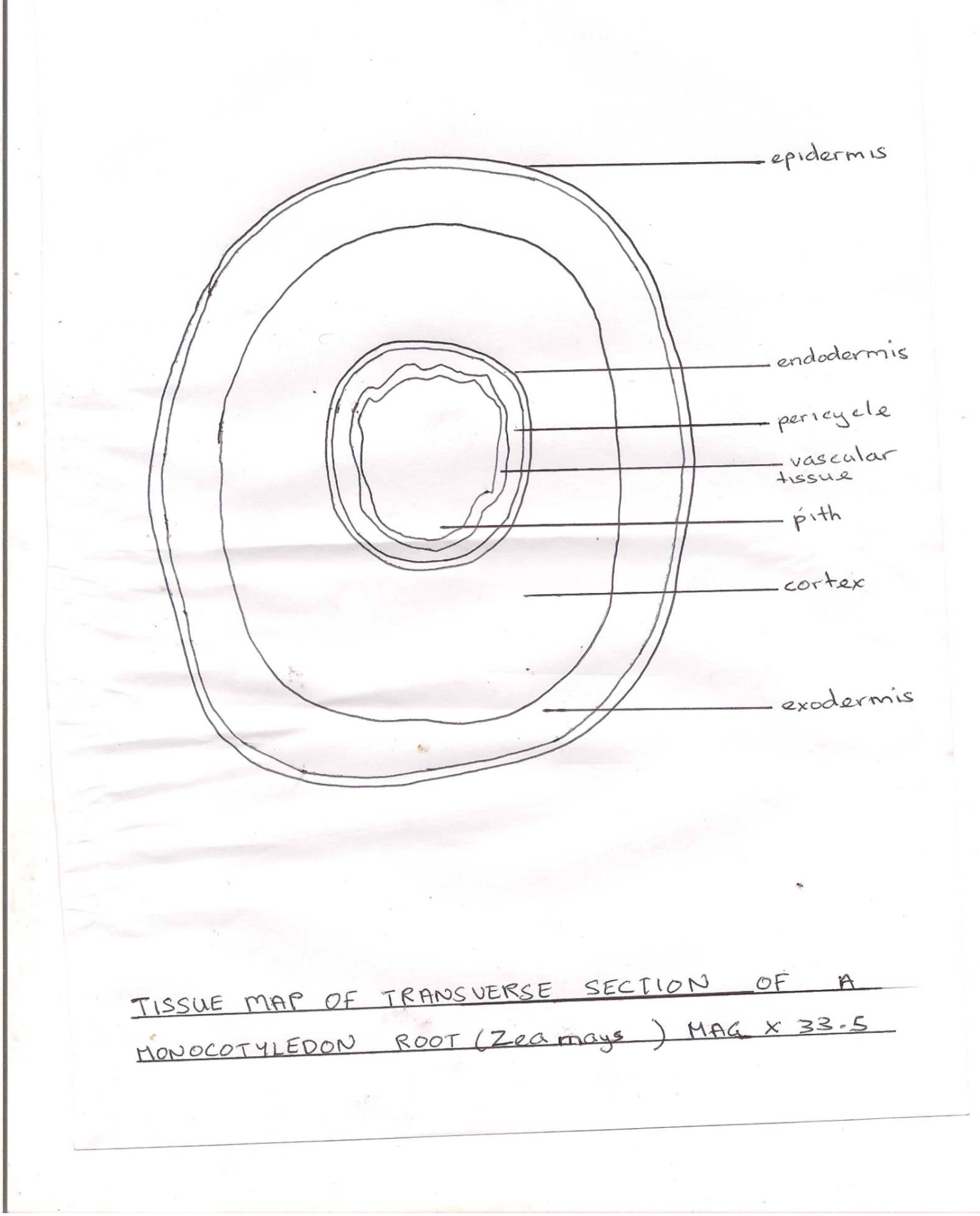
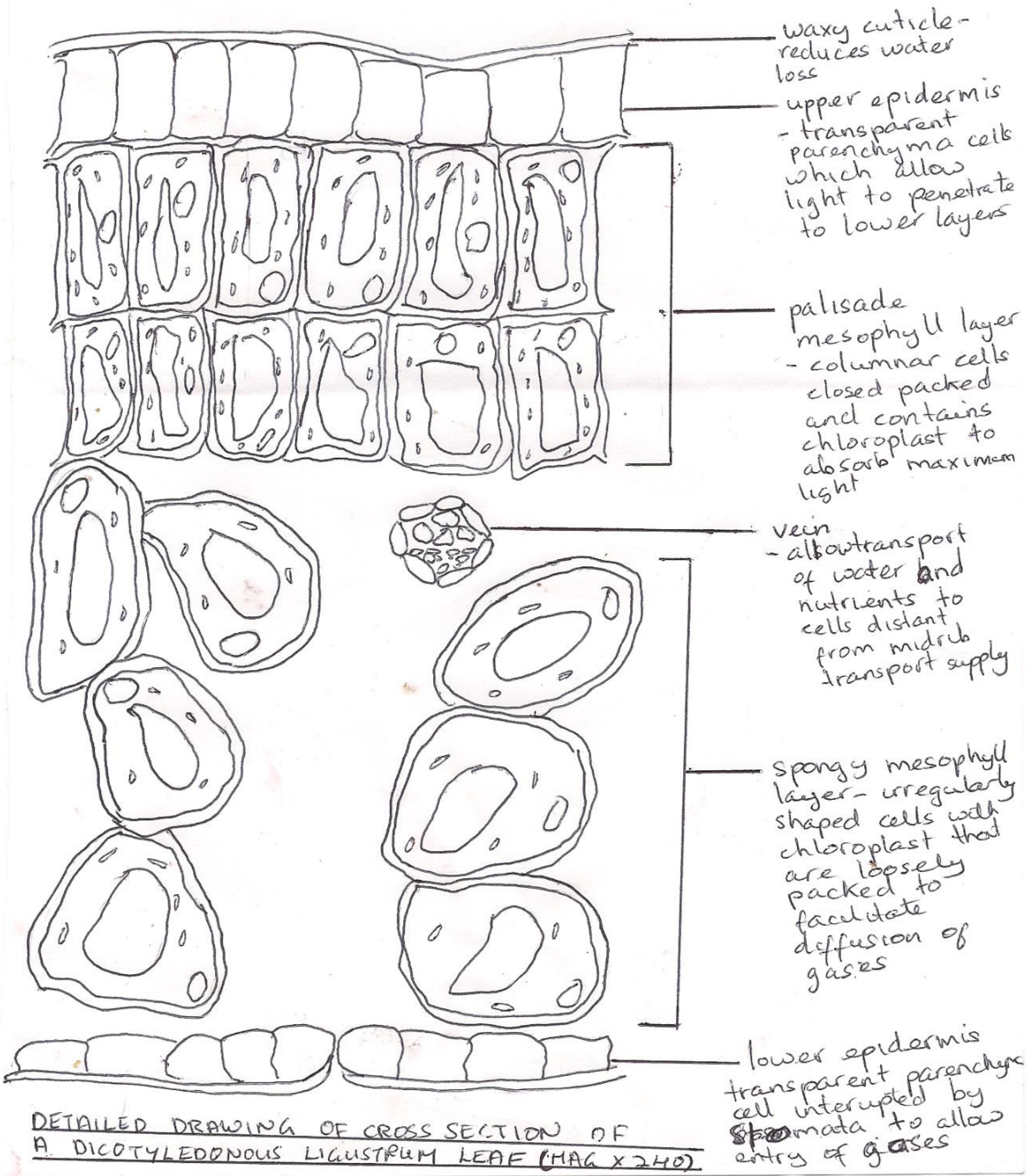


