**Table of Contents**

**P530/3**

The practical paper is composed of the following;

1. Zoology macro anatomy
   - Rat
   - Cockroach
   - Toad

1. External features
2. Habitat with reasons
3. Classification (kingdom – order)
4. Superficial features
5. Internal anatomy

- Visceral in situ (undisplaced state)
- Digestive system (Alimentary canal & associated Organs/ structures)
   - Circulatory system
   - Reproductive
   - Excretory
   - Urinogenetical
   - Nervous

2. Physiology

1. Food test
- Test procedure
- Observations
- Deduction

2. Enzyme reactions
- salivary amylase
- Yeast – Amylase
   - Sucrase (invertase) } hydrolyze
- Breaks down glucose
- Pepsin – Trypsin
- Catalase (plant and animal tissues)
- Enzymes from plant structures e.g. seeds, fruits.
- Diffusion
- Osmosis

3. Micro anatomy

- microscope

Fungi – Bread mould
- Mushroom
- prototista – spirogyra
- Plantae

i) Bryophyta
ii) Pteridophyta
iii) tracheophyta (monocots & dicots)
- Transverse sections, cells, pollen grains, spores
- Flowers, fruits, seeds, leaves.
- Worms
- Ticks
- Round worms
- Tape worms
- Liver flukes
- Genetics using seeds
- Arthropods

Practical paper is a paper involving
- Eyes on
- Hands on
- Minds on

# FOOD TEST

Food is any substance taken in i.e digested by the body to provide energy and raw materials for making new tissues or used in important processes of metabolism.

**Food has the following importance**

- Some food protects organisms against diseases like marasmus, kwashiorkor, rickets, beriberi e.t.c.
- Food is required for growth and repair of cells.
- Food provides energy for various chemical activities.
- Food is required in processes in the body for mechanical work.
- Some food is used in manufacture of other chemical compounds e.g. enzymes, hormones which performs various activities in life processes of living organisms.

Food tests are experiments, investigations carried out on various food materials in order to find out the chemical nature of the food they contain. These investigations are carried out in the laboratory.

**Importance of food tests**

Carrying out food tests can enable one to be diagonised to find out which food substance he or she is lacking. This is done medically e.g. through testing urine to find out whether it contains glucose.

**Types (classes of food)**

*There are six types of food, they include:*

- Carbohydrates
- Vitamins and roughages
- Mineral salts
- Water
- Proteins
- Lipids

**Carbohydrates**

These are organic compounds containing carbon, hydrogen and oxygen. They include monosaccharide, disaccharide and polysaccharides.

**Monosaccharide:**

Monosaccharide comes from two Greek words mono meaning one and sacchan meaning sugar therefore monosaccharide are one sugar molecule. They have a general formula $C_6H_{12}O_6$ where the ratio of Hydrogen to Oxygen is 2:1. Monosaccharides are sweet, soluble in water crystallisable. They are found in honey, fruits. Examples of monosaccharide include glucose, fructose and galactose.

**Testing for monosaccharides (reducing sugars)**

**Requirements**

Benedict's solution, unknown solution, test tubes, heat source.

**Procedure:**

Pour $1cm^3$ of unknown solution (solution X) in a test tube ad $1cm^3$of Benedicts solution and boil

**Observation**

The colourless solution turns to pale blue solution green solution, yellow solution, orange precipitate, red precipitate on boiling.

**Conclusions**

Reducing sugar present.

If the solution turns to pale blue solution and remains a pale blue solution on boiling then reducing sugars absent. Monosaccharides are known as reducing sugars because they reduce the $CU^{2+}$ (Copper II ions) in Benedict solution to $CU^{+}$ (copper I ion).

**(ii) Disaccharides (Non reducing sugars)**

Disaccharides comes from two Greek words Di meaning two and sachan meaning sugar therefore Disaccharides is a sugar with two molecules. They have a general formula $C_{12}H_{22}O_{11}$. They are sweet soluble. Examples of Disaccharides include maltose, lactose and sucrose.

| | |
|---|---|
| Maltose (milk sugar) | Glucose + Glucose |
| Lactose (milk sugar) | Glucose + Galactose |
| Sucrose (cane sugar) | Glucose + Fructose |

**Testing for non-reducing sugars**

To get a disaccharide two monosaccharides are added in a process known as condensation in which a water molecule is lost hence the formula $C_{12}H_{22}O_{11}$. Therefore when testing for a non-reducing

sugar is done hydrolysis (breaking down) the disaccharide to simple sugars is done. The process of hydrolysis is done using dilute hydrochloric acid (Hcl). Disaccharides are non-reducing sugars because they do not reduce the $CU^{2+}$ (copper II) ions in Benedicts to $CU^{+}$ (copper ion)

**Requirements**

1. Sodium hydroxide
2. Dilute hydroxide acid
3. Benedict's solution
4. Test tube
5. Unknown solution
6. Heat source

**Procedure:**

Pour $1cm^3$ of solution X in a test tube, add $1cm^3$ of dilute hydrochloric acid and boil, cool, add $1cm^3$ of sodium hydroxide followed by $2cm^3$ of Benedict's solution and boil again.

**Observation:**

The colourless solution turns to pale blue solution green solution, yellow precipitate, orange precipitate on boiling.

**Conclusion**

Non reducing sugars present.

If the colourless solution turns to blue solution on boiling then non reducing sugars absent.

**NB**The hydrochloric acid hydrolyses (breaks down) the non-reducing sugar to reducing sugars. The sodium hydroxide neutralizes the acidic medium. The sodium hydroxide must be added in excess.

(iii) **Polysaccharides**

Polysaccharides comes from poly meaning many and sacchan meaning sugar. Polysaccharides are not sweet, soluble highly in organic substances. Examples include starch, glycogen, cellulose, lignin.

**Test for starch**

**Requirements**

Iodine, dropper, unknown solution, test tube

**Procedure**

Pour $1cm^3$ of solution y in a test tube, add 2 drops of iodine solution.

**Observation**

The white/milky solution turns to blue-black solution. (blue or black)

**Conclusion**:

Starch present

If the white solution turns to pale brown solution/ pale yellow solution then starch absent.

**NB:** No heating is required in this

**Proteins**

These are organic components containing carbon, hydrogen, nitrogen and some contain phosphorus or sulphur. Proteins contain building blocks known as amino acids and these are 20in number. Proteins have the following functions:

- **i)** Fibrous proteins like actin and myosin of muscles cause muscle concentration.
- **ii)** Fibrous protein fibrin is important in blood clotting.
- **iii)** Enzymes are proteins in nature and they catalyse (speed up) bio chemical reactions.
- **iv)** Proteins form antibodies which fight against foreign bodies.
- **v)** Haemoglobin is made up of proteins and is important in carrying oxygen.
- **vi)** Hormones like insulin, adrenalin e.t.c. are proteins.
- **vii)** Proteins offer strength and elasticity e.g. keratin and collagen. Keratin is found in nails. **Lack** of proteins may lead to a deficiency known as kwashiorkor which has the following signs:

- Potted stomach
- Stunted growth
- Brown hair

**Testing for proteins**

*Proteins can be tested using the following*

(i) Burret test
(ii) Millons reagent
(iii) Xanthoproteic test
(iv) Coagulation

**A. Buirret test**

**Requirements**

Sodium hydroxide (NaOH), Copper (II) sulphate ($CuSO_4$) unknown solution, test tube

**Procedure**

To $1cm^3$ of solution A in a test tube add $1cm^3$ of sodium hydroxide solution followed by 3 drops of copper II sulphate.

**Observation**

The turbid solution turns to purple or violet solution.

Protein present

If the colourless solution turns to blue solution then proteins absent.

**NB:** Not heating is required.

B. Millon's reagent

**Requirements**

Millon reagent, test tube, unknown solution, heat source.

**Procedure**

To $1cm^3$ of solution X in a test tube add $1cm^3$ of Millons reagent and boil.

**Observation**

White precipitate turns to pink or red.

**Conclusion**

Proteins absent

If the colour of millons persists, proteins absent

**NB**: In this heating is required.

**C. Xanthoptoteic test**

**Requirements**

- Concentrated nitric acid
- Test tube
- Unknown solution
- Dilute ammonia solution
- Heat source.

**Procedure**

Pour $2cm^3$ of unknown solution in a test tube followed by $1cm^3$ of concentrated nitric acid carefully and heat the mixture.

**Observation**

The precipitate turn orange

**Conclusion**

Proteins present

When it is held in a container and dilutes ammonia solution is added.

**Observation**

The precipitates turn orange

**Conclusion**

Proteins present

**D. Coagulation method**

**Requirements**

Unknown solution, test tube, heat source

**Procedure**

Pour $1cm^3$ of unknown solution in a test tube and boil.

**Observation**

If coagulation occurs then proteins present. If no coagulation occurs proteins absent.

**Lipids**

They are organic compounds containing carbon, hydrogen and oxygen, the ration of hydrogen to oxygen atoms is 2:1. They are grouped into 2 i.e. fats and oil fats are solids at room temperature and come from animals while oils are liquids at room temperature and come from plants. The boiling units ate known as fatty acids and glycerol.

**Functions**

(i) They act as water proofing on body surfaces e.g. waxes.

(ii)They provide vitamin A, E and K.
(iii) They make up hormones e.g. sex hormones, adrenal hormones and bile acids.
(iv) They are components of cell membrane e.g phospholipids and steroids
(v)There are 3 methods these are Storage sources of food in plants since they are in soluble in water.

**Test for lipids**

1. Translucent mark
2. Emulsion test
3. Sudan III reagent

**(i) Translucent mark**

Oily substance, paper, ether

**Procedure**

Wrap on oily substance in a paper.

**Observation**

A translucent mark forms (the mark is transparent) when the paper is dripped in ether the translucent mark disappears.

**Conclusion**

Lipids present

**(ii) Emulsion test**

Unknown solution, test tubes, ethanol and water

**Procedure**

Pour 1cm$^3$ of solution X in a test tube, add 1cm$^3$ of ethanol and shake thoroughly well. Pour the mixture in a test tube containing water.

**Observation**

A cloudy white (milky) emulsion is observed.

**Conclusion**

Lipids present

**(iii) Sudan III Reagent**

**Requirements**

Sudan III, reagent, unknown solution, test tube.

**Procedure**

Pour 1cm$^3$ of unknown solution in a test tube, add 3drops of Sudan III reagent

**Observation**

Red droplets are formed

**Conclusion**

Lipids present

**Vitamin C**

It has a formula $C_6H_8O_6$ and is known as ascorbic acid which is a white crystalline and water soluble. It is found in green vegetables, potatoes, citrus fruit.

**Test for vitamin C**

**Requirements**

- DCPIP (Dichlorophenol Phenol)
- Unknown solution
- Dropper
- Test tube

**Procedure**

Pour 1cm$^3$ of DCPIP in a test tube; add 3 drops of unknown solution.

**Observation**

The deep blue solution turns to a colorless solution

**Conclusion**

Vitamin C present

**If** the deep blue solution remains a deep blue solution vitamin C absent.

**NB**

1. No. of drops used indicates abundance of vitamin C present.
2. Heating is not required, if it is done the ascorbic acid is destroyed therefore the blue colour of DCPIP will persist or more drops of the solution will be needed to decolourise DCPIP

**Functions of vitamin C**

1. It is an essential co enzyme in many metabolic reactions especially proteins break down and buildup of new amino acids to form proteins.
2. It aids on resistence against infection and healing of wounds.
3. Important in growth and maintainence of healthy tissues especially skin blood vessels, bones, gums Deficiency of vitamin C leads to a disease known as scurvy which results in poor collagen formation.

## Physiology

This is hidden theory examined practically

**SUMMARY OF REAGENTS, FOOD SUBSTANCES TESTED AND OBSERVATIONS.**

| **Reagent** | **Food substance tested** | **Colour change if present** | **If absent** |
|---|---|---|---|
| Iodine | Starch | Solution turns to black (blue-black) solution | Solution turns to pale brown solution |
| Millons and boil | Proteins | Solution turns to White precipitate, to pink precipitate | Solution remains colourless |
| Sodium hydroxide and copper II sulphate | Proteins | Solution turns to purple solution or violet solution | Solution turns to blue solution |
| Benedict's or Fehling's and boil | Reducing sugar | Solutions turns to pale blue solution, greensolution, yellow precipiate, orange precipitate or brown precipitate | Solution turns to pale blue solution and remains a pale blue solution |
| Dilute hydrochloric acid, boil, sodium hydroxide Benedict's or Fehling's boil again | Non reducing sugars | Solution turns to pale blue solution, green solution, yellow precipitate, orange precipitate or brown precipitate | Solution turns to pale blue solution and remains a pale blue solution |
| DCPIP | Vitamin C | Deep blue solution turns to colorless solution | Deep blue solution turns to a pale blue solution |
| Water and ethanol | Lipids | White emulsion formed | No emulsion formed |
| Sudan III | Lipids | Red droplets formed | No droplets formed. |

| TEST | OBSERVATION | DEDUCTION |
|---|---|---|
| STARCH/Iodine test<br><br>To $1cm^3$ of solution x/y in a test tube was added 2 drops of Iodine solution | Milky/cloudy solution turned to a black solution<br><br>Colourless solution turned to a pale brown solution | Much starch present<br><br>Starch absent |
| Reducing sugars/Benedict's<br><br>To $1cm^3$ of solution x/y in a test tube was added $1cm^3$ of Benedict's solution and boiled | Colourless solution turned to a pale blue solution, green solution, yellow ppt, orange ppt on boiling.<br><br>Colourless solution turned to a pale blue solution which remained a pale blue solution on boiling. | Much reducing sugars are present<br><br>Reducing sugars absent |

| | | |
|---|---|---|
| Non reducing sugars / hydrolyzing<br><br>To $1cm^3$ of solution x/y in a test tube was added $1cm^3$ of dilute hydrochloric acid and boiled, cooled, $1cm^3$ of dilute sodium hydroxide solution added, followed by $2cm^3$ of Benedict's solution and boiled | Colourless solution turned to a pale blue solution, green solution, yellow ppt, orange ppt on boiling.<br><br>Colourless solution turned to a pale blue solution and remained a pale blue solution on boiling. | Non reducing sugars present<br><br>Non reducing sugars absent |
| Protein / biuret test<br><br>To $1cm^3$ of solution x/y in a test tube was added $1cm^3$ of dilute sodium hydroxide solution followed by 3 drops of copper (ii) sulphate solution | Turbid solution turned to a colourless solution, deep purple solution.<br><br>Turbid solution turned to a colourless solution, pale blue ppt | Much proteins present<br><br>Proteins absent |
| DCPIP / Vitamin C<br><br>To $1cm^3$ of DCPIP solution in a test tube was added 3 drops of solution x/y. | Deep blue solution turned to a colorless solution.<br><br>Deep blue solution turned to a pale blue solution | Vitamin C<br><br>Present<br><br>Vitamin C<br><br>Absent |

Black spects/purple - little starch.
Deep blue solution/ blue solution - moderate starch.
Blue – black/black solution - much starch
Green solution - little reducing sugars
Yellow ppt - moderate reducing sugars.
Orange/brown/red ppt - much reducing sugars
Deep purple - much proteins
Violet - moderate proteins
Pale purple - little proteins

If asked

- Name the nature of the enzyme / solution
  Describe what the enzyme or solution has done e.g.
  -hydrolyzing enzyme
  -digests / hydrolyses / breaks down
- Name the active substance in the solution with reasons
  Give the specific or general name e.g.
  - starch digesting
  - Amylase
  - Catalase
  And give reasons that are general for the enzyme e.g.
  For hydrogen perioxide

***Precautions followed when carrying out food tests***

1. Use clean apparatus like droppers, test tubes or boiling tubes as dirty apparatus will affect results.
2. Use the measurements you have been told, use as little as possible solutions and reagents in order to get clear results.
3. Stir the solutions before as some food substances tend to settle down the beaker.
4. Record the color changes that you observe not what you think or know e.g. if the colour of benedicts turns from blue to green only, record that do not force to red colour this is because the colour series appears due to the quantity of the food substances present.
5. Record your observation in past tense e.g. persisted, remained, turned or present tense. NOT will turn, will persist.
6. Do not use one dropper or syringe from one solution to the other.
7. Do not use lyrics like bluish, darkish, brownish, greenish, and blackish.
8. Statements such as no colour change; no change must not be used when making observations
9. When asked to carry out a test one should always write down the test, reagent used in the test column before making the observations and conclusions.
10. Do not boil where you are not instructed and do not fail to boil where you are instructed to do so.

**NB:** The colour changes will indicate the amount of food substances present e.g.

- Benedicts blue colour changes to green only then little reducing sugars present
- Benedict blue colour turns to green, yellow then moderate reducing sugars present.
- Benedicts blue turns to green, yellow, orange or red, then much reducing sugars present.
- Iodine brown colour to black then much starch present.
- Traces of purple or violet then little proteins present
- Purple or violet observed then much proteins present.

**Example**

(a) You are provided with solution X use the reagents to carry out the following tests:

| **Test/Procedure** | **Observation** | **Conclusion or deduction** |
|---|---|---|
| To $1cm^3$ of solution X in a test tube add 2 drops of iodine solution | The colorless solution turns to black solution | Much starch present |
| To $1cm^3$ of solution X in a test tube add $1cm^3$ of Benedict's and boil | The colorless solution turns to pale blue, solution green solution yellow precipitate on boiling | Moderate reducing sugar present |
| To $1cm^3$ of solution X in a test tube, add $1cm^3$ of sodium hydroxide followed by 3 drops of copper II sulphate | The colorless solution turns to blue solution | Proteins absent |
| To $1cm^3$ of DCPIP in a test tube add 3 drops of solution X | The blue solution turns to colourless solution | Vitamin C present |

(b) Identify the food substance present in solution X
(c) Starch
(d) Reducing sugars
(e) Vitamin C

**<u>Enzymes</u>**

Enzymes are biological catalysts that control the direction and rate of chemical reactions in and out of cells.

Properties or characteristics of enzymes

- They are protein in nature
- They are specific in action
- They are needed in small concentration hence have a high turn over
- Their reactions they control are reservable.
- They work at an optimum PH range
- They are soluble in water
- They are slowed down by some chemicals called inhibitors
- They are not used up in the reaction they catalyse
- They are denatured (destroyed) at high temperatures and inactivated (slowed down) at low temperatures.

**Factors affecting the rate of enzyme activity**

*Enzyme activity is affected by the following*

1. Enzyme concentration
2. Substrate concentration
3. PH of medium
4. Temperature
5. Presence of inhibitors
6. Surface area.

The effects of the above factors are related to the properties of enzymes and are investigated together.

Boiling denatures the enzyme low temperatures inactivate the enzyme. As temperatures increase the rate of reaction increases to a maximum which is the optimum temperature above this the rate decreases. This can be investigated using a water bath where in our laboratories is made using a plastic beaker (mug) since it is a poor conductor of heat. A thermometer, cold water and hot water.

**NB:** Do not breathe heavily near the set up as this can change the temperature conditions. Keep on checking the thermometer reading and adjust the temperature using the cold or hot water.

When boiling is done the enzyme is denatured hence there will be no hydrolysis when an enzyme is boiled. When there is some hydrolysis it means that one did not boil for the required time so some enzymes were not denatured therefore it is important to boil for the specified time. If very cold water or ice are used the enzyme is inactivated hence no hydrolysis takes place. Therefore care should be taken to keep the temperature as specified.

The PH of the medium affects the activity of the enzyme by affecting ionic parts of the enzyme and alters the shape of the enzyme particularly its active sites hence affecting catalytic activity. Optimum PH is that at which the enzyme has maximum activity.

***The table shows enzymes and their optimum PH***

| Enzymes | Optimum PH |
|---|---|
| Pepsin | Acidic |
| Lipase | Alkaline |
| Catalase | Neutral or slightly alkaline |
| Salivary amylase | Neutral or slightly alkaline |
| Trypsin | Neutral or alkaline |

**NB**

It is important to use distilled water in the preparation of the enzyme so as to maintain the PH

**Enzyme controlled reactions**

These include the following reaction.

**(a) Hydrolysis of proteins**

Enzymes that hydrolyse proteins are known as proteases. They include pepsin, trypsin, rennin and are found in the stomach of duodenum. Fresh pineapple juice or apple juice contain these enzymes.Enzyme pepsin hydrolyses proteins in an alkaline PH (medium) while Trypsin does so in a neutral or alkaline PH.

The proteins are hydrolysed (broken down) to amino acids which are highly soluble in water. Most proteins due to their structure form suspensions not solutions.

Hydrolysis is confirmed by the appearance of the suspension. If the suspension remains turbid (milky) then hydrolysis has not taken place and if the suspension clears to form a colourless solution then hydrolysis has taken place.

**(b) Hydrolysis of lipids**

Lipids are taken down to fatty acids and glycerol by enzyme lipase which works in an alkaline PH. Lipase can be synthesized or from living tissues e.g. germinating seeds like castor oil, groundnuts. When hydrolysis has taken place lipids will be absent if hydrolysis has not taken place, lipids will be present.

**(c) Hydrolysis of sucrose**

Sucrose is a non-reducing sugar it is hydrolysed or broken down to glucose and fructose which are reducing sugars.

Sucrose is hydrolysed by enzymes sucrose or zymase which is found mainly in yeast suspension. When hydrolysis has taken place reducing sugar will be found present when benedicts for fehlings are used.

If hydrolysis has not taken place reducing sugar will be absent when the benedicts or Fehling tests are done. Hydrolysis occurs under neutral or alkaline PH.

**NB**

Boiling with hydrochloric acid can also hydrolyze sucrose.

**(d) Hydrolysis of starch**

Starch is hydrolyzed by enzymes amylase or diastase. Amylase is found in saliva and work in a neutral or slightly alkaline. When preparing salivary amylase collect about $2cm^3$ of own saliva in a test tube, dilute it with eave amount of distilled water. It can also be got on germinating seeds e.g. millet and barley, it can also be manufactured.

Diastase is got from germinating seeds e.g. Barley, soya beans or manufactured When preparing the enzymes from germinating seeds, the seeds are crushed, water is added to make an extract and then decanted.

**NB**: Residues should not be included in the extract therefore care must be done

Starch hydrolysed to maltose which is a diasaccharide or reducing sugars therefore iodine or benedicts are used at the end of incubation.

When iodine is used the brown colour persists showing that hydrolysis has occurred if the brown colour of iodine turns to black then starch is present and no hydrolysis has occurred.

When Benedicts is used and the blue colour turns to green, yellow, orange, red, this shows presence of reducing sugars indicating that hydrolysis has occurred, if the blue colour persists No hydrolysis has taken place hence reducing sugars absent.

**NB:**

The type of enzyme involved can be identified from the food test reagents. Properties especially optimum PH of the enzyme is vital and the acid or alkaline are normally labeled unknowns for one to identify them. The recordings of the observation and deductions remain the same as in the identification of the food substances. The explanations should be either: Food substances have been hydrolysed or not hydrolysed. Other physiological processes involving enzymes:

**(i) Decomposition of hydrogen peroxide**

During metabolic reactions in cells toxic (poisonous) substances are produced as waste products e.g. Hydrogen peroxide.

Accumulation of hydrogen peroxide in cells (tissue) would destroy them therefore hydrogen peroxide is decomposed to water and oxygen which are non-toxic, the process of decomposition of hydrogen peroxide ($H_2O_2$) is done by enzyme catalase.

$$2H_2O_2 \xrightarrow{\text{Catalase}} 2H_2O(i) + O_{2(g)}$$

Hydrogen peroxide is produced highest in metabolically active tissues hence containing more catalase.

Catalase is got in living tissues like liver, paw-paw, Irish potatoes. However animal tissues contain more catalase since they are more active compared to plant tissues which are not very active. The amount of catalase can be seen in the rate of decomposition of hydrogen peroxide. As oxygen is given off, bubbles rise from the liquid. Hydrogen peroxide is corrosive therefore should be handled with care. Factors like PH, temperature, surface affect the results in the experiment therefore explanations should be made in reference to these factors e.g. When the tissue is boiled the enzyme is denatured therefore there are no bubbles evolved (no effervescence)

When an alkaline medium is used vigorous affervescence occurs because favourable medium is provided. When crushed tissues are used vigorous effervescence occurs because the surface area has been increased

e.g, You are provided with solution A. solution B, pieces of liver, litmus, dropper, test tubes.

