

Paper 3 Essentials

Time: 2 h

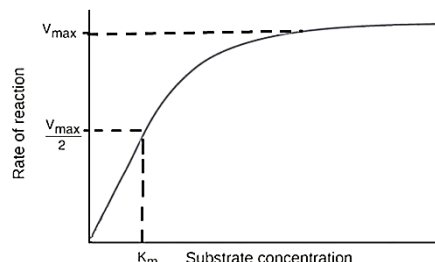
Total: 40 marks (scaled to 30 marks to give a total of 130 marks for AS)

Always read and understand the whole of Q1 and Q2 first! Plan the use of 2 hours. There should be no “idle time”. Multitasking is necessary! In the questions, find:

- Aim or hypothesis
- Independent variable
- Dependent variable
- Controlled variable (if any)

Maths Skills Required

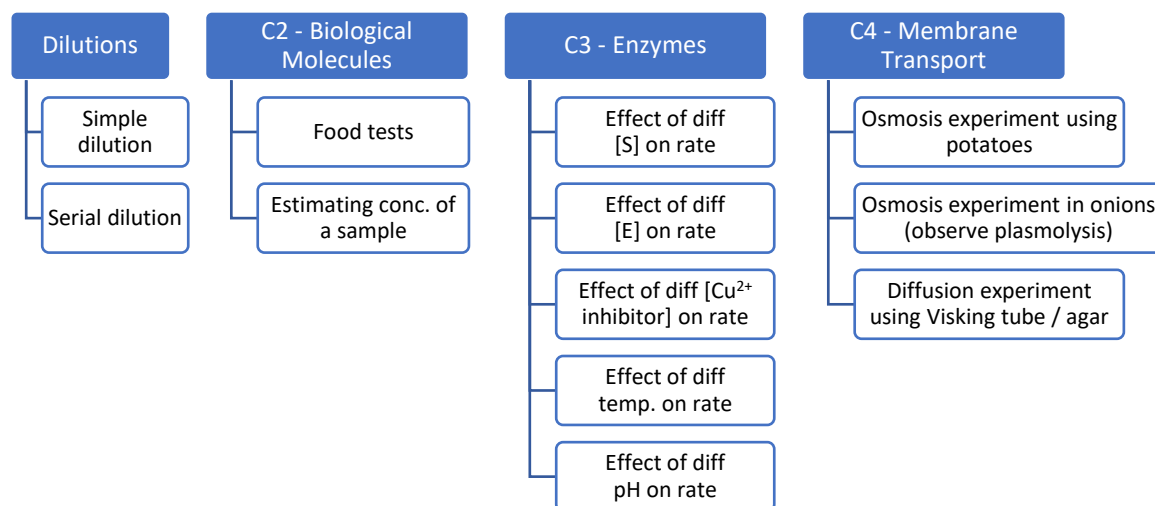
Skill	Formula / Requirements
Mean	Do not include anomalous results If the question asks for mean image length, take min 5 readings in <u>mm</u> (not cm!) and take a mean. Show all working.
Ratio	Express as simplest, whole numbers (E.g. 4:106 = 2:53, not 1:25)
Magnification	Magnification should be in whole number (E.g. x123) $\text{Magnification} = \frac{\text{Image}}{\text{Actual}}$
Error / Uncertainty	If measurements start from 0: $\text{error} = \pm \frac{\text{smallest division}}{2}$ But if measurements are taken at 2 points, the error doubles: $\text{error} = \pm \frac{\text{smallest division}}{2} \times 2$ $\text{error} = \pm \text{smallest division}$
Percentage error	$\text{percentage error} = \frac{\text{error}}{\text{reading}} \times 100$
Percentage change	$\text{percentage change} = \frac{\text{new} - \text{old}}{\text{old}} \times 100$ If there is an increase, the resulting value will be positive. If there is a decrease, the resulting value will be negative.
Rate	$\text{rate} = \frac{1}{\text{time}}$ OR gradient of graph of [S] or [P] against time
Vmax and Km	Must be read from a graph of rate against [S] Draw lines to show where the Vmax and Km are found! High Km , means high concentration of substrate to achieve $\frac{1}{2} V_{\max}$, hence it indicates that the enzyme has a low affinity for its substrate



Q1 – WET LAB

Common Questions

Watch: <https://youtube.com/playlist?list=PL8EBwIj-eOLMZ1pSIWzNNHnabAuAZxSht>



Simple Dilution

Watch: <https://youtu.be/xpetPtQnH28>

Use the formula $C_1V_1 = C_2V_2$. Alternatively, use the formula below to calculate the volume of stock solution and distilled water you will need to make each solution in simple dilution.

$$\text{Volume of stock solution} = \frac{\text{Final concentration} * \text{Final volume}}{\text{Concentration of stock solution}}$$

$$\text{Volume of distilled water} = \text{Final volume} - \text{Volume of stock solution}$$

For example, to make 10cm^3 of 8% glucose solution from a stock solution of 10%:

$$\text{Volume of stock solution} = (8\% * 10\text{cm}^3) / (10\%) = 8\text{cm}^3$$

$$\text{Volume of distilled water} = 10\text{cm}^3 - 8\text{cm}^3 = 2\text{cm}^3$$

A table like below is often used to show volume of stock solution and distilled water used for each conc. Make sure no units are in the body of the table, only headings have units, and same dp should be used in same column.

Use $C_1V_1 = C_2V_2$
 $V_1 = \frac{(30)(10)}{40}$
 $= 7.5$
 $V \text{ of } H_2O = 10 - 7.5$
 $= 2.5$

original 40% solution

Ethanol solution (%)	Volume of stock solution (cm ³)	Volume of distilled water (cm ³)
40	10.0	0.0
30	7.5	2.5
20	5.0	5.0
10	2.5	7.5
0	0.0	10.0

same decimal points just in case!