Figure 3: Illustrated example of a high power detailed drawing.



GUIDELINES FOR OBSERVATION RECORDING AND REPORTING (ORR) LABORATORY REPORTS

In accessing this group of skills, the teacher is evaluating the ability of students to make and record observation and then report faithfully. The report should be clear and accurate enough that someone who did not see the original observation or investigation can understand what transpired.

It is therefore, instrumental that accuracy is maintained throughout the report. The report should be presented using the following format:

1. **DATE:**
2. **FORM CLASS:**
3. **SUBJECT:**
4. **TEACHER:**
5. **LAB #**
6. **TITLE:**
7. **AIM:**
8. **INTRODUCTION:**
9. **APPARATUS/MATERIALS:**
10. **DIAGRAM:**
11. **PROCEDURE:**
12. **OBSERVATIONS/RESULTS:**
13. **DISCUSSION:**
14. **CONCLUSION:**

DATE:

1. **Write the date on which the experiment was conducted**, or on which it was started if observations are made over a number of days.
2. **Use the standard date format** used in your region e.g. in the United States the date is recorded as mm/dd/yy, whereas in Barbados dates are recorded as dd/mm/yy.

FORM CLASS:

State the name of your class e.g. U61 or L62

SUBJECT:

State the subject of study, i.e. Biology

TEACHER:

State your subject teacher's name, i.e., the teacher's surname written with the appropriate title e.g. Ms. Glasgow or Mrs. Deane-Paul.

LAB #:

1. **Indicate the order** in which labs were done by writing the lab number.
2. **Ensure that you have the correct order**, particularly is labs are ran concurrently.

TITLE:

The TITLE should be brief and descriptive. E.g. For the topic "Photosynthesis"….. *The Effect of Light Intensity on the rate of Photosynthesis*….. would be an appropriate title when experimenting on the Limiting factor of Light on Photosynthesis. The following are points to consider when formulating your title:

1. It is usually provided by your teacher or instructor and derived from your syllabus objectives.
2. **Examination bodies require investigations** to be carried out under given topics. Find out what they are and **compare** your lab titles with the list.
3. **Do not underestimate the significance of the title**; it reveals the underpinning theory for the experiment and should inform your background reading, understanding of the procedure and interpretation of the results.

AIM:

1. **States the purpose** or objective of the experiment
2. **The AIM usually starts with: 'To investigate...'**, 'To demonstrate...’ To test...’ etc.
3. **The AIM should be kept in sharp focus** throughout the experiment and write-up - including when writing the CONCLUSION. The CONCLUSION must answer the AIM.

INTRODUCTION:

This is a synopsis of the theory related to the lab at hand. The introduction concisely explains in 2 to 3 paragraphs the theory supporting the topic being investigated. Thus, if the title of the lab is the Effect of enzyme concentration on the rate of a reaction, then the introduction should briefly explain what is an enzyme and there mode of action. The emphasis of the introduction however, should be how enzyme concentration affects rates of reaction. Other factors affecting rates of reaction or enzyme activity can be briefly mentioned but in no great detail.

APPARATUS/MATERIALS:

The APPARATUS/MATERIALS section is a **comprehensive list** of all the apparatus and materials used.

1. **List all apparatus first, and then materials.** If no apparatus are used, then just Materials should be written. Apparatus are equipment e.g. Bunsen burner, thermometer, forceps; materials are not equipment but things consumed within the experiment e.g. red and blue litmus paper, ethanol and hibiscus leaves.
2. **Related apparatus may be grouped together**, preceded by the same bullet e.g. Bunsen burner, tripod stand and gauze mat.
3. **When conducting a number of tests**, e.g. food tests, use the names of the tests as sub-headings and list apparatus and materials below.
4. Some apparatus and materials are **implicit** and should not be mentioned e.g. matches.

DIAGRAM:

A **2D line diagram** of the experimental set-up is very insightful for anyone reading your report.

1. Diagrams should be drawn neatly and with a pencil.
2. **A diagram should be on one page**, not split over two pages. If this seems impossible, drawing it smaller, or splitting the diagrams and having more than one TITLE.

