the planning of the biological experiments

the procedure

when an investigation is being planned, a short description of the general approach & the method is required.
the approach should include:

- a brief account of how the procedure is to be carried out
- the fixed variables & the variable to change
  a variable is a quantity that may undergo changes in the course of an experiment.
  many experiments are designed to investigate the relationship between two quantities.
  hence, there are variables to be changed (usually only one), & there are variables to be kept constant.
  the variable to be changed is the variable under investigation, whose values are decided & fixed by the experimenter.
- **the data** to be collected
- how the data **is to be interpreted** to achieve the aim of the investigation

important:

for questions which ask for 'the effect' of one variable on another, **at least five different data readings must be obtained & a graph must be plotted to achieve the aim of the investigation**. the five different data readings **should have an appropriate range & should be of regular intervals**.
meanwhile, for questions which ask for 'the effect' of a high value of one variable on another & a low value of the same variable on another, a direct comparison can be made & there will as such, be no need to plot a graph.

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the planning worksheet

q | outline a method that one could use to find **the effect** of the temperature on the rate of pepsin activity.

a |

- add a fixed volume of the pepsin solution (**the constant variable**) & a fixed volume of a protein mixture, for example, the albumin mixture (**the constant variable**), to a test-tube that is placed in a water bath at 10°C.
- record the time taken for the cloudy protein mixture to become clear in a table (**the data to be collected**).
- repeat steps 1 to 2 & calculate the mean time taken for the protein mixture to become clear.
- repeat steps 1 to 3 on different test-tubes placed in a water bath at 20°C, 30°C, 40°C & 50°C (**the variable to be changed**).
- plot a graph of the time taken for the protein mixture to become clear against the temperature of water bath (**how the data obtained is to be made use of**).
- the region of the graph with a positive gradient shows that the rate of pepsin activity increases with an increase in temperature.
  the region of the graph with a negative gradient shows that the rate of pepsin activity decreases with an increase in temperature.
  meanwhile, the highest point of the graph shows the optimum temperature of pepsin.
  (**the interpretation of the data obtained**)

q | plan an investigation to show how one could determine the concentration of the cell sap of the cells in potato slices.

a |

- place a few potato strips of the same length (**the constant variable**) in 2%, 4%, 6%, 8% & 10% sucrose solutions (**the variable to be changed**) for a fixed period of time (**the constant variable**).
- record the final length of each potato strip in a table.
- calculate the mean change in the length of the potato strips for each concentration (**the data to be collected**).
- plot a graph of the mean change in the length of the potato strips against the concentration of the sucrose solutions (**how the data obtained is to be made use of**).
- the concentration of which there is no change in the length of the potato strip is the concentration of the cell sap of the potato slices (**the interpretation of the data obtained**).

q | outline how one would investigate **the effect** of varying temperature on the digestion of sucrose.

a |

- add equal volumes of a sucrose solution & a sucrase solution (**the constant variable**) to a test-tube that is placed in a water bath at 10°C for a fixed period of time (**the constant variable**).
- at the end of the experiment, carry out the benedict's test on each mixture.
- record the colour changes observed in a table (**the data to be collected**).
- repeat steps 1 to 3 on different test-tubes placed in a water bath at 20°C, 30°C, 40°C & 50°C (**the variable to be changed**).
- the concentration of reducing sugars in each mixture can be compared by the observation of the colour of the mixture at the end of the experiment (**how the data obtained is to be made use of**).
  the closer the intensity of the final colour of the mixture to brick red, the faster the rate of hydrolysis of sucrose at that temperature.
  a blue colour shows no hydrolysis of sucrose to reducing sugars while a brick red precipitate shows a high concentration of reducing sugars present in the mixture.
  (**the interpretation of the data obtained**)

q | plan an experiment to compare the rate of water loss from the leaves of three plants.

a |

- cut a section of a shoot from five different plants **(the variable to be changed)**.
  set up a potometer attached to each shoot in a room that has the same temperature & the same level of humidity **(the constant variable)**.
- let the potometer run for a fixed period of time **(the constant variable)**.
- calculate the volume of water lost by subtracting the initial reading from the final reading **(the data to be collected)**.
- repeat steps 1 to 3 to get the mean volume of water loss for each plant **(how the data obtained is to be made use of)**.
- to compare the rate of water loss for each plant, calculate the rate of water loss by dividing the mean volume of water loss with the time taken. record these values in a table. **(the interpretation of data)**

q | the activity of most enzymes, including catalase, is influenced by changes in pH. catalase occurs in many plant & animal tissues. it chemically breaks down toxic hydrogen peroxide into water & oxygen. one is given a cylinder of potato tissue, from which he is to cut twelve discs, each measured one mm in thickness. when each disc is placed in a hydrogen peroxide solution, it will rise due to the accumulation of oxygen bubbles formed around it. outline an investigation to determine **the effect** of pH on the activity of catalase & to determine the optimum pH of catalase.

a |

- cut a few pieces of potato discs of the same thickness & of the same dimension **(the constant variable)**.
  place each potato disc into a test-tube with solutions at pH 2, 4, 6, 8 & 10 **(the variable to be changed)**.
  adjust the pH of the mixture accordingly by adding dilute hydrochloric acid & sodium hydroxide to the solution.
- add a fixed volume of a 5% hydrogen peroxide solution to each test-tube **(the constant variable)**.
- record the time taken for each disc to rise to the surface of the mixture **(the data to be collected)**.
- repeat steps 1 to 3 to get a mean time taken.
- plot a graph of the mean time taken for the potato disc to rise to the surface against the pH of mixture **(how the data obtained is to be made use of)**.
  a positive gradient of the graph shows that as the pH of mixture increases, the rate of decomposition of hydrogen peroxide by catalase increases.
  a negative gradient of the graph shows that as the pH of the mixture increases, the rate of decomposition of hydrogen peroxide by catalase decreases.
  the pH of mixture with the shortest time taken for the potato disc to rise to the surface shows the optimum pH of catalase.
  (the interpretation of data)
- **important:**
  - some stated that one can measure the height at which the potato disc rises to, which is not possible as when the oxygen bubbles form around the discs, the potato will rise to the surface.
    as such, there is no way to stop the potato disc from rising to the surface for the height at which it rises to to be measured.
  - some students mentioned that one can vary the pH of catalase in the experiment. this is not possible as the catalase is **in the potato disc**. instead, one should use HCl & NaOH to adjust the pH of the mixture.

school 2019

q | suggest how this experiment could be extended in order to find out the value of the concentration of the onion tissue.

a |

- prepare some solutions of a concentration of 10%, 20%, 30%, 40% & 50% **(the variable to be changed)**.
- place two or more rings of onions into each concentration of solution.
- measure the changes in the length of the onion rings after 45 minutes **(the constant variable)**.
- calculate the average change in length of the onion rings of different concentrations of solutions **(the data to be collected)**.
- plot a graph of the average change in length of the onion rings against the concentrations of the solutions **(how the data obtained is to be made use of)**.
- obtain the value of the concentration of the onion tissue from where the graph cuts the horizontal axis. this indicates no change in length of the onion tissue. **(the interpretation of data)**

q | suggest one way to determine which underground stem has **a higher energy content**.
important: a higher energy content = a higher fat content

a |

- obtain some potato cubes & some ginger cubes of the same mass.
- obtain some test tubes with the same mass of water.
- light the specimens up using the bunsen burner & heat the test tubes of water up.
- the test tube with a higher temperature increase within a fixed period of time shows which underground stem has a higher energy content.

o level 2018

q | suggest two other ways in which **the rate** of transpiration of the suspension of yeast could be measured.

a |

- a gas syringe can be used to measure the volume of gas produced by the suspension of yeast over time.
- the height of froth produced by the suspension of yeast could be measured over 15 minutes with a ruler.

q | outline a method that one could use to find **the effect** of pH on **the rate** of respiration of a suspension of yeast cells.

a |

- place 5 cm^3 of a suspension of yeast cells in a glucose solution in a conical flask. **(the constant variable)** adjust the pH of the suspension of yeast cells to pH 2 with dilute hydrochloric acid & sodium hydroxide.
- attach a rubber stopper & a delivery tube at the mouth of the conical flask. attach a gas syringe at the end of the delivery tube.
- record the volume of gas collected in the gas syringe over 5 minutes in a table **(the data to be collected)**.
- repeat steps 1 to 3 five times & calculate the mean volume of gas collected at pH 2.
- repeat steps 1 to 4 with suspensions of pH 4, pH 6, pH 8 & pH 10 **(the variable to be changed)**. adjust the pH of the suspensions of yeast cells with dilute hydrochloric acid & sodium hydroxide.
- calculate the mean rate of respiration of the suspensions of yeast cells at each pH by dividing the mean volume of gas collected by five minutes.
- plot a graph of the mean rate of respiration against pH **(how the data obtained is to be made use of)**.
- determine the effect of pH on the rate of respiration through the analysis of the gradient of the graph **(the interpretation of data)**.

o level 2019

q | outline how one would investigate **the effect** of light intensity on **the rate** of photosynthesis of a chloroplast suspension.

a |

- place a 10 cm^3 mixture of a chloroplast suspension in a specimen tube **(the constant variable)**.
- place the specimen tube 10 cm away from a lamp.
- add 1 cm^3 of pink-purple indicator & 1 cm^3 of sulfuric acid to the specimen tube **(the constant variable)**. mix well.
- start the stopwatch immediately.
  record the time taken for the pink-purple indicator to turn colourless.
  (the data to be collected)
- repeat steps 1 to 4 for other distances of the specimen tube from the lamp, specifically, 15 cm, 20 cm, 25 cm & 30 cm **(the variable to be changed)**.
- for each distance of the specimen tube from the lamp, repeat the experiment three times.
  calculate the mean time taken for the pink-purple indicator to turn colourless for each distance of the specimen tube from the lamp.
- calculate the mean rate of photosynthesis for each distance of the specimen tube from the lamp using the formula, the rate of photosynthesis = 1000 / t.
- plot a graph of the rate of photosynthesis against the distance of the specimen tube from the lamp **(how the data obtained is to be made use of)**.
- determine the effect of light intensity on the rate of photosynthesis through the analysis of the gradient of the graph **(the interpretation of data)**.

Biology Practical Test

1. The practical examination is designed to test candidates' abilities to:

   (a) follow carefully a sequence of instructions within a set time allowance;
   (b) use familiar and unfamiliar techniques to record their observations and make deductions from them;
   (c) recognise and observe features of familiar and unfamiliar biological specimens, record their observations and make deductions about functions of whole specimens or their parts;
   (d) make clear line drawings of the specimens provided, indicate magnification and to label familiar structures;
   (e) interpret unfamiliar data and draw conclusions from their interpretations;
   (f) design/plan an investigation to solve a problem;
   (g) comment on a procedure used in an experiment and suggest an improvement;
   (h) employ manipulative skills in assembling apparatus, in using chemical reagents and in using such instruments as mounted needles, scalpels and razor blades, forceps and scissors;
   (i) observe reactions, read simple measuring instruments and perform simple arithmetical calculations;
   (j) measure to an accuracy of 1 mm, using a ruler.

2. Candidates may be asked to carry out simple physiological experiments, involving tests for food substances (specifically reducing sugars with Benedict's solution, starch using iodine solution, protein using the biuret test and fats using the ethanol emulsion test), enzyme reactions, hydrogen carbonate indicator solution, cobalt(II) chloride paper etc. It is expected that glassware and instruments normally found in a laboratory (e.g. beakers, test-tube racks, funnels, thermometers, droppers and so on) should be available for these experiments.

3. Candidates may be asked to carry out simple physiological experiments, involving the use of the above mentioned instruments 1(h) on plant or animal materials. Accurate observations of these specimens will need a hand lens of not less than x6 magnification for each candidate.

4. The material set will be closely related to the subject matter of the syllabus, but will not necessarily be limited to the particular types mentioned therein.