Carry out the following tests and record your observations and deductions in the table below. Label four test tubes 1, 2, 3 and 4. Place a piece of liver tissues provided in each test tube.

| Test tube | Test | Observation | Deduction |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | Add solution A to completely cover the piece of liver tissue add 1cm$^3$ of hydrogen peroxide | Effervescence occurs slowly and few bubbles are evolved. | Hydrogen peroxide is broken down/ decomposed to water and oxygen slowly |
| 2 | Add solution B to completely cover the piece of liver tissue add 1cm$^3$ of hydrogen peroxide | Effervescence occurs slowly and few bubbles are evolved. | Hydrogen peroxide is broken down/decomposed to water and oxygen slowly |
| | Test the mixture with red and blue litmus paper | Blue litmus paper turned red, red litmus remained red | Mixture is acidic |
| 3 | Add distilled water to cover the liver tissue, add 1cm$^3$ of hydrogen peroxide. | Effervescence occurs vigorously and many bubbles are evolved. | Hydrogen peroxide is broken down/decomposed to water and oxygen vigorously |
| | Test the mixture with the red and blue litmus | Red litmus remained red and blue litmus remained blue. | Mixture is neutral |
| 4 | Add distilled water to cover tissue, boil, add 1cm$^3$ of hydrogen peroxide | No effervescence / no bubbling. | No decomposition of hydrogen perioxide. |
| | Test the mixture with red and blue litmus | Blue litmus remained blue and red litmus remained red | Mixture is neutral |

(b) In which test tube was reaction most vigorous?

Test tube 3

(ii) What is the nature of solution?

(i) A-Alkaline / basic

(ii) B- Acidic

(c) In which medium is the active substance in the liver tissue most active? Neutral Medium

(d) What is the active substance in the liver tissue, give reason for your answer.

- It is denatured by heat
- It works in a specific PH

It decomposes hydrogen peroxide to water and oxygen off as a colourless gas.

(iii) What factors are being investigated in this experiment?

- Effect of heat on action of enzymes
- Effect of PH on action of enzymes

(e) What is the effect of heat on the active substance in the liver tissue?

- It denatures the active substance in the liver

Expected observations

Bubbles:

- very many bubbles
- moderate
- few
- very few
- no bubbles.

Effervescence very rapid, moderate, slow, very slow.

Label six test tubes 1, 2,3,4,5 and 6.

Mix the contents in each test tube as follows in the table below and record your observations.

| **Test** | **Observation** | **Deduction** |
|---|---|---|
| 2cm$^3$ of x + 2cm$^3$ of boiled and cooled y. | No effervescence / no bubbling. | No decomposition of solution x. |
| 2cm$^3$ of x + 2cm$^3$ of y at 35$^0$C to 40$^0$C | Very rapid effervescence /very many bubbles. | Very rapid decomposition of x. |
| 2cm$^3$ of y + 1cm$^3$ of HCl +2cm$^3$ of x. | No effervescence / no bubbling. | No decomposition of solution x. |
| 2cm$^3$ of y + 1cm$^3$ of NaOH + 2cm$^3$ of x. | Moderate effervescence/many bubbles. | Moderate decomposition of x. |

| | | |
|---|---|---|
| $2cm^3$ of y + $1cm^3$ of x. | Rapid effervescence/ very many bubbles. | Rapid decomposition of x. |
| $1cm^3$ of y + $2cm^3$ of x. | Moderate effervescence many bubbles. | Moderate decomposition of x. |
| Liver + x. | Very rapid effervescence. | Very rapid decomposition. |
| Lung + x. | Moderate effervescence. | Moderate decomposition. |
| Muscle + x | Moderate effervescence. | Moderate decomposition. |

Correctly identify the solution with the enzyme. For solution y has an active substance, which catalyse the breakdown of substrate in solution x.

**NB**

Rapid/ slow/ moderate effervescence
Many/ few bubbles
Rapid/ slow bubbling
No effervescence
} For observation

Don't record no observable change/ reaction

$H_2O_2$ decomposed/ broken down rapidly/ slowly/ moderately for conclusion don't write $H_2O_2$ hydrolyzed.

**QN.** Explain the result in test tube 1.

$T_1$ Boiling denature the active substance, resulting in no breakdown of substrate in solution x.
$35^0C$- $40^0C$ temperature provides optimum temperature which provides high kinetic energy increasing the chances of active substance and substrate molecules colliding resulting in very high rate of decomposition.

$T_2$. Room temperature provides low kinetic energy reducing chances of collusion between active substance and substrate molecules resulting in low rate of decomposition.

$T_3$. Addition of HCl provides unfavourable medium, resulting in denaturation of active substance resulting in no collusion not reacting molecules hence no decomposition of x.

$T_4$. Addition of solution hydroxide provides unfavourable medium which inhibit active substance resulting in reduced collusion of reacting molecules with reduced rate of breakdown of x.

$T_5$. Highest concentration of active substance of many active sites at any time increasing the chances of collusion with the substrate molecules causing a faster rate of breakdown of x.

$T_6$ Low concentration of active substance of few active sites reduced the chances of collision between substrate / of reacting molecules and reduced the rate of breakdown of x.

**Aim**: Investigate the effect of substrate concentration on the rate of reaction.

(i) Label **5** test tube as **1,2,3,4,** and **5,** and in each , make solution **X** as follows:

| Test tube | Vol. of **X**(ml) | Distilled water (ml) | Height of mixture (mm) |
|---|---|---|---|
| 1 | 20 | 0 | |
| 2 | 15 | 5 | |
| 3 | 10 | 10 | |
| 4 | 5 | 15 | |
| 5 | 0 | 20 | |

(ii) Use a ruler to measure and record the depth of the mixture in each test tube.

(iii) Accurately cut five (5) square piece from the filter paper, each of dimensions 5 mm x 5 mm (0.5 cm x 0.5 cm).

(iv) **Stir or shake** solution **Y** to mix the contents.

(v) Use forceps to dip one piece of filter paper into solution **Y** and drain the filter paper by touching it to the edge of test tube.

(vi) Drop the filter into test tube 1 and time how long it takes the filter paper to rise to the surface of **X.**

Repeat step (vi) for test tubes 2, 3, 4 and 5, ensuring that each time you use a different piece of filter paper.

(a) Complete the table below.

| Test tube | Time taken for paper to rise to surface of **X**(sec.) | Rate of reaction (mm $sec^{-1}$) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

Rate of reaction = Height or depth of **X** (mm) / time (sec).

**EXPLANATIONS:**

**TT1:** Substrate in X very much concentrated; very many catalase enzyme active sites in Y reacted; decomposing X into very many bubbles; which pushed the paper to rise very fast;

**TT2:** Substrate in X much concentrated; many catalase enzyme active sites in Y reacted; decomposing X into many bubbles; which pushed the paper rise fast;

**TT3:** Substrate in X moderately concentrated immediately many catalase enzyme active sites in Y reacted; decomposing X into moderately many bubbles; which pushed the paper to rise moderately fast;

**TT4:** Substrate in X in low concentration; few catalase enzyme active sites in Y reacted; decomposing X into few bubbles; which pushed the paper to rise slowly moderately many bubbles; which pushed the paper to rise slowly;

**TT5:** Substrate in X in very low concentration; very few catalase enzyme active sites in Y reacted; decomposing X into very few bubbles; which pushed the paper to rise slowly moderately many bubbles; which pushed the paper to rise slowly;

**Presentation of data using a suitable graph.**

*Graph of rate of reaction in different test tubes.*

***[Bar graph – Vert. Rate*** (mm $sec^{-1}$), **Hor. Test tubes**]

*Graph of time taken for paper to rise to surface of* **X** *in different test tubes.*

***[Bar graph – Vert. time taken for paper to rise (***sec), **Hor. Test tubes**]

*Graph of rate of reaction with volume of* **X**.

***[LINE GRAPH – Vert. Time take for paper to rise*** (sec), **Hor. Volume of X**]

*Graph of time taken for paper to rise to surface in different volume of* **X**.

| T.T | Observations | Deduction |
|---|---|---|
| **1** | Very many bubbles, paper rises to the surface very fast. | Solution **X** decomposed very fast by enzyme in **Y**. |
| **2** | Many bubbles, paper rises to the surface fast. | Solution **X** decomposed fast by enzyme in **Y**. |
| **3.** | Moderately many bubbles, paper rises to the surface moderately fast | Solution **X** decomposed moderately fast by enzyme in **Y**. |
| **4.** | Few bubbles, paper rises to the surface slowly | Solution **X** decomposed slowly by enzyme in **Y**. |
| **5.** | Very few bubbles, paper rises to the surface very slowly. | Solution **X** decomposed very slowly by enzyme in **Y**. |

**QN. 2**

(a) You are provided with extract **Q** which is from a plant organ and solution **P** which is a common laboratory reagent.
Carry out tests indicated in the table 1 below on the extract. Record your tests, observations and conclusions. *(15 marks)*
*Table 1*

| Test | Observations | Conclusions |
|---|---|---|
| Iodine | | |
| Reducing sugar | | |
| Burette | | |
| DCPIP Test | | |

(b) Cut out the stomach and the pancreas from specimen **K** of question 1. Open and discard the stomach contents. Cut it into small pieces then crush into a fine paste using a motor and pestle,

add 10cm$^3$ of water stir, leave to stand and decant into a test tube to obtain an extract labeled S. Repeat the same procedure for the pancreas and label the extract **T**.

Label test tube 1 and 2. In each test tube add 5cm$^3$ of extract **Q** add 2cm$^3$ of extract **S** to test tube 1 and 2cm$^3$ of extract **T** to test tube 2. Incubate the contents of the two test tubes at 35 – 40$^0$C for 1 hour while agitating occasionally. After this time, carry out the following tests. Record your observations and conclusions in table 2 below.

| **Test** | **Observations** | | **Conclusions** |
|---|---|---|---|
| Iodine | S + Q | | |
| | T + Q | | |
| Reducing sugar | S + Q | | |
| | T + Q | | |
| Biurete | S + Q | | |
| | T + Q | | |

Explain your results in table 2 with reference to table 1.

(c) Obtain two cubes: one from the liver and one from the thigh muscle. Crush them to obtain extracts. Transfer the extracts in 1 cm$^3$ of solution **P.** Record your observations and conclusions in the table below.

| Cube | Thigh muscle extract + **P** | Liver extract + **P** | **Q + P** |
|---|---|---|---|
| Observations | | | |
| Conclusions | | | |

Explain your results.

……

……

(d) You are provided with extract **Q** and solution **P.**

Make the following mixtures of **P** and water or NaOH or HCl as shown in the table below to obtain solutions in 7 test tubes.

| **Test tube** | **Volume of P** | **Volume of water/HCl/NaOH** |
|---|---|---|
| 1 | 10 | 0 of water |
| 2 | 8 | 2 of water |
| 3 | 6 | 4 of water |
| 4 | 3 | 7 of water |
| 5 | 1 | 9 of water |
| 6 | 8 | 2 cm$^3$ of NaOH |
| 7 | 8 | 2 cm$^3$ of HCl |

From the filter paper measure and cut out seven pieces measuring 5mm x 5mm. place in a dry petri dish. Remove one square piece of filter paper and soak in the extract **Q**. Use glass rod or spatula r forceps to remove and introduce into solution in test tube 1 as you start the stop clock.

Stop the clock when it is back to the surface. Repeat with test tubes 2 to 7. For each in the table the observation and time.

| **Test tube** | **Observation** | **Time taken/seconds** |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

(e) What is contained in extract **Q**?

……

(f) Using the results in the above table,

(i) Plot a histogram to represent the results in the table above.

(ii) What is the practical about?

……

(iii) Explain your observation in test tube 1.

……

……

(iv) Explain the differences (if any) in your findings in the experiment.

……

……

(g) Obtain three test tubes 1 – 3. To each add 1 ml of solution **P**, to test tube 1, add 2 drops of HCl, to test tube 2 add 2 drops of NaOH. Starting with test tube 1, add 1cm$^3$ of extract **Q** and start a stop clock. Record the length of the test tube contents after every 5 seconds for 30 seconds. Repeat the procedure for test tubes 2 and 3. Record your results in table below.

| Time | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|
| Test tube 1/cm | 5 | 5 | 5 | 5 | 5 | 5 |
| Test tube 2/cm | 6.0 | 6.2 | 6.5 | 6.8 | 7.0 | 7.8 |
| Test tube 3/cm | 7.0 | 7.4 | 7.6 | 8.2 | 8.8 | 9.2 |

Plot the results on a graph paper.

Explain your results.

……

……

(d) Obtain 7 test tubes with label paper 1.7. Add 4cm$^3$ of distilled water to each of the test tubes. Then add the volume of extract **Y** indicated in the table below for each of the test tubes. Add 5cm$^3$ of solution **X** in test tube. Read and record the temperature after 60 seconds in the table below.

Repeat the procedure for the remaining test tubes and record your readings in the table.

| T.T | Vol. of Y(cm$^3$) | Temperature of extract | Temperature of mixture after 60 seconds in $^0$C | Rate of reaction |
|---|---|---|---|---|
| 1 | 1.0 | | | |
| 2 | 1.5 | | | |
| 3 | 2.0 | | | |
| 4. | 2.5 | | | |
| 5 | 4.0 | | | |
| 6 | 6.0 | | | |
| 7 | 8.0 | | | |

| **Test tube** | **Observation** | **Time taken/seconds** |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

(c) Obtain 5 test tubes and label them 1-5. Add contents as indicated below

Record your observations in the table below including the height formed in each test tube (measured using the ruler provided.

| Test tube | Observation | Height |
|---|---|---|
| 1 | | |
| 2 | | |

**Enzyme activity**

*Introduction:*

**Properties of enzymes**

- Enzymes are organic catalysts of high molecular weight and complex structure, occurring in the protoplasm of living cells.
- Enzymes are proteins in nature and have all properties of proteins. The enzymes act by lowering activation energy required to initiate a particular reaction.
- Enzymes are specific in their action in that a single enzyme will only catalyse a particular chemical reaction.
- The activity of enzymes is affected by environmental factors like temperature and PH.

**Classification of enzymes**

**1. Hydrolytic enzymes**

These act by catalyzing addition of water molecules to a substrate to break it loose into smaller sub units.

(a) **Those acting on carbohydrates**.

**i)** Amylase / diastase: Catalyses conversion of starch to maltose and dextrin.
**ii)** Maltase: Catalyses conversion of maltose to glucose.
**iii)** Sucrase: Catalyses conversion of sucrose to fructrose and glucose
**iv)** Cellulase: Catalyses conversion of cellulose sugars to glucose

(b) **Proteolytic enzymes**.

These are hydrolytic enzymes acting on proteins, catalyzing their conversion to peptones/peptides and amino acids.

Examples include;

**i)** Pepsin – conversion of protein to peptones
**ii)** Trypsin – conversion of proteins to polypeptides and amino acids.

**(c) Those acting on lipids**

Those are called lipases and they catalyse conversion of lipids to fatty acids and glycerol

**2. Oxidation – reduction enzymes**

**(a) Oxidases:**

These are generally respiratory enzymes, catalyzing oxidation of chemical compounds in the presence of oxygen to produce energy. For example cytochrome oxidase enzymes.

**(b) Reductases**

These are respiratory enzymes catalyzing reduction of chemical compounds in the body.

**(c) Catalases:**

These decompose hydrogen peroxide ($H_2O_2$) to water ($H_2O$) and oxygen ($O_2$). They are widely distributed in living tissue of plants and animals.

**(d) Zymase:**

This is a complex of several enzymes usually extracted from yeast cells and concerned with redox processes. It is important in fermentation ie converting glucose to Ethyl alcohol and carbondioxide and finds use in breweries.

**Effects of heat on Ascorbic acid**

Ascorbic acid is very unstable to heat and is readily oxidized in air. To investigate the effect of heat on ascorbic acid, the following experiment is done.

**Requirements:**

- Fruit juice
- DCPIP solution
- 4 test – tubes
- 4 plastic cups
- Cold water
- Hot water

**Procedure**

(i) Add $2cm^3$ of fruit juice to four different test- tubes.
(ii) Incubate the test tubes in water baths maintained at $30^0c$, $40^0c$, $50^0c$ and $60^0c$ respectively for 10 minutes.
(iii) Test for presence of ascorbic acid in each test tube.

NB. Note the number of drops that decolorize the DCPIP

| TETEMPERATURE ($^0$C) | OBSERVATION | DEDUCTION |
|---|---|---|
| 30 | The deep blue solution turned to colorless solution | Ascorbic acid present |
| 40 | The deep blue solution turned to colorless solution | Ascorbic acid present |
| 50 | The deep blue solution remained a deep blue solution | Ascorbic acid nolonger present |
| 60 | The deep blue solution remained a deep blue solution | Ascorbic acid no longer present |

**Biological significance of the result**

**Ascorbic acid/vitamin c** is unstable to heat. Therefore to be of any nutritional value, food substances containing ascorbic acid should not be exposed to high temperature ie should not be cooked but consumed in raw form.

**Enzyme activity in relation to external factors**

**1. Temperature**

Being protein in nature, enzymes are liable to progressive disruption and coagulation when exposed to temperatures above certain critical values. The optimum temperature is that at which the enzyme catalyses its particular reaction at a maximum rate.

High temperature disrupts the primary structure of the enzyme and the substrate a process called **denaturation**

**EXPERIMENT I**

**Action of enzyme diastase on starch**

One way of investigating the influence of heat on the action of an enzyme is to expose the enzyme to a given temperature for a known period of time and to estimate how long it takes to catalyze is particular **reaction**.

In this experiment, samples of the enzyme diastase are exposed to different temperatures for exactly 5 minutes. The time required for each sample to hydrolyze a given amount of starch is then estimated.

**Requirements**;

- Five test tubes in a test tube rack
- Pipette ($3cm^3$)
- White tile
- Six glass rods
- Water baths maintained at $35^0$, $40^0$, $60^0$ and $80^0$
- $25cm^3$ of 0.5% starch
- $25cm^3$ of 0.2% diastase
- Dilute iodine solution

**PROCEDURE**:

- Label five test tubes, room temperature (control), $35^0$c, $40^0$c, $60^0$c and $80^0$c. To eac add

**(i)** $5cm^3$ of diastase solution.

**(ii)** Place each tube in the appropriate water bath for exactly five minutes. The first tube should be kept at room temperature.

**(iii)** At the end of the 5 minutes. Remove the tubes from the water baths and cool them rapidly to room temperature.

**(iv)** Now add, to each $5cm^3$ of starch solution and mix with a clean glass rod

**(v)** At intervals of 5 minutes, test each for the presence of the starch. Withdraw one drop of the starch – diastase mixture, place it on a white tile, and add one drop of Iodine solution.

NB: Avoid contaminating the mixtures by using a glass rod for each tube and a separate glass rod for the Iodine solution

**(vi)** Make a complete record of your observation, a in particular, how long it takes in each case before a blue colour ceases to be given when Iodine is added to the mixture.

**(vii)** Calculate activity or reaction rate 1/t, where t is the time taken for starch to be hydrolyzed.

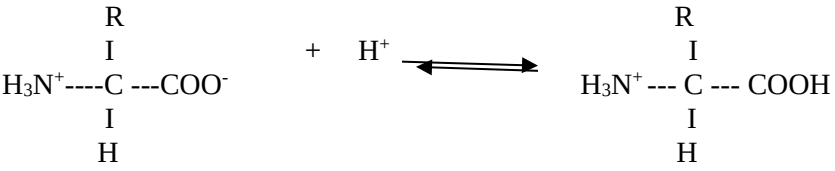
**(viii)** Plot a graph of reaction rate against temperature. Determine the optimum temperature for the action of diastase enzyme.

NB. All enzymes that work on hydrolysis of food substrates in the body of humans have optimum temperature around the body temperature. i.e $35^0 – 40^0$c

**$P^H$**

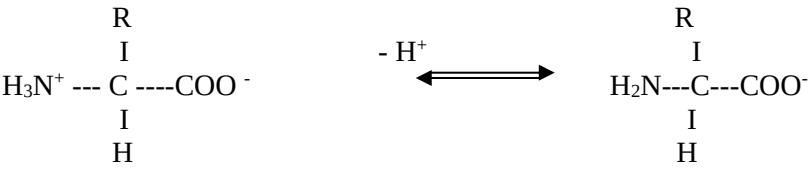
Like other proteins, enzymes are sensitive to PH of the medium in which they occur. The PH of the medium affects the character of the ionic bounding, both within the enzyme module and between the adjacent enzyme molecules.

In acid condition, for example, hydrogen ions are taken up by the carboxyl groups of the carboxyl terminal of a protein ie




(Proteins in a neutral solution) (Proteins in an acidic solution)

In alkaline conditions on the other hand, hydrogen Ions are released from the amino group of the amino terminal of the proteins ie




(Protein in a neutral solution) (Protein in an alkaline solution)

The above events disrupt the primary structure of the enzyme and therefore a given enzyme molecule will only 'fit' its substrate molecule over a limited $P^H$ range or at a particular $P^H$.

**EXPERIMENT II**

**To show the action of salivary amylase/ ptyalin on starch at different $p^h$ values**

**Requirements:**

- 4 test tubes
- 1 – 2% starch solution
- Salivary amylase; prepared as follows;
  Rinse your mouth with about 10.0$cm^3$ of warm water to obtain 10$cm^3$ of saliva solution (saliva contains salivary amylase)
- Dilute Hydrochloric acid
- 5% NaOH solution
- Water bath maintained at $37^0$C

**PROCEDURE**

(i) Set up four (40 test tubes in a rack and add the contents as follows;

- To test tube 1, add 5$cm^3$ of starch solutions followed by 1$cm^3$ of saliva solution.
- To test tube 2, add 5$cm^3$ of starch solution followed by 1$cm^3$ of saliva plus 5drops of dilute HCl
- To test tube 3, add 5$cm^3$ of starch solution plus 5drops of 5% NaOH
- To test tube 4, add 5$cm^3$ of starch solution, followed by 1$cm^3$ of saliva plus 5 drops of 5% NaOH

(ii) Place the test tubes in a water bath maintained at a temperature of $37^0$c for 15 minutes

(iii) After 15 minutes, withdraw a drop of each solution and add it to a drop of Iodine on a white tile.

**RESULTS**

The results are shown in the table below.

| Test Tube | Observation | Deduction |
|---|---|---|
| 1 | The colourless solution turned to a brown solution/yellow solution | Starch hydrolised, therefore no longer present |
| 2 | The colourless solution turned to blue solution | Starch present |
| 3 | The colourless solution turned to a blue solution | Starch present |

| | | |
|---|---|---|
| 4 | The colourless solution turned to a brown solution/yellow solution | Starch hydrolised, therefore nolonger present. |

**EXPLAINATION**

**Test tube 1**

Starch was nolonger present at the end of 15 minutes. All starch has been converted by ptyalin to dextrin and maltose. Hence the absence of blue colour with Iodine

**Test tube 2**

Starch was present at the end of 15 minutes, because it was not acted on by ptyalin in the acidic medium.

**Test tube 3**

Starch was present after the 15 minutes because there was no enzyme to act on it even when appropriate temperature of $37^0$c and alkaline PH was present.

**Test tube 4**

Starch was nolonger present at the end of 15 minutes. All starch has been converted by ptyalin to dextrin and maltose. Hence the absence of blue colour with Iodine. This is because appropriate conditions of temperature $37^0$c and alkaline PH are present.

**CONCLUSSION**

(i) At $37^0$c ptyalin converts starch to dextrin and maltose

(ii) Ptyalin acts best in neutral or slightly alkaline conditions and is inactive in acidic medium.

**EXPERIMENT III**

**Action of proteolytic enzyme on albumen**

**Requirement:**

- Solution of egg albumen made by getting egg albumen from one egg and mixed with 1litre of distilled water to make solution.
- Eight (8) test tubes in a rack
- 5% NaOH solution
- Dilute HCl
- 1% pepsin solution
- Water bath maintained at $37^0$c

**PROCEDURE**

(i) Label four (4) test tube $T_1$, $T_2$, $T_3$ and $T_4$ and put them in a test tube rack

(ii) Add the contents to the test tubes as follows;

- To $T_1$ add $2cm^3$ of albumen solution plus $1cm^3$ of pepsin solution and 4 drops of 5% NaOH solution
- To $T_2$ add $2cm^3$ of albumen solution plus $1cm^3$ of pepsin solution and 4 drops of dilute HCl solution
- To $T_3$ add $2cm^3$ of albumen solution plus $1cm^3$ of pepsin solution
- To $T_4$ add $2cm^3$ of albumen, 5 drops of dilute HCl.

(iii) Place the test tubes in a water bath maintained at $37^0$c for 15 minutes.

(iv) After 15 minutes observe and record the nature of the findings.

(v) Record your results in a suitable table.