3. **Alternatively, a photograph of the actual laboratory apparatus can be presented and labelled as follows.**
4. **Labels** must be in lowercase script and correctly spelled.
5. **Labelling lines** should be drawn neatly with a pencil and ruler, should not cross each other, nor should they have arrowheads. Labelling lines should touch the structures which they are labelling.
6. **Include the TITLE underneath the diagram.** The title should in uppercase, in pen, centred and underlined in pencil. The title should be descriptive e.g. DIAGRAM OF THE APPARATUS FOR BOILING A LEAF IN ETHANOL

PROCEDURE:

The PROCEDURE is a descriptive yet concise account of all the steps taken, in a sequential order.

1. **Write in paragraph form**.
2. **Mention the staggering of or repetition of tasks at intervals.**
3. **Include adequate detail so that the experiments can be duplicated**, including the set-up of the positive and negative controls, use of equipment, measurements taken and where, when and how they were obtained and precautions taken with their justifications.
4. **The PROCEDURE should be written in the past tense and passive voice.**
5. **Include any significant deviations from the PROCEDURE** if you had followed the PROCEDURE from a book, hand-out, etc.

<u>OBSERVATIONS/RESULTS:</u>

Observations are sometimes referred to as **RAW DATA** and are obtained **directly** through the use of our senses, or **indirectly** through the use of instruments which extend our senses.

1. **Observations should be relevant, giving rise to qualitative and/or quantitative data.** Thorough theoretical research before the experiments will help you to determine what is relevant or not and will improve the quality of your observations.

    Carefully consideration must be made, therefore, in presenting this data. Typically, tables and graphs are used.

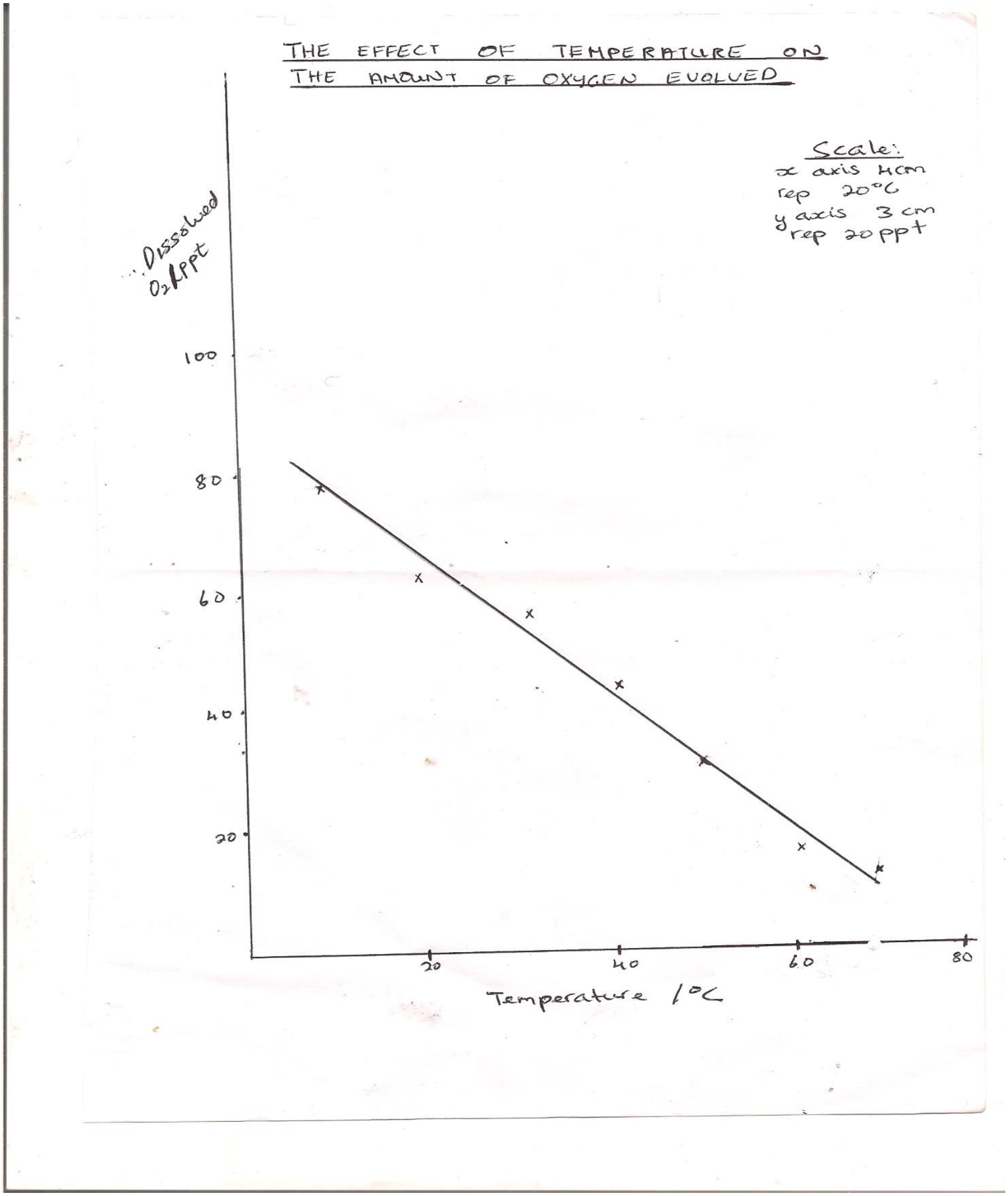
- **Tables** must be neatly presented with a proper title above the table and table headings with relevant units. All relevant observations must be accurately recorded in this table. **(See figure 4)**
- **Graphs** must occupy at least 80% of page and the points must be accurately plotted. Thus, an appropriate scale must be determined when plotting a graph and shown on the top right corner of the graph, for the x and y axes. The best fit curve or line must always be drawn. All axes are to be appropriately labelled with the relevant units. The graph must also contain a proper title written in uppercase at the top of the graph and centred. NB. The title of the graph is always to show the effect of the independent variable on the responding variable. (**See figure 5**)

Figure 4: Illustrated example of essential features of a table.

The concentration and size of potato cylinders in varying sucrose solutions.