POINTS TO NOTE ON SCIENCE (BIOLOGY) PRACTICAL

- Read instructions on the cover page of exam booklet.
- Check number of pages in exam booklet and note the last page.
- Listen to given **verbal** instructions e.g check all specimens or apparatus on the bench and the questions to be attempted first.
- Read all questions briefly before starting.
- **Identify** topics tested on.
- Time for paper is 1h 30 mins, allocate 45 minutes each for Physics/Chemistry & Biology questions.
- Place writing equipment and answer script away from sink and on dry part of the bench.
- If you are not sure, **ask**!
  e.g unsure of identity of specimens (in case of mix-up), change of specimens, insufficient specimens, change of faulty equipment.
- To prevent mix-up, remove and study one specimen at a time and put it back in its container before you study the next specimen.
- Label every test-tube at its top.
- Keep cool! Don't panic.
  Questions and specimens may be new to you, but the principle is within your ability.

Bring along the following Materials:

- A good drawing pencil
- Rubber
- Calculator
- Ruler
- Watch with clear minute markings

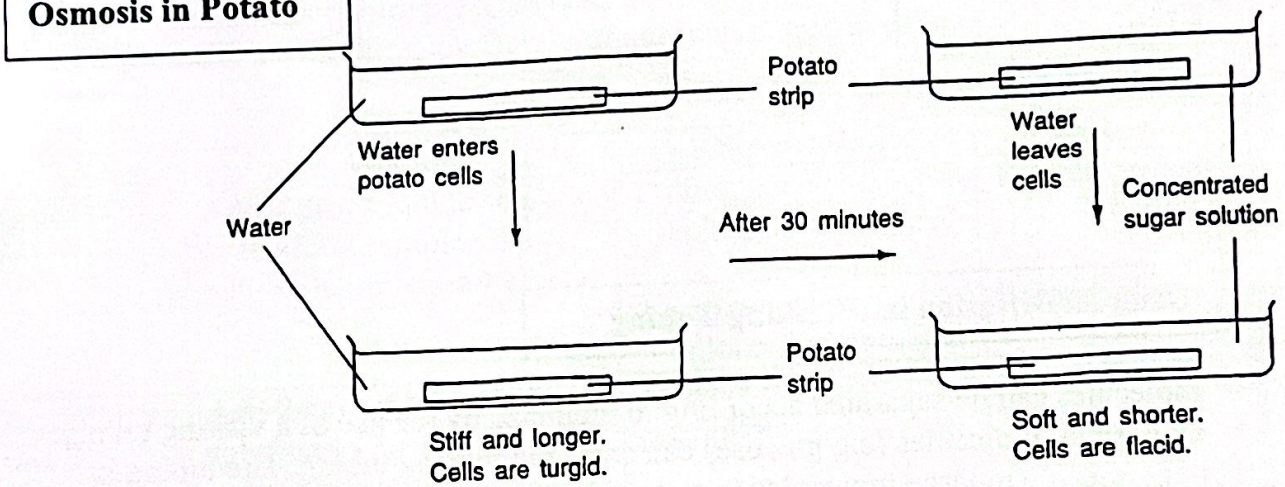
1. Osmosis

describe condition of cells = either turgid or flaccid
describe texture of cells = rough or smooth
describe solution = either has a higher/lower/equal water potential to that of the cell sap

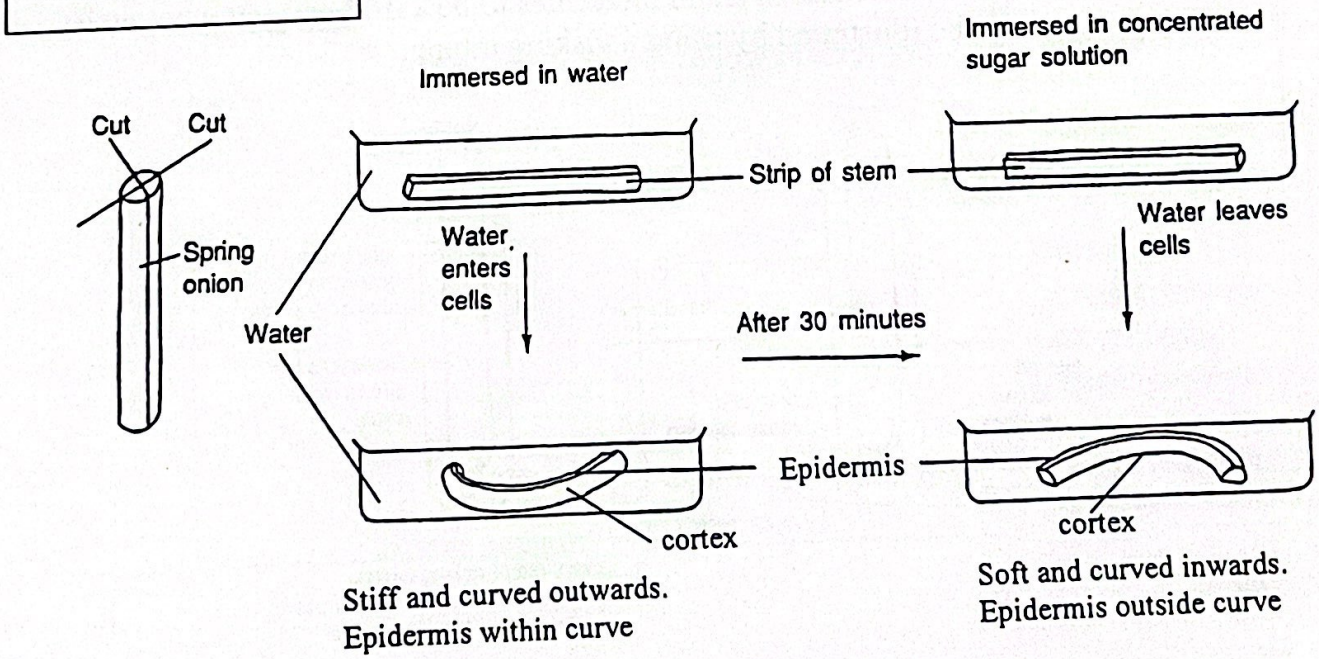
Recordings of change in length of plant tissue

- record in the units (mm or cm) indicated in question
- record to the required number of decimal places indicated in question
- indicate whether it is a positive or negative change in length

Osmosis in Potato



Osmosis in a Stem

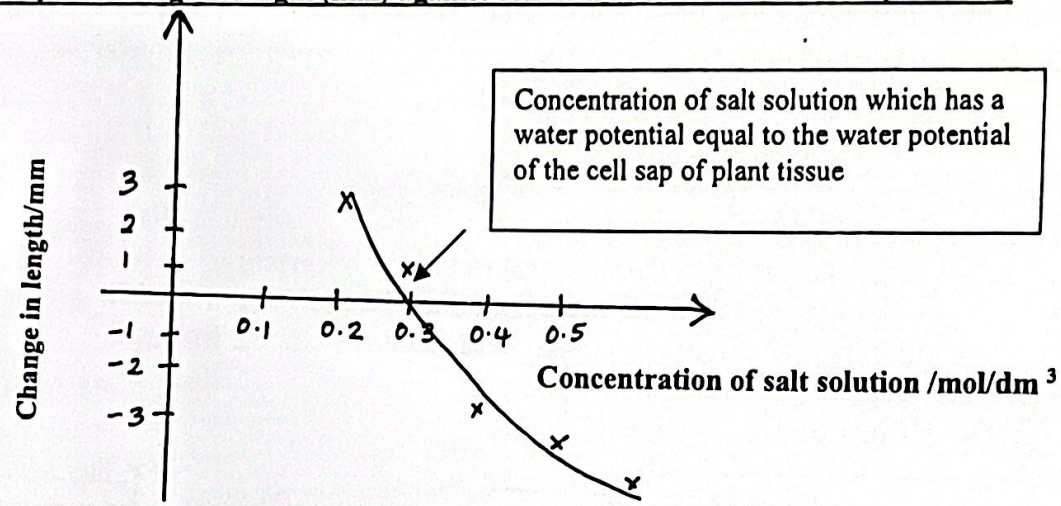


Epidermis does not change in length because it is covered by waterproof cuticle. only cortex cells show osmosis resulting in an increase/decrease in length.

Extension Question on Osmosis

How can the water concentration/potential of the cell sap of the plant tissue be determined?

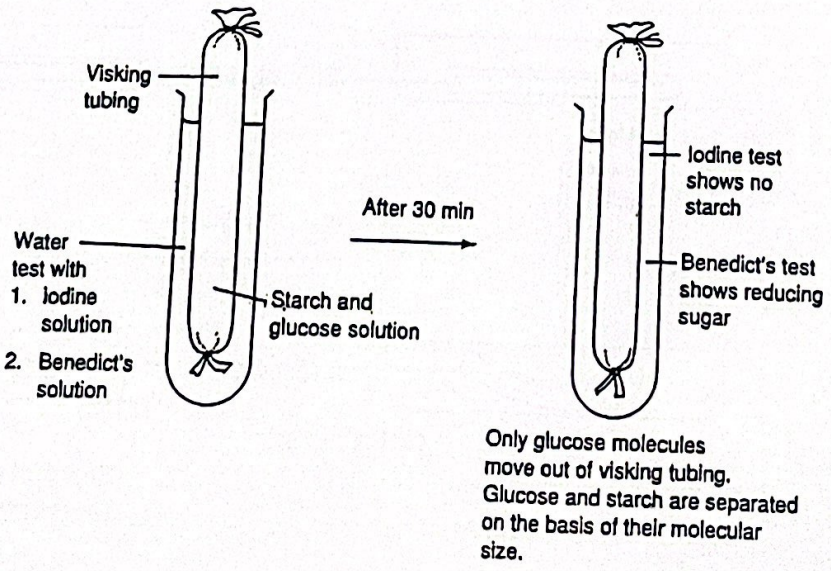
Graph of change in length (mm) against concentration of salt solution (mol/dm^3)



Osmosis/Diffusion in a Visking Tubing

Molecules can be separated according to their size by the use of a visking tubing. Only small molecules (e.g glucose) can cross the visking tubing. The tubing is impermeable to large molecules (e.g starch).

Food needs to be soluble and in small molecules to be absorbed by the gut wall. This process can be illustrated by using a visking tubing.



2. Food Tests

If you are testing for reducing sugar, set up water-bath first (usually water is pre-heated for you, just bring to a boil).

For any other food test, there is no need for water-bath.

<u>If Sample to be tested is in solid form, the following needs to be done to prepare for Benedict's & Biuret Test:</u>

•Crush/cut sample given
- ➢ break up cells & release nutrients stored in cells
- ➢ increase surface area of food materials to react with reagents

•Add distilled water, equal volume to food sample
- ➢ to dissolve out nutrients from cells
- ➢ & make a concentrated solution of nutrients stored in cells

Food test	Method	Observation	Conclusion
Iodine solution test for Starch	Add 2 drops iodine solution to the food sample on a white tile (or test-tube).	1 blue-black colouration obtained	1 starch present
		2 yellow/brown colouration obtained	2 starch absent
Benedict's test for reducing sugar	Add 2 cm^3 of benedict's solution to 2 cm^3 of food extract in a test-tube. Shake thoroughly to mix. Heat mixture in a boiling water-bath.	1orange/brick-red precipitate	1 high concentration of reducing sugar present
		2 yellow precipitate	2 moderate amount of reducing sugar present
		3 green precipitate	3 low concentration of reducing sugar present
		4 Benedict's solution remained blue	4 reducing sugar absent

Food test	Method	Observation	Conclusion
Ethanol-emulsion test for fat	Add 2 cm^3 of ethanol to food sample in a test-tube. Shake vigorously for 5 minutes. Allow particles to settle (for solids). Decant into another test-tube (for solids). Add 2 cm^3 water. Shake.	Cloudy suspension turns clear when solid particles settle. 1 white emulsion formed 2 solution remains clear	1 fats present 2 fats absent
Biuret test for proteins	Add 2 cm^3 of biuret reagent to 2 cm^3 of the food extract. Shake thoroughly to mix.	1 purple colouration 2 blue colouration	1 proteins present 2 protein absent

Why are these food types important?

a) carbohydrates

- energy source, e.g glucose is used as a respiratory substrate, provides energy for moving, growing and keeping warm
- energy store, e.g starch is stored by plants in storage organs, like roots, stems & leaves
- building material, e.g cellulose is used by plants to form cell wall

b) fats

- energy source, e.g when used as a respiratory substrate
- energy store, has almost twice the energy value of carbohydrates in animals, stored fats also provide insulation against cold

c) proteins

- used to form protoplasm in cells
- formation of enzymes/hormones

3. Enzymes (requires waiting time)

Enzymes are necessary to break food materials into smaller molecules before they can be absorbed and be of use to our body.
Enzymes are protein in nature. They have a specific shape. Each enzyme has an active site where a particular substrate molecule combines to form an enzyme-substrate complex before the substrate breaks into its smaller molecules (e.g a digestive enzyme).
Enzymes can also build up large molecules from smaller ones (e.g photosynthetic enzymes).

$$\text{Starch} \xrightarrow{\text{amylase}} \text{maltose (reducing sugar)}$$

$$\text{Fats} \xrightarrow{\text{lipase}} \text{fatty acid + glycerol}$$

$$\text{Protein} \xrightarrow[\text{Trysin (pancreatic juice)}]{\text{Pepsin (gastric juice)}} \text{polypeptides (peptones)} \xrightarrow{\text{peptidases (intestinal juice)}} \text{amino acids}$$

Action of amylase on starch

Tube	Content	Observations		Conclusion
		Iodine test	Benedict's test	
1	Starch + saliva (amylase)	Yellow/brown colouration	Orange precipitate	Reducing sugar present Starch absent
2	Starch + water	Blue-black colouration	Benedict's solution remains blue	Starch present Reducing sugar absent
3	Starch + boiled saliva (boiled amylase)	Blue-black colouration	Benedict's solution remains blue	Starch present Reducing sugar absent

Conclusion : amylase in saliva digests starch to reducing sugar (maltose). Boiled saliva has no action on starch. Amylase is an enzyme (protein) which is denatured by extreme temperatures. Thus starch remains unchanged when treated with boiled saliva.