**RESULTS**

| Test Tube | Observation | Deduction |
|---|---|---|
| $T_1$ | The turbid solution remained a turbid solution | No hydrolysis / digestion occurred. |
| $T_2$ | The turbid solution turned to a clear solution | Hydrolysis / digestion of proteins occurred |
| $T_3$ | The turbid solution remained a turbid solution | No hydrolysis/digestion occurred |
| $T_4$ | The turbid solution remained a turbid solution | No hydrolysis / digestion occurred |

**EXPLAINATION**

$T_1$: Turned to a clear solution because the protein was digested by the enzyme in appropriate conditions of temperature $37^0$c and acidic PH.

$T_{2, 3, 4}$: The solution remained turbid because the protein was not hydrolyzed for different reasons.

- In $T_1$ the alkaline PH did not favour the enzyme action since it works well in acidic PH

- $T_3$ neutral PH was not favorable
- $T_4$ there was no enzyme though the conditions were favorable

**CONCLUSSION**

- Pepsin hydrolyses protein at $37^0$c
- Pepsin acts well in acid medium and is inhibited by neutral and alkaline media

**2. Enzyme specificity**

Enzymes work on specific substrates not on a range of substrates. This supports the idea that the active site if an enzyme molecule is three dimensional and can only fit a particular substrate and shape like a key in a lock eg pepsin works on proteins not starch vice versa amylase works on starch not proteins.

**3. Substrate concentration**

As the hypothesis states, an enzyme acts on substrates by forming an enzyme substrate complex at the enzyme active site. It follows therefore that there should be a limit to the amount of substrates that can be changed at any one given time than the amount of enzyme present

A study of the effect of substrate concentration on enzyme activity can be made by studying the effect of zymase on fermentation of sucrose

**EXPERIMENT IV**

**The effect of enzyme zymase on various sucrose concentrations**

**Requirements:**

- Sucrose of solutions of varying concentrations 0.1%, 0.05%, 0.025% and 0.0125%
- Zymase solution (Solution of budding yeast cells)
- Benedict's solution
- Water bath of $37^0$c
- Test tubes and a rack

**PROCEDURE**

- Label four (4) test tubes with different concentration of sucrose ie 0.1%, 0.05%, 0.025% and 0.0125%
- Put $5cm^3$ of each of these solutions in their respective test tubes
- Add $2cm^3$ of zymase solution to each test tube
- Place them in a water bath maintained at $37^0$c for 15 minutes
- Perform benedicts test on each test tube. Note and compare the range of colour changes produced and try to grade them.

**Hydrolysis of sucrose by invertase**

This enzyme is found in yeast and brings about the conversion of sucrose to glucose and fructose, both of which are reducing sugars.

In this experiment, the sucrose yeast suspension is kept at temperature around $37^0$c for some time, after which the sample is tested for reducing sugars using **B**enedict's/ **F**ehling's solution. You should be able to recognize this test and to note that in cases when one is asked to test either the yeast solution or sucrose solution with **B**enedict's/**F**ehling's solution negative results are expected. (These are actually control experiments)

**Alcoholic fermentation using enzymes in yeast**

Take care to note that this experiment and the one described above look similar.

But in this case the sugar used is glucose and the experiment is done under anaerobic conditions. The results are tested using solutions of indicators or lime water (calcium hydroxide). The other product alcohol apart from being its otherwise sweet aroma (odour) may not be tested at this level. The $CO_2$ reacts with water in these solutions to form a weak solution of carbonic acid ($H_2CO_3$) which is then detected by these indicators.

When lime water is used it changes to milky (or cloudy) due to the formation of calcium carbonate in the presence of $CO_2$

**General sources of error during the experiment.**

(i) Time: The enzyme should be allowed the full – time given/started to carry out the reaction. However, extra time does not affect the results.

(ii) Arrangement of the apparatus. The delivery tube must reach the indicator lime water solution. If this is not done the resulting $CO_2$ gas does not bubble through this solution and consequently no colour change is observed
(iii) For getting to add oil, obviously allows in air and water other than alcohol.
(iv) Failure to cork the test tube in such a way that it is tight has similar effect to those outlined in (iii) above
(v) Using unclean test tubes, the indicator may change colour before thereaction proceeds due to impurities in the test tubes

## OSMOSIS

It is important to master the concept of osmosis and to be able to apply terms relating to plant water relations like flaccid turgid, plasmolysed correctly.

One should have a great theoretical back ground in regards to osmosis when carrying out experiments on it.

Osmosis is the movement of water from a region of higher water potential to one of lower water potential across a selectively permeable membrane.

**Plant – water relations**

The basic plant – water relations equation is $\Psi$cell = ΨS + ΨP. Ie water potential is equal to the solute potential plus the pressure potential, where water potential is the tendency of a cell to draw in water by osmosis. The water potential of pure water is zero. Addition of solutes to water lowers the water potential making it negative hence osmosis is in a sense movement of water from a less negative to a more negative solution.

The cell membrane is a selective permeable membrane. Water potential is measured in kpa.

Solute potential is the component of the water potential dual to the presence of solute molecules. It always has a negative value as solutes lower the water potential of a system.

Pressure potential is the component of water due to the hydrostatic pressure that is exerted on water in a cell by the cell wall.

In turgid plant cell, it has a positive value, in xylem vessels, there is negative water potential or tension as a result of transpiration, water on atmospheric pressure has a pressure potential of zero.

Flaccid describes a plant tissue in which the cells have been plasmolysed and the tissue has become soft and less rigid.

**NB**: This term is not applicable to animal tissues.

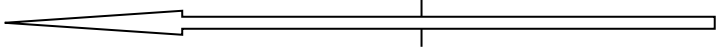
Turgid is where a plant cell the turgor pressure is maintained at a normal level. Turgid cells have taken in a maximum amount of water and their protoplast is distended pushing the protoplast against the cell wall and is therefore at its maximum size.

**NB:** this term applies to cells and not tissues of plants. Its not applicable to animal cells or tissues.

Plasmolysis is the shrinkage and contraction of the protoplast of a plant cell when the cell is placed in a hypertonic solution.

**Relationship between terms**

| | | |
|---|---|---|
| Low water potential | | High water potential |
| More negative water potential | | Less negative water potential |
| High solute concentration | | Low solute concentration |
| Hypertonic solution | isotonic solution | Hypotonic solution |



***Direction of water movement***

Experiments of this nature can easily be detected from almost in variable use of sucrose solutions of various concentrations or molarities with plant tissues eg stem cuttings, cylinders cut using a cork borer from a potato, pawpaw, etc.

- **Curvature of plant tissues:**
  Solutions of various concentrations of sucrose or salt and a young soft stem of a plant eg comelina or young flower stalks of canalily or any other plant. The stem or stalk is the cut into equal strips and one is placed in each solution and allowed to stand for some time.
  Observe the strips and feel them using your figure after this period of time.
  The strips tend to curve in some solutions and remain unchanged in others.
  The degree of curvature is a measure of the extent of osmosis and of the relative strength of the external solution in relation to the cell sap.
- Strips in solutions whose concentrations are near or similar to that of the cell sap ie isotonic solution remain straight/retain original degree of curvature and are strong
- Strips in solutions of lower water potential than their cell sap ie hypertonic solution curve outward with the epidermis inner most and are strong and rigid. This is because the cortical cells have taken in water by osmosis and expanded more than the epidermal cells.

- Strips in solutions of higher water potential than cell sap ie hypotonic solutions curve inwards with the epidermis outer most and are weak. This is because the cortical cells have lost water by osmosis and shrunk more than the epidermal cells
- Change in volume:
  In this experiment, instead of measuring the length of the potato cylinders/strips, volume will be considered.
- Change in length:
  In this experiment, change in length is got by final length minus initial length.
  Percentage change in length is got by $\frac{\text{final length minus initial length}}{\textit{initial length}}$ **X 100**

  A typical growth of percentage change in length of potato cylinders with sucrose concentration can be plotted.
- Change in density(determination of water potential of plant cells)
  In this experiment two sets of sucrose solutions of varying concentrations e.g.;
  Are arranged in test tubes in two raws with one them stained with a coloured dye e.g. methlene blue plant material e.g. potato disc or strips;; cassava leaves etc are placed in the plant material is removed and using a pipette or dropper a drop of coloured solution is transferred into each of the clear solutions of the same concentrations just below the surface beginning from the most dilute to most concentrated
  The behavior of the coloured drop is then used to tell whether the external solution has more or less water potential than the plant material that were in it
  Generally where the drop rises the solution is at a higher water potential than the plant material and therefore water had entered the plant material by osmosis causing the surrounding solution to be more dense.
  Where the drop remains stable the solution was at the same water potential to that of the cells in the plant material therefore there was no net movement of water and the density remained the same
  Where the drop sinks the solution is of lower water potential than the plant material and water moved out of the plant material by osmosis into the solution there by causing it to be less dense
  Note this experiment uses the level of plasmolysis to determine the water potential of plant material usually cells of leaf epidermis:

**Important terms used**

- Osmotic pressure: The ability of plant tissue or solution to take in water molecules. It's usually positive and a cell / solution which is highly concentrated has the highest osmotic potential.
- Osmotic Potential: It's always negative and is similar in definition as above or the reduction in water potential as a result of adding solute molecules to solution. A solution with lower water potential has more solutes and hence high osmotic pressure such that it takes in much water by osmosis. Conversely a solution with higher osmotic potential (less negative) has less ability to gain water by osmosis.
- Solute potential: This is similar to osmotic potential, a solution with the lowest solute potential is more negative and has great tendency to take in water by osmosis.
- Water potential: This is the ability of a plant tissue to lose water. It is always negative. A solution with a less negative water potential higher water potential or is more dilute and hence it easily loses water. A solution with the lowest water potential has a lower ability to lose water.
- Hypotonic solution: This is a solution which is more dilute and can easily lose water to a concentrated plant tissue.
- Isotonic solution: This is the solution which has a concentration similar to that of the plant tissue or to the other solution.
- Hypertonic solution: This is a highly concentrated solution which can easily gain water from dilute solution or dilute plant tissue.

**Experiment used to determine the water potential of plant tissue**

Water potential of a plant tissue can be determined by using the following experiments
Change in length of the potato cylinders:
Cylinders of the same length and diameter are immersed in solutions of different concentration and left to stand for 45-60 minutes. After 60 minutes, remove the cylinders and accurately measure and record the final length and diameter, then obtain the difference in the length and diameter.

- ✓ The solution, in which the change in length and diameter is almost zero, is isotonic to the plant tissue.
- ✓ The cylinder placed in hypotonic solution absorbs water by osmosis and increase in length and diameter thus the change in length and diameter is positive.
- ✓ The change in length and diameter is negative when the cylinder loses water by osmosis to a hypertonic solution.

If a change in length is plotted on a graph against varying concentration, a linear graph is obtained. The vertical axis must have negative and positive figures
Study the illustration below;
When the ratio of initial length (IL) to the final length (FL) i.e. (IL/FL) is plotted against concentration a linear graph is obtained.
Study the illustration below
When difference in the volume of the cylinders is plotted against the concentration a curve is obtained. The difference in the volume is inversely proportional to the concentration. To obtain the difference in the volume, subtract initial volume from the final volume (FV-IV)
Study the graph below

**NB:**
When epidermal layer such as of a commelina leaf is placed in solutions of different concentrations, the guard cells may absorb or lose water depending on the concentrations of the solution.

- ✓ If the epidermal layer is placed in hypotonic solution (high osmotic potential) the guard cells with hypertonic cell sap (low osmotic potential) absorb water by osmosis and expand outwards the thin cell wall open the stoma widely.
- ✓ In hypertonic solution, the guard cells lose water by osmosis dilute solution and they shrink to close the stoma.
- ✓ In isotonic solution, there is no net loose or gain of water by guard cells making the guard cells slightly turgid.

**The drawing of a stoma with surrounding epidermal cells in hypotonic**

**Change in the volume of the solutions**
Solutions of varying concentration are set. Cylinder of same size is made at least 1cm diameter and 6cm length. Immerse one cylinder in each solution. Let the experiment stand for 60 minutes. Remove the cylinder without losing any drop of the solution.
Then measure and record the final volume of the solution.

- ✓ The solution whose volume remains the same or closest to the original volume, has a concentration similar to that of the potato cylinder. Such solution gives a ratio of initial volume to final volume of 1:1 or nearest to that.
- ✓ The solution which increased in the volume osmotically gained water from the hypotonic potato cylinder. Thus the solution was more concentrated or has lower potential or has higher osmotic pressure or lower osmotic potential, than the cylinder.
- ✓ The solution which reduced in the volume, osmotically lost water to the hypertonic cylinder. Thus the solution is less concentrated or has a higher water potential or a lower osmotic pressure or higher osmotic potential than the potato cylinder.

When arranging solution in decreasing water potential or osmotic potential, start with more dilute solution and end with more concentrated solution. This is because a more dilute solution has higher osmotic potential or water potential.

- ✓ The cylinders in the solution with higher osmotic potential are characterized by being hard or turgid or rigid or stiff, longer, swollen or bigger and with a rough texture.
- ✓ The cylinders in the solution the lowest osmotic potential are characterized by being soft or flabby, shrunken, shorter and with a smooth texture.

**The importance of the above characteristics of the cylinders in different concentrations are;**

- The herbaceous plant takes in water by osmosis to become turgid and gain support.
- Turgidity enables plants to store water.
- Flabby nature leads to wilting of plant leaves to reduce water loss.

(iii) **Wall pressure (YP)**

This is an inward pressure exerted by the cellulose wall against the protoplast. It is a positive pressure by convention since it causes an increase in cell turgidity and thus tends to squeeze the water out.

(iv) **Turgor pressure (Yt)**

The pressure exerted by the contents of a plant cell on the cell was as a result of an equal oppositely directed wall pressure. It is, therefore, equal but opposite to wall pressure and it thus negative by convention.

Generally Yu – Yp – Yp …..(i)

**Determination of osmotic potential of cell sap**

**Theory of experiment**

Presence of solutes in a cell vacuole gives it an osmotic potential i.e. tendency to take in water from the surrounding bathing solution of a lower osmotic potential (hypotonic solution).

If the water potential of the vacuolar sap remains more negative than that of the bathing solution, the cell will continue to take up water from the bathing solution.

As water is taken up, the osmotic potential of the vacuolar sap becomes less negative as the sap becomes more dilute. As this occurs, the cell swells outward but is opposed by the mechanical wall pressure.

The value of water potential increases until it is equal to the osmotic potential of the bathing solution. Water uptake then stops and the cells is said to be at full turgidity.

**Since Yu – Yp – Yp, and at full turgidity;**

**(wall pressure) Yp – Yp (water potential)**

**Therefore, water potential (Yu) – O, at full turgidity.**

Conversely, when the cell is placed in a hypertonic medium, its vacuole loses water to the surrounding solution across the membrance. The protoplast withdraws from the cell wall and the cell is said to undergo plasmolysis.

This continues until a point called incipient plasmolysis, is reached when the wall pressure is just reducing to zero.

**From the formula; Yu – Yp – Yp,**

**When Yp – O (at incipient plasmolysis),**

**Yu (water potential – Yp (Osmotic potential)**

To measure osmotic potential of cell sap, the osmotic potential of the sap is balanced with an external solution that produces incipient plasmolysis.

However, it is hard to tell the point of incipient plasmolysis for a single cell in a tissue since plasmolysis is not an instantaneous process. But the concentration of the bathing solution in which 50% of the cells in a tissue are **plasmolysed** is isotonic to the cell's vacuolar sap. Once this concentration is obtained from a graph plotted, its osmotic potential is equivalent to that of the cell sap.

**EXPERIMENT**

Requirement;

Different concentration of sucrose, (0, 0.1, 0.2, 0.3, ……. 1.0M)

Test – tubes in racks

Pieces of epidermal tissue from uitable plant e.g. onion, or commelina.

**Determination of water potential of cell sap by chardakov's method**

**Requirements**

Sucrose solution (0, 0.1, 0.2, 0.3, 0.4, 1.0M)

2 sets of test – tubes in racks each with number of test tubes equal to the range of concentrations of sucrose solutions.

Pieces of leaf epidermis from suitable plant e.g.Onion or commelina

Stain such as methyene blue.
Fine droppers.

**Procedure:**
1. Make various concentrations of sucrose (0, 0.1, 0.2, 0.3, 0.4, 1.0M).
2. Add them to the 2 series of test tubes in the racks, arranged one directly behind the other.
3. Cut thin strips of leaf epidermis (1-2mm) and place them in each of the front tubes (about 4 strips per tube).

**NB:**
A test tube in front should have same concentration of sucrose solution as that of the test – tube directly behind it.

4. To the hind tubes, add a grain of the blue dye (e.g. methylene blue).
5. After equilibrium of 15 minutes, remove the tissue.
6. Carefully add a drop of the corresponding colored control solution from a fine pipette below the surface of the solution.
7. Note whether the colored drop rises or falls or remains stationary.

**IMPLICATION**
The solution where the colored drop does not rise or fall has osmotic potential equal to the water potential of the plant tissue.

**Explanation**
If the water from the bathing solution has been absorbed by the tissue, the solution will become more concentrated and denser. Therefore, the colored drop added to it will tend to float in the solution and therefore appears to rise.
If water has been lost from the tissue to the bathing solution, the solution becomes more dilute and less dense and so the colored drop will sink since it is now denser than the solution.
If no water has been exchanged between the tissues and solution, i.e. if the solution is isotonic to the cell sap, the solution retains its concentration. The colored drop added to it does not rise or fall since it has the same concentration and density as the solution.

**EXAMINATION QUESTIONS WITH SOLUTION**
You are provided with flower stalks labeled A and sucrose solutions labeled B1, B2, B3, B4, KB5 and B6. Obtain 3 flower stalks of 4 -5cm. cut each stalk longitudinally to obtain size sections; note the normal curvature of the section and make a labeled drawing of one them in the space below:

**Drawing of normal curvature**

Place each section into solution B1, B2, B3, B4, KB5 and B6 in a petri dish and leave to stand for 30 – 45 minutes while agitating.

(i) After making observations, describe and draw the nature of curvature of each of the stalks in each solution.

**Solution B1**
**Drawing of curvature**

**Description**
Greatly curved outwards into a U-shape with parenchyma tissue outside and epidermis inside the curve

**Solution B2**
**Drawing of curvature**

**Description**
Slightly curved outwards into a comma – shape, with parenchyma tissue outside and epidermis inside the curve.

**Solution B3**
**Drawing of curvature**

**Description**
Curved outwards into a C – shape, with parenchyma tissue outside and epidermis inside the curve.

**Solution B4**

**Description**
Curved outwards into a C- Shape, with parenchyma tissue outside and epidermis inside the curve

**Solution B5**
**Drawing of curvature**

**Description**
Slightly curved inwards into a comma – shape, with parenchyma inside and epidermis outside the curve.

**Solution B6**
**Drawing of curvature**

**Description**
Curved inwards into a C- shape, with parenchyma tissue inside and epidermis outside the curve.

(ii) Arrange the solutions in ascending order of concentration and explain your Results

Solution

The order of concentration of the solution is

B3 > B6 > B5 > B2>B4 > B1

**Explanation**

Water moves across the parenchyma tissue (semi – permeable) by osmosis. Depending on the concentration of the external solution with respect to the cell sap of parenchyma cells, water moves into or out of the parenchyma cells.

When the external solution is hypertonic to the cell sap, water moves from the parenchyma cells to the solution. The parenchyma cells become flaccid and shrink, pulling the epidermis over them, curving the section inwards. The greater the degree of inward curvature, the stronger the external solution. This is greater in solution I, which is, therefore, strongest.

When the external solution is hypotonic to the parenchyma cell sap, water moves from the solution into the parenchyma tissue. The cells become turgid and push over the epidermis, making the tissue to curve outwards. The degree of outward curvature indicates hypo-tonicity of the solution. This is greatest in solution G which is thus the most hypotonic (i.e. has the lowest concentration).

(iii) **Why do the sections bend outwards as soon as they have been split from the stalk?**

Parenchyma cells are storage cells and thus, naturally more turgid than epidermal cells. This makes the parenchyma to bend over the epidermis, immediately the flower stalk is opened into sections.

(iii) **What possible errors could have arisen out of the experiment?**

Use of hard / mature flower stalks whose cells are relatively impermeable and insensitive to forces of turgidity.

Cutting stalks into unequal sections.

**REQUIREMENTS:**

H – Flower stalks of dandelion / soft stolons of commenlina).

2. You are provided with specimen H and Six solutions of sucrose of concentration 0.3M, 0.35, 0.4M, 0.5M, 0.6M and 0.8M. You are required to determine the osmotic potential of the cell sap of the cells of H.

**PROCEDURE**

- Remove one of the fleshy storage leaves of specimen H. while it is still attached to the leaf, cut the inner epidermis into six squares of approximately 5mm using a sharp razor blade or scalpel. Remove each of the six squares using a fine forceps and immediately place one square of tissue into each test – tube gently to ensure that the tissue is completely immersed and washed with the sucrose solution. Leave to stand for about 20minutes.
- Remove the tissue from the 0.8M solution and, using a brush, mount on a slide in sucrose solution of the same concentration. Add a cover – slip and examine with a microscope.
- Select a suitable area of cell using low power. Switch to a medium objective and move the slid through the selected area, recording the state of the 1st 100 cells viewed. Cell in which there is any sign of the protoplast pulling away from the cell wall should be counted as plasmolysed.
- Repeat for all other squares of tissue, mounting them in their respective solutions.
- From the total number of cells counted and number of cells plasmolysed. Determine the percentage of plasmolysed cells for each solution. Record you results in the table below.
- Plot a graph of percentage plasmolysis against concentration of sucrose.
- From your graph, determine the concentration of sucrose in solution which causes 50% of the cells to plasmolyse.

| Sucrose concentration / Mol/L | Total No. of cells | No. of plasmolysed cells | Percentage plasmolysis |
|---|---|---|---|
| 0.30 | 100 | 14 | 35 |
| 0.35 | 100 | 35 | 35 |
| 0.40 | 100 | 58 | 58 |
| 0.50 | 100 | 82 | 82 |
| 0.60 | 100 | 94 | 94 |
| 0.80 | 100 | 100 | 100 |

**Solution**

**From the graph 0.38M sucrose solution causes 50% plasmolysis.**

(b) Make a well labeleld drawing of 3 cells of the specimen in solution of 0.8M sucrose as observed in medium power.

3. You are provided with specimen O. using a sharp blade, cut it into two cubes of dimensions 1cm X 1cm X 1cm (labeled A1) and 2cm X 2cm X 2cm (Labelled B1).

(a) Calculate the surface area (A1), volume (B1) and surface to volume ratio for each of the cubes A1 and B1. Record you results in the table below.

| **Specimen** | **Surface area (A)** | **Volume (V)** | **A : V** |
|---|---|---|---|
| A1 | $A1 = 61^2$<br>$= 6 X (I)^2$<br>$= 6cm^2$ | $V = (I)^3$<br>$= 1cm$ | 6 : 1<br>= 6 |
| B1 | $B1 = 61^2$<br>$= 6 X (2)^2$<br>$= 24cm^2$ | $V = I^3$<br>$V = (2)^3$<br>$= 8cm^3$ | 24 : 8<br>= 3 |

(b) (i) Immerse the cubes in 10% KMNO4 solution for 15 minutes.

After the 15 minutes, remove the cubes from the solution and dry them gently with bloting paper.

Using a sharp blade, cut the cubes transversely into two equal halves

Measure and record the length of cross – section (X) of each section and the length (y) of the unstained portion of section in transverse section.

**The specimen appears as show when cut**

**Record your results in the table below**

| **Specimen** | **Length of cross section X / cm** | **Length of unstained portion, y/cm** | **% percentage $\frac{(x-y)}{x}$ X 100** |
|---|---|---|---|
| A | 1.0 | 0.6 | 40.0 |
| B | 2.0 | 1.6 | 20.0 |

(ii) Explain the results in b (i) above.

**Solution**

$KMNO_4$ penetrates a greater percentage of specimen A than specimen B. specimen A presents a greater surface area to volume ratio and thus diffusion rate is high enough to suffice rapid penetration of the substance to a larger volume of the specimen.

**(c) (i) If the colored substance represents an important chemical of life. What advantage would specimen A have over specimen B.**

Specimen A would obtain the chemical of life faster than specimen B by simple diffusion across its cells.

**(ii) How would specimen B overcome its disadvantage?**

Specimen B can develop a special vascular transport system to ensure that the chemical of life is transported to all parts of the body.

**(d) Explain the significance of the above results**

Small organisms have a large surface area to the volume ratio and large organisms have a small surface area to the volume ratio.

Small organisms can rely on simple diffusion to obtain important nutrients while large organisms have to develop a special transport system in order to survive.