	Solution A			Solution B			Solution C		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Concentration (M)									
Diameter of potato cylinder before submergence in solution (cm3)									
Diameter of potato cylinder after submergence in solution (cm3)									

Figure 5: The Illustrated example of essential features of a graph.



DISCUSSION:

The discussion of the laboratory report explains the results given in the tables and or graphs. Here, the observed trends are explained and justified using theoretical knowledge as well as specific data obtained from the experiment, that indicate significant change. If the obtained results deviate from expected, you explain what should have resulted based on your background information about the topic. Also to be included in your discussion are: sources of errors, limitations and recommendations. You must not simply state limits or improvement, but describe what limited or presented errors in the experiment and why as well as how these can be mitigated or circumvented. **Further details are given in the session on Analysis and Interpretation.**

CONCLUSION:

This is a brief statement bringing closure to your laboratory report. This conclusive statement answers the aim based on the results obtained. Thus, the conclusion responds to the aim and complies with the observations of the experiment.

LANGUAGE:

Carefully consideration must also be made to language use and expression in ORR reports. The entire report must be written in the reported speech with few or no grammatical errors. Grammar, syntax and quality of expression are also accessed to ensure CAPE students meet and maintain CAPE standards of scientific reporting.

GUIDELINES FOR ANALYSIS AND INTERPRETATION LABORATORY REPORT

Analysis and interpretation is a process that involves the systematic identification, examination and evaluation of the various components of a whole. It involves linking and understanding the relationships between those components. In the analysis of an experiment, cause and effect must be determined. Inductive and deductive reasoning must also be applied to draw logical conclusions from data. These logical conclusions must be supported with established biological facts and theories. Accurate calculations are needed, as well as the identification of any assumptions or limitations of data to properly analyze the experiment.

The process of analysis and interpretation involves the application of higher order skills to assay a particular subject. Students should execute the following in the written analysis of a lab:

Discuss- Provide arguments for and against a particular case or elucidate the significance of a biological phenomenon

Assess - Present reasons for the importance of particular structures, relationships or processes

Explain- Account for a particular finding and clarify the reasons for such

Justify – Show a satisfactory reason for a finding, observation, trend or pattern

Deduce - Make an educated connection between two or more pieces of information

Suggest – provide possible solutions to problems based on findings, previous knowledge and deductions

The following are the key components of a complete lab report that would be assessed for effective analysis and interpretation or contributions towards such:

INTRODUCTION: The introduction serves to give the reader sufficient background on the topic and initiates the reader to the principles behind the experiment. Molecular structures, chemical equations for reactions and explanations for relevant biochemical, cellular, and physiological processes should always be provided. The introduction should not provide information that answers questions posed by the lab aim. It should not provide an explanation of the results.

The introduction must always provide information about the various chemicals used in the method or tests performed and the reasons behind why they were used. E.g. In an experiment to determine the effect of pH on the rate of hydrolysis of triglycerides, the student should discuss the reasons behind using phenolphthalein in the method. Necessary reactions should be described for support and clarity.

AIM: This is a statement of intent indirectly divulging a problem. It must be as specific as possible. It should include an indication of the variables under examination. E.g. 'Aim: To investigate the effect of solutions of pH 2-10 on the rate of digestion of protein albumin by the enzyme pepsin and to determine the optimum pH of the reaction.'

METHOD: This is an account of the activities carried out during the performance of the experiment. It should be detailed, precise and presented logically in the order in which the apparatus was set up and the activities were performed during the experiment. It should be written in the past tense and not in the first person. Using the information given, another scientist should be able to repeat the experiment.

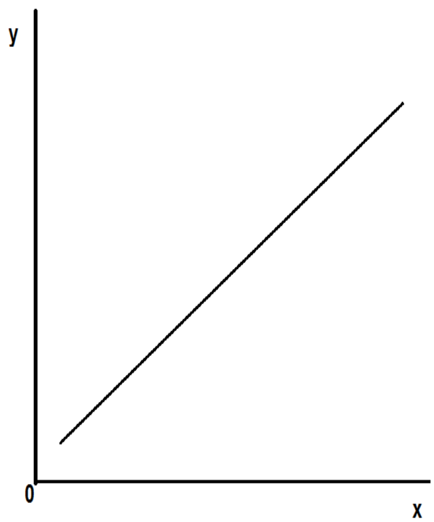
RESULTS: These may be qualitative or quantitative and should be presented as clearly as possible in some appropriate form or forms such as verbal description, tables of data, graphs, histograms, bar charts, kite diagrams and so on. If several numerical values are obtained for repeated measurement of one variable, the mean (x) should be calculated and recorded.

DISCUSSION: This is the most important aspect of analysis and interpretation. The bulk of the analysis is demonstrated in this section and this section typically carries the most weighting in terms of marks. The discussion should be as comprehensive as possible without containing irrelevant details. It should take the form of the answer(s) to possible questions posed by the hypothesis or confirmation of the aim. The discussion should not be a verbal repetition of the results, but an attempt to relate theoretical knowledge of the experimental variables to the results obtained.

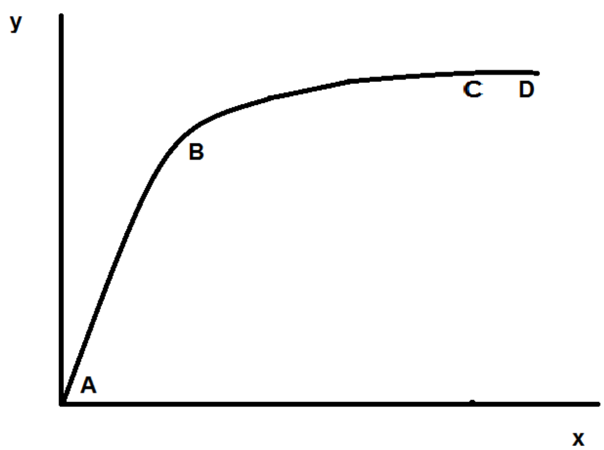
For the lab whose aim was stated above, the discussion of the results should contain aspects of the experiment such as a detailed explanation of the enzymatic reaction and the possible chemical and physical aspects of the effects of pH on the three dimensional structure of the enzyme molecules. These should be directly linked to actual numerical values from the graph (values must be stated). E.g. According to the graph, from pH 2.2 to 5.1 it was found that there was a gradual increase in the rate of the enzymatic reaction. This can be attributed to the fact that the greater the pH, the more H^+ there are in solution. More H^+ in solution changes the conformation of the active site and its biochemical properties making it more conducive to forming the enzyme-substrate complexes in solution.