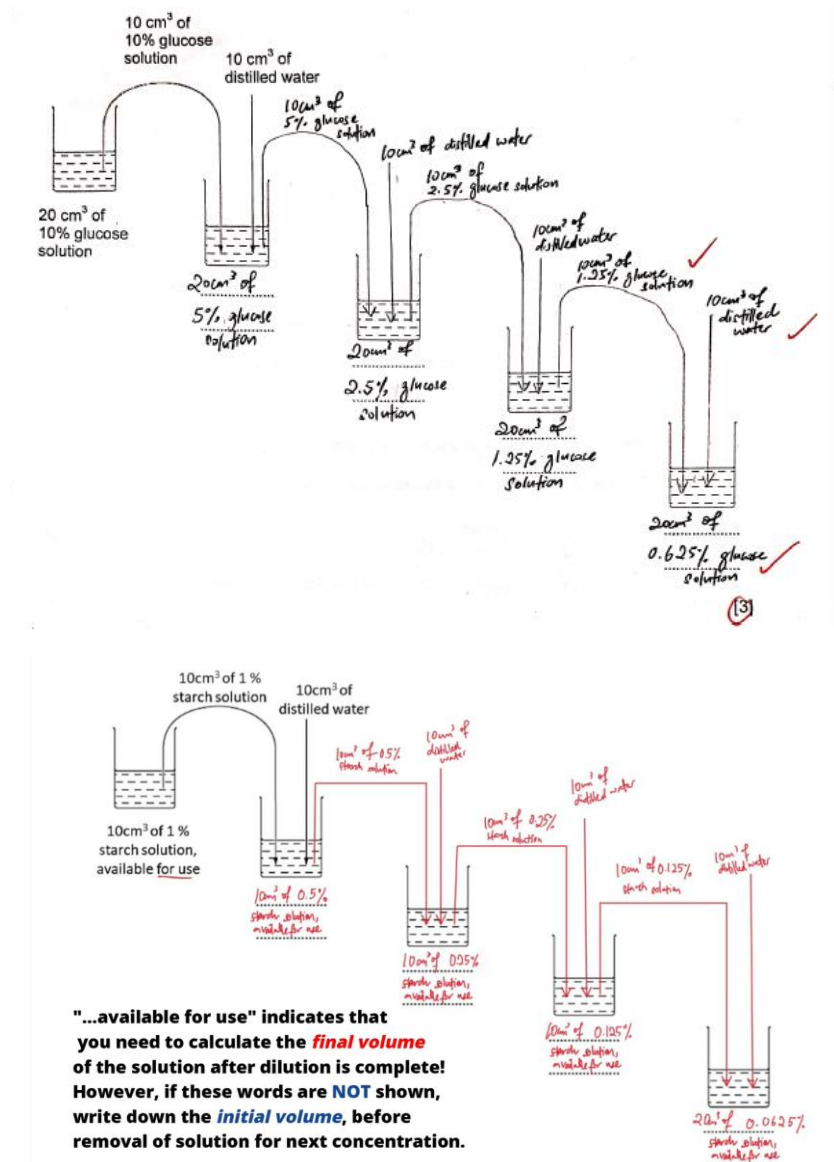
(2)

Serial Dilution

Watch: <https://youtu.be/cx6nPux5Idk>

- To conduct serial dilution, read the question properly. Determine whether they want you to:
 - 1) Reduce the concentration of the solution by **half** each time OR
 - 2) Dilute the solution by a **factor of 10** each time
- 1) To reduce the concentration of the solution by **half** each time, add an **equal** volume of solution from the previous concentration and distilled water to make your solution
- 2) To dilute the solution by a **factor of 10** each time, Add **1cm³** of solution from the previous concentration and **9cm³** of distilled water to make a solution of 10cm³.
- Pro tip: it may be easier to add the fixed volume of distilled water into each beaker first, before transferring solutions from the previous concentrations in a serial, sequential manner.

A diagram as below should be drawn. Typically, the first 2 beakers would already be drawn for you. Follow the formatting given, draw all arrows, show units, conc and volumes!



Biological Tests

- You need to remember and know how to conduct these tests without instructions.

Test	Procedure	Explanation	Colours (0 to high conc.)	Type of Product
Benedict's test / Reducing-sugar test	2cm ³ of Benedict's solution + 2cm ³ of glucose solution + heat at 90°C	Reducing sugar reduces Cu ²⁺ into Cu ⁺	Blue → green → yellow → orange → brown → brick-red	Precipitate
Non-reducing sugar test	2cm ³ of HCl + 2cm ³ of sucrose + heat of 90°C Then, neutralize with 2cm ³ of NaOH 2cm ³ of Benedict's solution + 2cm ³ of solution + heat at 90°C	the acid hydrolyses the non-reducing sugar into reducing sugar, which reduces Cu ²⁺ into Cu ⁺	(Alternatively, take time taken for first sign of colour change (s))	
Iodine test	Add few drops of iodine solution into starch solution	Starch and iodine form a complex	Yellow → Dark blue → Black (intensity can be measured using a colorimeter)	Solution
Biuret test	2cm ³ of Biuret reagent + 2cm ³ of albumin	N atoms in peptide bonds and Cu ²⁺ form a complex	Blue → purple	Solution
Emulsion test	1 drop of oil + 5cm ³ of ethanol + shake Then, fill test tube with distilled water	Lipid is soluble in alcohol, but insoluble in water	Clear → cloudy, white	Emulsion

Table of Results

- Use a pencil and a ruler to draw lines of a results table.
Draw horizontal lines to separate every row.
- Readings and results should be written in pen.

Headers:

- Headers should be **Independent Variable (unit)** first on the left, then **Dependent Variable (unit)** on the right. IV and DV should be written in full. Note: Beaker 1, 2, 3, 4, 5, 6 is NOT the true IV
- **No units in table other than headings!**

Independent Variable:

- Arrange your IV in descending/ascending order.
- Include unknowns as letters (given in question) under IV, just in case.
- When asked, express your estimated concentration as a **range**, based on your results.
E.g. A is in between 0.1% to 1%

Dependent Variable / Results:

- Your results should **show a trend**. You can predict this by understanding the experiment.
- Write each reading to the **same number of decimal places**.
- Record all values to the appropriate number of significant figures.
E.g. number of bubbles should be recorded as a whole number; volume measured by a syringe has 1 decimal place.
- **Time is usually recorded as seconds in whole number**. This rule applies to the mean.
- Full marks for result tables are usually 4. If 5 or 6 marks are given for the table, repeat the experiment. Include 3 readings and a mean in your result table.
- Show all raw results (unprocessed) and calculated results (processed).

Concentration of glucose (%)	Time taken for first sign of colour change (s)			
	1	2	3	Mean
1.000	5	6	6	6
0.100	25	22	27	25
0.010	90	98	95	94
0.001	111	123	116	117
0.000	>180	>180	>180	>180
A	14	15	15	14.7 (not accepted, should be whole no. = 15)

Graphs

Watch: <https://www.youtube.com/watch?v=j20TxxjClkA>

Use pencil throughout.

Orientation / Axis:

Plot independent variable on x-axis against dependent variable on y-axis.

IV is on left column, DV is on right column.

Label clearly with variable name and units, according to question.

If there are multiple readings taken, plot the mean.

Scale:

Start from zero. Use multiples of 1/2/5 (E.g. for multiple of 5 – 0, 0.5, 1.0, 1.5 etc.).

Label every 2cm or 10 small boxes.

Boxes given should be just enough if you start at the outer left bottom corner.