**4.** You are provided with two sets of sucrose solutions of molarities 0.10M, 0.125M, 0.25M and 1.0M. One set of solution has been dyed (colored).

Using a cork borer, obtain five cylinders from the Irish potato provided. Trim them to a uniform length of 3.0cm. Immerse one cylinder into each colored solution. Leave the experiment to stand for one hour. After this period, remove all the cylinders from the colored solutions. Suck a little colored solution from the 0.1M solution into a pipette or dropper. Carefully immerse the tip of the dropper or pipette into the corresponding clear solution such that the tip appears way below the meniscus of the solution. Release a drop of coloured carefully into the clear solution.

Observe whether the drop sinks, rises or spreads. Repeat the procedure on the remaining pairs of solutions.

(i) Record your results in the table below;

| SUCROSE CONCENTRATION | OBSERVATION |
|---|---|
| 0.100M | The drop sinks rapidly |
| 0.125M | The drop sinks slowly |
| 0.250 | the drop spreads |
| 0.500M | The drop rises slowly |
| 1.000M | The drop rises rapidly |

(ii) Briefly explain the movements of the coloured drops in the clear solutions.

**Where the drop sinks**

When the coloured drop sinks, its density is greater than that of the clear solution.
This is an indication that the concentration, and therefore, the osmotic potential of the solution is less than that of the cell sap such that water moves from the solution into the potato tissue by osmosis. This concentrates the colored solution and makes it denser than it was. This makes the colored drop to sink when added to the corresponding clear solution.

**Where the drop rises**

When the drop rises, its density is less than that of the clear solution. This is an indication that the osmotic potential of the solution is greater than that of the cell sap such that water move from the potato tissue to the solution by osmosis. This dilutes the solution and makes it less dense than before. Thus, the colored drop added to the corresponding clear solution rises.

**Where the drop spreads**

When the drop spreads, its density is the same as that of the clear solution.
This is an indication that the osmotic potential of the solution is the same as that of the cell sap such that there is no net exchange of water by osmosis and the solution retains its concentration.

**(b) What is the appropriate concentration of the irish potato cell sap? Explain how you arrive at this conclusion**

The appropriate concentration of the Irish potato cell sap is 0.25M.

**Explanation**

The coloured drop spreads when immersed in this solution. This shows that there was no exchange of water between the Irish potato cells and the sucrose solution. Therefore the concentration of the sucrose solution is the same as that as that of a 0.25M sucrose solution.

(c) State up one other set of coloured sucrose solutions of corresponding concentration but keep them with no piece of Irish potato added. After one hour, repeat the procedures above with these coloured solutions.

**Observations**

The drop spreads in the clear solution for all the solutions.

**Conclusion**

There is no change in concentration of the solutions.
Change in concentration is only as a result of exchange of water between the solutions and the cell sap.

(ii) Set up of one other set of color sucrose solutions of corresponding concentration and to each add a piece of boiled Irish potato cylinder of the same size. After one hour, treat them like the other solutions.

**Observation**

The coloured drop floats in all the clear solutions of corresponding concentration.

**Conclusion**

All the solutions where now denser. The boiled potato tissue lost its osmotic potential during boiling and became uniformly perforated by water which is released into the solutions with which they are mixed. This dilutes the solutions, making them to float in the corresponding solutions.

Qn: You are provided with specimen S and T and solutions A, B and C, specimens S and T are from plants of the same species but grown under different habitats. Solutions A, B and C are sucrose solutions of different concentrations.

a) Examine specimens S and T using a hand lens where necessary and state one difference between the specimens.

b). Label four microscope slides at their edge as S-upper epidermis, S-lower epidermis, T-upper epidermis and T-lower epidermis. From each specimen peel a small piece of the upper epidermis and lower epidermis one at a time and mount in a drop of water on the corresponding microscope

slide. Cover the mountings with cover slips and view them one at a time, under the low power of a microscope.

For each piece of epidermis viewed, count the number of stomata visible in the field of view and record your results in table 3.

| Specimen | Number of stomata on upper epidermis | Number of stomata on lower epidermis |
|---|---|---|
| S | 20-70 | 80-500 |
| T | 15-40 | 60-350 |

C) From your results in (a) and (b) suggest the type of habitat from which each specimen was obtained giving two reasons.

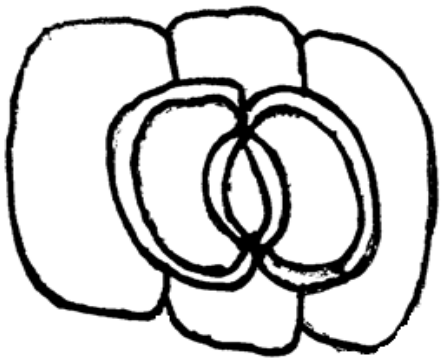
d) Label three microscope slides at their edges as A, B and C and on each slide, add a drop of the corresponding solution. Peel three small pieces of the lower epidermis from specimen and mount a piece with the outer-side, uppermost, in each solution on the slides. Leave the set up for 20 minutes. After 20 minutes cover each mounted piece with a cover slip and observe under the low power of a microscope.

Draw one stoma with its adjacent cells from each slid in the space provided

(i)From slide A

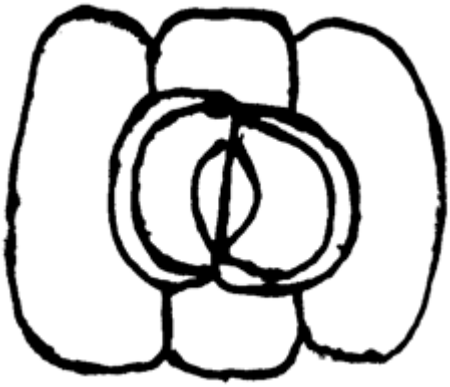
Wide aperture

(ii)From slide B



Narrow aperture

(iii)From slide C.



Closed aperture

e)Explain what is observed from each slide.

(i)From slide A

*Solution had lowest concentration/high water potential/low osmotic pressure/high solute potential/very dilute/hypotonic solution compared to the cell sap which caused the guard cell to take up water/absorb water by osmosis, resulting into the high turgidity/cells becoming turgid hence stoma open widely.*

(i) From slide B

*Solution was slightly/less concentrated/same concentration with the cell sap which caused the guard cell to slightly take up/water absorbed by osmosis resulting into less/slight turgidity hence stoma slightly open.*

(ii) From slide C

*Solution had the highest concentration/lowest water potential/high osmotic pressure/low solute potential/hypertonic solution compared to the cell sap which caused the guard cell to lose water by osmosis resulting into cells becoming plasmolysed hence flaccid hence stoma close.*

Qn: You are provided with specimen p and sucrose solution of different concentrations labelled A, B, C, D and E. You are to carry out tests on the specimen using the solutions.

Label 5 Petri dishes as A, B, C, D and E and put 10$cm^3$ of the corresponding solution in each. Cut two pieces of stem from specimen P, each measuring 3$cm$ long preferably from the same internodes or from internodes next to each other. Cut each piece longitudinally into four equal pieces. Put a piece into each Petri dish containing the sucrose solution and leave for 40 minutes.

Meanwhile ,peel off strips of lower epidermis from the leaf of specimen P .put a strip in each of the Petri dishes containing the solutions A,B,C,D and E ,leave for 10 minutes.

After 10 minutes mount the epidermal strip from each solution one at a time, onto a slide in a drop of its corresponding solution and view under medium power of a microscope. Count 20 purple colored cells, and count the number of cells that are plasmolysed out of the 20 cells.

a (i)compute the percentage of plasmolysis for the strips from each solution and enter the results in Table 1

Table 1

| Sucrose solution | Number of plasmolysed cells | Percentage of plasmolysis |
|---|---|---|
| A | | |
| B | | |
| C | | |
| D | | |
| E | | |

II) Plot a graph to show the relationship between percentage plasmolysis with sucrose solutions

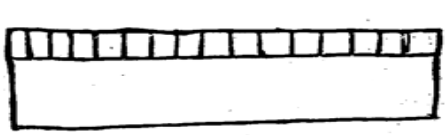
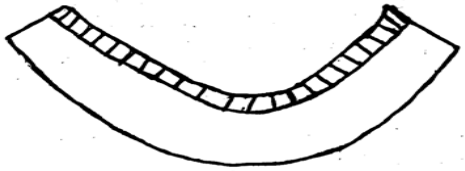
Graph

iii) On your graph mark point X to show the solution with the concentration that would have 50% plasmolysis (01 mark)

b) After 40 minutes observe the pieces of stem of P from the solutions in the Petri dishes .Draw the shape of each piece in Table 2 and on each drawing, label the outer surface of the piece.(05mks)

Table 2

| Piece of stem from solution | Shape of stem after 40 minutes |
|---|---|
| A |  |
| B |  |

| | |
|---|---|
| C |  |
| D |  |
| E |  |

C) From your results;

i) Suggest the solution with the concentration nearest to that of the cell sap of specimen P.Explain your answer (o3 mks)

ii) Arrange the sucrose solutions starting with the most concentrated. Explain your answer (5 mks)

2. You are provided with specimen P and sugar solutions of varying concentrations labeled A, B, C, D, E and F.

a. Measure 8.0cm3 of each solution and transfer the solutions into test tubes labeled correspondingly. Using a cork borer, obtain six equal sized cylinders of at least 1cm diameter, from specimen P and trim the cylinders to a uniform length of 6.cm. immerse a cylinder into each of the solutions in the test tubes and leave for 1 ½ hours. (You may proceed with other work)

i. After 1 ½ hours, transfer solution A into a measuring cylinder and record the final volume in the Table I.
Repeat the procedure for the remaining solutions.

**Table I**

| Solutions | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| Final volume | | | | | | |
| Initial volume<br>Final volume<br>Ratio | | | | | | |

ii. Calculate the initial volume to final volume ratio, of the solutions, in the spaces provided in Table I.

b. From the table,

i. Suggest the solution with the concentration nearest to that of the cell sap of specimen P. explain your answer.

……
……
……
……

ii. Arrange solutions A to F in order of decreasing osmotic potential. Explain your answer.

c. Explain the results obtained in test tubes A, D and E.

Test tube A

……
……
……

Test tube D

……
……
……
Test tube E
……
……
……

d. Examine the cylinders placed in solutions B and F.
   i. Compare the physical condition of the cylinders from the two solutions.

……
……

   ii. Suggest the ecological significance of your observations in (d)(i) in the life cycle of specimen P.

……
……

3. You are provided with specimen K and sucrose solutions of different concentrations as shown in Table 2. Carry out tests on the specimen using the solutions, according to the following instructions.

i. Cut long strips out of K using a cork borer of 0.5 cm diameter. All strips must be cut along the same axis.
ii. From the long strips, cut out six strips each measuring 3cm in length.
iii. Place one strip in each of the sucrose solutions ensuring that the strip is immersed.
iv. Leave the set-up for 1 hour (You may proceed with other work in the meantime).
v. After 1 hour, remove one strip at a time and measure its final length.

a. Record the measurements appropriately in Table 2
b. Complete the table by working out the initial length: final length ratio for each piece.

Table 2

| Morality of sucrose solution | Initial length (cm) | Final length (cm) | Initial length: final length ratio |
|---|---|---|---|
| 0.0M(Distilled water) | | | |
| 0.1M | | | |
| 0.25M | | | |
| 0.50M | | | |
| 0.75M | | | |
| 1.0M | | | |

c. In the space provided, plot a graph of the initial length: final length ratio against the morality of the sucrose solution.
d. From the graph,
   i. Deduce how turgor pressure and osmotic pressure of the tissue of K varied, in the different sucrose solutions.

……
……
……

   ii. Determine the morality of sucrose solution that is isotonic to that the cell saps of K. show your working on the graph.

……

## DIFFUSION

This is the net movement of molecules of ions from a region of high concentration to a region of lower concentration.

Diffusion enables cells get nourishment, communicate with other cells and get rid of wastes.

**Factors affecting diffusion.**

1. **Temperature**

The higher the temperature, the faster the rate of diffusion. Temperature increases the kinetic energy of diffusing molecules / ions and thus enhances the rate of diffusion.

2. **Diffusion distance**

This is the distance a cross which molecules traverse between two regions with differing concentration of the molecules. When the distance is short, the molecules reach a cross the regions in a short time, implying a fast enough rate of diffusion. Thus the rate of diffusion is inversely proportional to the diffusion distance.

3. **Diffusion gradient**

It indicates the difference in concentration of the diffusing molecules between two regions across which diffusion has to occur. The bigger the difference the steeper / higher the diffusion gradient and the higher the rate of diffusion as a result of the greater tendency of molecules to move from the region of high concentration to a region of low concentration.

4. **Size of diffusing molecules**

The larger the size of the diffusing particles the slower the rate of diffusion and vice versa larger particles are slow to move because of their larger amount of potential energy which cannot easily be surmounted by the forces of diffusion, thus a slow rate of diffusion.

5. **Surface area**

The greater the surface area the greater the rate of diffusion due to the fact that the molecules then will have a greater exposure and therefore access to the region of lower concentration.

## FLOWERING PLANT

### FLOWER

**Terms used in flowers**

*(i)* Complete flower: It is a flower which has all the floral parts e.g. petals, pistil, and anthers etc.
(ii) *Incomplete flower: T*his is a flower which lacks one or more floral parts
(iii) Bisexual flower is a flower which has both the gynoecia (pistil) and stamen (androecia).
(iv) Unisexual flower is a flower which has either pistil or stamen only so a flower that is either pistillate or stamenate.
(v) Essential organs (parts) of flower, these are the important parts of a flower that is gynoceium and Androceium.
(vi) Non-essential parts of a flower these are the parts that are not important on a flower e.g. epicalyx, calyx, pedicel, receptacle.
(vii) Single flower, it is a flower which is one on a single stalk.
(viii) Inflorescence, it is a group of flowers on a single stalk.
(ix) Regular/actinomorphic flowers; it is a flower with more than one line of symmetry e.g. sweet potatoes.
(x) Irregular/zygomorphic flower; it is a flower with only one line of symmetry e.g. cassia, crotalaria, bean flower.
(xi) Monoecious plants are plants which have male and female flowers on different plants e.g. maize.
(xii) Dioecious plants are plants which have male and female flowers on separate plants e.g. paw-paw.
(xiii) Hermaphrodite plants that contains both stamens and carpel e.g. Hibiscus

### Parts of a flower

**1. Epicalyx**

This is the floral whorl external to the calyx. It can be present and if present the number of leaves should be specified e.g., one, two e.t.c.

- Fused or not fused
- Dull or brightly coloured
- Smooth or hairy

**2. Calyx**

It consists of sepals which are either present or absent. If present the number of sepals maybe specified e.g. three, five e.t.c.

**i)** Gamosepalous that is fused
**ii)** Polysepalous that is they are free (not fused)
**iii)** Dull or brightly coloured.
**iv)** Petaloid if of same colour as petals
**v)** Shortened/ very short or long

**vi)** Smooth
**vii)** Pointed tips

**3. Corolla**

It consists of petals they are either present or absent. If present,the number of petals should be specified

**i)** Gamopetalous that is petals which are fused.
**ii)** Polypetalous that is petals which are free (not fused)
**iii)** Brightly coloured or dull coloured. The colour should be specified.
**iv)** Petals are either small i.e. inconspicuous or large that is conspicuous.
**v)** Petals may be scented or not scented.
**vi)** Tubular
**vii)** Smooth
**viii)** Hairy
**ix)** Pointed tips
**x)** Nectarines maybe present or absent

**Monocotyledonous flowers** the outer parts of the whorls look alike and are known perianth

**4. Androecium** (stamen)

This is the male part of a flower, it can be present or absent, it consists of filament and anthers head.

**i)** Short or long filaments
**ii)** Filaments may be fused to form a tube surrounding the styles called staminode and is known as gynondrous e.g. in hibiscus.
**iii)** Filaments may be fused to form a filament sheath around the ovary e.g. crotalaria.
**iv)** Has a lot of pollen grain or little pollen grains.
**v)** The stamens may be attached to the receptacle or to the corolla and this is known as epipetalous.
**vi)** Anthers may hang out of the corolla or completely enclosed by the corolla.
**vii)** The pollen grains may be light or thick sticky pollen grains
**viii)** Enclosed or not enclosed in corolla
**ix)** Brightly / dark colored
**x)** Elongated anthers/ filaments
**xi)** Stamens maybe attached on corolla

**5. Gynoecium (Pistil)**

This is the female part of a flower. It may be present or absent, the Gynoecium consists of the stigma, style, ovary which bears the ovules. The stigma, style and ovary form a carpel which may be:

**i)** Monocarpous pistil i.e. has one carpel
**ii)** Apocarpous pistil i.e. has more than one carpel but not fused i.e. free, so is separate from one another.
**iii)** Syncarpous pistil i.e. has more than one carpel which are fused i.e. the ovaries are joined together.
**iv)** If present the style may be long or short
**v)** The style may be curved or straight.
**vi)** The Gynoceium may have single or lobed stigma
**vii)** The stigma may be sticky or smooth
**viii)** The ovary may be inferior, semi-infection or superior.
**ix)** Stigma maybe rounded/ oval/ clubbed / knobbed
**x)** Long/ elongated ovary
**xi)** Smooth/ hairy stigma

**Inferior ovary**

It is where the ovary develops when the receptacle and actually fuses with it, and the sepal, petals and stamen borne at the top of the ovary. The flower is said to be epigenous e.g. guava, carnality.

**Semi-inferior or half inferior ovary**

It is where the receptacle is cup shape and bears the gynoecium is in the centre while the sepals, petals and stamens are attached to its edge. The flower is said to be perigynous e.g. rose flower.

**Superior ovary**

It is where the receptacle is conical shaped on which the sepals, petals, stamens and carpels are arranged in order with carpels at the top. The flower is said to be Hypogenous e.g. cassia, Hibiscus, mango

## FLORAL DIAGRAM AND FLORAL FORMULA

After carrying out the above investigations, the flower structure can be represented both diagrammatically (floral diagram) and by symbols and numbers (floral formula)

### FLORAL DIAGRAM

A floral diagram is a floral map representing the different parts of a flower, their number, structure and arrangement, the relation they bear to one another (ie where fused or not) and how they are arranged on the mother axis.

When constructing a floral diagram, hold the flower so that the pedicel is furthest from you and the petals face you directly

Standard symbols are normally used in making the floral diagram representing the different floral whorl. They include;

0 - shows position of the main axis and usually written at the top of the diagram

∞ - single stamen

NB: If they are many (more than 10) represent only a few.

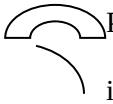
O - One free carpel

NB. If fused, the number of carpels is indicated by sectioning ie


Two fused carpel


Four fused carpel


Sepals or calyx


Petals or corolla


is used to connect fused parts

**When** constructing a floral diagram, hold the flower so that the pedicel is furthest from you and the petals face you directly. Therefore, the resulting diagram must show the actual appearance of the flower in surface view.

For example, in cassia flower there are

- 5 free sepals
- 5 – free petals
- 7 – stamens and 3 staminodes
- Single carpel with superior ovary

### OVARY

An inferior ovary is an ovary that lies below the origin of the floral parts

The terms superior, hypogynouse, inferior and epigenous are often confused and to be the same.

While the term superior and inferior apply to the ovary, the terms hypognouse, epigynouse and perigynouse apply to the rest of the flower

- ✓ Epigynouse: a flower in which the receptacle completely encloses and fuse with an inferior ovary such that the other floral parts i.e. sepals and petals and stamens are borne at the point above it e.g. in apple
- ✓ Hypogynouse:a flower in which the sepals, petals and stamens are borne in the receptacle at a point below the carpel i.e. a flower with a superior gynoecium e.g. tulip, buttercup
- ✓ Perigynouse:this is the intermediate condition where the sepals, petals and stamens are born on the margin of the concave receptacle, with the carpel of a superior ovary at the center of the receptacle ie other floral parts are at the level around the gynoecium e.g. in rose cherry and plum flowers

### RECEPTACLE

Is the apex of the flower stalk where the four whorls of a flower are attached

### DESCRIPTION OF MONOCOTYLEDONOUS FLOWERS

- ✓ Glume: small scale like bracts, a pair of glumes enclose a grass spikelet

- ✓ Lemma(lemma) small bract in whose axil arises the grass flower
- ✓ Palea small bract arising from the axis of the flower stalk, just below the flower. The palea and lemma together enclose the young grass flower just like the sepals in the dicot flower
- ✓ Lodicules: two tinny scale like structures below the grass flowers, represent a much reduced perianth
- ✓ Alarn: this is a slender, stiff bristle like process on the apex of a glume found in many grass spikelets e.g. wheat, it protects the flower from being destroyed by birds.

NB: preianth: when undifferentiated into calyx and corolla, no bracts.

## INFLORESCENCES

**Introduction:**

Definition: This refers to the arrangement of flowers on a plant. Flowers may develop singularly or grouped. OR: Is a collection of flowers borne on the same main stalk or arrangement of flowers on plants. An inflorescence also refers to the growth of many flowers is called peduncle or main axis. It may be divided into branches of different length or not divided.

Is a flowering shoot consisting of a group of flowers on a single main stalk called peduncle and also to the arrangement of a flower on an axis

Each flower is called a **floret.**

Flowers may be at the apex of the main shoot or one of its branches in which case the vegetative activity at the apex cease and the vegetative parts are replaced by the reproductive structures.

When the flowers are grouped, the main axis on which they are borne is called the **peduncle.**

On this, the individual flowers are developed usually in the axils of bracts, which may be ordinary **foliage** leaves but frequently are much smaller and scale-like. They may be colored like petals (i.e. petaloid)

The small out growths often found on the pedicel are called **bracteoles.** This may be regarded as reduced leaves

A floret may be free or they are closed in the set of bracts.

Glume – is a blact like structure, two of which endose a spikelet.

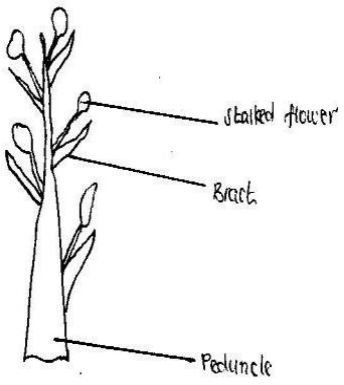
Lemma / lower / outer blact. Is a small bract is whose axil arises a grass flower.

Palea: upper / inner bract – a small bract arising from the axil of a flower stalk, just above the flower.

***Types of inflorescences.***

**1. Idenfinate/ racemose/ Raceme inflorescence.**

Flower buds are initiated at the apex, and this contains indefinitely. Different classes of indefinite inflorescence include;



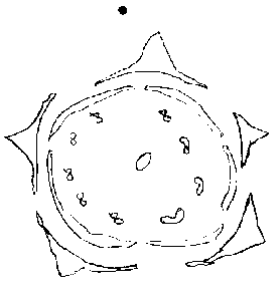

Raceme inflorescence consists of individual stalked flowers arranged along a single undivided peduncle as in jacaranda, hyacinth and **cassia**.

**Cassia inflorescence :**as an example of Raceme

**Characteristics:**

- The peduncle bears stalked flowers arising singly from it.
- No flower form at the apex of the peduncle to grow is never considered to be ended i.e. indefinite/racemose inflorescence.

**Floral diagram.**



**Floral formula**

**Jacaranda inflorescence**

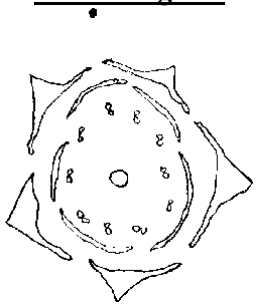
**Characteristics;**

- Has a long firm peduncle with stalked flowers arising singly from it.
- No flower is formed at the apex of the axis so growth is never considered to be ended. I.e. indefinite (racemose inflorescence).

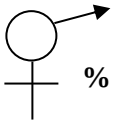
**Characteristics of floret**

- Has a long solid pedicel/stalk
- Bisexual and zygomorphic
- Calyx consists of 5 free thick petaloid sepals, red inside and green on the outside.
- Corolla consists of 5 free petals
- Androecium consists of 10 free stamens with long thick filaments, hairy at the base.
- Gynoecium consists of a bean shaped ovary that is superior with a long curved style with a flat stigma

**Floral diagram**



**Floral formula**

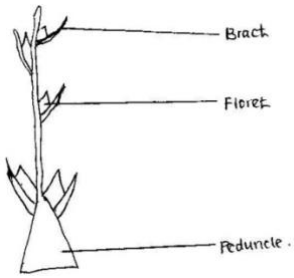


**% $K_5$ $C_5$ $A_{10}$ $G_1$**

**2. The spike inflorescence.**

Individual, sessile flowers are arranged along a single undivided peduncle e.g plantain, maize (male flower), grasses and cereals.