Action of lipase on fats (Phenolphthalein is carcinogenic and will no longer be used in school laboratories)

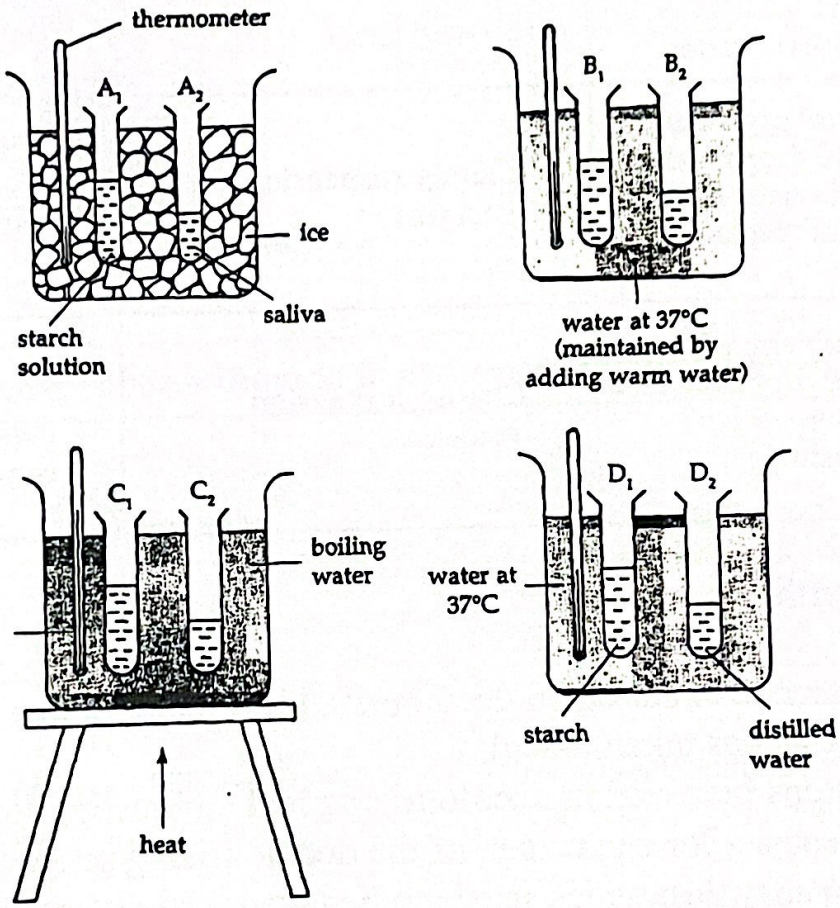
Tube	Content	Observations		Conclusion
		Initial colour	Final colour	
R	1 cm^3 water + 3 cm^3 oil + 5 drops phenolphthalein 5 drops sodium carbonate + 1 cm^3 lipase	Pink suspension	Pink colour takes a longer time to disappear	Absence of bile salts to emulsify fats, fats took a longer time to get digested to fatty acids & glycerol by lipase. Thus phenolphthalein took a longer time to become colourless.
S	1 cm^3 water + 3 cm^3 oil + 5 drops phenolphthalein 5 drops sodium carbonate + 1 cm^3 bile salts	Pink suspension	Pink colour remains	No digestion took place, no enzyme present, no fatty acids released, phenolphthalein remained pink
T	3 cm^3 oil + 5 drops phenolphthalein 5 drops sodium carbonate + 1 cm^3 bile salts+ 1 cm^3 lipase	Pink suspension	Pink colour disappears fastest	bile salts present to emulsify fats to smaller fat droplets before it gets digested to fatty acids & glycerol by lipase. Thus phenolphthalein became colourless very quickly due to the presence of fatty acids.

Note: Lipase digested the fats to fatty acids and glycerol. Release of fatty acids caused the mixture to turn acidic, phenolphthalein is pink in alkaline conditions and turns colourless in acidic conditions.

***Bromothymol blue** indicator may be used in place of Phenolphthalein. Bromothymol blue is blue in alkaline conditions and yellow in acidic conditions. Predict the results you would obtain if Bromothymol blue were used in the above experiment.

May be required to investigate effect of temperature or pH on enzyme activity.
Enzyme may have been previously subjected to either high temperature or acid before 'reaction' with test sample.
Be prepared to comment on enzyme activity or non-activity.

To show the effect of temperature on activity of enzyme



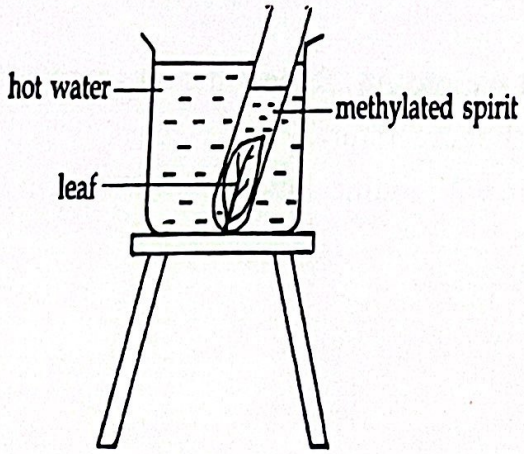
- Leave the tubes for 5 minutes to allow solutions in the tubes to reach the temperature of the water bath.
- Pour contents of tubes labelled A_1 into A_2. Repeat process for B_1, C_1 and D
- Continue to maintain water-bath temperature.
- After 20 minutes, test each tube with iodine solution.
- Predict the results of each test.

To show the effect of pH on activity of enzyme

Test tube	Contents	Observations	Conclusion
A	3 cm^3 egg white + 10 drops dilute hydrochloric acid + 3 cm^3 pepsin	**Cloudy suspension turns colourless**	**Protein digested to peptones. Pepsin works best in acidic conditions**
B	3 cm^3 egg white + 10 drops dilute hydrochloric acid + 3 cm^3 distilled water	**Cloudy suspension remains**	**Protein not digested. Enzyme absent. Acts as control.**
C	3 cm^3 egg white + 10 drops sodium carbonate + 3 cm^3 pepsin	**Cloudy suspension remains**	**Protein not digested.. Pepsin inactive in alkaline conditions**
D	3 cm^3 egg white + 10 drops distilled water + 3 cm^3 pepsin	**Cloudy suspension remains**	**Protein not digested.. Pepsin inactive in neutral conditions**

4. Photosynthesis

Test for presence of starch on decolourised leaf using iodine (indicates whether photosynthesis has taken place).
Know the steps involved in decolourising leaf and testing for starch.
Know the reasons for each stage of the decolourising process.
Know the **precaution** which needs to be taken when using hot alcohol (do not use direct heating with Bunsen burner as alcohol is flammable,use a water-bath to heat alcohol).



1 **Immerse leaf in boiling water**
→Removes the waxy cuticle which prevents entry of iodine solution.
→ Ruptures cell membranes to make starch granules in cytoplasm and chloroplasts accessible to iodine solution. Cell membranes are partially permeable and do not readily allow the penetration of iodine.
→ denature enzyme & stop chemical reactions

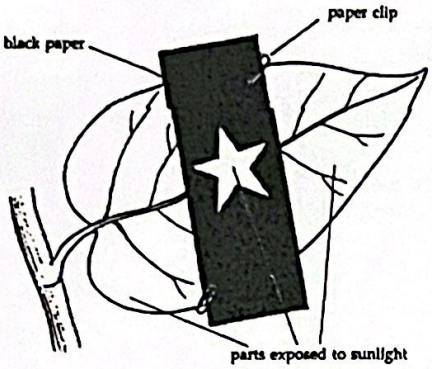
2 **Immerse leaf in hot alcohol**
→ decolourise leaf, by dissolving out chlorophyll from leaf

3 **Dip Leaf in hot water**
→soften leaf, make it more permeable to iodine solution

4 **Cover leaf with Iodine solution**
→Test for presence of starch

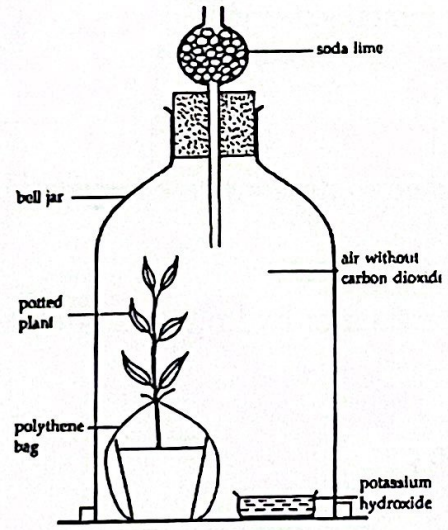
Be familiar with photosynthesis experiments.
Know when & how to destarch a plant.
Know how to test a plant to see if it has been completely destarched.

To Show sunlight is necessary for photosynthesis



Leaf turns blue-black only in regions exposed to sunlight.

To show that carbon dioxide is necessary for photosynthesis.



A control is set up with pebbles instead of soda lime, & water in the dish.
Place set-ups in strong sunlight for a few hours.

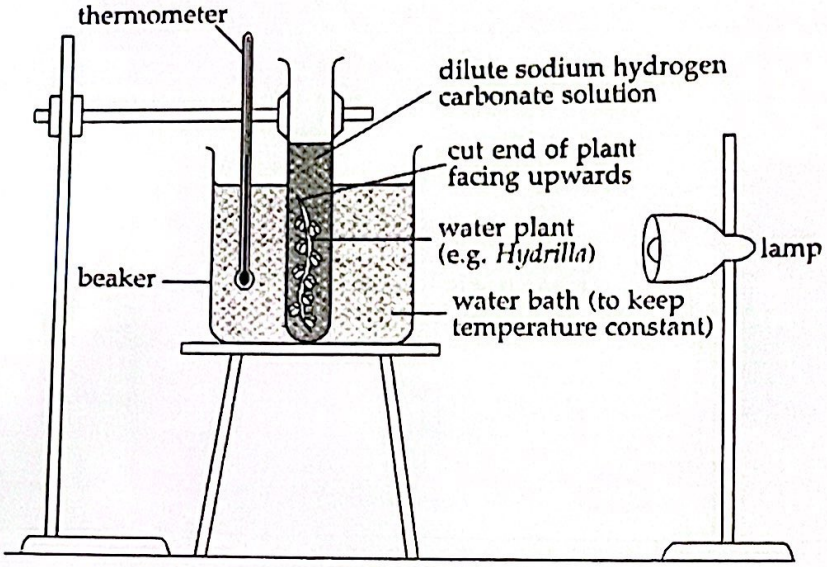
Blue-black colouration present in the control only.
Thus CO_2 is required for Photosynthesis.