Plot:

Points – draw small cross (<2mm, or do not the “tails” exceed half a box) accurately.

Bar – use ruler, no shading. Use regular gaps between bars for bar charts. No gaps if histogram.

Line:

Draw a thin line (~0.5mm) accurately point-to-point with a ruler.

Never draw a best fit line, unless specifically asked to.

Never extrapolate data.

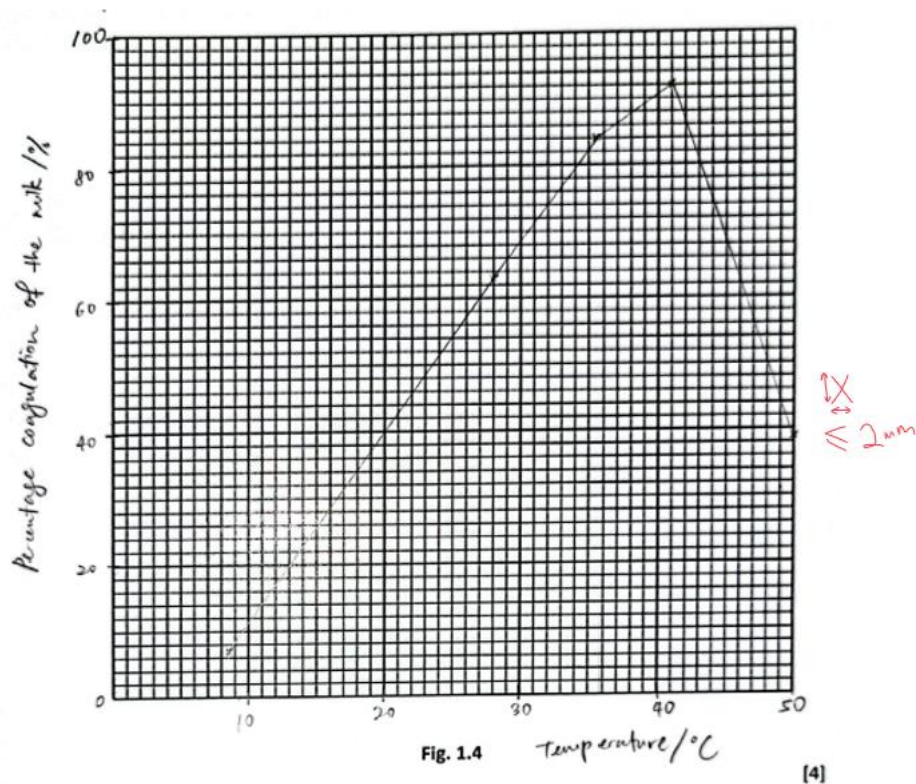
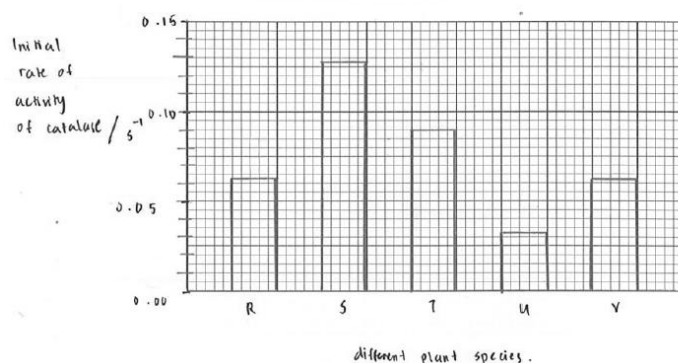


Table 1.1

different plant species	initial rate of activity of catalase /s ⁻¹
R	0.0750
S	0.1275
T	0.0900
U	0.0325
V	0.0625

You are required to use a sharp pencil for charts.

Plot a chart of the data shown in Table 1.1.



The axes are labelled accurately and the correct scale is used, but the plotting point for the data for R is incorrect and the horizontal line for V is too thick.

Mark for (c) = 2/4

Modifying Experiments

- You would need to suggest how to extend the investigation to answer a new question
- E.g. same procedure but different independent variable, or new method of measuring DV
- Your answer should include 3 parts:

1) Independent variable

- Use / prepare **min 5**
- List min 5 reasonable values you would choose with units (E.g. 10°C, 30°C, 50°C, 70°C, 90°C)
- Apparatus / Method? (E.g. simple/serial dilution, pH buffer etc.)

2) Dependent variable

- What are you directly measuring? This is usually found in the question given.
- Apparatus / Method?

3) Controlled variable

- Use the same conc. / temp / pH?
- Apparatus? (E.g. pH buffer, thermostatically-controlled water bath)

Sources of Error and Improving Experiments

- *Sources of error* are errors that cannot be avoided, i.e. not your mistakes! *Sources of error* may account for discrepancies between individuals or groups.
- Systematic errors (E.g. faulty equipment) may not affect the trend in results.
- Random error (E.g. fluctuations in factors that are not controlled, subjectivity in perception) may affect the trend.

Reliability:

- Improvements for reliability means to 'acquire results that are close to each other' (but not necessarily close to actual)
- E.g. Address sources of error. Fix controlled variables (E.g. temp, pH). **Repeat at least 3 times at each concentration AND obtain mean.**

Accuracy:

- Improvements for accuracy means to 'acquire results that are as close to the actual true value' E.g. Address sources of error. Use smaller intervals for the values of the independent variable. Use more precise measuring instruments. Use more accurate method of measuring the dependent variable.
- If question asks "suggest how you could improve this experiment" in general, you can include methods to improve **BOTH** reliability and accuracy.

Common MS points:

*Starred, bolded points are **most** commonly seen points that can be applied in many questions.

Source of Error	Method of improvement
General Improvements	
N/A	Repeat at least 3 times at each concentration AND obtain mean*
N/A	Repeat experiment using smaller intervals / wider range of concentrations*
N/A	Use more accurate measuring instruments* (specific equipment must be named E.g. burette / graduated pipette / syringe instead of measuring cylinder, vernier calipers)
Fixing Controlled Variables	
Temperature not controlled	Use thermostatically controlled water bath*
pH not measured / not controlled	Use pH buffer*
Condition of cells differ	Use same potato / onion