**Diagrammatic representation.**




It is characterized of family gramineae which includes annual or perenial herbs with occational woody forms. Many grasses and cereals belong to this group.

**General description of inflorescence:**

Each inflorescence is composed of one or more unity spike-lets which may be arranged on the central axis or rachis in various ways.

Each spike-like may consist of one several flowers or flores attached to a central axis the rachilla.

At the base of the rachilla is a pair of bract-like structures known as the **glumes.** They include; outer/first/lower glumes and **inner/2nd/upper glumes,** which enclose a series of florets.

Each floret has, at its base, a pair of green bracts known by various names by different authorities. The lower bract may be known as the lemma or the lower pale or the **flowering glumes** or the valve The upper bract may be known as the pale or upper pale or the valvule.

**Examples of spikes**

(a) **Banana inflorescence.**

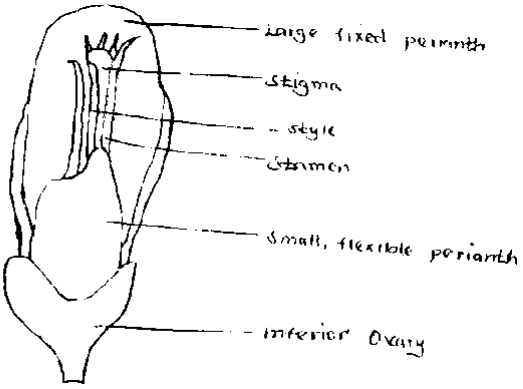
It is a special form of spike inflorescence called **spadix**

**Reasons**

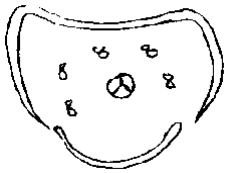
- The axis/peduncle is thick.
- Has a thick fleshy bracts called the **spathe.**

**Characteristics of floret**

- Has two types of perianth; one large, boat-shaped and attached firmly to the ovary: the other, short, small, relatively free and boat shaped.
- Has five free stamens.
- Has an inferior ovary.
- It is irregular and bisexual.
- Has a syncarpous pistil of three carpals.




**Floral diagram**



**Floral formula**

% ♀ $P_2$ $A_5G_{(3)}$

(b) **Male maize inflorescence.**

**Characteristics:**

- Has no petal.
- Has no sepal.
- Has dull colored bracts, thick and rough outer bracts (glumes) and thin and smooth inner bracts (pale/palea).
- It is unisexual, having stamen (staminate) only.
- It is irregular/zygomorphic.
- Has three (3) stamens which have large lobed anthers hanging on long slender filaments outside the bracts.

**Inflorescence**

Has main axis(peduncle),with lateral branches(spikes),each bearing many paired alternately attacked spikelets,one spikelet from a pair is stalked, the other is sessile(lacks stalk)

One spikelet

Each is enclosed by two hardened, rough, boat shaped, pointed bracts, one placed a little above the other; inside the spikelet are four (4) inner bracts, 2 from each of the two florets.

Symmetry is bilateral/zygomorphorphic

Bracts are 3(three), hardened, rough, boat shaped and pointed, 2 inner bracts are thin and translucent

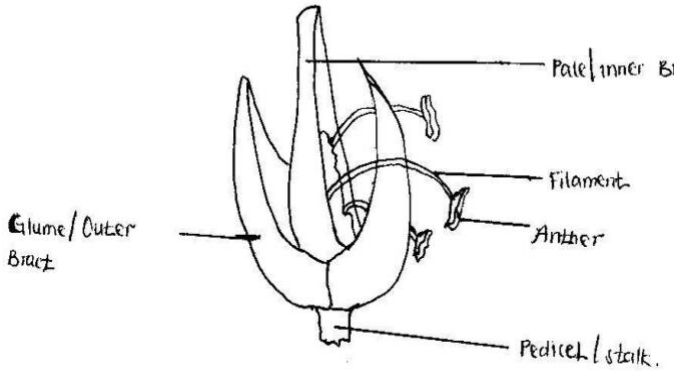
Androceium: made up of three, free stamens, anthers are bilobed, broad, elongated and supported on thin flexible long filaments.

Gynoecium: no pistil/carpel, gynoceium

**How pollination is facilitated by the androceium of maize**

- ✓ Flexible filaments that easily swing anthers to disperse pollen
- ✓ Long filaments for exposing anther heads with pollen to wind
- ✓ Anthers loosely attached for filaments, thus easily shaken to scatter pollen
- ✓ Large/broad anther heads to produce very many pollen to enhance survival/increase chances of pollination

**Structure of Male Maize Floret.**




Within the outer pale, stand the floral parts. These consists of pair of delicate **scales** known as **lodicules,** representing a very reduced corolla, three stamens with long delicate filaments and often versatile anthers and a tri-carpellary ovary with a single loculus enclosing a single anatropous ovule. The ovary is superior and from its apex are borne two feathery stigmas on short styles.

**The advantage of alternate arrangement of florets.**

- If to expose the florets for easy pollination.
- The advantage of the floral arrangement of florets or spikelets is that it makes the inflorescence, large or conspicuous to the herbivores for easy predation.
- The large anthers produce numerous pollen grains that make pollination easy.
- The loose attachment of anthers to the filament makes pollination easy.
- The long nature of filaments exposes the anthers hence making pollination easy.

**c) Gynandropsis gynandra.**

This is common inflorescence with many florets which are alternately / spirally and individually attached by long pedicel, along one main peduncle. The mature or lower florets have longer pedicel than younger or upper florets making all the florets a hair the same level each florets has, each florets has;

- No bracts.
- Calyx / sepals: five, green net veined, hairy, free, tapering towards the tip / curved.
- Corolla / petals: five, free, smooth, veined, narrow base and broad apex.
- Pedicel: long, smooth and bright coloured.
- Stamens: with long, slender, free, smooth filaments with elongated, bilobed, bright coloured anthers.
- The elongated anthers produce large amounts of pollen grains to enhance cross pollination. The stamens are exposed to ease dispersing of pollens to enhance cross pollination.
- Pistil: with superior, elongated, hairy, slender ovary and short hairy style, and bilobed spherical.
- Stigma: the spherical stigma provided a large surface area for landing of the insect during pollination.

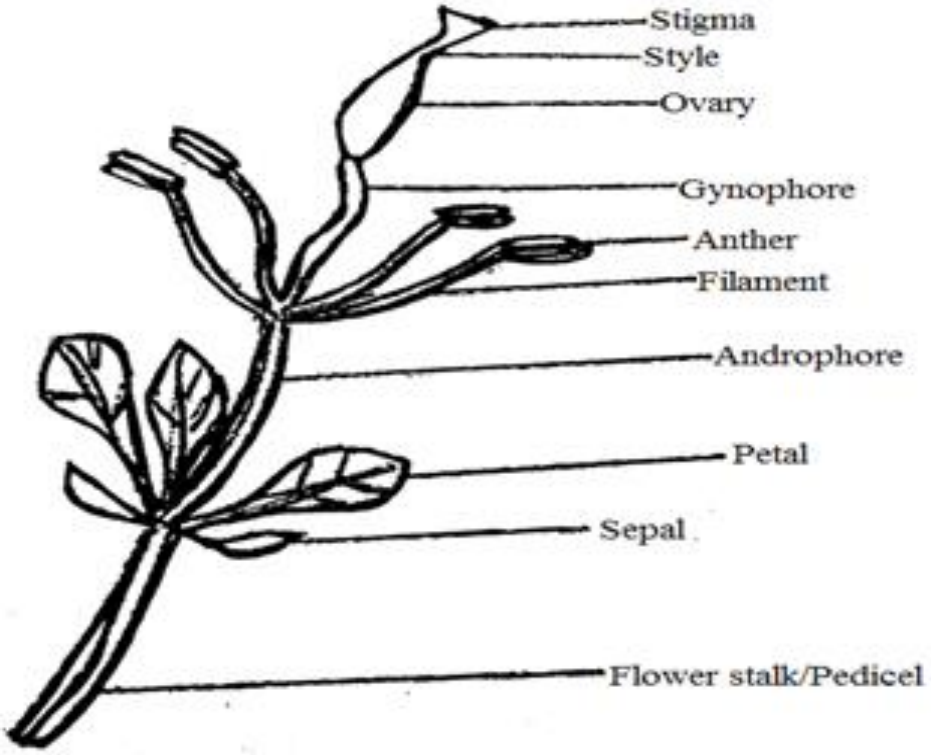
Note: The bright coloured structural features of these of this flower attracted pollinator leading to cross pollination by insects.

The receptacles of each floret has distinct internodes and nodes to which floral structures are attached N's stamen are attached to long internodes called andropheres and the ovary is attached to internodes called gynophores. The arrangement exposes the essential structures of the flower for easy pollination leading to ensured higher chances of fertilization.

Note: The inflorescence that is pollinated by wind has pollen grain which is small, round / circular and smooth being small, reduces its weight so that it can easily be blown by wind. The smoothness reduces air resistance and hence blown by air easily.

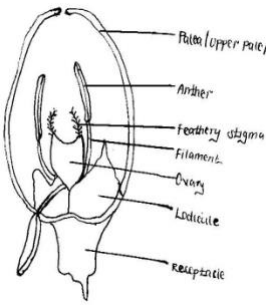
- The inflorescence pollinated by insects is large, circular and spiky surface easily attach onto the insect or stigma to easy pollination. The large size of pollen provides a large surface area for attachment to the insect. N.B The florets considered above are aimed at acquainting the students and the teachers with the necessary information that can be used to analyze any other flower and inflorescence.

**Drawing of Gynandropsis gynandra floret**

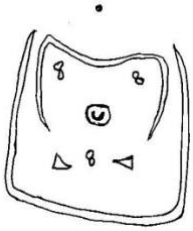



d) Elephant grass

**Structure of a flower of elephant grass.**




**Floral diagram**



**Floral formula**

$\% \nearrow O_+ P_O A_3 \underline{G_{(3)}}$

**GUINEA GRASS**

**Description of inflorescence**

The main axis has lateral branches of variable length, reducing towards the apex, some attached wholly, some alternately, others oppositely on the main axis, on each lateral branch of the axes are numerous spikes bearing several spikelet attached alternately, both main and lateral axes terminate into individual or double spikelet

**Description of single flower**

- ✓ Spikelet: stalked/pedicellate,each enclosed by three hardened,smooth,parallel veined, curved and anterioely tapering bracts(glumes),one placed a little below the two, inside the spikelet are two florets, arising from short stem axes
- ✓ Corolla: no petals

- ✓ Calyx: no sepals
- ✓ Bracts: outer bracts(glumes) are three hardened,smooth,parallel veined,curved,and anterioly tapering one placed a little below the two, dull colored, inner bracts are paired, thin( membranous),dull colored,transluscent
- ✓ Stamens: the lower floret is unisexual, bearing only three stamens, which are yellow, free, pendulous/flexible, dull colored, with bilobed anthers, that are supported on thin, flexible, long filament. Upper floret is bisexual, bearing three stamens.
- ✓ Carpels:upper floret bears one superior ovary, with two featherly,red-purple stigmas
- ✓ Symmetry: upper floret is actinomorphic and lower floret is zygomorphic

**Adaptations of guinea grass for reproduction/pollination**

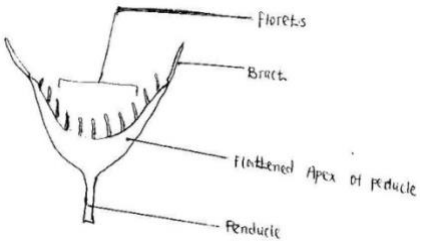
- ✓ Broad anthers are producing much pollen grains to increase chances of pollination by wind
- ✓ Flexible filaments for swinging to disperse pollen in different directions

Crowded florets result in production of much pollen grains to increase chances of wind pollination

**Drawing of a floret of gunea grass after removing all the non essential parts**


**2. A capitulum**

- This consists of sessile flowers arranged in the same plane end of an expanded apex of the peduncle. Examples include;
- Inflorescence of *Biddens pilosa*, dandelion, daisy, etc. The head of the flowers is surrounded by a number of sterile bracts collectively termed the involucres. The individual flowers may or may not be in the axils of bracts on the disc-like head. Thus;




**A capitulum of biddens pilosa.**

**Description /characteristic**

- Consists of numerous sessile flowers (floret) arising from flattened axis surrounded by a calyx-like involucres of bracts.

**Structure of floret/Characteristics.**

- It is hermaphrodite (5 fused androecium and 2 fused gynaecium).
- It is regular/actinomorphic.
- Floral parts are cylindrically arranged.
- Has an inferior ovary.
- The calyx, when present at all, is represented by hairs, scales or teeth to form a pappus.
- The corolla is made up of five fused petals united to form a tube, at least at the base.

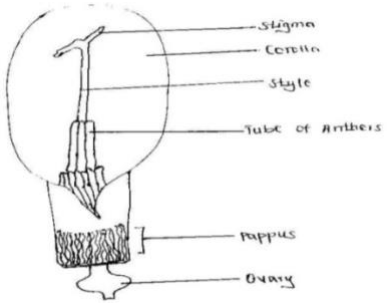
**NB:**

Dimorphism of florets is very noticeable, particularly in the form of corolla and the florets may be distinguished into two i.e.

**Ray/lingulate floret**

In these, the corolla tube is extended as a strap-shaped or lingulate expanse. They are normally located at the outer circumference of the inflorescence.

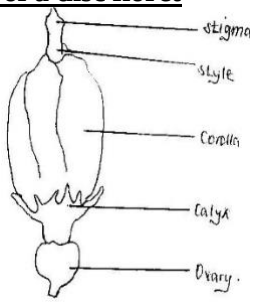
**Drawing of a ray floret**



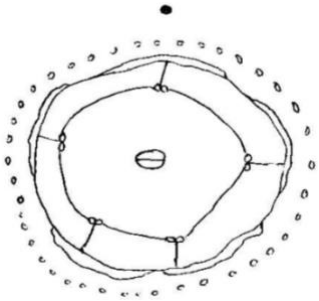

**Disc/ tubular floret;**

In these, the corolla remains more or less symmetrically tubular with five equal teeth. They are found in the centre of the inflorescence.

**Drawing of a disc floret**



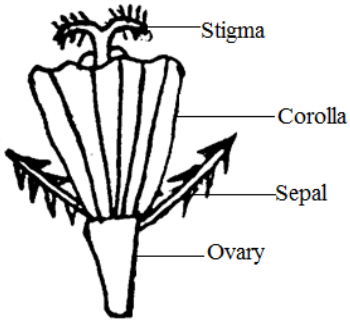

**Floral Diagram**



**Floral formula**

$\% K_{(paltus)} C_{(5)} A_{(5)} G_{(2)}$

**Structure of the inner floret of black**




**Structure of Inflorence**

Numerous,crowded,sessile florets/flowers attached onto the apex/tip and of a flattened/cup shaped/expanded/slightly curved, main axis/penduncle,with a radial/ring/circular pattern of floret arrangement, tubular/disc florets at the center, surrounded by ray/ligulate floret on the outermost side, curved by/surrounded by involuncre of bracts

**Other Characteristics**

- ✓ Hermaphrodite (5 fused androceium and 2 fused gynoceium
- ✓ Regular/actinomorphic
- ✓ Floral parts are cylindrically arranged
- ✓ Inferior ovary
- ✓ Corolla made of small,smooth,thin,net veins of five fused petals to form a tube
- ✓ Calyx when present at all is represented by hairs, scales or teeth like to form apappus, free, slender/thin, pointed/tapering.

**Disc Floret**

Sessile floret, with fused petals/corolla, with tubular corolla, free, spiny sepals/calyx, is bisexual, pistil with long/elongated inferior ovary, and forked stigma, the stamen with fused, bilobed, elongated anthers, with short filament.

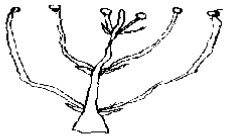
It is actinormorphic/regular/radial symmetry

**Corymb inflorescence**

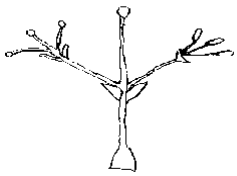
**Characteristics:**

Stalked flower are arranged along a single undivided peduncle but with pedicels all of different lengths, so that the flowers are all brought to the same level. For example in lantana and candy tuft flowers, *Lantana camara*

**Diagrammatically**



3. **Dichasical /cyme**



Two lateral branches arise at the same level each with flowers, as in bougainvillea.

**<u>Bougain villea inflorescence as an example of a Dichasial cyme</u>**

**<u>Characteristics:</u>**

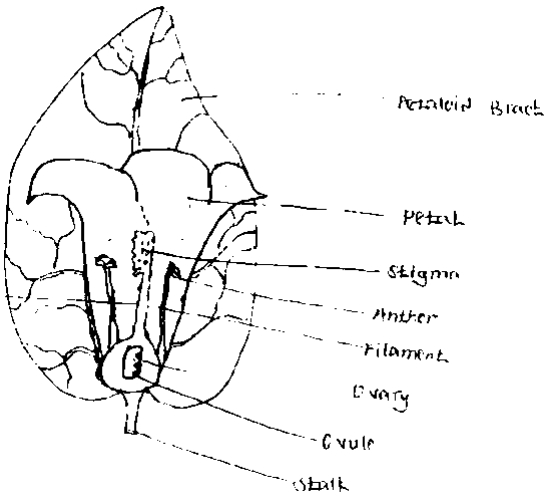
**Inflorescence**

- Flowers form at the apex of the peduncles to terminate growth
- Two lateral branches arise at the same level, each with flowers.
- Flowers develop attached to petaloid bracts.
- Flower has short pedicels, the flower form at the apex of the peduncle to terminate growth.
- Each floret attached on its bract
- Three stalked florets, attached on the midrib/main vein of a large bract

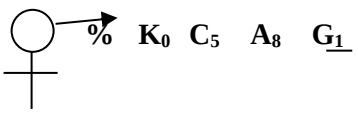
**Characteristics of a single flower**

- ✓ Bi sexual, actinormorphic
- ✓ Androceium of 8 stamens, at different heights anther heads are bilobed
- ✓ Corolla:five,fused,small,net veined petals
- ✓ Gynoeceium: club shaped stigma, elongated, hairy, thin style, and superior ovary.
- ✓ No sepals
- ✓ Have a brightly colored bract/petaloid bract.

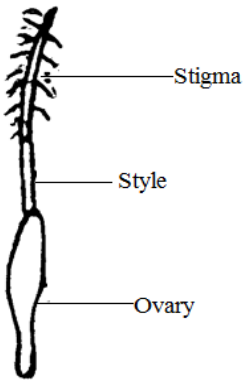
**<u>Structure of longitudinal section of floret</u>**




**Floral formula**



**Gynoecuim of bougnivillae**




**NB**

Large/ broad brightly coloured bract to make it conspicuous

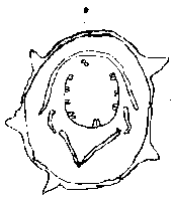
**OTHER FLOWERS**

**Bean Flower.**

**Characteristics**

- Has a short stalk/pedicel
- It's a hermaphoradite and zygomorphite flower.
- Calyx consists of five fused sepals
- Corolla consists of five patals of varying size i.e. the large one often seen known as the standard petals, two fused petals enclosing the essential parts known as the keel petals and two free petals on the sides of the keels known as the using petals. This is the basic structure of a class of flowers known as **crotalaria**
- The androecium consists of 9 fused stamens forming a tube around the gynoecium and 1 free stamen.
- The gynoecium has a bean shaped ovary which is superior with a short style, at the end of which is a flat stigma.

**Floral diagram**



**Floral formula**

**% $K_5C_{(2)+3}$ $A_{(9)+1}$ $\underline{G_1}$**

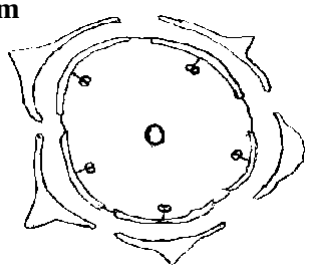
**Morning glory**

- ✓ Short hairy pedicel, four sided in transverse section
- ✓ Bisexual
- ✓ Actinomorphic
- ✓ Epicarlyx with three, hairy parts
- ✓ Calyx of five, free stamens, with hairy filaments at the base, attached to the petals
- ✓ Gynoecium with bilobed stigma, globular and superior ovary embedded in receptacle

**Characteristics**

- Has a short hairy pedicel which is four – sided in transverse section.
- Have an epicalyx of three hairy parts and a calyx of five hairy sepals.
- Androecium consists of five free stamens with filaments hairy at the base and epipetalous.
- Gynoecium consists of a bi – lobed stigma, a globular superior ovary embedded in a cup shaped ovary.

**Floral diagram**



**Floral formula**

**$K_5$ $C_5$ $\overset{\frown}{A_5}$ $\underline{G_1}$**

**Hibiscus flower**

- ✓ Sex:bisexual
- ✓ Symmetry:actinomorphophic
- ✓ Calyx:5(five),fused,small,hairy,veined,tapering/pointed
- ✓ Corolla:5(free),free/separate, net veined, broad at apex, narrow at base,long,smooth,over lap at bottom brightly colored petals
- ✓ Epicalyx: 5/6/7, free, slender, tapering/pointed, short, narrow, hairy.
- ✓ Androceium:numerous,free stamens, short fused filllaments to form stamina tube which is attached to the petals
- ✓ Gynoceium:superior ovary, made of 5 carpels,free stigmas, that are hairy, style fused

**Pollination agent: insect because**

- ✓ Petals brightly colored to attract insects
- ✓ Sticky pollen grains for adhering onto insect body

Type of pollination: cross pollination because anthers lower than stigma hence pollen other floers on a visiting insect is most likely to pollinate

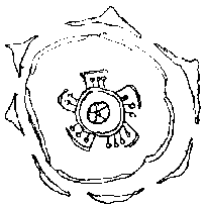
**Adaptation for reproduction**

- ✓ Brightly colored petals for attracting pollinators
- ✓ Numerous stamens to increase the production of pollen grains
- ✓ Hairy stigmas for trapping pollen grains
- ✓ Has both stamens and pistil thus increasing chances of pollination

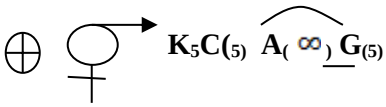
**Characteristics:**

- Has a short pedicel attached to a bract
- Have an epicalyx of 6 – 8 free parts and a hairy calyx of 5 fused sepals.
- Corolla consists of 5 free brightly coloured and veined petals.
- Androecium consists of many free stamens with short filaments fused of the base to form a stamina tube around the style.
- Gynoecium consists of a superior ovary with a long threadlike style branched into 5 parts at the stigma

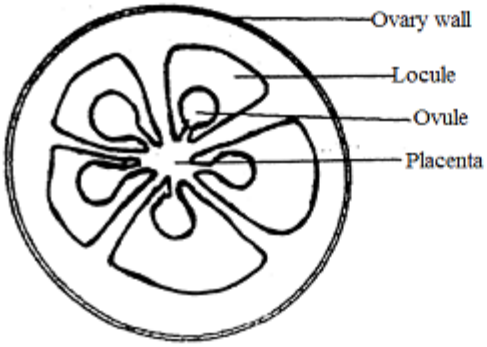
**Floral diagram**



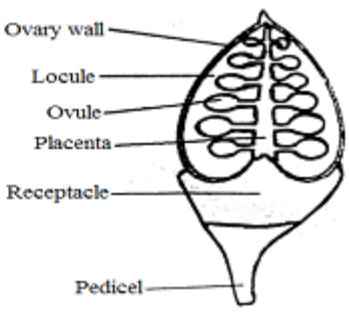
**Floral formula**




**Transeverse section through Hibiscus ovary**




**Longitudinal section through Hibiscus ovary**



**Bean flower/crotalaria**

Has short pedicel which is cylindrical solid

- ✓ Sex:bisexual
- ✓ Symmetry:zygomorphic
- ✓ Calyx: of five petals of different sizes i.e. a large, veined petal called standard petal, two fused petals enclosing the essential parts called keel petals and two free petals in the outside of the keels called wing petals.
- ✓ The androceium consists of ten stamens of which 9 are used to form a stamina tube around the gynoecium and one free stamen
- ✓ The gynoecium/carpel has a bean shaped ovary elongated ovary, superior ovary with a short style at the end of which is a flat stigma,expanded.