Show that chlorophyll is necessary for Photosynthesis using a variegated leaf

1 Destarch a plant with variegated leaves in darkness for 2 days.
2 Expose leaf to strong sunlight for at least 6 hours.
3 Remove one leaf. Make a drawing to show the distribution of the green parts.
4 Denature enzymes in leaf & decolourise it & test it for starch.

Conclusion : Blue-black colouration obtained only in regions which were green i.e contained chlorophyll

Describe experiments to investigate the effect of different light intensities/temperature/carbon dioxide concentration on the rate of photosynthesis



Ref to text Bk/notes for details of experimental set-ups.

5. Respiration

Very often yeast/germinating seeds are used to demonstrate respiration.

Carbon dioxide is produced during respiration.
Gas produced may be passed through limewater or hydrogencarbonate indicator as both will show a colour change.

i) Limewater will turn chalky/form white ppt

ii) Hydrogencarbonate indicator will turn yellow if carbon dioxide is passed into it

e.g Germinating seeds may be placed in hydrogencarbonate indicator

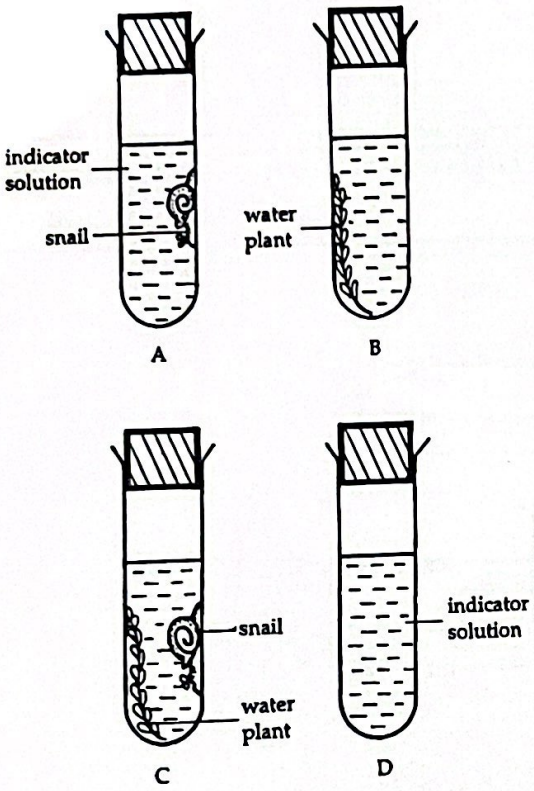
Yellow (acidic) ⟵ red (neutral) ⟶ purple (alkaline)

If indicator turns yellow after sometime, indicates carbon dioxide was produced.
Note : This test with hydrogencarbonate indicator may not be very successful.

Initial colour of indicator given to you will be a deep red. If carbon dioxide

was produced by germinating seeds, indicator colour may turn to a lighter red /orange only , may not turn to yellow. Therefore always compare with a sample of indicator which does not have any germinating seeds (control).

Sometimes you may be asked to blow expired air into indicator solution. Note colour change and be able to explain why.



What are the colour changes you would see?

Tube A --
Tube B--
Tube C--
Tube D--

State the processes taking place in each tube and account for the colour changes.

Tube A --

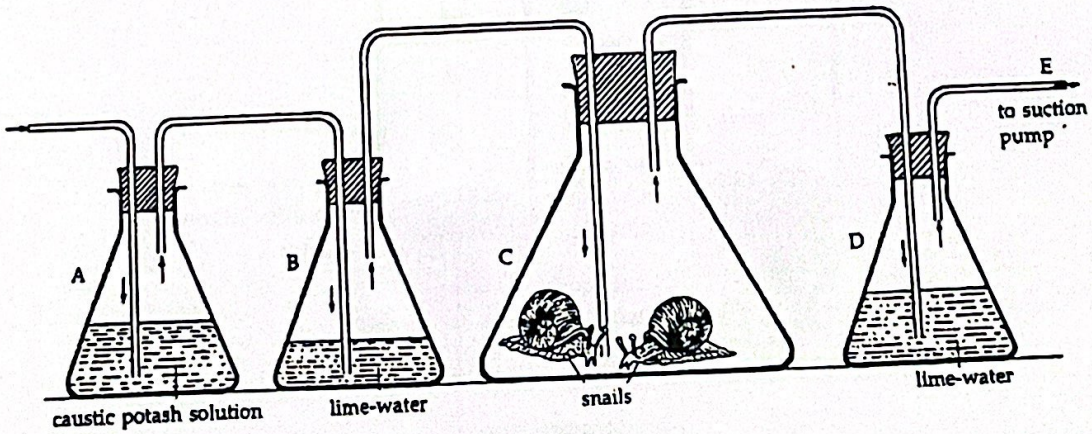
Tube B--

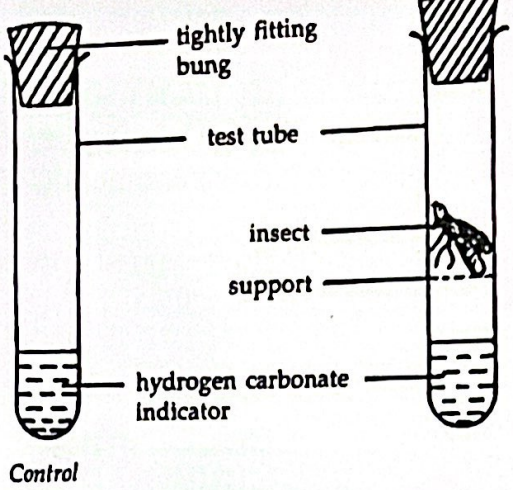
Tube C--

Tube D--

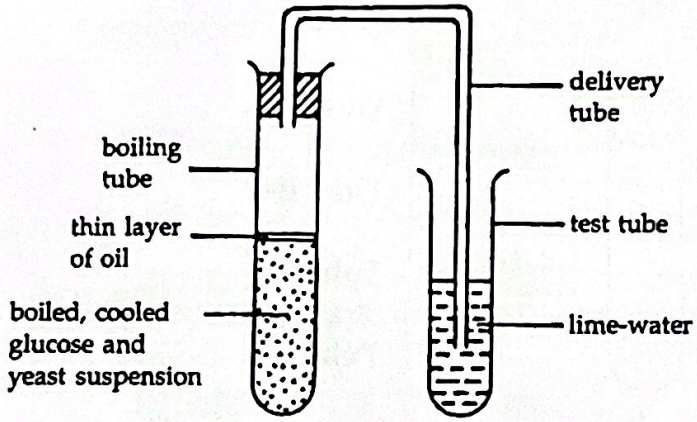
Be familiar with respiration experiments.

Experiments to show carbon dioxide is given off during respiration

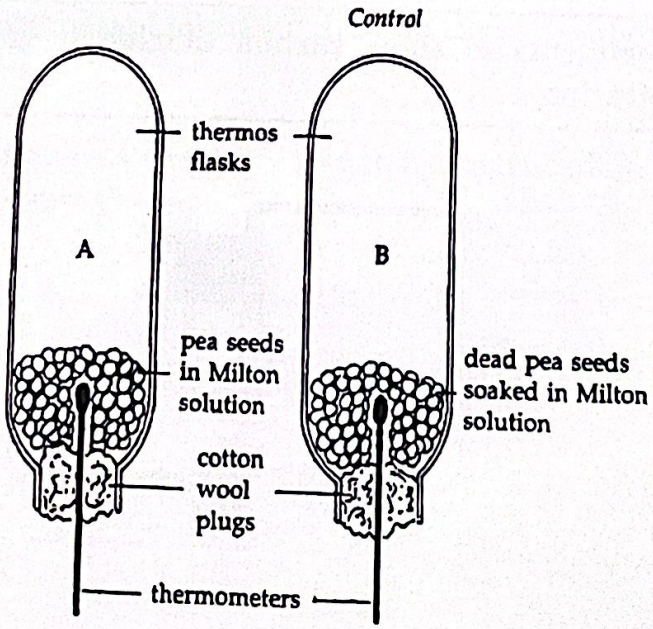




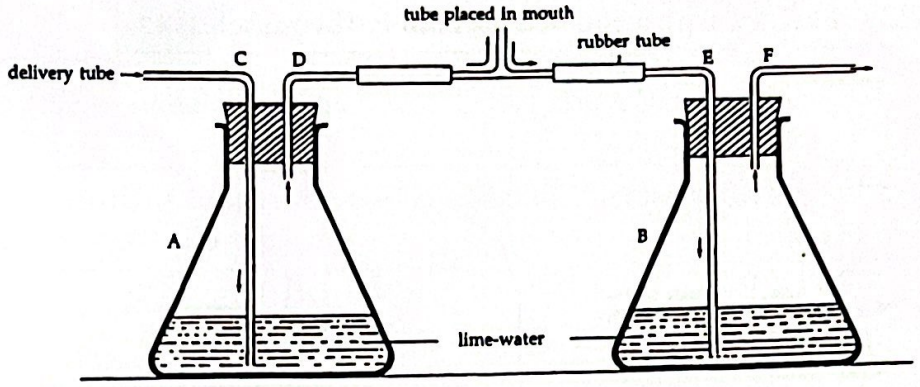
Experiment to show carbon dioxide is given off during fermentation



Experiment to show heat is produced during respiration

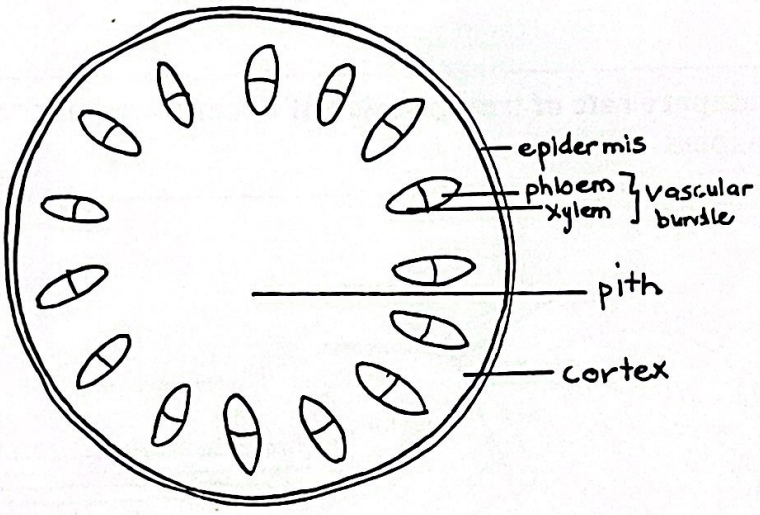


Experiment to compare the amount of CO_2 in inspired (inhaled) & expired (exhaled) air

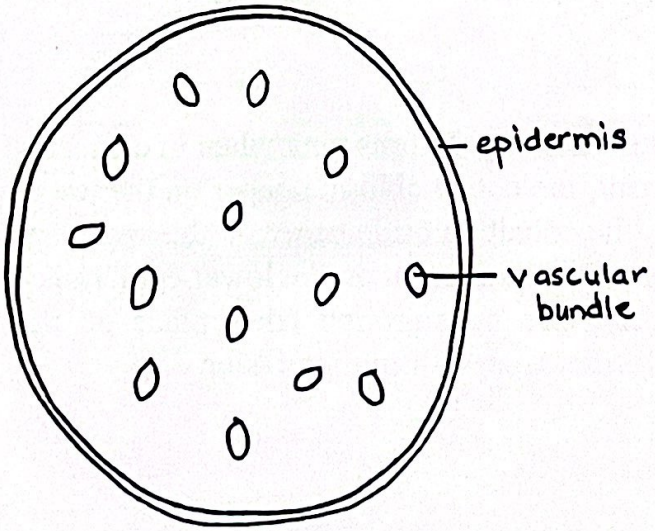


6. Transport in Plants

Be able to draw cross section of a dicotyledonous stem and monocotyledonous stem to show the distribution of vascular bundles.