Source of Error	Method of improvement
Measuring Dependent Variables	
Difficulty in judging change in colour	Weigh mass of precipitate (Ben's test) Use colorimeter (iodine test) White card to show colour change
Difficulty in having same time (E.g. time needed to remove samples and add indicator) Cells left different times/too short a time/not long enough	Longer time Do one experiment at a time Stagger starting time of experiments
Loss of gas / apparatus not airtight	Used a closed system / use syringe to add substrate Use petroleum jelly to seal
Bubbles of diff sizes	Collect volume of gas instead of counting bubbles Use gas syringe / inverted measuring cylinder
Evaporation / oxidation of H_2O_2	Cover solution to prevent evaporation
Size of drop varies	<i>Use graduated pipette / syringe</i>
Others	
Experiment lacks a control	Boil enzyme / test using distilled water (common mark point when they ask for control in enzyme experiments, less common in experiment improvement questions)
Sources of error related to measuring cells: Microscope preparation squashed Specimen is in between divisions of eye piece graticule Cannot focus on both EPG and stage micrometer scales at same time	N/A
Unavoidable sources of error: Potato strips / agar blocks / filter paper stick to side of container Dye unevenly distributed Rate of mixing differs	N/A

Q2 – MICROSCOPY

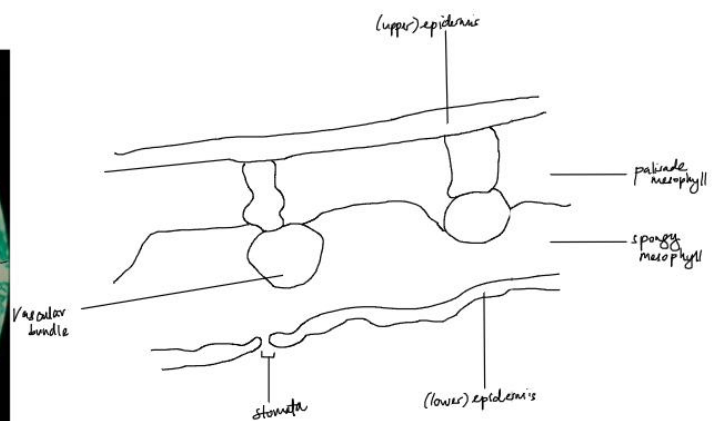
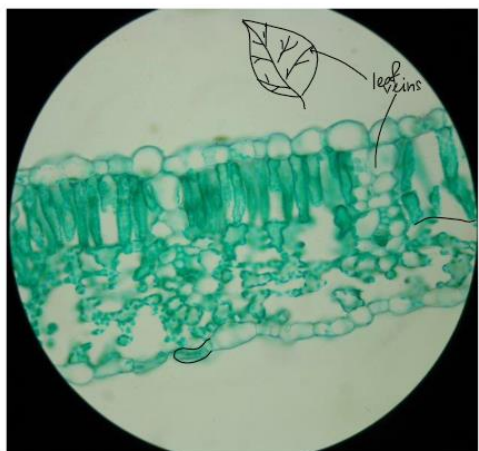
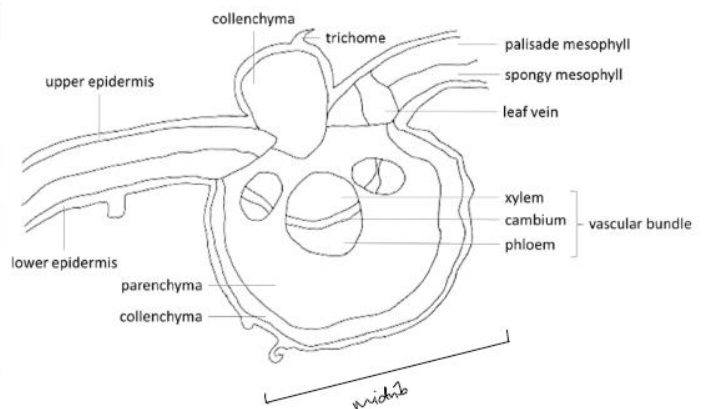
*Disclaimer: Although Q2 is often a microscopy question, there are instances in past year which it included a simple wet lab instead.

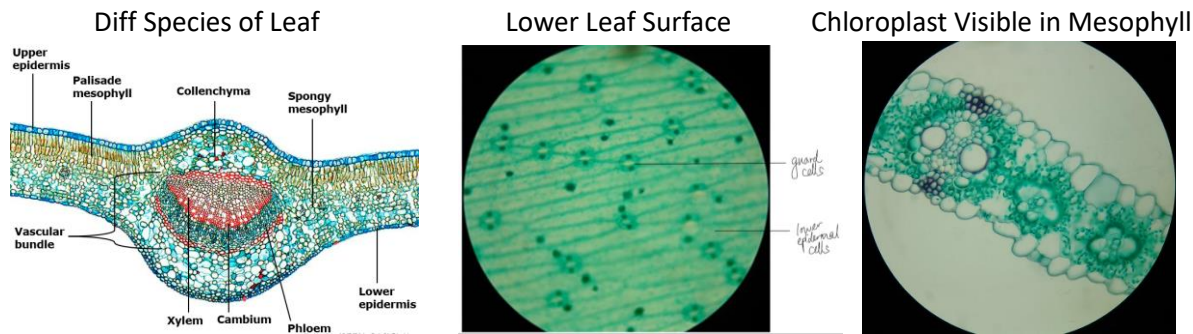
How to Use A Microscope and Calibrate the Eyepiece Graticule

Watch: https://youtu.be/_rOkRifrH34

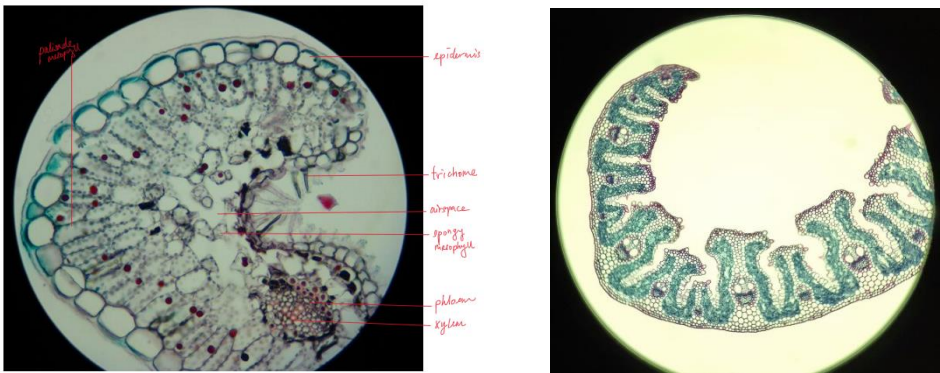
- Practice using the microscope virtually here
<https://www1.udel.edu/biology/ketcham/microscope/scope.html>
- You must calibrate your scale every time you use a new objective lens.
- How to calibrate the eyepiece graticule:
 1. Calibrate the eyepiece graticule using a stage micrometre! (E.g. 1 EPG = 10 μm)
 2. Measure your specimen in EPG (arbitrary units) under the microscope (E.g. 11 EPG)
 3. Calculate actual size (E.g. 11 EPG * 10 μm = 110 μm)
- Types of specimens you need to familiarise with are as below!
Note that they can show you species of plants you are unfamiliar with.
Pro-tip: Xylem is usually stained pink/purple/red-ish!