Floral formular

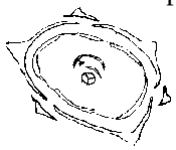
$k_{(5)}c_{(2)+3}A_{(9)+1}G_1$

**Canna Lily**

**Characteristics**

- Have three bracts, 2 large and one small.
- Has a short and thick stalk.
- Has 3 membranous epicalyx.
- Has 3 petaloid calyx
- Has 5 petals; 4 arranged cylindrically around one central petal which is divided into parts; one part peripheral and large containing one stamen and the other (small, central and club shaped) acting as a pollen guide.
- Gynoecium consists of a syncarpous pistil of 3 ovaries, all inferior with a sunken ovary.
- There is no style; pollen grains follow the pollen guide to the sunken stigma through a tubular structure formed by the base of the petals.

**Floral Diagram**



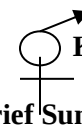
**Floral formula**

**% $K_6C_{(5)}$ $\overbrace{A_1 \; G_{(3)}}$**

**<u>Description of single flower/floret</u>**

- Has a short pedicel
- It is bisexual and zygomorphic (irregular)
- It has a calyx of five (5) free sepals and a corolla of five (5) free petals
- The gynoceium consists of a bean – shaped curved ovary that is superior with a short style and a flat stigma

**Floral Formula**



**% $K_5$ $C_5$ $A_{10}$ $\underline{G_1}$**

**Brief Summary description of the essential parts of some flowers**

| Specimen | Characteristics of androecium | Characteristics of Gynoecium. |
|---|---|---|
| Hibiscus Flower | Numerous, filaments fused with a stamen tube, which is long, red of the filament are free and attach anthers which are bilobed, round and brightly coloured. | Five: carpel, and fused, broad hairy stigma leads style, long, flexible free superior ovary broad base. |
| Crotalaria flower | 10 stamens, nine fused into stamen tube, which are grooved, curved and long with free short filaments, anthers bilobed, round, elongated, brightly coloured. | One carpel, stigma long, flattered, hairy, short style, superior long curved smooth ovary. |

| | | |
|---|---|---|
| Morning Glory / sweet potato flower | Five stamens, long, free and slender, thin filaments, hairy at the base attached to the petals, filaments tape at the Apex, bilobed, long, large anthers. | 2/3 carpels, fused, stigma. Bilobbed / trilobbed, round, hairy style, long, thin, superior ovary round and smooth. |
| Flower of guinea grass. | Three stamen, filaments long, thin anthers pendulous, dull coloured, bilobed large, long loosely attached to filament. | Two feathery brightly coloured, long stigma, style, is short, ovary superior and round. |
| Male flower of maize | Three free stamen free filaments, anthers free, long, slender pendulous smooth large bilobed brightly coloured and loosely attached to filament which are thin, long, flexible and slender. | No gynoecium. |

**Description of some flowers and florets**

| Specimen | Gynoecium | Androecium | Features of petals and sepals. |
|---|---|---|---|
| Maize floret | No gynoecium | Three free stamen:<br>Free filaments, anther<br>Free: long, slender pendulous smooth large bilobed brightly coloured and loosely attaché to filament which are thin, long, flexible and slender. | Dull coloured: bisexual / staminate anther hanging outside the bracts;<br>inflorescence/raceme flowers are borne in pairs spikelets;<br>Pendulous stamens;<br>zygomorphic. |
| Maize inflorescence | It consists of a main axis called peduncles with which branches into many branches that alternately attached to the peduncles to expose the florets for easy pollination. Each branch bears numenous and paired spikelets which is also alternately attached to the branches. The spikelets in the pair one is stalked / asessile and the other is sessile unstalked.<br>The spikelets (florets) are alternatively attached to the pednucles and irregular. Each spikelets bears two florets which are covered by bracts. The outer bracts are called glume and are hairly, hard, tough and curved or boat shaped, the inner bracts called paled are membranous are this, smooth, curved in wards are occur in pairs, both inner and outer bracts are parallel veined and dark coloured. | | |
| crotalaria | One carpel; stigma, long/flattened;<br>hairy short style; superior long curred smooth ovary. | 10 stamens, nine fused into stamen tube; which are grooved; curved and long with free short filaments, anthers bilobed; loud; elongated; brightly coloured. | |
| | Bisexual; irregular / zygomorphic; five calyx; not are same size/two big/large ones; corolla five petals; two fused keel petals/3 free ones, veined smooth and this petals.<br>Androecium – ten stamen' 9 fused and one free, stamen part of the filaments fused (9 fused) to form a stamen tube long filament for the single stamen and short filaments for the 9 stamens.<br>Two types of anthers / 7 elongated rounded and shorten.<br>Monocarpous pistil, very short style and hairy in crotolaria. | | |
| Bougainvillea floret | Each floret a pistil with 9 elongated, superior, overy with short, thin style and elongated, hairy stigma. | Florets have eight, long, thin/slender, free, smooth filaments and bilobed round / circular anthers. | |
| Bougainvillea Inflorescence. | It consists of three asessile, bisexual, and zygomorphin florets all attached to the end of the penduncle. Each floret is attached on inner upper surface along the midrib of the bract. The pedicel of the floret is fused with the midrib of the bract which is brightly coloured, Large and veined. Each floret has perianth which is dull coloured and fused into funnel tube.<br>Bracts, large/broad, veined, thin, smooth, tapering towards the apex. | | |

| | | | |
|---|---|---|---|
| commelina floret | Each florets has syncarpous with stigma trilobed, hairy attached on relatively long style thin and slender and brightly coloured, superior overy. | Free stamen consisting of brightly coloured, bilobed, elongated anthers that are supported by long, thin, hairy middle way and flexible filament. | |
| commelina-inflorescence | It has one or few florets on the penducle which are asessile (stalked). Each floret has a single, curved, hairy, dull coloured and parallel veined spathe (petal like bract). Each floret is stalked, be sexual, irregular/zygomorphic, have three, broad, veined, thin smooth, curved free brightly coloured petals and calyx three, tapering veined, thin and hairy. | | |
| Bidens Pilosa. floret | Pistil with long/enlongated inferior overy and two / forked fused, hairy, stigma. | It has five stamens with fused, bilobed, elongated / long anthers and short, filaments, with regular symmetry | |
| Bidens Pilosa - inflorescence | It has numerous sessile florets which are attached onto a flattened (cup shaped) and expanded apex of the penduncle surrounded by a calyx – like involucres of bracts. Two types of floret occur, both sessile with fused corolla, free and spiny calyx and an inferior ovary with one ovule attached at the base of the fruit.<br>The numerous, sessile inner florets called the disc or tubular florets are arranged in the circular pattern around the centre and closely packed.<br>The disc or tubular floret are bisexual, action morphic and consists of five fused petals which forms a tube hence the name tubular floret. Its petals have many corolla projections. It has five stamens with fused, bilobed, and elongated anthers and short filaments, pistil has long forked stigma.<br>The ray / outer florets are called ligulate floret in which the corolla tube is extended and has no stamens and pistil (is stevile) and are covered by numerous over lapping and dull coloured bracts making the involucres.<br>The ray (ligulate) florets are zygomorphic and found at the peripheral of the expanded apex of penduncles. It consists of broad / open petals at the apex which are tubular at the base. | | |
| Lantana camara | The florets have a syncapous pistil that consists of boiled / bilocular / bicarpel, knob – like, a bliquely attached stigma to broad base, superior, ovary by a short, thin style. | Four stamens with large bilobed, enlogated ovoid shaped anthers attached to a short, thin, fused with petals filaments. | |
| Inflorescence of lantana | The inflorescence consists of the thorny main axis / peduncle from which numerous, sessile / unstalked, bisexual, zygomorphic, florets / flowers attached on a cubbled apex of peduncle at almost the same or different points. The inner / young florets are arranged around the centre and closely packed while the older florets are found to the peripheral of the expanded apex of penducle.<br>All florets are enclosed by dull coloured, oblong / ovate, hairy, tapering, thick, free, parallel veined, bracts.<br>Floret:<br>Each floret is bisexual, zygomorphic, sessile unstalked and their petals are brightly coloured, four, thin, curved, veined, lobed and smooth, fused to form a tube hence are tubular.<br>Florets have a syncarpous pistil that consists of bilobed / bilocular / bicarpel, knob – like, obliquely attached stigma to broad base, superior overy by a short, thin style. All florets have thin / membranous fused and veined sepals. All the florets are enclosed by dull coloured bracts. | | |
| Banana inflorescence | The pistil is syncarpous, consisting of inferior, elongated, curved, and tapering ovary to wards rhe base, with long, | Flattened, elongated, grooved, bilobed, brightly coloured and curved (shove) anthers and | |

| | | | |
|---|---|---|---|
| | curved, grooved style with trilobed stigma (3fused stigmatic surfaces) and brightly coloured. | filaments are long, flattened, and thick. | |
| Inflorescence. | It consists of a stout main axis / peduncle on which numerous, sessile / unstalked, bisexual, zygomorphic and clustered florets which are zygomorphic and clustered florets which are arranged in two rows and attached at the base of inner surface of the dull coloured, prominently parallel veined, large, thick (fleshy) and in ward curved / boat shaped spathe / bract.<br>Each floret has two perianth which are curved / boat / shaped, parallel veined, dull coloured and attached to the overy.<br>One of the perianth is large and long while the other is short and small.<br>The pistil of the floret is syncar pous, consists of inferior, elongated and posteriorly tapering overy, elongated, grooved style with trilobed stigma (3 fused stigmatic surface).<br>Its stamens consists of long and slender filaments supporting flattened, elongated, grooved, bilobed, brightly coloured are curved (shovel anthers). | | |
| Hibiscus flower | Syncarpous pistil with five carpel, and fused, broad nairy, sticky, branched, stigma attached to free, broad base, superior ovary by long, flexible, thin, slender, free style. | Androecium consists of numerous, filaments fused with a stamen tube, which is long, end of the filament are free, and attach anthers which are bilobed, around and brightly coloured. | Calyx / sepals are 5 fused, taper towards apex, parallel veined, hairy, thick and dull coloured. |
| Morning glory sweet potato | 2/3 carpels, fused, stigma bilobed / trilobed round, hairy style, long, thin, superior ovary round and smooth. | Five stamens, long free and slender, thin filaments, hairy at the base attached to the petals, filaments taper at the apex, bilobed, long, large anthers. | |
| Guinea grass | Two feathery brightly colour red, long stigma, style, short, ovary superior and round. | Three stamen, filament long, thin anthers pendulous, dull coloured, bilobed large, long loosely attached to filament. | |
| Guinea grass inflorescence. | Has main axis / peduncle / rachis with lateral branches of variable length reducing up wards towards the apex, attached oppositely / whorly / alternately having many florets / flowers / spikelets.<br>Some spikelets are single / in groups of 213 all having stalks which are of varying length attached alternately on the peduncles and lateral branches / main axis terminating into a spikelet. | | |
| Gynandopisis gynandra | Slender, elongated, superior ovary, with short / reduced, hairy style, and bilobed, hairy spherical, stigma. | Free, long, slender filaments with bilobed, elongated anthers. | |
| Gynandra inflorescence | Individual un stalked flowers, attached along elongated main axis / peduncle, arranged spirally / alternately, with older flowers lower most, and younger flowers uppermost, ending at the same level.<br><br>Petals are free, smooth, veined, narrow at the tip, calyx are free, hairy, taper towards the tip / boat shaped / curved in wards. | | |
| cassia | It is monocarpous pistil, with elongated dull coloured, curved, and superior ovary, short style and hairy flattened stigma surface. | Each floret has numerous stamens with filaments of varying length which bear bilobed, elongated, thick and curved anthers with variable sizes. | |

| | | | |
|---|---|---|---|
| Cassia inflorescence | It consists of numerous, bisexual and zygomorphic florets attached to a cubbled end of the peduncle florets have long stalks (pedicel).<br>Florets have curved, free (polypetalous), brightly coloured, large prominently veined and papery (thin) petals. | | |
| Male pawpaw flower. | No pistil / gynoecium | Ten, brightly coloured, stamens fused with corolla tube, with large, bilobed, elongated anthers attached onto short, thin filaments; | Five fused, short, tapering towards the tip veined, dull coloured, five brightly coloured, fused forming a corolla tube towards the base, and towards the apex they are free and broad. |
| Solonum / entengotengo | It bears lobea small stigma, short hairless, style, and superior ovary. | Five brightly coloured, having short filaments, have large, elongated, bilobed brightly coloured anthers. | Five tapering at apex, green in colour, free (separate), bear spines and dull coloured; use of spine is protection against predation, green colour is for photosynthesis. |
| | | | Five, bright coloured fused, large (broad) smooth, lower surface covered with hairs, veined and bear poller guide, brightly coloured to attract pollinators (insect).<br>Large to provide a large surface area for landing of the insect. |

**NB**

- Radial/ many lines/ regular/ actinomorphic symmetry.
- One line/ bilateral/ irregular/ zygomorphic symmetry

**Adaptation of lantana to self-pollination**

- Has both the stamens and pistil in the same flower to allow for self-pollination.
- Anthers are above/ higher than the stigma for self-pollination.

**Differences between floral whorls of Bidens pilosa and morning glory**

| Bidens pilosa | Morning glory |
|---|---|
| Inferior ovary | Superior ovary |
| Elongated ovary | Rounded ovary |
| Divided/ folked stigma head | Rounded stigma head |
| Hairy stigma head | Not hairy stigma head |

Differences

| Bouganivillae | Crotalaria |
|---|---|
| Hairy stigma | Stigma not hairy |
| Stigma tapering towards apex | Stigma tapering towards base/ club shaped |

**Similarities between Bouganivillae and Crotalaria gynocuim**

- Both have elongated ovary
- Both have superior ovary

- Both have flattened ovary
- Both have short style

**Pollination Mechanism**

Special remarks about pollination mechanism should be made from observations in the field by deduction from flowers construction. For example, presence or absence of nactaries, nature of pollen grains, etc.

By studying the nature of pollen grains under a microscope, it is possible to tell where a flower is insect pollinated or wind pollinated.

**Microscopic examination of pollen grains.**

- Collect pollen grains from the anthers of the flower provided.
- Mount them in water and examine under high power.
- To obtain a clear view of the structure of pollen grins, clear some pollen grains in a drop of chloral hydrate or phenol and mount in iodine or methyl green in acetic acid. Examine under high power.

**Structure of a pollen grain of an insect pollinated flower**. **Structure of a pollen grain of a wind pollinated flower.**

**Observation:**

A pollen grain has two walls, an anther wall and the inner wall. There are two nuclei, one large (the generative nucleus) and the other being small (the pollen tube nucleus). The outer wall of the pollen grain from an insect pollinated flower is thick and sticky. That of a pollen grain from a wind pollinated flower is thin and contains an air float.

**Wind pollinated grain**

Is oval shaped, smaller sized, even surface, dull colored and occur singularly

**Insect pollinated flower**

Is round shaped/spherical, larger sized, spiny surface, brightly colored and are clumped together

**MONOCOTYLEDONOUS AND DICOTYLEDONOUS PLANTS.**

**Classification:**

| | **Monocotyledonous** | **Dicotyledoneae** |
|---|---|---|
| | Monocot | dicot |
| Kingdom | Plantae | Plantae |
| Phylum | Spermatophyta/Tracheophyta | Spermatophyta/Tracheophyta |
| Class | Monocotyledonae | Dicotyledonae |

**Phylum Tracheophyta/Spermatophyta**

They are the seed bearing plants.

They have the following characteristics;

-Body differentiated into roots, stem sand leaves

-presence of flowers.

Presence of vascular bundles.

They consist of two classes

(i) class monocotyledonae (ii) Class Dicotyledonae

**Reasons**

**Monocotyledonae**

-parallel veined leaved -Leaf sheath.
-fibrous root system. -Narrow and Elongated leaves
-Vascular bundles distributed randomly in the stem

**Dicotyledonae**

- Network veined leaves
- Leaves attached to stem by solid long stalk.
- Presence of one main root with main root with numerous lateral branches which is tapering and long.
- leaves with broad/large lamina.
- Vascular bundles radially arranged on the ring of the cambium.
- Has a central pith and a clear cortex.
- Star arrangement of xylem tissues in whose arms are the phloem tissue.

**General characteristics of vascular plants.**

- Persisting vegetative body divided into roots, leaves and stem.
- High degree of internal tissue spocialization.
- The store, with clearly defined conducting elements (xylomandphloem).
- Well defined sexual reproduction.
- They are flower producing plants.

**Differentiating characteristics;**

| **Monocotyledonous plants** | **Dicotyledonous plants** |
|---|---|
| Leaves have parallel arrangement of veins.(parallel venation) | (i) Leaves have network venation. |
| Have a fibrous root system | (ii) Have a tap root system. |
| Leaves are joined to the plant by a shoot. | (iii) Leaves are joined to the plant by a solid stalk called petiole. |
| Flowers are usually small and inconspicuous (pollinated by wind) | (iv) Flowers are large and brightly colored (pollinated by insects). |

**INTERNAL STRUCRURES OF PLANTS.**

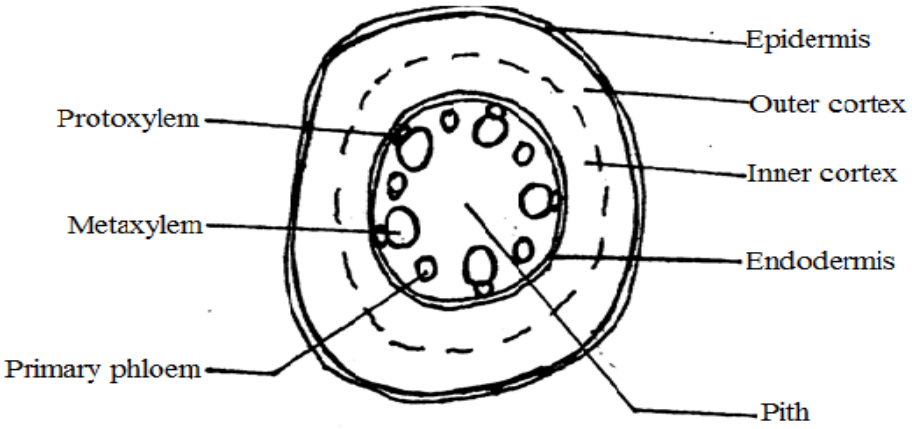
**a) Root structure.**

Differences occur in the arrangement of vascular bundles. The vascular system forms a cylinder made up of primary xylem, primary phloem and parenchyma. The vascular cylinder is called the stele.

(i) **Monocotyledonous roots**.

- Have a larger number of vascular bundles.
- Xylem and phloem alternate with a larger metaxylom being internal to the much small protoxylem.
- Endodermis is clearly defined.
- Pericycle, cortex and piliferous layer are present.
- The centre has a pith of parenchymatous tissue.

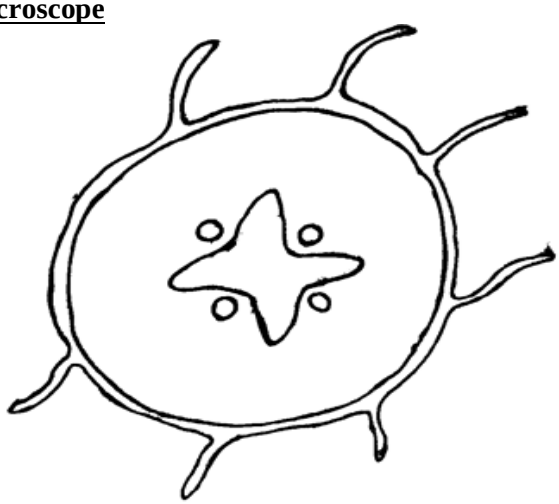
**Structure as seen in a microscope**




**(ii) Dicotyledonous roots.**

- Outside is the piliferous layer which is a single layer of cells, with some cells elongated to form root hairs.
- In the centre is the stele of vascular bundles consisting of alternating single bundles of xylem and phloem.
- The pith is usually absent.

**Structure as seen in the microscope**



**PREPARATION OF SPECIMEN FOR OBSERVATION.**

i) Obtain a young primary root (one that has not laid down secondary tissue). For dicotyledonous plants, butter cup or broad bean is recommended while for monocotyledonous plants the prop root of maize is recommended.
ii) To hold the root firm, insert a short length of it into a vertical slit made down the centre of moistened elder pith or carrot tuber.
iii) Hold the pith or carrot in one hand and cut transverse sections of root, rapidly and smoothly with a sharp razor blade, hold in the other hand.
iv) Place the sections in a dish of clean water. Select one or two thin sections and transfer them with a fine brush onto a microscope slid the cut surface upper most.
v) Mount in a drop of iodine solution and observe under a microscope.

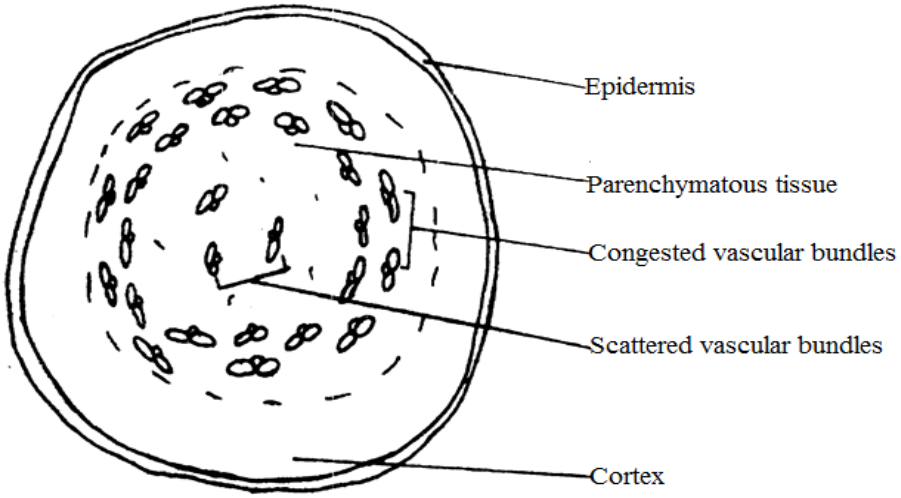
b) **Stem structure.**

**i) Monocot stem.**

- Surrounded by an epidermis with usually cutinized outer walls.
- Within the epidermis is a narrow zone of schlerenchyma. One or two cells thick which consists of an ill-defined cortex.
- The remaining part of the stem is parenchymatous ground tissue in which are embedded numerous irregularly scattered vascular bundles.

These are large and more spaced in the centre and become progressively smaller and more crowded as the peripheral region is approached.

**Structure as seen in a microscope**



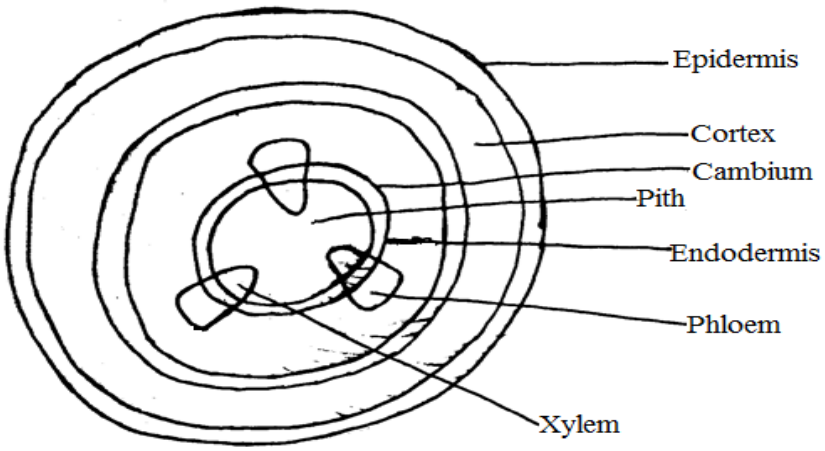

**ii) Dicotyledonous stem**

- The epidermis, the outer most layer, is a single layer of cells with multicellular hairs and with cutinized outer walls (these stain red with sudan III).
- The cortex is narrower than in the root but with too many layers of cells consisting of collenchymas and parenchyma cells.
- Endodermis stains blue or black with iodine.

The vascular bundles occur inside the endodermis forming a ring and consisting of the stelo. Each bundle has phloem on the outside and inside on the same radius (they are collateral).

The two are separated by a primary meristem which is several cells thick known as the intra-pascular cambium. It is a layer of thin walls cells which appear rectangular in shape.

**Structure as seen in the microscope**




**PROCEDURE OF SPECIMEN PREPARATION**

Requirements

- ✓ Slides and covorslides
- ✓ Dish for sections
- ✓ Fine brush
- ✓ Sharp razor blade or (cut throat) razor
- ✓ Iodine solution
- ✓ Stem of sunflower (helianthus)
- ✓ Stem of monocotyledon e.g maize, iris or lily

**Procedure**

i) Cut smoothly and rapidly thin transverse sections of young primary stem of a plant.

ii) Place the sections into a dish of water.
iii) Select, mount them in a drop of iodine on a microscope slide.