Students must show the ability to recognize and explain trends from the graph, correlations and/ or patterns. Students should be able to give general descriptions of graphs e.g. using the terms sigmoid shaped, hyperbole shaped, straight line, steep gradient, low gradient, plateau, gradual increase, sharp increase, best fit line, best fit curve etc. These trends and patterns must be justified, supported and connected with biological literature, theories and facts.

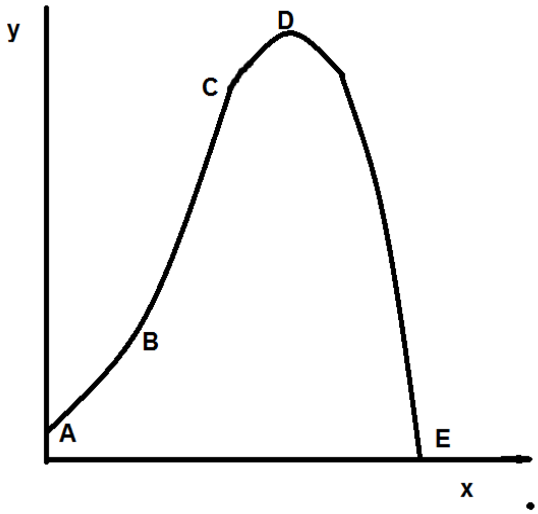
Examples of different graphs and their descriptions are shown below:



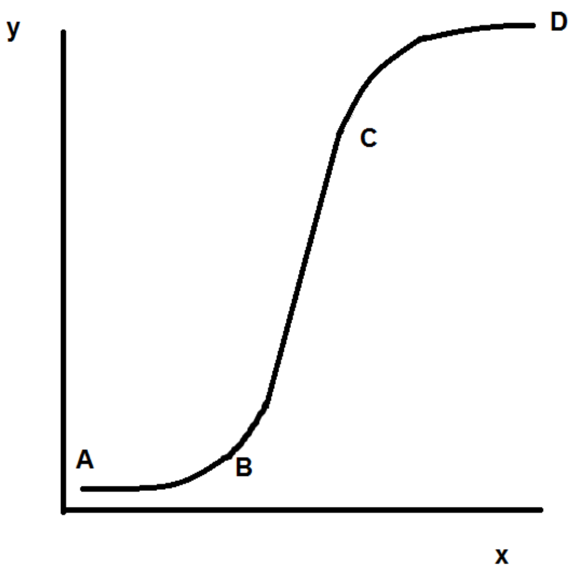
This straight line graph has a constant gradient. As y increases, so too does x in a constant manner.



This curve generally has a positive gradient. There is a general increase in y with increase in x. From points A to B there is a linear increase of y with respect to x. At point B, the gradient of the curve begins to decrease. From point B to C there is a sharp decrease in gradient –change in y decreases drastically with change in x. At point C, the curve begins to plateau. From points C to D the curve plateaus.



This curve begins with a positive gradient. There is a general increase in y with respect to x from A to D. There is a gradual increase in y from points A to B. There is an even greater increase in y from point B to C. There is a steep positive gradient in this region. From points C to D the incline decreases. At point D there is no more increase of y with respect to X. This is the peak of the curve. From D to E there is a relatively sharp decrease in y with respect to x until y is 0.



This sigmoid shaped curve begins with a region from A to B where there is a very low increase of A with respect to B. From point B to C y increases exponentially with respect to x. i.e. for very little increases in x, y increases drastically. From point C this increase in y lessens with respect to x until y no longer increases. The curve then finally plateaus. This curve is typical for population growth over time.

DISCUSSION CONTINUED:

Any sources of error, limitations of the method and suggestions should be mentioned in the final paragraph of the discussion. These should not be presented under separate headings since they are part of the discussion. Limitations are uncontrolled occurrences during the experiment whose effects may be considered when analysing the raw data. Students should make a note to refrain from conducting experiments with avoidable sources of error. If these avoidable sources of error are included in the report, penalties (deduction of marks) may be applied. Avoidable sources or error may result in faulty analysis and interpretation. Certain sources of error that are possibly uncontrollable are be reaction time errors. These errors are usually negligible and should not drastically affect the results of the experiment. The resolution of various measuring instruments may also affect results.

CONCLUSION: The conclusion must always be separate from the discussion and must be used to show the student understands the relationship between the aim/ hypothesis and the results obtained. It must logically answer the aim and may make predictions from data. For example, for the aim given above a conclusion should state that there is a relationship between pH and enzyme activity and for this reaction the optimum is x.

Sample Analysis and Interpretation mark scheme:

Note: A minimum of two labs will be assessed for this skill.

Key words have been highlighted in **BOLD** typeface.

Aim: TO DETERMINE THE EFFECT OF LIGHT INTENSITY ON THE RATE OF THE HILL REACTION

- **Explain** the nature of light elucidating its significance to the process of photosynthesis. **(1mk)**
- **Assess** the importance of the hill reaction relating it to the process of photosynthesis. Give reasons behind using various chemicals such as DCPIP in the reaction. **(1mk)**
- Use values from the graph to explain results. **(2mks)**
- **Discuss** relations and patterns from the graph : Discuss shape of graph **(1mk)**
- **Identify** any trends **justifying** them with **support**ing information. (**2 mks**)
- State that as light intensity increases the rate of the hill reaction increases and **explain** why. **(2mks)**
- Precautions/ limitations/ suggestions (at least two points) **(1mk)**
- Conclusion must **relate** to aim. **(2mks)**

TOTAL 12 MARKS

GUIDELINES FOR PLANNING AND DESIGN LABORATORY REPORT

The plan and design laboratory exercises test the student's ability to create an entire experiment based on his or her knowledge of a particular topic. The CAPE Biology syllabus also clearly states that these exercises are to be executed. The lab write up is an individual exercise. Students who have the same written report will receive zero (0) as their lab mark.