1. Plant Leaf

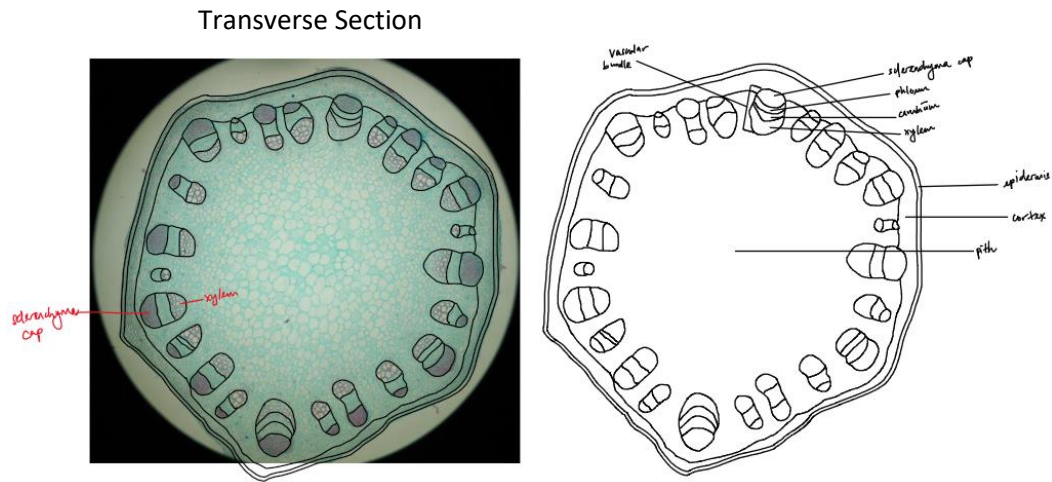




2. Xerophyte Plant Leaf

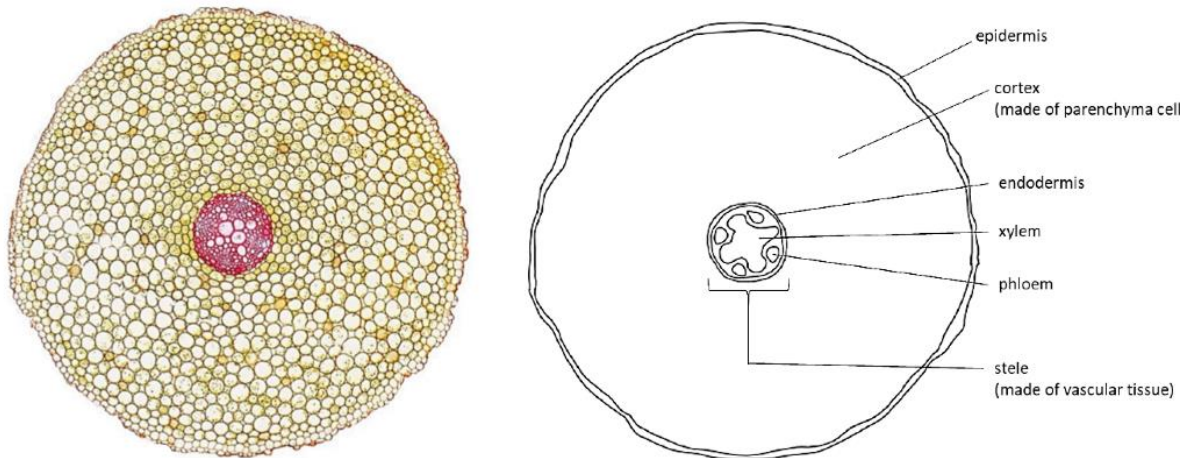


3. Plant Stem

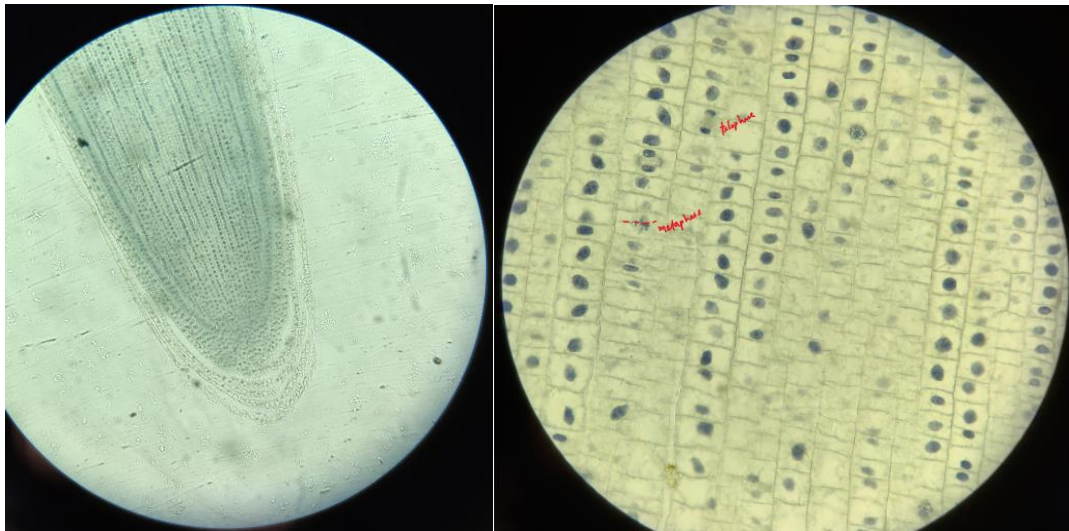


4. Plant Root

Transverse Section

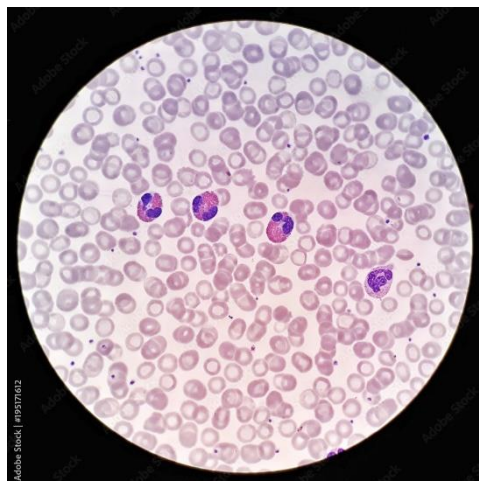


Longitudinal Section with Zone of Elongation showing Mitotic Cells

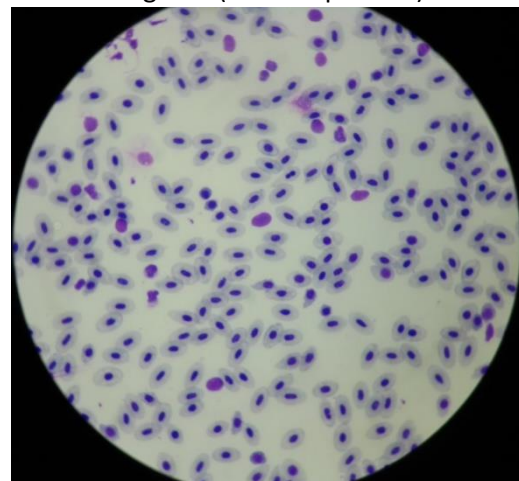


5. Blood Smears of Human and Frog

Human RBC and WBC

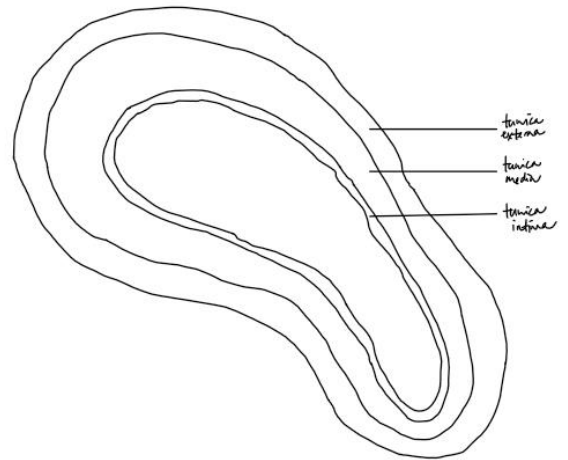