## IDENTIFICATION OF DIFFERENT PLANT TISSUES:

There are four basic permanent tissues in the plant each with a distinct location and function.
They include:-

- Epidermal tissue.
- Parenchyma tissue
- Collenchyma tissue.
- Schlerenchyma tissue.

All can be identified by observing thin sections of different plant parts under a microscope.

**Parenchyma tissue.**

Characteristics:

They have the following tissues;

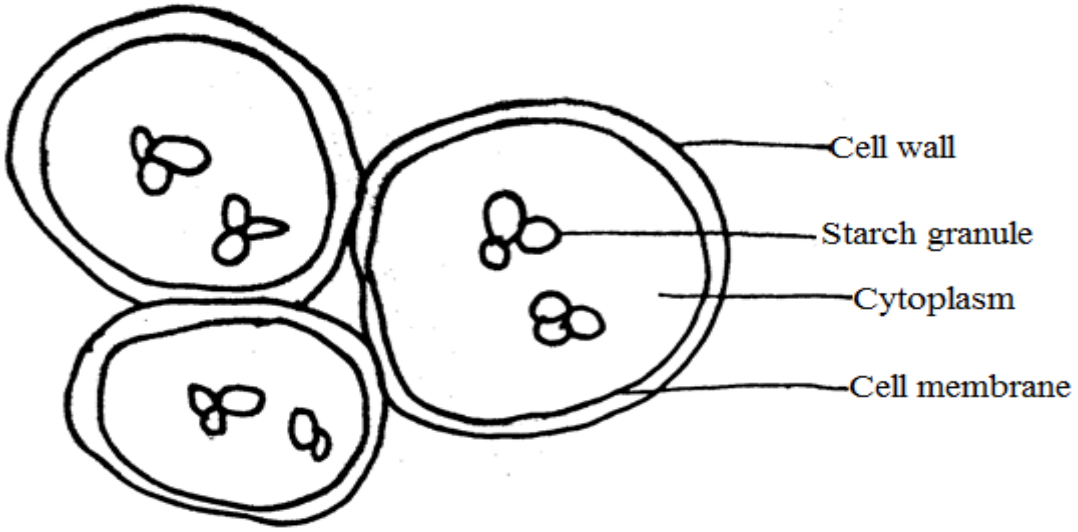
i. Parenchyma tissue
   - Its cells have large food vacuole.
   - Made of spherical or round cells.
   - Its cells are closely packed.
   - Its cells have starch granules.
   - Its cells have thin walls.

**Functions.**

- ✓ It is used for storage of food due to possessing of starch granules and large food vacuole.
- ✓ Used for support when turgid due to being closely packed
- ✓ That in the leaf is specialized for photosynthesis (palisade cells are parenchyma cells).

**Parenchyma cells form background tissue in most parts of a plant including:**

- ✓ Cortex of stems.
- ✓ Cortex of roots.
- ✓ Mesophyll layer of leaves




Also found scattered amongst xylem vessels and phloem sieve tubes in the vascular bundles.

**Collechyma tissue**

This tissue stains blue with schultz's solution because of its high content of cellulose.

**Characteristics**

- Cells with thick cell wall.
- Polygonal/rectangular cells.
- Closely packed cells.

**NB**.All the above are adaptations of collechyma as supporting tissues in plants.

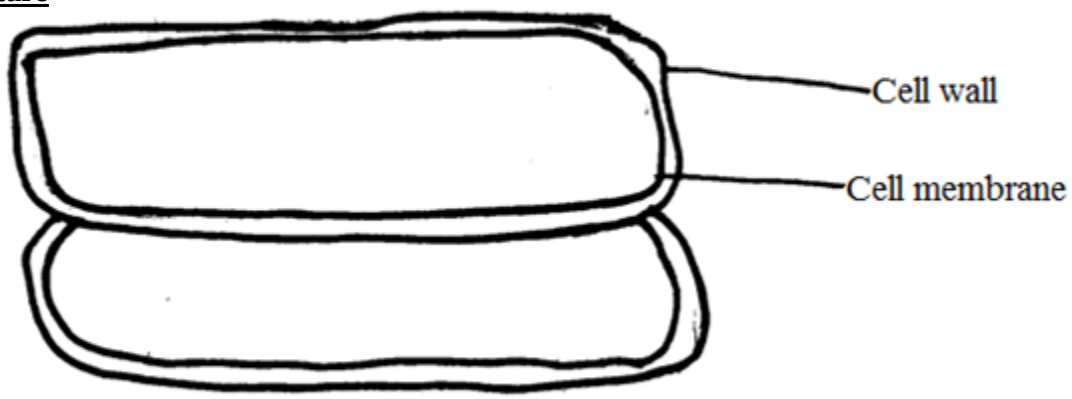
**Location**

Outer cortex, just below the epidermis

**Functions.**

- For support due to its closely packed cells with a thick cell wall.

**Structure**



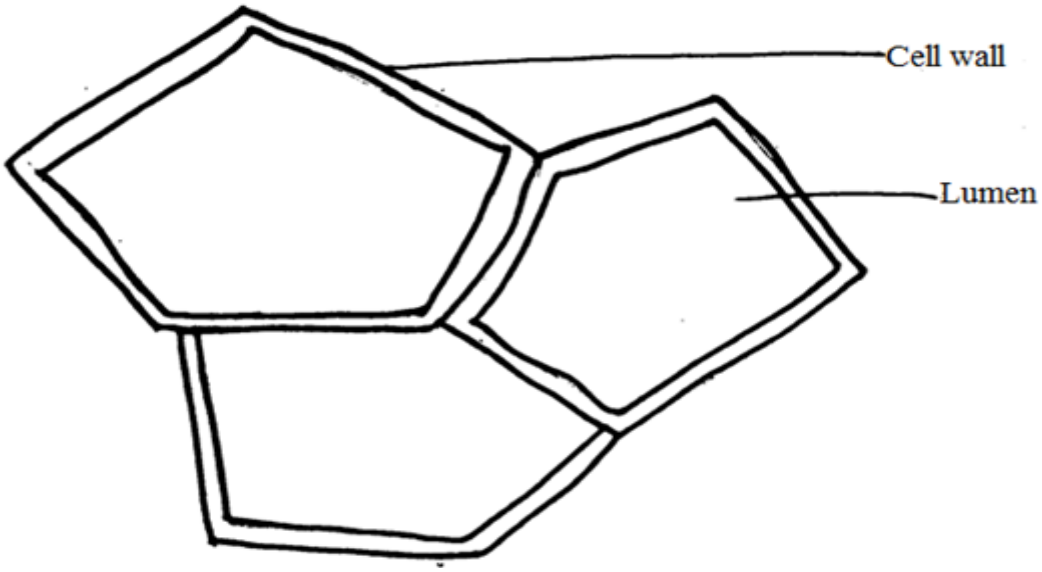

**Sclerencyma tissue**

- Thick walled cells.
- Cells with no cytoplasm
- Lignified cell wall.
- Hollow and elongated cells.
- Cells with narrow lumen.
- Polygonal cell tissue.

**Functions**

- It is used for support due to possession of a very thick lignified cell wall.
- Its cells are hollow for easy flow of materials.
- Its cells have a narrow lumen to facilitate capillarity.

**Structure**




**Location and function**

**Sclerencyma tissue** is located immediately around each vascular bundle.

- It is specialized supporting tissues of the plant.

**Epidermal tissue**

- Cells are closely packed
- It is thin and less transparent
- Has thick cell wall.
- Cells are polygonal/rectangular
- They are elongated

**Functions**

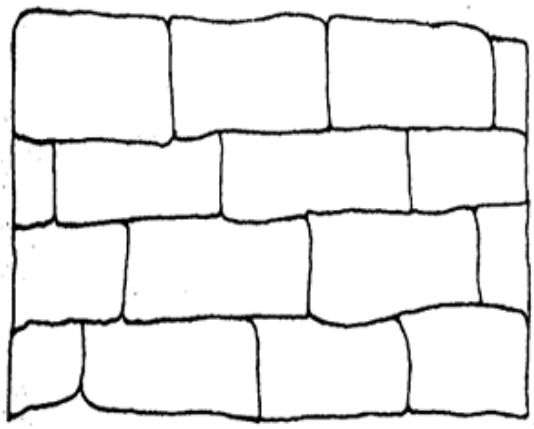
- Closely packed to protect inner tissue from physical injuries.

- Thick cell wall for protection.
- Elongated cells offer a large surface for protection.

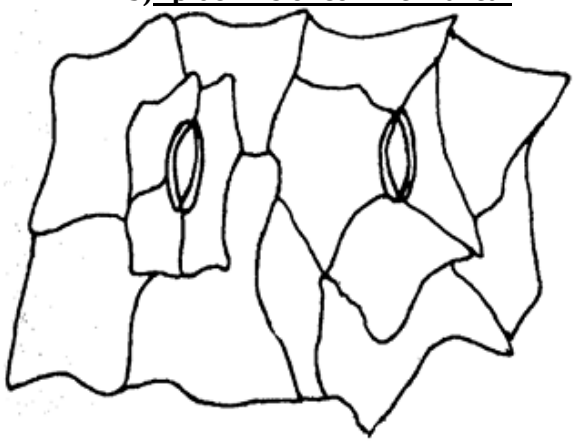
**NB;** When a cross section of a stem is stained with acidified pyloroglucinol, lignin in the tissue of sclerenchyma and xylem stains red or pink.

**Drawings Showing the structure of epidermal tissue**

**a) Onion Epidermis**



**b)Epidermis of commelina leaf**



**Procedures of obtaining epidermal tissues:**

- Carefully peel off a single epidermal lay of cells from an onion or commelina leaf using a forcops.
- Mount in a drop of water and observe under a microscope.

NB

The epidemics of leaves are interrupted at intervals by small pores called stomata.

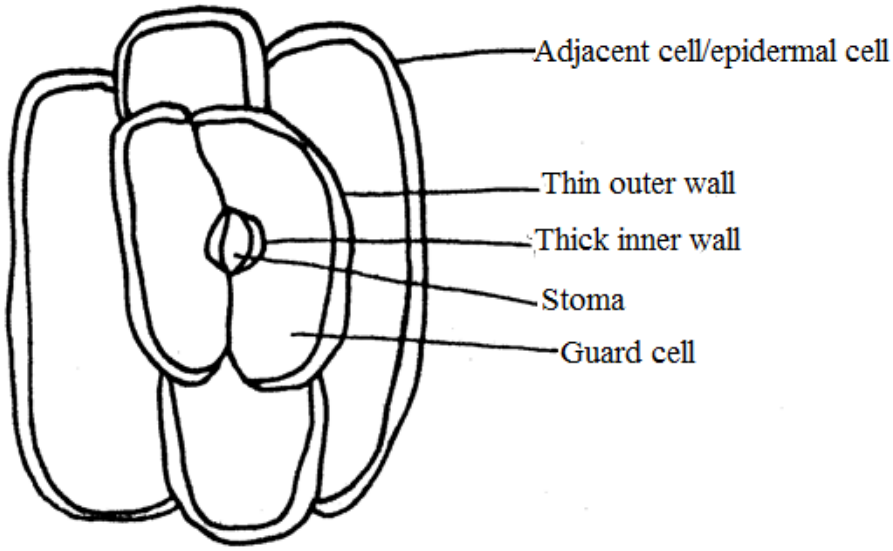
Using a microscope, the number of stomata in the upper and lower epidermis of a leaf can be interrupted at internals by small pores called stomata.

This is always indicative of the habitant of the plant, from which the leaf was picked for example.

1) Land plants from relatively dry areas and other plants with aerial leave have a larger number of stomata in the lower epidermis than in the upper epidermis.
2) I floating leaves such as those of water lilies have more stomata on upper surface and very few or none on the lower surface.
3) Submerged leaves lack
4) stomata on both surfaces.

The physiology of stomata movements can also be practically.

**Two guard cells adjacent to each other**




**LICHENS**

Lichens are a symbiotic relationship between a fungus and a green algae. They live on the barks of trees. Rocks surfaces and in the soil there are of three types:

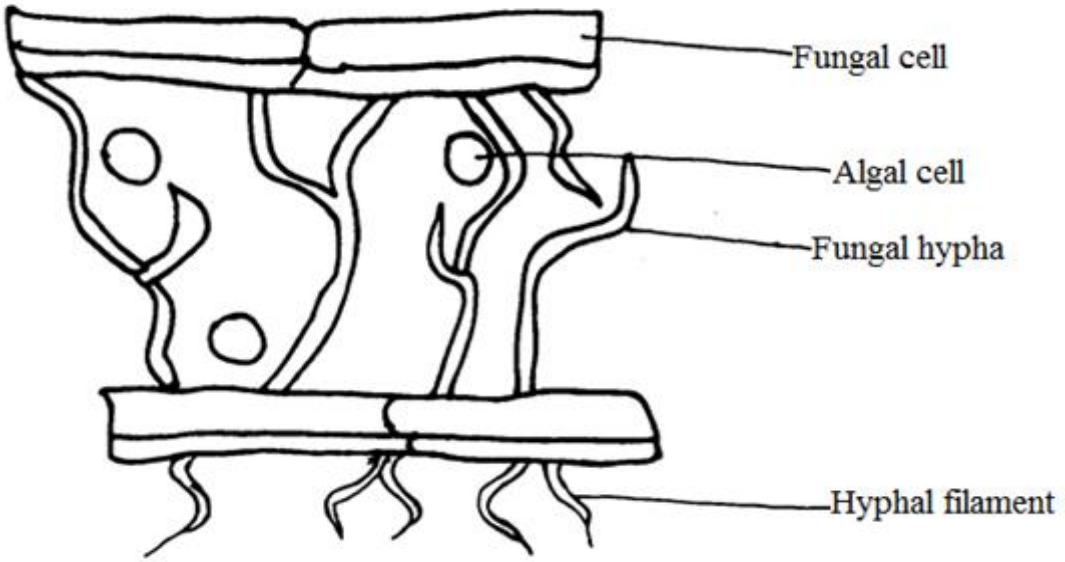
The crustaceous lichens in which the thallus is in the form of an incrustation.
The fallacious lichens with a flattered thallus. The fruticose lichens with a branched filamentous thallus.The fungus is in almost all cases one of those known as a scomyeotes and the algae green (belonging to the zygnematophyceae).
Cently macerate lichen in a drop of water on a slide. Discardary solid material, place a cover slip and observe under low or middle power.
You will be able to see the oval shaped alga cells among the fungal cells.

**Description of structure**

Crustose/crust like /flattened body, undifferentiated body has
hyphae/filaments/rhizoid/orbed/regularly shaped.

**Adaptations**

-hyphal filaments for support on to the substratum and for absorption of water /mineral salts.
-Thin to reduce on the diffusion distance of the gases during gaseous exchange.
-Numerous soredia containing spores for propagation.
-Broad to increase surface area for trapping a lot of solar energy for the algal to carryout photosynthesis.
-Numerous lobules which can break off and developed into a new lichen dispersing the algal and fungus together.
-Numerous hyphal filaments for ancharge.
-Green round algal cell for absorption of sunlight for photosynthesis.
Elongated fungal cells to offer protection of the algal cells.
-Numerous fungal hyphae for protection of the algal cell from drying out




**FERN**

**Classification**

| | |
|---|---|
| Kingdom | Plantae |
| Phylum | Filicinophyta / pteridophyta |
| Class | Filicineae |
| Order | Filicales |
| Genus | Dryopteris. |

**PHYLUM**: Filicinophyta / Pteridophyta.

Reasons

- Possession of relatively large leaves.
- Sori underside / lower surface of the leaf lets.
- Numerous adventitious roots.

**Description of structure**

- Differentiated into adventitious roots / rhizome, leaves / fronds, lamina divided into leaflets / pinna with pinnules,
- Lower surface has sori / groups of sponrangia,

- It has large leaves (fronds) arising from a thin rhizome. The rhizome bears a mass of fibrous adventitious roots.

**Characteristics of fern plant.**

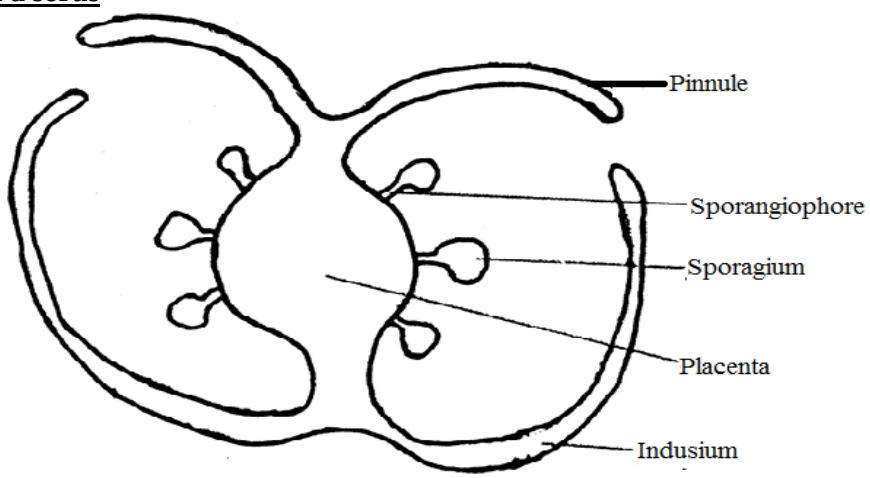
- It bears relatively large leaves.
- It bears adventitious roots.
- It bears numerous sori underside the leaflets.
- It has along hard leaf stalks with vascular bundles.

**Adaptations of the fern plant to its environment.**

- It has relatively large leaves for losing excess water and absorbing more light for photosynthesis.
- It has long adventitious roots for anchorages and for absorbing water.
- It has numerous sori for producing many spores increasing chances for reproduction.
- It has long leaf stalk to raise the spore case/sori high for easy dispersal of spores.
- It has buds for vegetative reproduction.

The leaves are compound, each consisting of the main axis (rachis) have a thick base or petiole bearing leaflets called pinnae, each of which is subdivided into pinnules.
The lower surface of the pinnae bears some clusters of sporangia.

**Drawing of a sorus**




**THE MOSS**

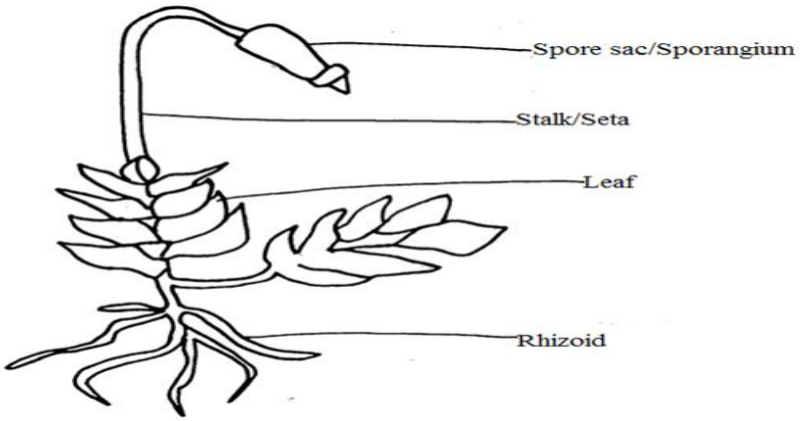
**Kingdom** **Plantae**
**Phylum** **Bryophyta** because:
-spirally arranged leaf like structures/simple leaves/ false leaves.
-Body differenciated into simple leaves and stem attached to gametophyte anchored by rhizoids.
-Spore bearing capsule/sporangium at the end of the seta/staik.
**Class** **Musci because**
-prominent spore bearing capsule.
-Presence of thin rhizoids.
-Small sized stem with spirally arranged leaf –like structures
**Genus** **Funaria**

**Adaptations that enables it to survive in its habitat.**

- It has numerous rhizoids for anchorage and absorption of water from substratum.
- It has a large / swollen spore capsule to produce numerous spores allow quick colonization of sporophyte on the land.
- Has long seta/sporongiophore stalk to raise the spore capsule high for easy dispersal of spores.
- Has spirally leaves to increase surface areal exposure to sun light for photosynthesis.
- Numerous leaves to increase surface area for light absorption.
- Thin rhizoids to ease absorption of nutrients.

- Large / swollen sporangium/capsule to store many spores.
- Erect stem to expose leaves for photosynthesis.
- Erect / upright sporongiophore to expose sporangium for easy dispersal of spores.
- Thin sporongiophore for easy swing for dispersal of spores.

**Drawing of a Moss**




## SPIROGYRA

**Classification of spirogyra.**

| | | |
|---|---|---|
| **Kingdom** | : | Protista. |
| **Division** | : | Chlorophyta. |
| **Subdivision** | : | Algae |
| **Class** | : | Zygnomatophyceae/chlorophyceae |
| **Order** | : | Conjugales (zygnomatales) |
| **Family** | : | zygnematacea. |
| **Genus** | : | spirogyra. |

**Microscopic examination of spirogyra**

**Procedure**

Mount a single filament of spirogyra in water under low power.
The filament is seen as unbranched thallus of identical cylindrical cells.
Under high power the following are seen.
The cell wall with protoplasmic lining.
The nucleus contains anucleous and suspended by protoplasmic strands.
The spiral choroplasts with wavy edges containing a number of circular pyrenoids.
The rest of the cell vacuole.

**Staining**

Decolorize a filament in warm alcohol, mount in schultzos- solution.
The cell wall turns blue due to the cellulose it contains
The pyranoid turn brown
The starch grains turn blue
Decolorize filament in warm alcohol stain with safranin or haematoxylin and mount in dilute glycerin.
The nucleus and protoplasmic strands stain red with safranin.
The nucleus and protoplasmic stands stain blue with haematoxylin.
Staining with iodine makes nucleus stain brown and pyrenoids stain blue.

**Drawing showing a filament of spirogyra**

**NB**

The spirogyra stays in fresh water ponds or slow following water streams or barks of logs.

**The spirogyra is adapted to its habitant in following ways**

- It is filamentous, long and thin to increase surface are for photosynthesis or gaseous exchange.
- It is shiny or slimy to reduce chances of being fed on or mechanical damage by entanglement.
- It is green because has chlorophyll to enable it trap sunlight to manufacture food.
- Pyrenoids serve to store manufactured food.
- The large vacuole reduces weight allowing it float on water surface a strategic position to receive light for photosynthesis.
- Has high rate of reproduction given the fact that it reproduce both sexually and asexually hence enabling to colonise its habitant in a short period of time.
- Thick cell wall for protection
- Filamentous for floating on water.
- Septate for fragmentation/asexual reproduction and for flexibility

**Adaptations for nutrition**

1. Has chloroplasts for trapping light for photosynthesis
2. Spiral chloroplasts to increase surface area for trapping light for photosynthesis.
3. Pyranoids for food storage.

**NB:** Spirogyra is known as filamentous green algae or filament spirogyra because it has the following characteristics

- Has elongated cylindrical solitary cell joined end to end.
- Have spiral chloroplasts which occur with the cytoplasm of cell.
- Pyrenoids are present on a spiral; choloplast.
- Un branched filamentous, haploid body.
- Numerous cytoplsmic strands present suspending the nucleus.
- Slimy mucilage appears on the surface of the green thread like filaments.
- Has nucleus suspended by cytoplasmic strands.

  Its long,thin un branched and filamentous, filaments are septate length wise, spiral shaped chloroplasts numerous pyrenoids, large vacuole , thick cell wall, thin cytoplasm, green, slimy and light.

**Economic importance of spirogyra**

(i)Slime is used to make agar for bacteria culture media used in hospital and industrial micro biology laboratories.

(ii) Important in ridding fresh of carbodioxide produced by water animals and production of oxygen that can be used by fresh water animals hence important in regulating water PH

## MOULDS

Known also as Mucor- Dung mould
Rhizopus – Bread mould

**Classification**.

Kingdom : Fungi.
Phylum : Zygomycota/Eumycota/zygomycetes.
Class : Zygomycetes/Phycomycetes.
Order : Zygomycetales/Murales.

**Reasons** for being in phylum Zygomycota/Eumycota/zygomycetes

- ✓ Has sporagiophore/stalk with sporangia
- ✓ Branched hyphae/mycelium
- ✓ Non septate hyphae

**Habitat.**

Shady places on dead decaying organic matter, dams.

**Adaptations to habitat.**

- ✓ Fungal mycelium spreads in all directions over its food source to ensure sufficient to nourishment.
- ✓ Produce spores that are resistant to adverse conditions such as excessive drought or coldness and thus continue the life cycle when favorable conditions appear.
- ✓ Roolet hyphae penetrate into food substrate and secrete enzymes that digest it and also absorb the digested food.