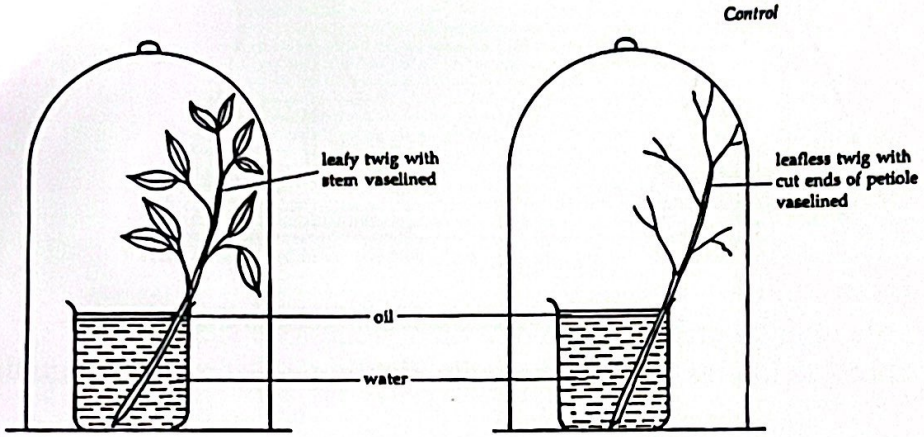
Cross-section of a dicotyledonous stem



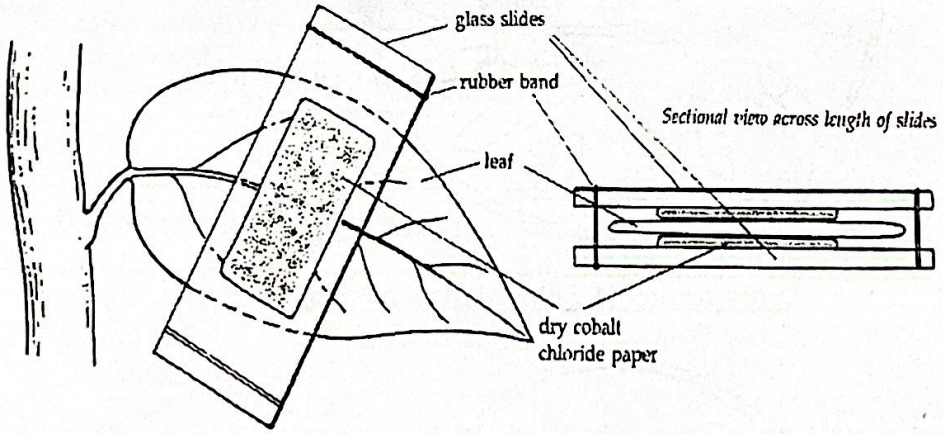
Cross-section of a monocotyledonous stem

- Know effect of standing a plant stem in red dye.
  Make transverse section of a stem that has been standing in red dye.
  Explanation of why xylem tissues are stained red.
  Know the structure & function of xylem tissues.

Experiment to show transpiration occurs mainly through leaves



Experiment to compare rate of transpiration of upper/lower surfaces of leaf using cobalt chloride papers



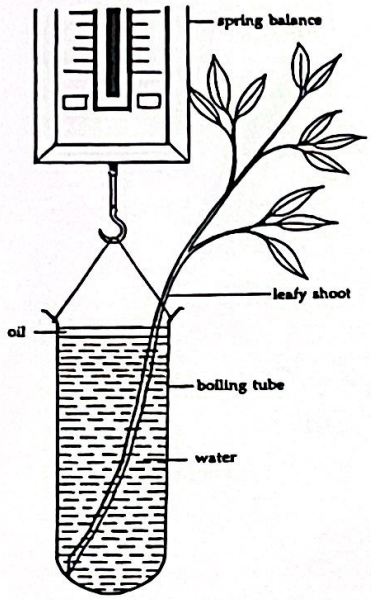
Cobalt chloride is blue when dry. It turns pink when in contact with moisture.
In the above experiment, the cobalt chloride paper on the lower epidermis of leaf turns pink faster than the cobalt chloride paper on the upper epidermis of the leaf because there are more stomata present on the lower epidermis of the leaf than the upper epidermis. Thus more transpiration takes place on the lower epidermis causing the cobalt chloride paper to turn pink faster.

- Factors affecting rate of transpiration:
  –Humidity
  –Temperature
  –Wind
  –Light intensity

❖ Be able to explain how the above factors affect transpiration rate

Experiments to investigate the effect of the above factors on the rate of transpiration in a plant.

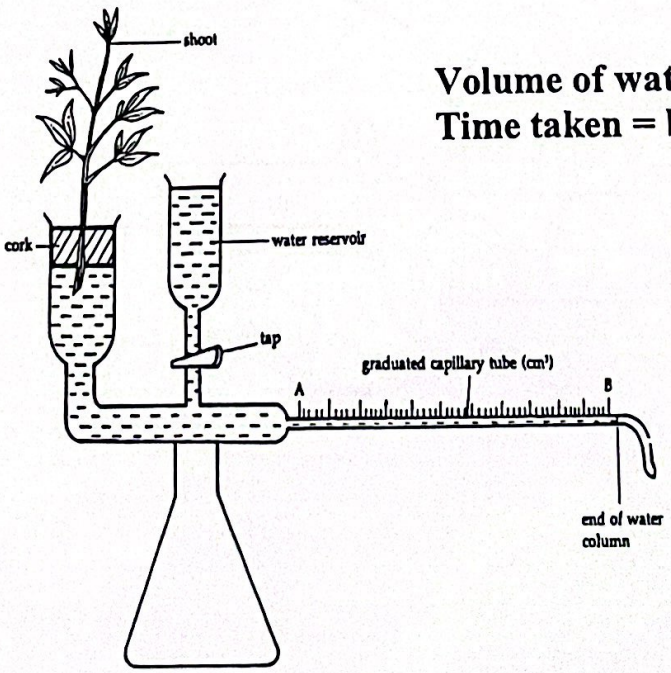
To measure the rate of transpiration of a shoot using a spring balance



Mass of tube with shoot = a g
Mass of tube with shoot after 5 hours = b g

Rate of transpiration
= loss in mass / time taken
= (a-b) g/h / 5

To measure the rate of transpiration using a potometer



Volume of water column from B to A = a cm^3
Time taken = b minutes

Rate of transpiration
= a/b cm^3 /minute

7 .Reproduction in Plants

a) Flowers

Draw and label.
Normally, a flower with structure similar to clitoria given.

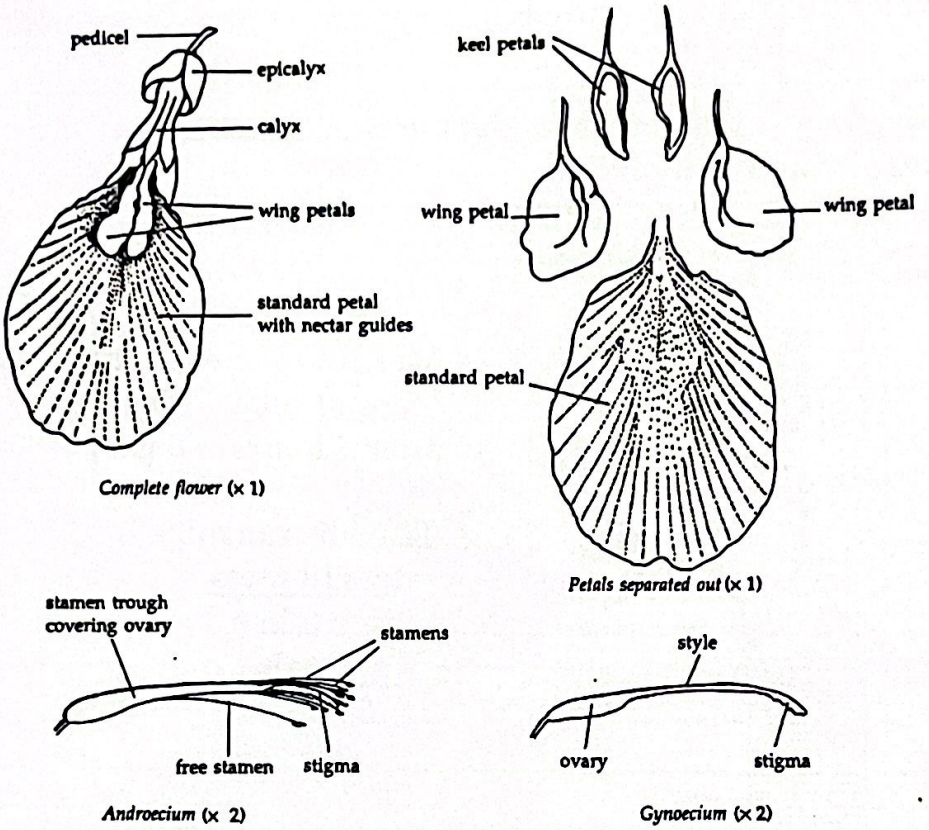
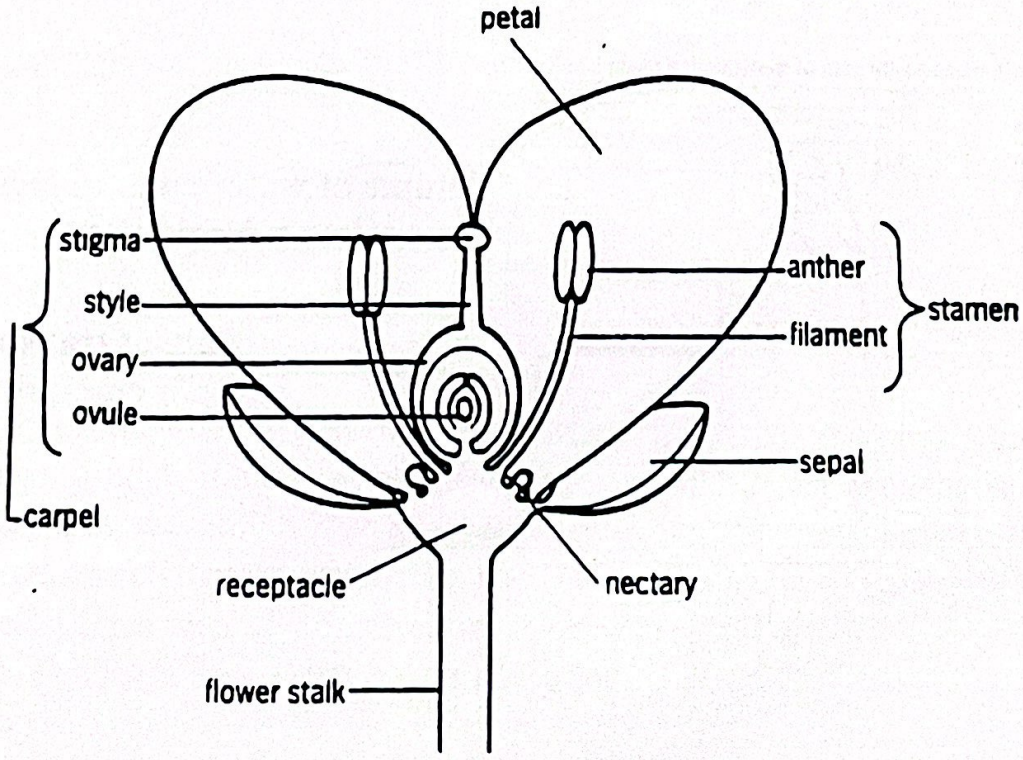


FIG. 19.12 THE *CLITORIA* FLOWER



Identify/state whether flower is insect or wind-pollinated.
(State features which are visible to the naked eye!!!!)
This can be done by looking at the colour (dull or bright).
Colour can only be mentioned if real specimens are given.
Don't mention colour if black and white picture is given.
Also, use the presence of enclosed stigma, short filaments of anther (insect-pollinated) or protruding, feathery stigma, pendulous anthers (wind-pollinated) to judge.
Large petals normally indicate that flower is insect-pollinated.
The above characteristics can easily be seen in photographs.
Don't use smell as an indicator unless flowers are fresh and very fragrant.