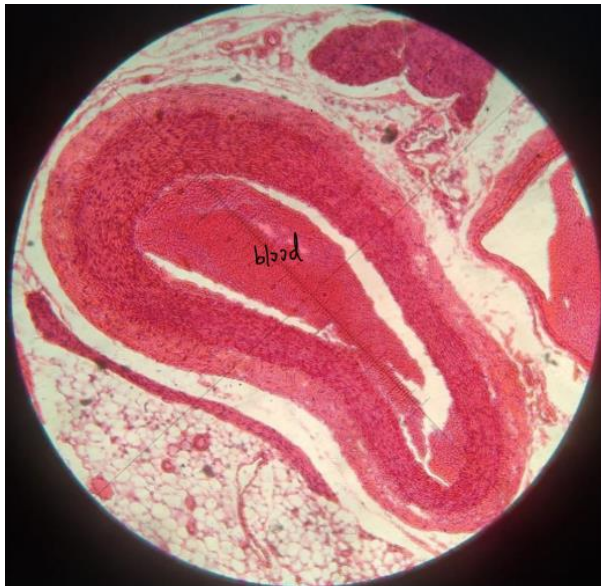


Frog RBC (nucleus present)

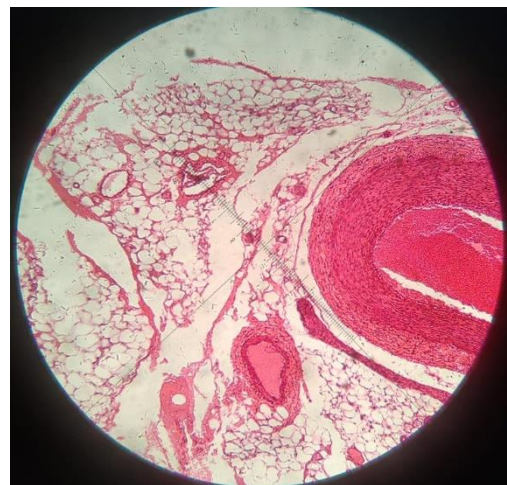


6. Arteries, Veins and Capillaries

Artery



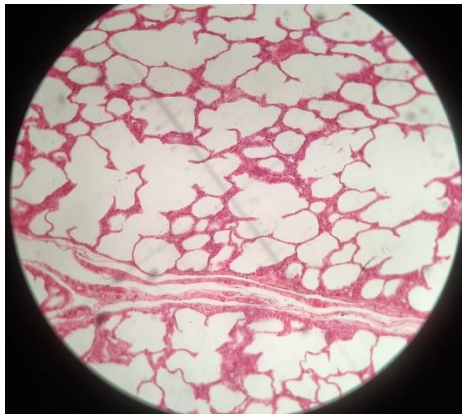
Artery (thickest layer is tunica media) and Vein (thickest layer is tunica externa) – it's not about overall diameter, it's about the proportion of tunica media to other layers. Capillaries are one-cell thick and very, very small.