Students will be given problem statements, questions or observations which may serve as the basis for their hypothesis. This must be stated before the aim and hypothesis. This particular exercise also serves to test their problem solving abilities.

The ability to adhere to previously practiced formats, rules and guidelines for writing up labs will be tested. Students must strictly adhere to correct written report formatting as outlined below:

1. **DATE:**
2. **FORM CLASS:**
3. **SUBJECT:**
4. **TEACHER:**
5. **LAB #:**
6. **PROBLEM STATEMENT:**
7. **TITLE:**
8. **HYPOTHESIS:**
9. **AIM:**
10. **INTRODUCTION:**
11. **APPARATUS/MATERIALS:**
12. **DIAGRAM:**
13. **PROCEDURE:**
14. **RESULTS:**
15. **DISCUSSION:**
16. **CONCLUSION:**

PROBLEM STATEMENT: Will be provided by the teacher or the student may use his/her own problem statement if desired.

Some examples of problem statements are as follows:

1. It was observed that different varieties of plants have either a preference for shaded or sunlit areas. Using this information investigate whether these varieties exhibit differences in the rate of the Hill reaction.
2. Design and experiment to determine if sun loving and shade loving plants have varying numbers of chloroplasts.
3. Suzie went to the gynecologist and she was diagnosed with a yeast infection. The doctor told her that the normal pH of her vagina had been affected by her diabetes.

   Question: Which pH condition is most favorable for yeast growth?
4. Bakers often place dough in a warm container throughout the dough preparation process before baking. We know that the higher the temperature the greater the volume of carbon dioxide in the bread. Does temperature also affect yeast population growth?
5. What substrate is best for yeast population growth?
6. Plant leaves come in different colours. Do variegated leaves have a wider variety of pigments than monochromatic leaves (leaves that appear to be a single colour)?
7. Which concentration of sucrose is best for yeast population growth?
8. Does yeast have a preference for a particular substrate, if so which substrate would best promote yeast population growth?

9. The senior food production researcher at a company would like to expand the company's product line to include yoghurt. S/he would like to determine which conditions are most favorable for bacterial population growth in yoghurt. Plan and design an experiment to assist her/him.
10. There appears to be a different composition of plants in sunlit areas when compared to shaded areas. Design an experiment to determine which varieties of plant prefer shaded areas and which varieties prefer sunlit areas.
11. What is the optimum penicillin concentration for inhibiting bacterial population growth/ numbers?
12. A student observed that there appears to be more living organisms in river water than coastal waters.

<u>TITLE:</u> This should be a clear statement outlining the problem to be investigated. For example 'Experiment to investigate the effect of pH on enzyme activity'. It should be a broad statement of intent which is made specific by the hypothesis or aim. For the plan and design, students are required to create their own title.

<u>HYPOTHESIS:</u> The ability to formulate a logical and testable hypothesis will be assessed. While writing the hypothesis, students should take into consideration that only one variable at a time should be tested per experiment.

<u>AIM:</u> The aim of the experiment must be stated in a clear and concise manner after the hypothesis. It must relate to the hypothesis and the problem statement given.

<u>APPARATUS AND MATERIALS:</u> A complete list of apparatus and materials must be provided by the student.

DIAGRAM: The diagram of the apparatus set-up must be drawn by hand or produced as the student's original design on the computer. The diagram must be labelled correctly and must contain an appropriate title beneath it. The title must be underlined.

METHOD: The method must be written in a clear, logical and detailed **instructional** format. It must be in point form. Past tense is **not** to be used. The method must include precautions and controls. Independent, dependent/responding and controlled variables must be identified in the method. The method must detail an experiment that can test the hypothesis and fulfil the aim. Students must indicate steps that show repetition of the experiment under identical conditions. Students must show an understanding of the limitations which affect the design of the experiment and the extent to which limitations can affect the outcome and results.

NB: The lab must be executed.

RESULTS: All lab results must be shown in an appropriate table of results and graph. See section on **Observation, Recording and Reporting** for guidelines. Penalties will be given for labs where results are clearly contrived.

DISCUSSION: A discussion should be included and must give an explanation of the actual results obtained. Guidelines from the Analysis and Interpretation section should be followed when writing the plan and design discussion.

CONCLUSION: A concise statement either accepting or rejecting the hypothesis must be given in the conclusion. Marks will be deducted if the conclusion is not consistent with the results and the graph drawn.

Sample Plan and Design Lab Mark Scheme:

- Problem statement included: May be an observation, question or statement. AIM: Must be suitable created based on a given observation, problem statement or question. (1mark)
- Hypothesis: Use knowledge and understanding of the topic under consideration to make a quantitative, testable prediction of the likely outcome for the experiment. (1 marks)
- Apparatus and materials: Create a comprehensive and suitable apparatus list. Include a diagram. (1mark)
- Method: Develop a detailed, original and executable method written in instructional form. (1 marks)
- Precautions: Carry out a simple risk assessment of the plan, identifying areas of risk and suggesting suitable safety precautions to be taken to be included in method. (1 mark)
- Identify independent, dependent and controlled variables and strategy to test one variable at a time. (1mark)
- Include suitable controls in the experiment. (1 mark)
- Include at least 2 repetitions per measurement for accuracy. (1 mark)
- Results**:** Well-structured table (s) with title, headings with units, graph with title, axes labelled correctly with units, scale and must occupy at least 80% of page (1mark)
- Discussion / Treatment of results must link results to hypothesis. The main steps by which the results are analyzed by using biological principles and supporting information must be shown. (1mark)
- Limitations, sources of error, assumptions and recommendations included in discussion. (1mark)

- Conclusion: Must confirm whether hypothesis is accepted or rejected in a summary statement. (1mark)

GUIDELINES FOR MANIPULATION AND MEASUREMENT LABORATORY REPORTS

This skill refers to a student’s ability to do the following:

- Listen to and follow instructions carefully and diligently.
- Set up and use apparatus correctly e.g. microscope for use of low and high objectives.
- Handle materials and apparatus carefully.
- Follow precautionary measures astutely.
- Take measurements/ readings accurately: e.g. eyepiece graticule and stage micrometer

See Appendix for readings on microscope use.