Characteristics of insect-pollinated (or entomophilous) flowers	Characteristics of wind-pollinated (or anemophilous) flowers
1. Flowers are usually large, brightly-coloured and scented to attract insects. If the flowers are small they may group together to form conspicuous inflorescences.	1. Flowers are usually small, dull-coloured and scentless and thus not attractive to insects.
2. Nectar is often present to attract insects.	2. Nectar is usually absent.
3. Pollen is fairly abundant. Pollen grains are large, sticky and heavy, usually with rough surfaces so that they can readily cling onto the insects' bodies.	3. Pollen is abundant as wastage is higher. Pollen grains are small, dry, smooth and light so that they are buoyant and easily blown about by air currents.
4. Stamens may not be pendulous.	4. Stamens usually have long, slender filaments that sway in the slightest wind and pollen grains are hence easily shaken out from the anthers.
5. Stigmas are usually not feathery and do not protrude. They are sticky so that pollen grains settling on them are not easily displaced.	5. Stigmas protrude and are large and feathery so that they provide a large surface area to catch pollen floating in the air.
6. Markings or nectar guides may be seen on the petals. These markings guide the insect towards the nectar.	6. Nectar guides are absent.

Be able to compare the structural similarities/differences between a flower and its fruit.

Flower parts	Fruit parts that developed
ovary	Fruit If dry: forms the pericarp If fleshy: usually 3 layers – Epicarp, mesocarp, endocarp
ovule	seed
Ovule wall	Testa
Zygote	Embryo : made up of plumule, radicle, cotyledons.
receptacle	In some fruits, becomes the fleshy part of fruits e.g. apples, strawberries, pears.
Sepals, style	Shrivels and fall off May persist to form structures that will help in dispersal.

b) Fruits (popular question)

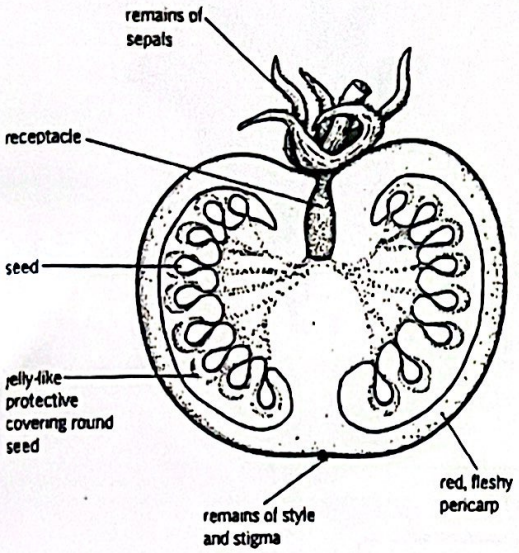
Be able to cut correctly a transverse section (T.S)/cross section or longitudinal section (L.S) of a fruit (Please get this clear).

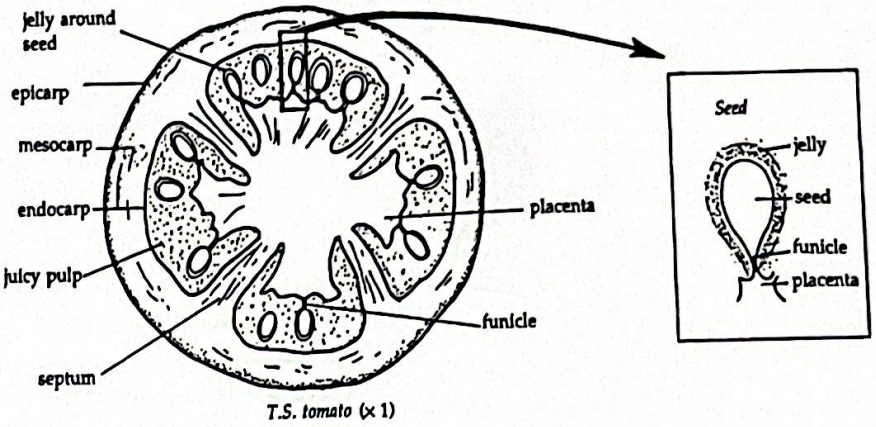
Draw and Label

Label :

i) Fruit wall (pericarp) if undifferentiated.
ii) Skin (epicarp), flesh (mesocarp, endocarp) if differentiated.
iii) Seeds
iv) seed stalk (funicle)
v) placenta
vi) fruit chamber (made up of one loculus or many loculi)
vii) oil glands (orange)
viii) vascular bundles (banana, cucumber)
ix) remains of style (scar)
x) remains of fruit stalk (scar)
xi) remains of calyx (made up of sepals)
xii) fruit stalk (pedicel)

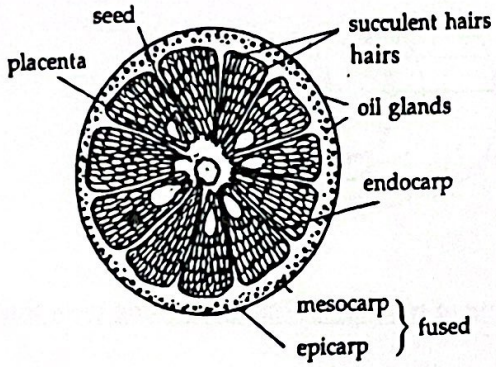
Animal Dispersed --Succulent fruits



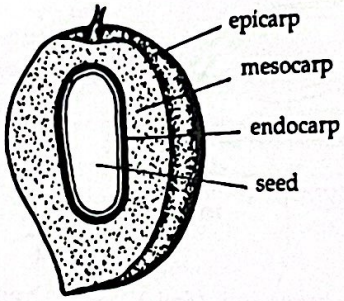


T.S. tomato (× 1)

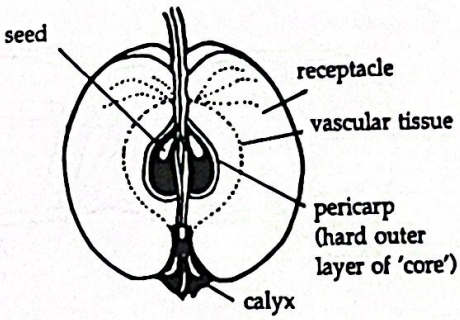
The tough testas and coat of jelly around the seeds allow them to pass unharmed through an animal's digestive system.



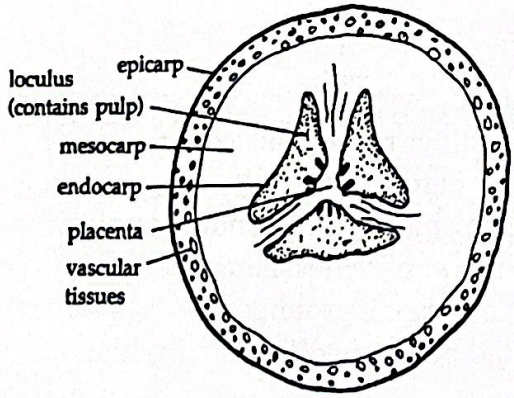
T.S. orange (× 1/2)



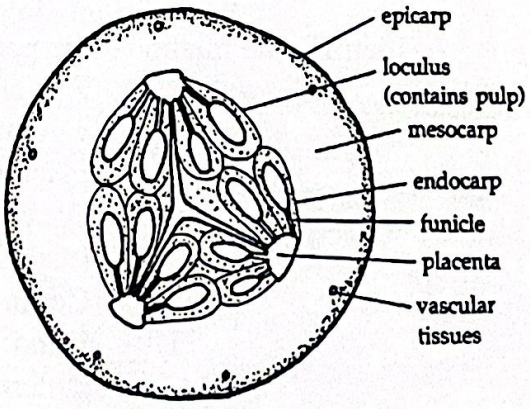
L.S. mango fruit (× 1/3)



L.S. apple (× 1/2)

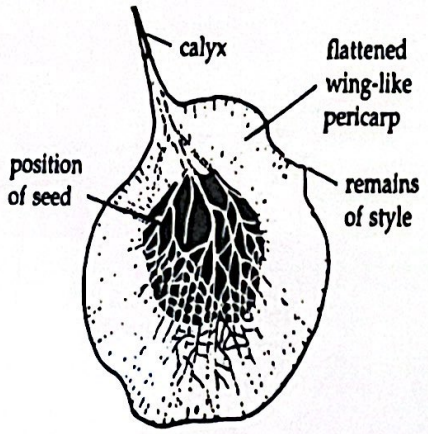


T.S. banana fruit

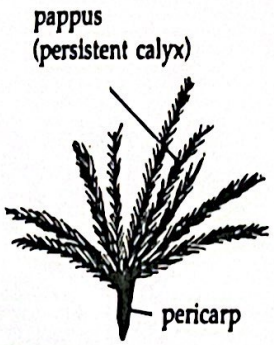


T.S. cucumber fruit

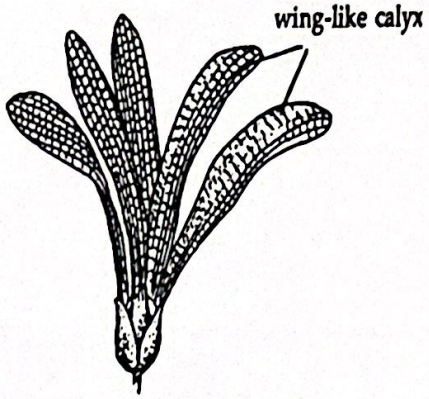
Wind dispersed Fruits & Seeds



Angsana fruit (x 1)

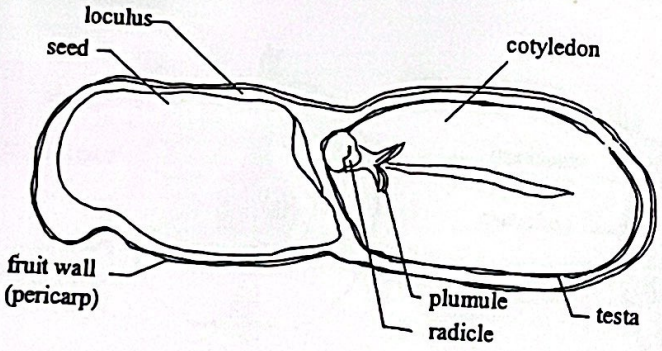


Tridex fruit (x 2)

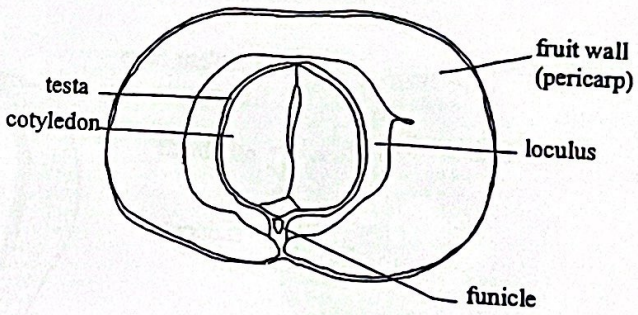


Shorea fruit (x ½)

Dispersal by Explosive mechanism



Drawing of longitudinal section of a groundnut (fruit) (showing details of a seed)



Drawing of transverse section of a long bean fruit

Identify the method of dispersal

i) By animals; coloured, scented, succulent, seeds cannot be digested, either passed out with faeces or discarded after fleshy part is eaten.

ii) By explosive mechanism; pericarp undifferentiated (usually), dry, has line(s) of dehiscence. Common in legumes (beans), groundnut.

iii) Wind; light, extended pericarp to form wing-like structures, feathery.

Reasons for dispersal

1 Avoid overcrowding & competition for food & light with parent plants
2 Enable plants to colonise new & favourable habitats
3 Reduce spread of diseases

c) Seeds

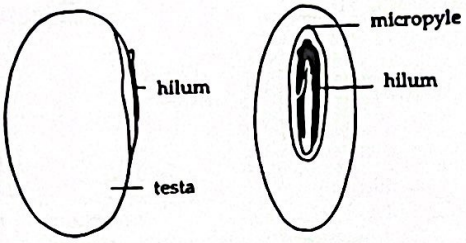
Structure

- testa, hilum, micropyle, cotyledon, plumule, radicle

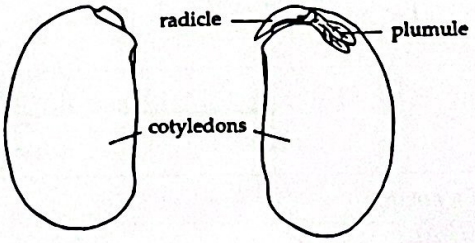
Function of stored food in seed

- germination, growth, development of seedling
- State the functions of the different types of stored food (proteins, fats, starch) in the cotyledons during the process of germination.