7. TS of Lung Tissue – Alveoli, Bronchioles, Bronchi, Trachea

Watch: <https://youtu.be/9dey IOV30E>

Alveoli



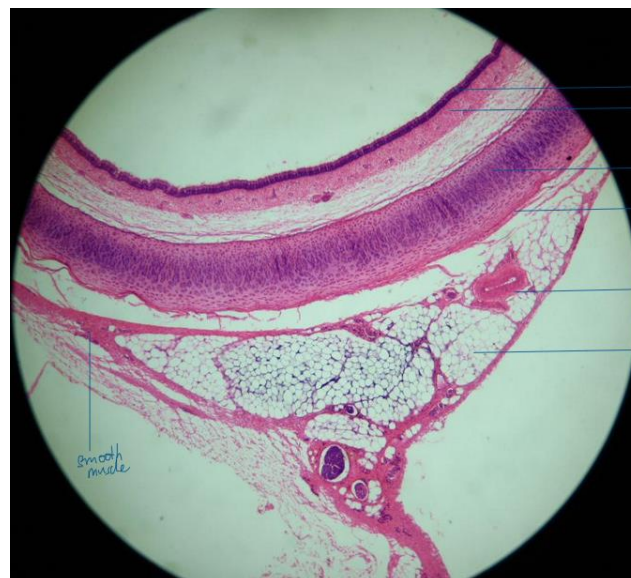
Bronchioles



Bronchus



Trachea

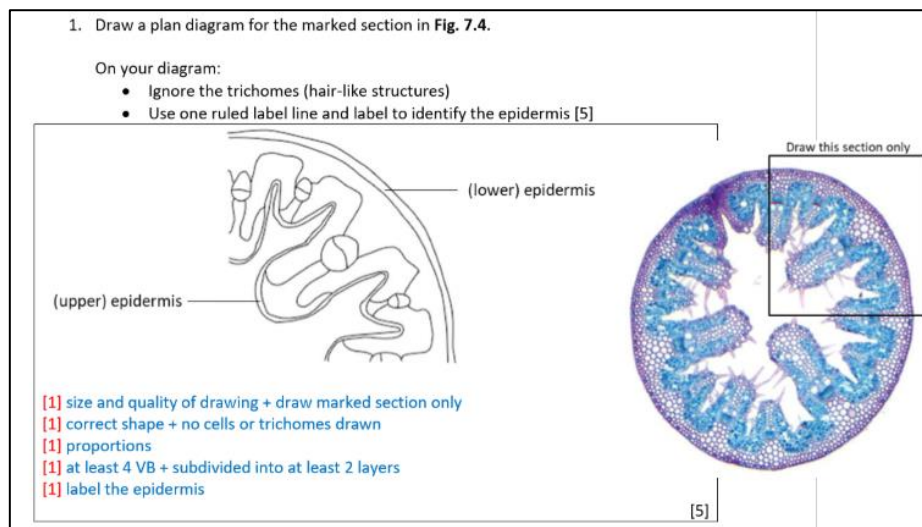
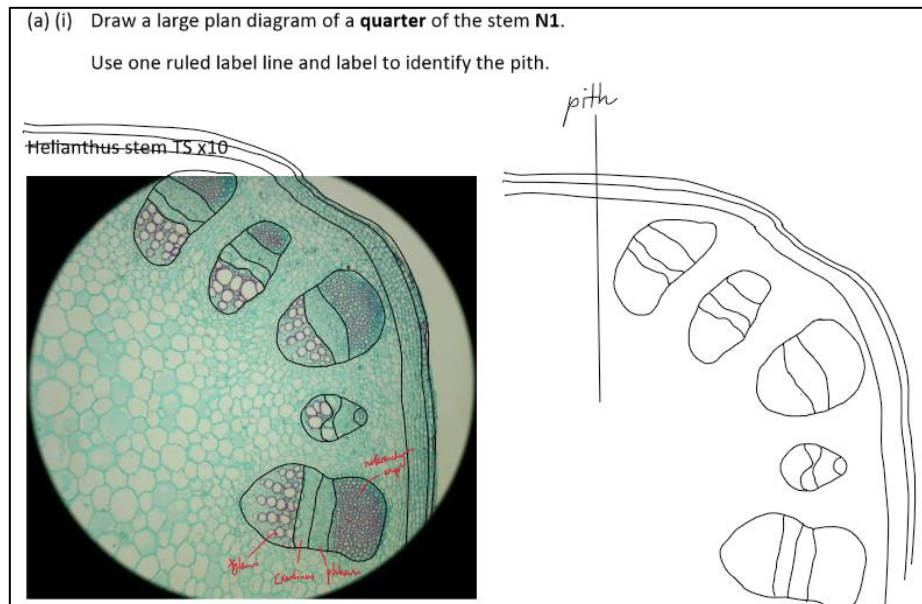


Drawing Low-Power Plan Diagrams

Watch: <https://www.youtube.com/watch?v=VQCj1UK4zyY>

General rule: Draw what you see, not what you think you should see. Section off what you can!

1. Use pencil throughout.
2. Draw to fill at least 2/3 of space given
3. Clear, sharp lines
4. No open diagrams
5. No shading
6. Draw in proportions
7. NO cells (unless it is a “high-power drawing” of cells)
8. Only label when asked! Label with ruler and pencil outside the diagram.
Use a simple line, NO arrows. Make sure the label lines touch the object.



Drawing High-Power Cell Diagrams

Cell Diagrams you need to know: <https://www.youtube.com/watch?v=VlcOVgpGxBg>

General rule: Draw what you see, not what you think you should see.

Rules are same as plan diagrams, except:

1. Draw exactly the number of cells stated in the question. Note the proportions of the cell!
E.g. what size is the nucleus in proportion to the whole cell?
2. Do not include half cells. The questions always state “whole cells”.
3. Cells should not overlap but may touch each other or share an outermost line.
4. Always draw **2 lines** for cell wall for plant cells.
If cells must touch, there should be **three lines**.

(ii) Observe the cells in the xylem of N1.

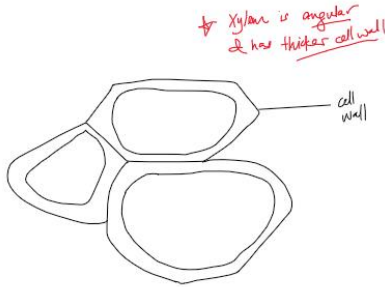
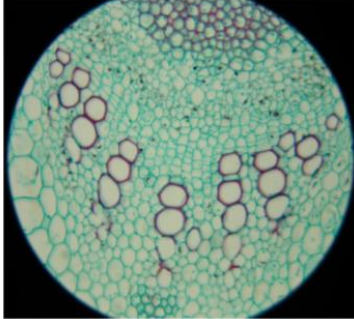
Select **three** adjacent, touching cells which show observable features of the xylem tissue.

Each cell must touch at least two other cells.

Make a large drawing of this group of **three** touching cells.

Use **one** ruled label line and label to identify the cell wall of **one** cell.

Helianthus stem TS x40



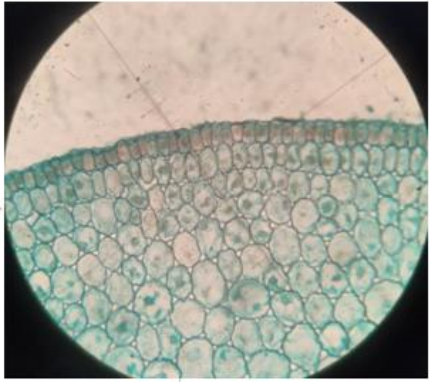
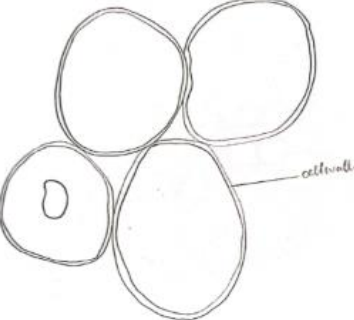
ii Observe the cells in the cortex of the root on EBRD312.

Select **four** adjacent, touching cells which show observable features of the cortex tissue.

Each cell must touch at least two other cells.

Make a large drawing of this group of **four** touching cells.

Use **one** ruled label line and label to identify the cell wall of **one** cell.