Sample Manipulation and Measurement mark scheme:

The method for the experiment has been included for better understanding of the mark scheme:

Aim: To determine the effect of wind speed on transpiration rate of a *Ricinus communis* shoot.

Method:

1. Select a suitable leafy plant, cut off the shoot and immerse the cut end immediately in a bucket of water to minimize the risk of air being drawn into the xylem. Immediately cut the shoot again under water with a slanting cut, a few centimeters above the original cut. The stem must be thick enough to fit tightly into the bung of the photometer.
2. Submerge a conical flask in a sink of water to fill it with water. Transfer the leafy shoot from bucket to sink and again immediately make a slanting cut a few centimeters above the last cut. Fit the shoot into the bung of the flask under water and push the bung in to make a tight fit.
3. Submerge the graduated capillary tube, with rubber bung attached, in the sink, fill it with water and attach it to the side arm of the filter flak.
4. Remove the apparatus from the sink and set up the syringe with the needle pushed into the rubber tubing. The syringe can be clamped in a vertical position. The joint between the shoot and bung should be smeared with Vaseline to make sure it is airtight.
5. As the shoot takes up water, the end of the water column in the capillary tube can be seen to move. It may be returned to the open end of the tube by pushing

in water from the syringe. Allow the shoot to equilibrate for 5min whilst regularly replacing the water taken up.

6. Expose the plant to various wind intensities- use a small electric fan. Do not strongly buffet the fan or the stomata will close.
7. Measure the time taken for the water column to move a given distance along the capillary tube and express the rate of water uptake in convenient units such as $cmmin^{-1}$.
8. A number of readings should be taken to ensure that the rate is fairly constant, and the mean result calculated. The temperature of the air around the plant should be noted.
9. Each time the air bubble reaches the end of the graduated section of the tube return it to its original position with the syringe.

Mark Scheme:

- Follow instructions carefully. (2 marks)
- Cut the shoot quickly and under water to prevent air from entering xylem. (2 marks)
- Set up the syringe with the needle pushed into the rubber tubing correctly. (1 mark**)**
- Make the apparatus airtight with Vaseline. (1 mark)
- Allow the set up to equilibrate for 5min. (**2** marks)
- Measure the time taken for the water column to move a given distance along the capillary tube. (1 mark)
- Each time the air bubble reaches the end of the graduated section of the tube return it to its original position with the syringe. (1 mark)
- Taking at least 2 repeat measurements. (2 marks)

TOTAL 12 MARKS

APPENDIX

iii. Guidelines for Microscopy

The microscope is an indispensable tool for the student of zoology. Unfortunately it is often used without any effective understanding of its construction and operation. This results in poor and misleading interpretations of what is (barely) seen. While there are several different types of microscopes, two are used routinely:- (1) THE COMPOUND MICROSCOPE and (2) THE STEREOMICROSCOPE. Either type may be in two forms, monocular and binocular. As the names suggest, monocular microscopes have one eyepiece whereas binocular microscopes have two eyepieces.

THE COMPOUND MICROSCOPE

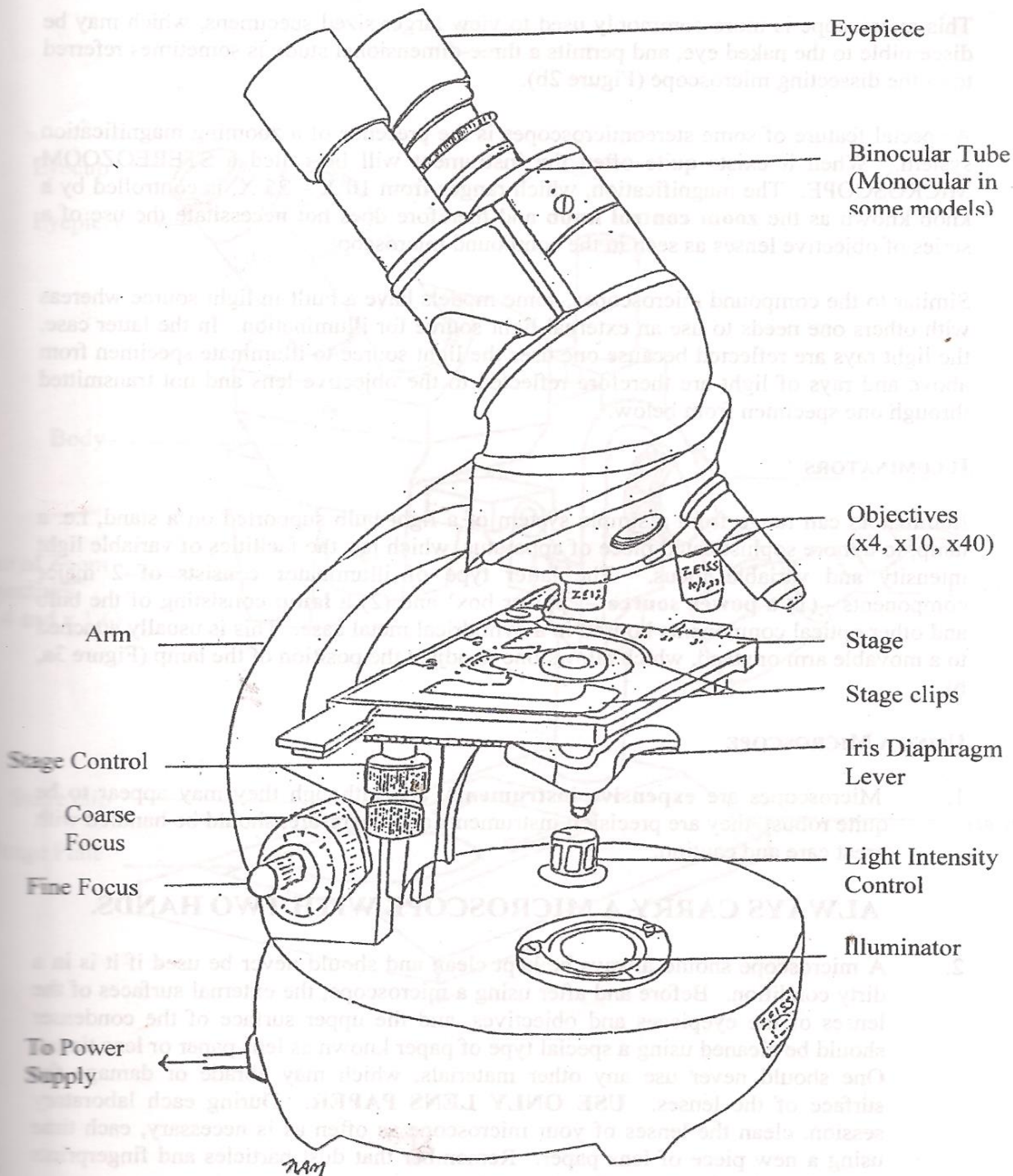
This instrument is used to view organisms and specimens, which are not discernible with the naked eye. Basically the microscope consists of a body or **stand** which houses and supports the optical system. The optical system consists essentially of a **condenser**, an **objective** and an **eyepiece** (Figure 2a). Rays from a light source are directed into the condenser, which brings them to a common focus on the specimen. In most microscopes the condenser is positioned below a part of the microscope known as the **stage** (Figure 2a) and hence the condenser is referred as being a sub-stage condenser. The stage is the holding area for the specimen slide and in this position, the specimen slide lies between the condenser and the objective. Having brought the light rays to a common focus, the specimen is illuminated and the light rays then pass through the **objective lens**. The objective lens is the magnifying agent and most microscopes are equipped with a range of objectives having different levels of magnification, e.g. 10 X, 25 X, 40 X, 100 X. The rays of light emitted at the upper end of the objective form an image viewed through the eyepiece. The eyepiece can also magnify the image produced by the objective and usually microscopes are equipped with 10 X eyepieces.