A generalized dicotyledonous seed



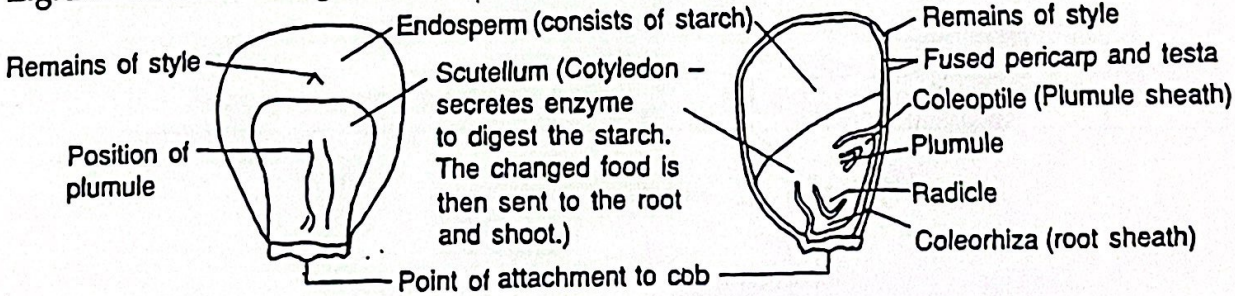
External features of sword bean seed



Seed with testa removed and cotyledons separated

A generalized monocotyledonous seed

E.g. maize. The maize grain is a fruit and the fruit wall is fused with the seed coat (testa).



Magnification: × 4.0

(a) External feature (front view)

Magnification: × 4.0

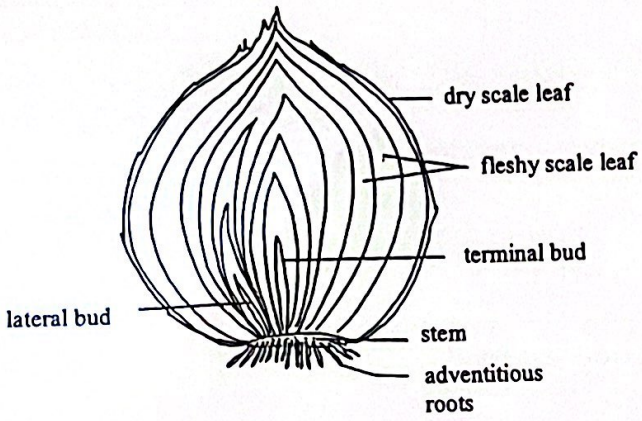
(b) Longitudinal section

Fig. 1.28 Structure of maize (endospermic — food stored outside embryo)

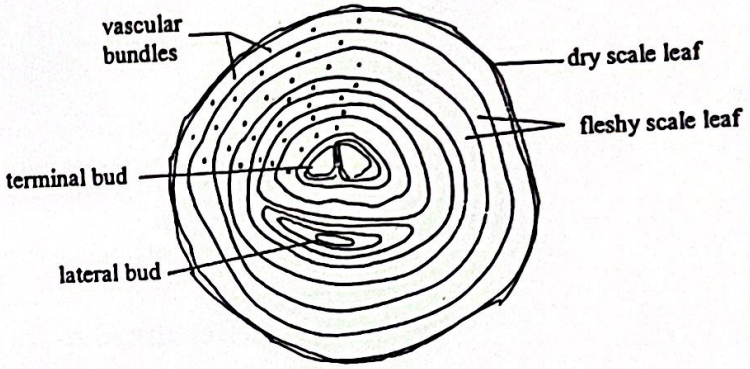
d) Storage Organs

Popular specimens include :

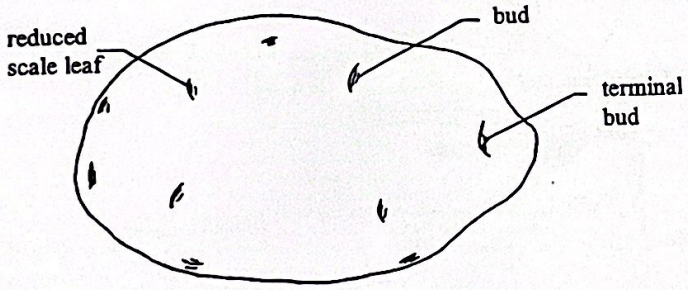
i) Onion (underground storage leaf)
ii) Potato (underground storage stem)
iii) Carrot (underground storage root)
iv) Ginger (underground storage stem)



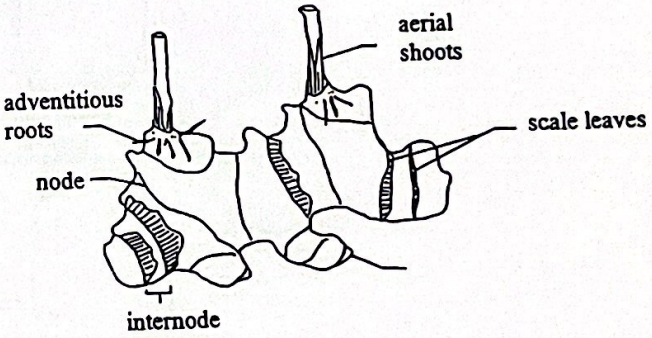
Longitudinal section of an onion bulb (storage leaf)



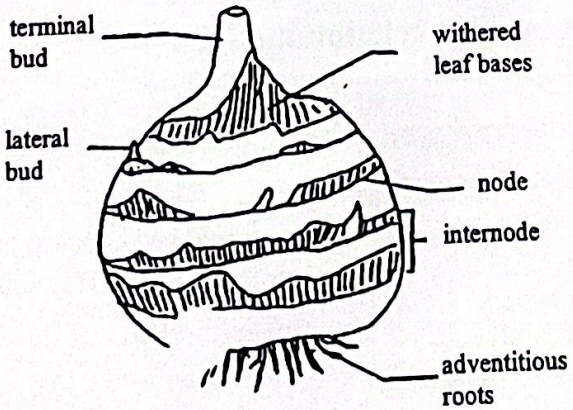
Tranverse section of an onion bulb



Drawing of external view of a potato tuber (underground storage stem)

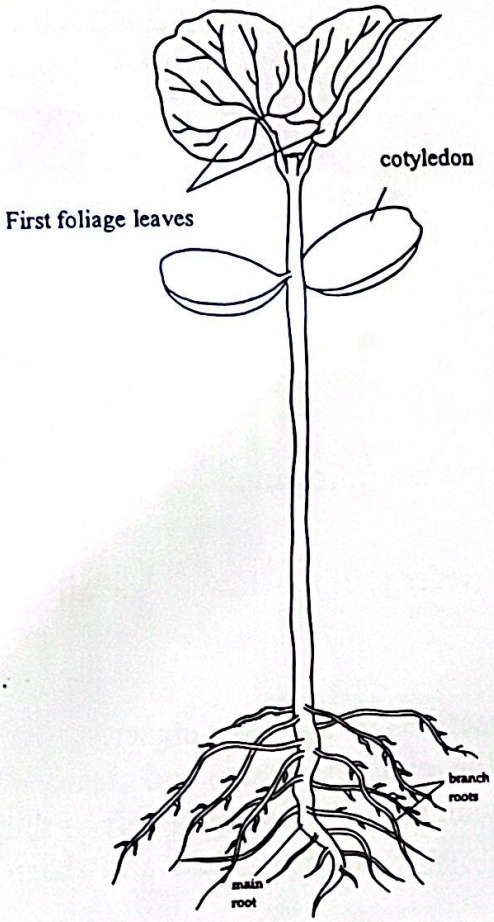


Drawing of external view of a ginger (underground storage stem)

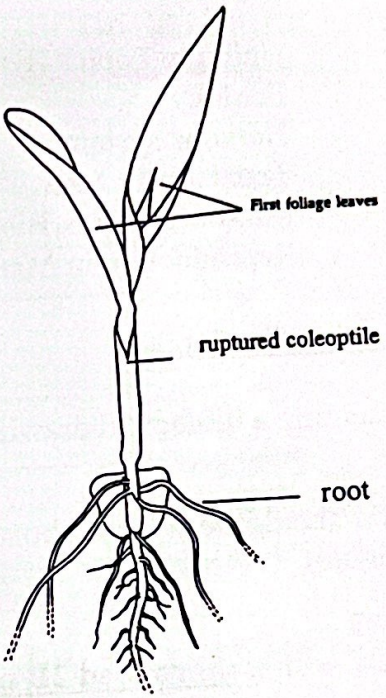


Drawing of external view of a water chestnut (underground storage stem)

Germinating dicotyledonous seed



Germinating monocotyledonous seed



Differences between seedlings grown in the dark and those grown in the light

Seedling grown in sunlight	Seedling grown in the dark
• Leaves and stem are green due to the presence of chlorophyll • Leaves are large and spread out • Internodes are short and stout • Not etiolated • Veins prominent • Root system well established	• Leaves and stem are yellow due to absence of chlorophyll. • Leaves are small and folded • Internodes are long and thin • Etiolated • Veins not prominent • Root system poorly developed

Other topics (Revise Practicals)
Eye
Inheritance
Digestion in Man
Hormone

Unlikely Topics (For Practicals)
Ecology
Nervous system
Transport in Man
Microorganisms/Biotechnology
Reproduction in Man

Drawings and diagrams

When presenting a biological drawing, please include / note the following:

1) **Title**
   - Title should be written above or below drawing. (refer to Fig below for details to include)

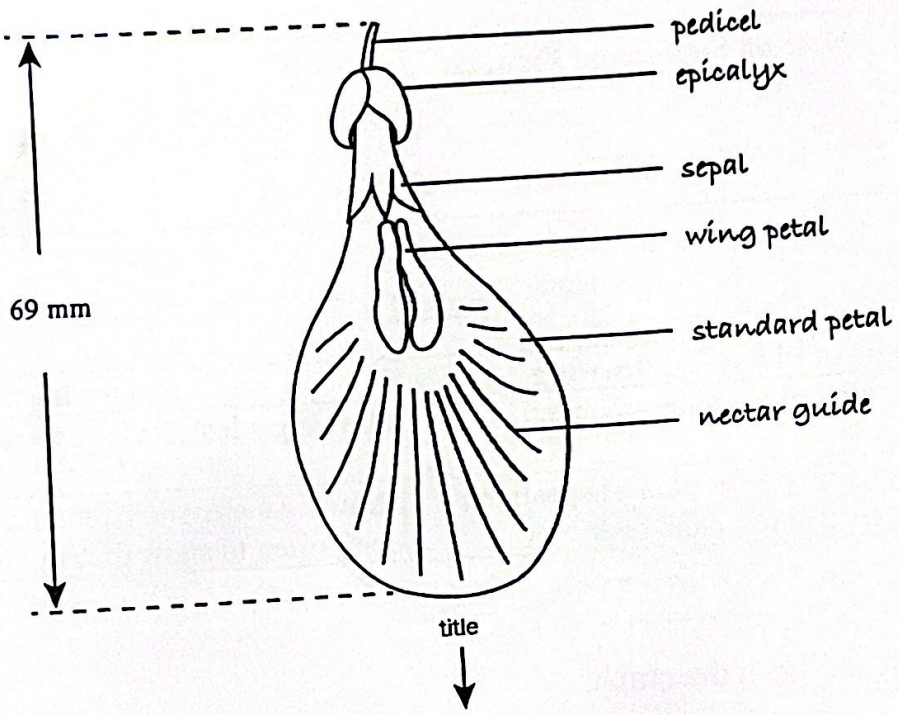
2) **Drawing**
   - Draw with a **sharpened 2B pencil** and make corrections using a soft eraser.
   - Your drawing should be **large** (occupying 2/3 of the available space) and clear.
   - Use smooth, continuous lines to represent all relevant and observable details of the specimen. Draw the outline of the specimen first, draw a clean, clear and sharp outline.
   - Your drawing should be **precise** and in the **accurate proportion** by following closely the shape, structure and proportions of the actual specimen.
   - Use double lines to represent thicker regions of the specimen e.g. the cell wall.
   - Use of compasses, ruler, and correcting fluid must be avoided.
   - Examination rubric should always be studied carefully in order to avoid such practices as labelling when labels are not called for, or more seriously, submitting unlabelled drawings when labelling is specifically requested.