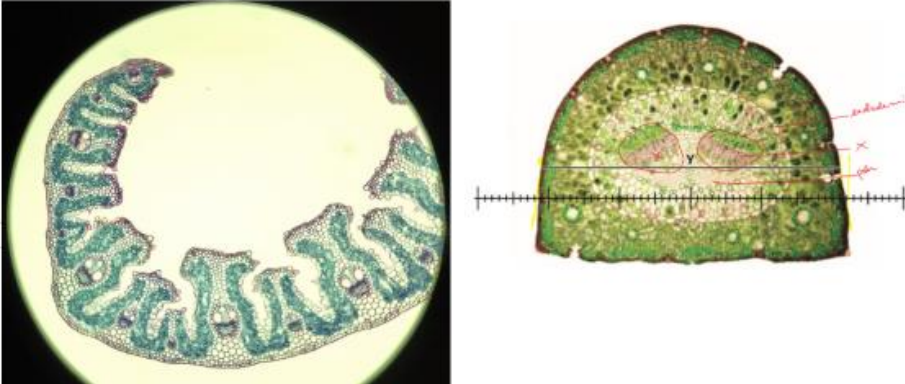
Compare and Contrast Observable Differences

- Compare = both similarities and differences
- Contrast = differences only
- If a question states “record observable differences” then all responses will be marked.
- If a question states “identify two” then write 2 only!
Marks may be awarded for simply following instructions.
Only the first two responses will be marked.

- Use a table with 3 columns! There is usually 1 mark just for drawing the table.

Feature	Fig 1.1	Fig 1.2

- Comment on **thickness, arrangement, shape, number, or absence / presence** of cell structures OR tissue layers.
- You would need to know tissue names to talk about them! For plants, the shape / arrangement / size of **vascular bundle** is usually a very noticeable difference.
- DO NOT use ticks and crosses!
- Comment on **size** between diagrams only if magnification is the same.
- Use comparative language that are opposites of each other (E.g. thicker, thinner).
- DO NOT comment on colour or 3D shape (E.g. biconcave not allowed, use circular; cuboidal not allowed, use square/rectangular).



c The *Ammophila* leaf on the slide J1 and the leaf in Fig. 2.2 are adapted to living in dry conditions.

Prepare the space below so that it is suitable for you to record **observable differences** in xerophytic adaptations between these two specimens.

Record your observations in the space you have prepared.

Feature	J1	Fig 2.2
Overall leaf shape	Curled	Not curled / Rounded / Semi-circular
No. of vascular bundles	Many	Fewer
Location of vascular bundles	Along the length of leaf	Central
Epidermis	Folded	Not folded
Size of leaf	Longer / Wider	Narrower / Smaller

- However, if the question asks you to label the differences on the diagram, do as they say! Remember to represent both images in your answer. (E.g. A is..., whereas B is....)

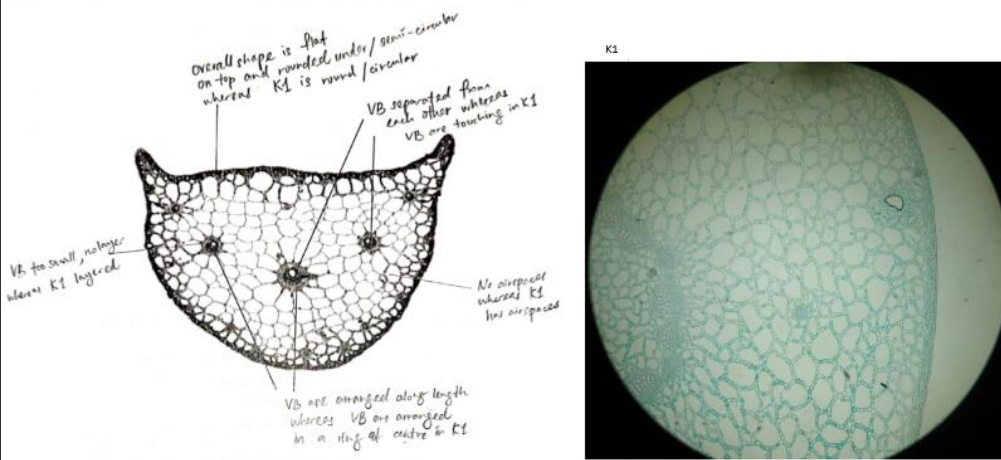


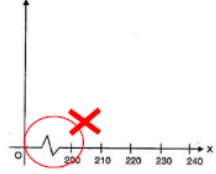
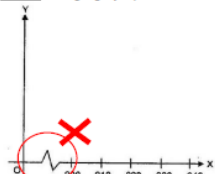
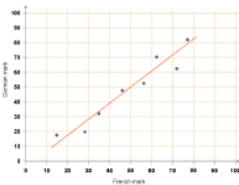
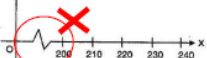
Fig. 2.3

c Annotate Fig. 2.3 to describe three observable differences between the stem sections in Fig. 2.3 and on K1 by:

- drawing label lines to three features in Fig. 2.3 that show these differences
- describing next to each line how each feature is different from the specimen on K1.

[3]

COMPARISON of PAPER 3

	BIOLOGY	CHEMISTRY	PHYSICS
Drawing Graphs	- Connect all points WITH RULER CANNOT extrapolate NEED NOT to start from zero Do NOT use 'zig-zag' / jump scale line  - Connect from first plot to last - Plot can be in the middle of square - Plot size must not be more than half a small square 	- Best fit line - can be curve or straight line if passing through maximum points - Rate of reaction graph will usually start from ZERO - Enthalpy change graph will NOT start from ZERO Do NOT use 'zig-zag' / jump scale line  MUST extrapolate graph - Plot can be in the middle of square - Plot size must not be more than half a small square 	- Draw best fit line – balanced and close to line  NEED NOT to start from zero (must zoom in) and make sure the graph plots fit more than half the graph paper Do NOT use 'zig-zag' / jump scale line  - To find y-intercept, use formula $Y = mx + c$ - Plot MUST NOT be in the middle of square - Plot size must not be more than half a small square 
Anomaly	Ignore the anomalous value when calculating mean	Maximum only 2 anomalous point allowed	Maximum 1 anomalous point allowed
Percentage uncertainty	Half of the smallest scale x 100%	$\frac{(\text{Half of the smallest scale}) \times \text{no of readings}}{\text{value}} \times 100\%$	$\frac{\text{Smallest scale}}{\text{value}} \times 100\%$ - absolute uncertainty can be 2-5 times smallest scale – depending on the experiment
Time measurement	Round to the nearest whole second Eg. 24.3s = 24 s	Round to the nearest whole second Eg. 48.5s = 49 s	Write to the precision of the instrument Eg. 23.29 s
Recommendation/Modification of experiment	NO VIDEO CAMERA	VIDEO CAMERA allowed	VIDEO CAMERA frame-by-frame with timer and scale allowed