Some compound microscopes have a light source built into the base of the stand; others do not. In the latter case, an external form of illumination is needed and this, when used in conjunction with a mirror, is directed to the condenser. The mirror is positioned at the base of the stand below the condenser. This type of illumination, where light rays are directed through the specimen is known as transmitted light.

When viewing a specimen one needs to focus the objective lens and for this purpose there are two knobs:- (1) **COARSE FOCUS** and (2) **FINE FOCUS**. Their proper use will be explained later on.

If a student wishes to attain proficiency with the compound microscope he or she must become familiar with the name, location, use and care of the parts of the microscope.

Figure 2a. Zeiss Binocular Compound Microscopes



LENGTH MEASUREMENTS

It is always useful to know the size of a specimen and quite often, e.g. with protozoans, size is an important feature.

Measurement of microscopic objects is a relatively simple process and uses two pieces of apparatus – (1) OCULAR MICROMETER, (2) STAGE MICROMETER.

The ocular (eyepiece) micrometer is a glass disc with a scale (Figure 5a). The divisions of the scale are of equal size but the intrinsic value of the divisions differs with the objective used and hence this scale has to be calibrated for each objective. This disc is inserted into the eyepiece of the microscope and usually is left there permanently.

The stage micrometer is used to calibrate the eyepiece micrometer and in essence it is a conventional slide having a scale graduated in units of 0.1 mm (Figure 5b).

The eyepiece micrometer is calibrated using the following procedure:-

1. Remove the eyepiece from the microscope, unscrew the upper eyepiece lens and insert the ocular micrometer – scale upwards. Screw the eyepiece together again and replace into the tube.

2. Place the stage micrometer on the microscope stage and using the lowest power objective focus on the scale.

3. Once you have focused sharply, both scales should be clearly defined. Turn the eyepieces until the two scales lie parallel to each other.

4. Adjust the stage micrometer so that two lines on its scale coincide exactly with two lines on the ocular micrometer (Figure 5c).

   Determine the number of ocular divisions, which correspond to a certain distance on the stage micrometer.

   e.g. 70 divisions on the ocular scale correspond to 0.4 mm

   Having done this, calculate the length which corresponds to one division of the eyepiece.

   i.e. 70 divisions = 0.4 mm

$$1 \text{ division} = \frac{0.4 \text{ mm}}{7.0}$$

$$= 0.0057\text{mm}$$

5. The ocular micrometer value determined above applies only for the objective with which the calibration was made. Repeat the procedure for the other objectives. Record these values for future use.

   Subsequently when measuring, only the ocular micrometer is used and it is only necessary to multiply the number of divisions recorded by the micrometer value (at that particular objective) in order to determine the size of the object being viewed.

6. Sometimes, an ocular micrometer is not available and therefore another approach may be used.

   One can measure the diameter of the diameter of the field of view using the stage micrometer (a separate measurement being made for each objective) and use this as approximation for the size of the object under view, e.g. if at 10 X objective, the diameter of the field is 10 µm then a specimen which occupies half of the field of view is approximately 5 µm in length.

7. It may be useful to remember the following unit of measurement:-

1 micrometer (µm)	=	**0.000001 or 10^{-6} metre**
1 nanometer (nm)	=	**0.000000001 or 10^{-9} metre**
1 angstrom	=	**0.0000000001 or 10^{-10} metre**

   $1\ m = 10^3\ mm = 10^6\ \mu m = 10^9\ nm = 10^{10}\ A^0$

EXERCISES WITH THE COMPOUND MICROSCOPE

1. Examine samples of thread, crystals of salt or sugar and a sample of your hair. Estimate the size of your specimens.

2. Repeat the above exercise using living and/or preserved organisms which may be available. Sketch some of these organisms and obtain accurate measurements for the size of some of them, following the guidelines provided.

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