3) **Labels**
   - Label should be written on either side of the drawing and not within the drawing.
   - Use a ruler to draw straight labelling lines to join the labels with their corresponding structures. The lines should not cut across large sections of your drawing or intersect one another. Arrowheads should not be drawn.
   - Annotations, when required, must be clear and comprehensive. Notes may include observations on colour, shape, size, density, distribution and position etc.

4) **Line with Arrowheads drawn**
   - This indicates where measurement was taken and provides a reference of the scale of the drawing as compared to the actual size.
   - Measure the longest length across, unless you are instructed to do otherwise.

5) **Magnification of drawing**

- Should be calculated on the right-hand/left-hand side/bottom of the drawing as shown in the Fig below.
- When labelling is not required : measurements, lines with arrowheads to show where measurements were taken and magnifications should still be included if it is not already asked for in the question.



External features of a clitoria flower

Actual size of flower = 59 mm

$$\text{Magnification} = \frac{\text{Length of drawing}}{\text{Length of original specimen}}$$

$$= \frac{69 \text{ mm}}{59 \text{ mm}}$$

$$= \text{x } 1.2 \text{ (to 2 significant figures)}$$

--- for measurement done in **mm**, magnification should be rounded off to 2 significant figures.
--- measure in **cm** for large specimens only

- If you are asked to draw a magnified diagram from a photograph, then during the calculation of the final magnification, the magnification of the photograph needs to be considered.

e.g photograph magnification = x 2
Magnification of your drawing = x 3.2

Therefore final magnification = 3.2 x 2
= x 6.4 (2 s.f)

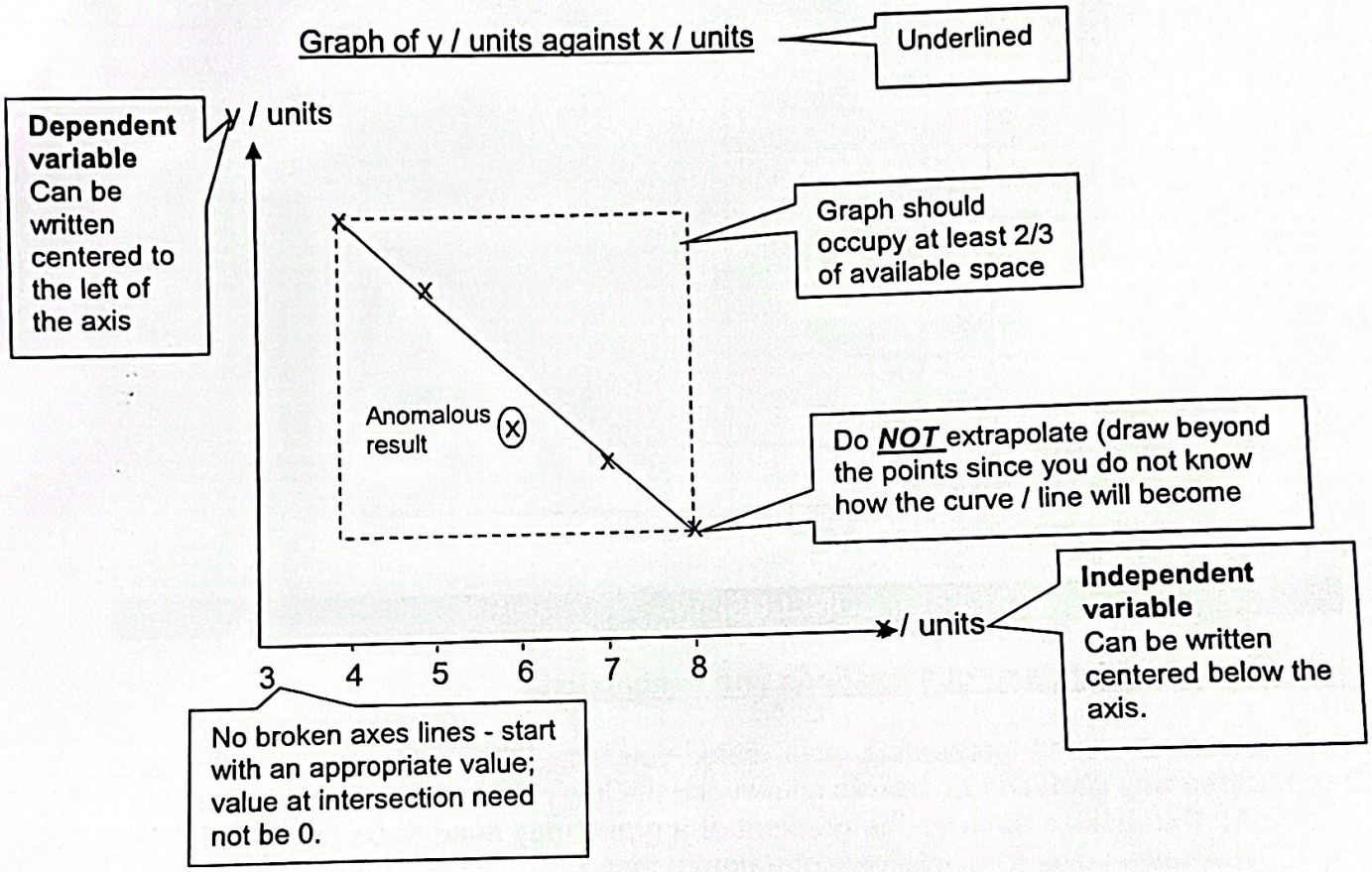
Note on Significant Figures: 3.0 (2 s.f)
0.010 (2 s.f)
10.010 (5.s.f)
520.0 (4 s.f)

Type of biological drawing	Examples
Drawing of a whole specimen	Drawing a leaf, fruit or a cross-section of a fruit
Drawing a low power plan of specimen seen under hand lens	Drawing a cross-section of a stem, root or leaf, often to show distribution of tissues

Graphs
Include the following in the graph:

1) **Title**
   - "**Graph of** *y-axis / units* **against** *x-axis / units*", which should be underlined
2) **Axes**
   - Axes should be labelled with units where applicable in this format "y / units"
   - Labels should be placed at the centre or the ends of the axes.
   - Note the positions of the **independent variable** (x-axis) and the **dependent variable** (y-axis).
3) **Scale**
   - Ensure that the graph covers at least **two-thirds of the space provided.**
   - Mark off the axes at regular intervals. Use intervals that are easily divisible by the number of squares.
   - Do **not** use broken axes lines – start with an appropriate value; value at intersection need not be 0.
4) **Plotting of data points**
   - Data points should be plotted correctly and accurately.
     - Use different symbols to distinguish the points from different sets of experimental data if necessary (do not use different colours).
     - If the line / curve passes through the x axis, the coordinates should be written.

5) **Line / curve of best fit**
   - **'Best-fit'** means that
     - Number of points above and below the line are equal, OR
     - All points fall on the line or curve, with at most one point off the line.
   - **Anomalous results** refer to points falling too far away from the line / curve of best fit and should be ignored where applicable. Indicate this by circling the anomalous plotted point and annotating it as 'anomalous result'.
   - Curves should be drawn with smooth lines.
   - Do **not** extrapolate.



Plotting Histograms

A histogram is a graphical display of the frequency distribution of data using bars. The x-axis is the variable that is being measured, while the y-axis is the frequency in which the variable appears.

For example:

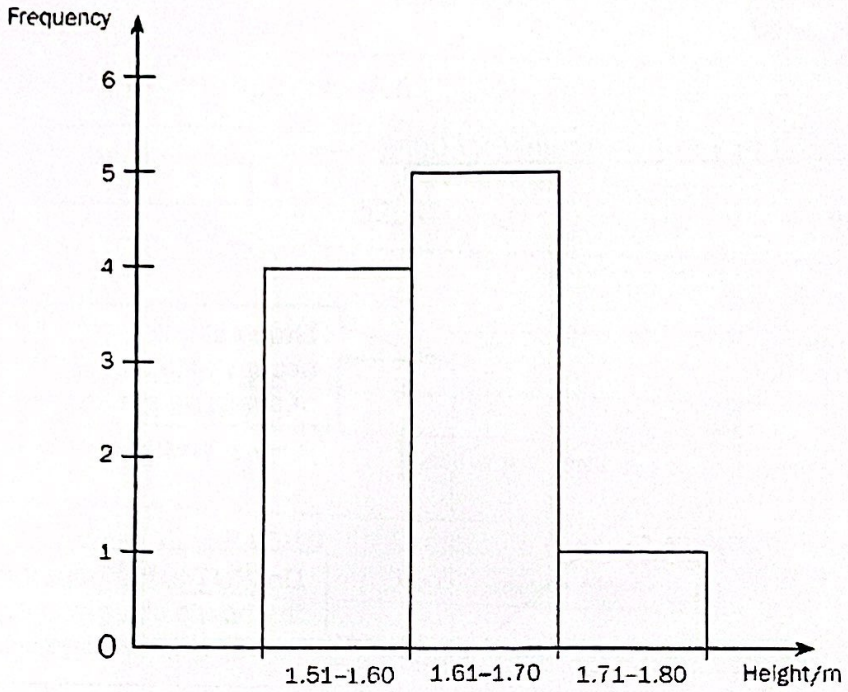
Plot a histogram that shows the frequency of the heights of students in a class of ten.

Range of height of students / m	Frequency
1.51 – 1.60	4
1.61 – 1.70	5
1.71 – 1.80	1

A frequency of 4 in the range of height of students of 1.51 – 1.60 m means that there are 4 students in the class whose heights are between 1.51 m to 1.60 m, for example student A is 1.55 m, student B is 1.56 m, student C is 1.58 m and student D is 1.53 m.

A frequency of 1 in the range of height of students of 1.71 – 1.80 m means that there is only 1 student whose height is between 1.71 m to 1.80 m.

The above data can be represented graphically using a histogram.



ANALYSIS, CONCLUSIONS AND EVALUATION

Interpretation of data or observations and conclusions

After processing and presenting your data, you should be able to **describe and summarise any patterns or trends** shown and the key points of a set of observations.

- Further values such as the gradient of a graph may need to be calculated, or an unknown value (e.g. intercept of a graph) found.
- Quote the values when describing the trend where appropriate.

Useful terms used to describe relationship between two variables (e.g after drawing a graph):

- **Directly proportional / indirectly proportional**
- General **increase / decrease**
- Curve is **linear / non-linear / exponential**
- **Peaks** (maxima) and **troughs** (minima) in the curve
- Curve levels off as a **plateau**

You should use evidence obtained in the experiment to support a given hypothesis, to draw conclusions from the interpretation of observations, data or calculated values and to make scientific (*i.e.* you must use the standard terms of reference) explanations of the data, observations and conclusions.

Discuss whether the trends provide support to the initial prediction and/or reinforce current understanding on the topic. All explanations must be supported by **biological principles.**

Whatever conclusions are drawn, they must be based firmly on the **evidence** obtained from the experiment.

Precision of Instrument

No	Apparatus	Smallest Division	Uncertainty	Examples of recording
1	**Burette**	0.1 cm^3	0.05 cm^3	25.0 cm^3 25.00 cm^3, 25.05 cm^3
2	**Electronic balance**	0.1g	0.1 g	120.0 g, 121.1 g
		0.01 g	0.01 g	121.00 g, 121.10 g
3	**Ruler**	0.1 cm	0.1 cm	12.0 cm, 12.1 cm
4	**Measuring cylinder (100 cm^3)**	1 cm^3	0.5 cm^3	18.0 cm^3, 18.5 cm^3
5	**Stopwatch (analogue)**	0.1 s	0.1 s	36.0 s, 36.1 s
6	**Stopwatch (digital)**	0.1 s	0.1 s	28.1 s
		0.01 s	0.01 s	28.00 s, 28.11 s
7	**Thermometer (–10 °C to 110 °C)**	1 °C	0.5 °C	23.0 °C, 23.5 °C

Conclusion :

Read the whole question to determine aim of experiment and not just a particular sub-question.

Recall the topic tested, look for points related to question and THINK!!!

Good luck!!!