**Economic importance.**

Some species such as mucor javanicus has special enzymes that ferment sugar to alcohol and so finds use in breweries.

They enhance recycling of nutrients in an ecosystem by acting as decomposers of dead organic matter.

**Characteristics of rhizopous.**

Aerial hyphae (sporangiophore) grow upwards with dark spherical heads (sporangia) on their free ends.

Made up of branching filaments or tubes called hyphae.

Hyphoe are a septale i.e. have a continuous cytoplasm with no septum.

Hyphae form a complex, tangled network called.

**Drawing of mucor**

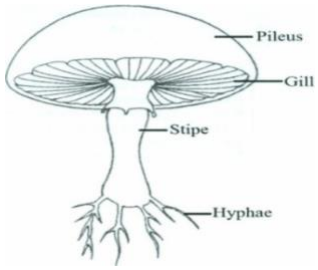
## MUSHROOM

**Characteristics of a mushroom**

- ✓ Sporangium/spore capsule is round/spherical, dull/black heads
- ✓ Sporangiophore is thin/slender and long
- ✓ Rhizoids/rooting hyphae are numerous, thin and slender
- ✓ Stolon/linking hyphae are thin slender and form a network

**Adaptations**

1. Sporangiophore is thin/flexible for easy spore dispersal
2. Rhizoids are thin and many to penetrate into substratum to absorb nutrients/ provide large surface area to absorb nutrients
3. Sporangium ball like/round to store many spores
4. Stolon forms network for support/cover wide area
5. Small spores which are light to easily blown by wind.
6. Produce many spores to increase chances of propagation/colonising
7. Long Sporangiophore to expose sporangium to ease spore dispersal




## YEAST CELLS

**Yeast cells (saccharomyces).**

Mix a little baker's yeast (saccharomyces cerevisae) with water, put a drop of the mixture on a slide and add a cover slip and examine under high pocoer.

Observe that the yeast is unicellular. Colorless and oval in shape. Observe the cell wall eytoplasm which is faintly granular in appearance and the control vacuole.

Irrigate with a little iodine solution and note that the eyto plasma stains yellow. Observe the reddish brown areas showing the carbohydrate glycogen. The nucleus may be visible beside the vacuole

**To examine budding in yeast.**

Prepare a culture by mixing some yeast with a 290 solution of ordinary malt extract. Keep this culture in a warm place for about 24hrs and then examine a drop of it under the low or high power of a microscope. Many of the yeast cells will now be inactive state of vegetative multiplication by budding.

## COMMELINA PLANT.

It is a flowering plant found in phylum angiosperm a phyla /spermatophyte/tracheophyta.
Its habitat is terrestrial and its adaptations are:
Have veins in leaves to transport dissolved foods, water and mineral salts.
Have stomata for gaseous exchange.
Thin to reduce distance of diffusion of gases.
Being green it has chlorophyll to enable in trapping sunlight for manufacturing food.
Flat surface increases surface area for photosynthesis.
Have more stomata on the lower surface and less on the upper surface to reduce water loss.
Thick and fleshy for storage of water.

**Differences between commelina growing in a open land and that in a shady area.**

| Open land | Shady area |
|---|---|
| Has short internodes | Has long internodes |
| Has pale green leaves | Has dark green leaves |
| Has thin leaves | Has thick leaves |
| Has more hairy leaves | Has less hairly leaves |
| Has narrow or short leaves | Has broad or long leaves |
| More hairy | Less hairy |
| Thick lamina | Thin leaf surface |

**Adaptations to open land**

- Hairly leaves to minimize water land
- Narrow or short leaves minimize exposure to heat and so minimize water loss
- Few stomata on upper surface and more on the lower surface to reduce on water loss.

**Adaptations to shady area**

- Less hairy leaves as there is little to do with minimizing water loss.
- Have broad or long leaves to maximize capture of sunlight for photosynthesis.
- Few stomata on upper surface and many on lower surface to reduce on water loss.

**Reasons for habitat**

**Sunny / open terrestrial habitat**

-Fewer number of stomata to reduces water loss.
-Narrow leaf surface / lamina reduce surface area to minimize water loss.
-Much more stomata on lower surface and fewer stomata on upper epidermis to reduce water loss.
-More number of stomata to increase water loss hence rapid cooling.

**Shady/damp terrestrial habitat**

-More number of stomata on the lower surface than upper surface to minimize water loss.
-Deep green, much chlorophyll to maximize light absorption.
-Broad lamina to increase surface area exposed to sunlight/for maximum light absorption.
-Less hairy because need to conserve water / to enhance transpiration.

## WATER LILLY

It is a flowering plant and its habitat is aquatic/ water/swamp.
Class : Dicotyledoneae
Subclass: Magnolidae.
Order: Nymphaeles
Genus: Nymphaea

**General features.**

Weak stems with flat broad leaves on upper surface.
Leaves are net veined thick, simple, broad, smooth, alternate, spiral, opposite or whorled with the petiole is long, attached near the centre it is smooth with stipules at the base of the stalk.
he stem is shorter with many nodes, thicker rhizome with fibrous roots.
Flowers are solitary with both stamens and pistils, has a radial symmetry long smooth pedicle. Petals are four to twelve, broad, sepal like overlapping, smooth, fused to each other at the base, broad intergrading with stamens. Stamens are three to many, free or attached at the base of the petals with

elongated smooth filaments and elongated anthers. The ovary is half inferior, the style is long and smooth .
Roots are fibrous, thick, long, and spongy/soft.
**N.B:** When a small piece of a leaf is cut and observed under low power of a microscope numerous, small, brightly lit patches/pores/air spaces are observed.
And when the epidermis is peeled off from the leaf on both sides numerous/many stomata are observed in the upper epidermis because it the upper epidermis which is exposed to air/atmosphere to increase rate of gaseous exchange/transpiration.

**Adaptations of water lily to its habitat**

- Broad flat leaves to increase S.A for maximum trapping of sunlight.
- Has numerous wide air spaces in leaves and stems provide buoyancy.
- Has numerous wide stomatal opening on upper epidermis for transpiration to get rid of excess
- water.
- Has broad leaf lamina increasing S.A for over which stomata are distributed for loss of excess
- water.
- Stem is weak and flexible preventing the impact of strong winds and water currents that would cause breakage.
- Numerous fibrous roots increases surface area for support, absorption of water and mineral salts.
- Long leaf stalk exposing the leaf to the water surface to trap solar energy.
- Have buds to give rise to new plants.
- Has long flower stalk/pedicel to expose the flower to pollinating agents
- Brightly cloured petals/flowers to attract pollinators
- Bisexual flowers increase chances

**Upper epidermis**

- Has very many large sized stomatal
- Openings to increase the rate of transpiration getting rid of excess water.

**Lower epidermis.**

- Has no stomata.
- The lower surface is usually in direct contact with water.
- Gaseous exchange occurs by simple diffusion.

**Drawing of transverse section of stem of water lily**.

**Flower of water lily**

Scattered arrangement of vascular bundles within the cortex
**NB:**
Has more vascular bundles.
No air spaces in tissues.
Has more lignified tissue.
**NUT GRASS**
Kingdom plantae.
Reasons: Possession of roots, stems and leaves
Phylum Angiospermatopohyta
Reason Bears: Flower.
Possession of flower.
Class: Monocotledoneae

Reason: Parallel veins in leaf lamina, long and narrow lamina, has leaf sheath.
The leaves are long, linear, parallel veined, pointed apex with rough margin, long leaf stalk which is sheathed.
The stem is long with few nodes, long internodes and thin rhizome with scale leaves.
Has a smooth, long triangular in cross section flower stem (penducle) with swollen base. The inflorescence is terminal, open; subtended by several leaf brasts which are pointed, apex, parallel veined, near with a rough margin. Several un equal rays/branches radiating from the tip of the penducle with several flattened spikelets each with several pointed flattened smooth over lapping brasts.

**Roots**

Several fibrous roots arising from true stem. Roots are thin, short, solid /compact/hard long and slender hairy.

**NB:** When a small piece of leaf is cut and observed under low power of microscope, small, numerous, polygonal, closely packed cells/cells joined end to end are observed.
When the upper and lower epidermis is removed numerous/many stomata are seen in the low epidermis to minimize exposure to light hence reducing to rate of transpiration.

**Drawing of nut grass inflorescence**

**Description of inflorescence.**

Several rachis of varing length a rising wholly on the apex of stem.
Peduncle has lateral branches.
Each lateral branch has numerous florets which are sessile, alternately arranged and sessile packed.

**Internal structure of a floret**

**Structure of pistil of nut grass.**

**Adaptations to its habitat**

- Numerous fibrous roots increasing surface area for support, absorption of water and mineral salts
- Long flower stem to expose the inflorescent to wind for dispersal.
- Has both stamens and pistil increasing chances of fertilization.
- Thick flower stem for firm support on the substratum
- Swollen flower stem base increasing support into the soil.
- The stem is a rhizome swollen with food stores to survive unfavorable conditions, then resume growth when conditions are favorable.
- Rhizome has buds for vegetative propagation.
- Long leaves increasing surface area for trapping solar energy needed for photosynthesis.

- Numerous spikelets increasing chances of pollination.
  **NB:** Has fewer vascular bundles.
  Numerous air spaces in tissues.
  Has less lignified tissues.

Classify the specimen into the following taxa, giving two reasons (2 diagnostic features) for class

| ***Specimen*** | ***Kingdom*** | ***Phylum*** | ***Class*** | ***Diagnostic features*** |
|---|---|---|---|---|
| Bread mould | Fungi | Zgomycota | Zygomycetes | Has: (i) filamentous body<br>(ii) sporangium atop sporangiophore<br>(iii) branching mycelia |
| Mushroom | Fungi | Basidiomycota | Agaricomycetes | Has: (i) pileus with gills at underside<br>(ii) stipe<br>(iii) rhizoids |
| Moss | Plantae | Bryophyta | Music | Has: (i) un branched Rhizoids<br>(ii) sporangium with operculum<br>(iii) simple leaf-like structures |
| Fern | Plantae | Pteridophyta | Filicales | Has: (i) horizontal rhizome,<br>(ii) fronds with sori at underside |

**Description of the structures of each specimen**

| Parts | Moss | Fern | Bread mould | Mushrrom | lichen |
|---|---|---|---|---|---|
| (a) Vegetation structures | Vertical stem with many leaves, non-woody | Horizontal stem with many leaves, herbaceous | Vertically growing, thin sporangiophores each support a spherical sporangium. Sporangia have spores | Vertically growing, fleshy stipe which supports an expanded doom-shaped pileus. Many gills radiate from underside of pileus. | The thallus is generally flattened broad, lobed pale green on top a combination of brown and black at the bottom |
| (i) Leaves | Leaf arrangement: crowded on a short stem at same point( Rosette) Each leaf is green coloured, thin with prominent midrib and pointed apex. Leaf type: simple | Leaf arrangement: alternate each leaf has long stalk, is divided into leaflets (pinnae) which further divide into pinnules. Leaf type: compound bipi-nnate | No leaves | No leaves | Thallus body |
| (ii) Stem | Upright/vertical non-woody, very short green coloured, crowded with leaves branched at base, has long curved seta with a capsule at the top. Fibrous root where roots are un branched, few short thin. | Horizontal, short, rhizome with many hairy, branched adventitious roots has many buds. | Has enlongated vertical sporangiophores, each supporting a spherical sporangium. Sporangia have spores. Sporangiophores are thin | Thick, fleshy, vertical stipe which supports an expanded dome-shaped pileus | Thallus body |

| | | | | | |
|---|---|---|---|---|---|
| (iii) Root system | Fibrous roots where roots are un branched, few, short, thin | Fibrous root system with many adventitious roots which are relatively long, hairy, curved | Many horizontally growing, thin hyphae | Rhizoids are short, un branched, few | No roots |
| (b) Reproductive structures | Sporophyte has a long seta bearing spores capsule which is oval shaped with a calyptra at the apex. Gametophyte is side branched. | Has many sori at underside of pinnules. The sari are semi circular | Long sporangiophore bears a spherical sporangium with many spores | Has many spores inside the gills | Bumpy/ disc shaped dark-coloured structures at the surface of the thallus |
| Type of reproduction | Asexual evidence: has spore capsule with spores to facilitate asexual reproduction | Asexual evidence: has sari at underside of leaves with spores for asexual reproduction | Asexual: Evidence : has sporangium with spores for asexual reproduction | Asexual Evidence: has gills with spores for sexual reproduction | Asexual Evidence: bumpy structures at the surface of the thallus have spores for asexual reproduction |
| Mode of nutrition | Autotrophic Reason: green colour indicates presence of chlorophyll for trapping sunlight | Autotrophic Reason: green colour indicates presence of chlorophyll for trapping sunlight | Heterotrophic Reason: no chlorophyll | Heterotrophic Reason: no chlorophyll | Autotrophic Reason: green colour indicates presence of chlorophyll for trapping sunlight |

**Adaptations for life in the habitat**

| Specimen | Habitat | Adaptations for survival |
|---|---|---|
| **Bread mould** | Terrestrial on decaying organic matter | i) Sporangium broad for massive reproduction of spores for rapid propagation.<br>ii) very many spores produced for increased the rate of propagation<br>iii) sporangiophore elongated for increased chances of propagation of spores<br>iv)many rhizoids for firm anchorage into substratum<br>v) long sporangiophore for carrying sporangium to increase dispersal by wind.<br>vi)Rooting hyphae to absorb readymade food/anchorage<br>vii) Sporangia has spores which are easily dispersed. |
| **Mushroom** | Terrestrial on decaying organic matter | (i)stipe is raised for dispersal of spores during vegetative propagation<br>(ii) many hypae for anchorage into substratum<br>(iii) pileus contains many for increased spore production during asexual reproduction |
| **Lichen** | Terrestrial on tree trunks | (i)green colour indicates presence of chlorophyll for trapping sunlight, energy for photosynthesis<br>(ii) thin walls for faster diffusion of nutrition |

| | | |
|---|---|---|
| | | (iii) many spore producing structure for increased chances of asexual reproduction |
| **Moss** | Terrestrial on damp water tanks, damp verandas, damp tree logs /tree trunks/dump shaded terrestrial soil/walls of houses | (i)seta stalk for increased chance of dispersal spores<br>(ii)spores capsule is broad for manufacturing<br>(iii)whole body (except) roots have chlorophyll for increased photosynthesis<br>(iv) thin wall leaves for faster diffusion of water |
| **Fern** | | (i)Leaves are broad to increase the surface area for trapping sunlight into photosynthesis<br>(ii)many sori for forming many spores to increase propagation chance<br>(iii) leaf stall is long to expose lamina to much sunlight for increased photosynthesis<br>(iv) many adventitious root increase water absorption<br>(v) stem is hairy to reduce transpiration |

***Ecological role in the habitat***

| Specimen | Ecological role in the habitat |
|---|---|
| Bread mould | 1. Cause dead bodies to be disposed of by decomposition which would accumulate everywhere<br>2. Decomposition releases mineral nutrients from dead bodies into the soil for plant growth |
| Mushroom | 1. Causes dead bodies to be disposed of by decomposition which would accumulate everywhere<br>2. Decomposition releases mineral nutrients from dead bodies into the soil for plant growth<br>3. Some are edible and therefore use a food by humans |
| Lichen | 1. Being sensitive to air pollution, they are indictors of environmental pollution<br>2. During photosynthesis, oxygen is released which joins the main circulation for respiration<br>3. Being resistant to drought, lichens are among pioneer colonisers during primary succession<br>4. Can be fed on by animals<br>5. Lichens degrade some environmental chemicals like polyester resins |
| Moss | 1. During photosynthesis, oxygen is released which joins the main circulation for respiration<br>2. Being resistant to drought, mosses are among early colonizer during primary succession<br>3. Provide shelter and humidity for some invertebrates |
| Fern | 1. During photosynthesis, oxygen is released which joins the main circulation for respiration<br>2. Ferns are also ecological indicators that tell about the environmental pollution<br>3. Fern serves as an ecological filter, shape density and species composition of environment |

**Similarities between moss and Rhizopous**

- Both form spores
- Both have sporangiophores
- Both have sporangium

- Both have rhizoids

**Differences**

| Moss | Rhizopous |
|---|---|
| Has leaf like structures | Lacks leaf like structures |
| Has chlorophyll | No chlorophyll |
| Has calyptra on sporangium | Lacks calyptra on sporangium |
| Rhizoids un branched | Rhizoids branched |
| Lacks stolon | Has stolon |
| Has one sporangium | Has several sporangia |

## SEED STRUCTURE AND GERMINATION PHYSIOLOGY

**Introduction**

A Seed is an embryo plant together with its store of food. The whole structure is encased in a seed coat called the testa. The embryo consists of an immature shoot, the plumule, and an undeverloped root, the radical.

In the seeds of monocotyledonous plants such as grasses and maize, the embryo is attached to a single seed leaf called the cotyledon. There are, however, two seed leaves in dicotyledonous plants, a reason for which the respective names of such plants.

The food reserve is stored in swollen cotyledons in sun flower and bean seeds. In maize, the food is stored in a separate tissue called endosperm.

**Morphological aspects of seed germination:**

Germination is the first step in the development of a mature plant from the embryo of the seed. The appearance of a seedling plant marks the end of germination. However, the way in which this happens differs from one species to another. The various patterns of germination can best be appreciated by studying the germination of seeds of several species. Here are two examples:-

**1. Germination of a bean seed**

**(a) Seed structure**

Seeds of beans develop as a single row inside an elongated pod – shaped pericarp. Each seed is attached to the pod by a stalk, called the funicle, at the base of which is a hole called the micropyle. When the funicle detaches, a scar called hilum remains on the side of the testa (seed coat).

Each seed has two large cotyledons packed with starch and protein. The embryo is tucked between the cotyledons to which it is attached by two short stalks.

**a) Structure of bean seed** **b) Testa removed:**

**Structure of maize**

- A maize seed is enclosed in a tough pericarp which is fused with the testa. This is a type of fruit called a caryopsis and develops with several others on a cob.
- At the tapered base of the fruit is a scar showing its point of attachment to the cob. On the broader sides of the fruit, a light oval area can be seen under which the embryo is found.
- The radical is enclosed in a hollow tube called the coleorhizae. The plumule is surrounded by a similar structure called the coleoptile.
- There is a small triangular cotyledon, the scutellum, to one side of which, the embryo is attached.
- At its other side, the scutellum is fused to the endosperm, which stores starch, protein and oil.

**Structure of the maize seed**

## GERMINATION:

**Germination of a bean seed**

Placed in moist suitable temperature, the seed quickly swells as it absorbs water. Shortly afterwards, the radical elongates and pushes its way through the microplye, busting open the testa as it does so.
The hypocotyl, the part of the embryo between the cotyledon stalks and the radical, begins to elongate. As it grows, it becomes hook – shaped and the cotyledons with the tiny plumule tucked between them, are dragged above the soil level where the hypocotyl straightens. The cotyledons, by now shrunken because their food reserves have been up, become green and start to photosynthesize.
At this stage, the plumule elongates and the first simple mature leaves appear.
This type of germination is called epigeal, since cotyledons appear above the soil level.

**Germination of Maize**

Shortly after water uptake, the radical emerges, piercing the coleorhizae as it grows.
Shortly afterwards, the coleoptiles appears, enclosing the plumule as it grow upwards through the soil.
The coleoptile grows mainly from its base which is called the mesocotyl.
Once through the soil surface, the coleoptiles soon stops growing and the first long, strap –shaped leaf bursts through its tip.
Adventitious roots grow from the mesocotyle to form a fibrous root system.
Because the cotyledon remains below the soil level, the germination of maize is hypogeal.

### PRATICAL INVESTIGATION OF TYPE OF GERMINATION

There are two types of germination, distinguished by whether or not cotyledons appear above the soil level after germination.
When the cotyledons appear above the soil level, it is epigeal germination as opposed to hypogeal germination when they remain below the soil level.
Whether or not the cotyledons remain in the soil depends on the relative rates of growth of the epicotyls and hypocotyls.
NB: The epicotyl is the part of the embryo between the cotyledon stalks and the plumule while phypocotyl is the region of the embryo between the cotyledon stalks and the radicle.
When the hypocotyls grows faster than the epicotyls, it drags the cotyledons together with the plumule, above the soil level. This results in epigeal germination.
When the epicotyls grows faster than the hypocotyls, the plumule is pushed above the soil level leaving the cotyledons under the soil. The result is hypogeal germination.

**Procedure:**

Viable seeds are placed under suitable conditions for germination.
Shortly after the plumule and radical are vividly grown, the length of the epicotyls and hypocotyl are measured and recorded.
This is done for seeds grown for different days and the rate of growth of both the hypocotyls and epicotyls is determined from:

$$\text{Rate of growth} = \frac{\text{Length after 'n' days}}{\text{Number of days}} \text{ cm / day}$$

**Conclusion:**

For seedlings where the rate of epicotyls growth is greater than the rate of hypocotyl growth, a hypogeal germination is deduced.
For seedlings where the rate of epicotyl growth is less than that of the hypocotyl, an epigeal germination is deduced.

### PHYSIOLOGY OF GERMINATION

Structural changes that occur during germination are the consequences of physiological changes occurring inside the cells and tissues of the germination seed.
Initial changes are mainly as a result of cell expansion following uptake of water. Later changes involve the growth of new cells and tissues at the pieces of the radical and plumule. Growth requires energy and raw materials and initially occurs at the expense of energy rich molecules such as starch and lipids stored in the seed.

Once the leaves of the young plant have expanded the seedling photosynthesis. Different seeds store a variety of food materials, as shown in the table below;

| SPECIES | % DRY MASS |
|---|---|

| | (STARCH) CARBOHYDRATES | PROTEINS | LIPIDS |
|---|---|---|---|
| (i) Maize | 50 – 75 | 10 | 5 |
| (ii) Wheat | 65 – 75 | 13 | 2 |
| (iii) Rice | 65 – 75 | 10 | 2 |
| (iv) Bean | 57 | 36 | 2 |
| (v) Sunflower | 2 | 25 | 40 – 50 |
| (vi) Pea | 34 – 46 | 20 | 2 |

**Mobilization of stored food during germination**

Food reserves in seeds are insoluble in water and cannot be transported in the seedling. They must be broken down into relatively simple, soluble molecules which dissolve in water for easy transportation to growing apices of the plumule and radical.

As in the mammalian gut, hydrolytic enzymes catalyze the breakdown of proteins, lipids and polysaccharides such as starch.

**1. Carbohydrates:**

Starch is hydrolyzed into the soluble disaccharide sugar maltose catalyzed by a complex of enzyme called amylase.

Under natural conditions, maltose is further hydrolyzed by the enzyeme maltase to glucose which is converted to sucrose, for transport to the growing apices. Sucrose is used for synthesis of cellulose, hemicelluloses and pectins, the main components of plant cell walls.

Some is respired to provide free energy for growth.

**2. Proteins**

Proteins are hydrolyzed to polyeptides and amino acids by peptidase enzymes. Some amino acids are moved in solution to the embryo. Most are transported as amides.

At the growing points of the plumule and radical, the amides are deaminated and the amino acids are used to synthesize structural and enzymatic proteins.

Hormonal basis of the physiological and structural changes during germination:

Secretion of hydrolytic enzymes in seeds during germination is triggered off by the hormone, Gibberllic Acid (GA) made by the embryo. In cereals, release of the enzymes takes place in the aleurone layer surrounding the endosperm. In other seeds, the hydrolytic enzymes are found in lysosomes in the food – string cells.

Other hormones, notably cytokine and indole – 3 – Acetic Acid (IAA) promote cell division and enlargement at the growing apices of the embryo. IAA also controls differentiation of vascular tissue in the developing shoot and root of the seedling.

**QUESTIONS:**

1. You are supplied with three lots of sorghum seeds at different stages of their germination labeled O, P and Q. you are also provided with solutions of sucrose, maltose and yeast.

(1) Take about 10g of O and grind it into a paste using a mortar and pestle. Mix with 5.0$cm^3$ of water.

(2) Decant about 2 $cm^3$ of the extract into two separate test – tubes. To one add 1.0$cm^3$ of yeast solution. Mix well and leave to stand. Leave the second as a control.

(3) Repeat the above operations with seeds from lots P and Q.

(4) Also put 2.0$cm^3$ of sucrose solution in two different test tubes. To one, add 1.0$cm^3$ of yeast solution, mix well and allow standing. Leave the second as a control.

(5) Repeat step (4) above using maltose solution.

(6) Leave the test – tubes to stand for one hour. After this period, test all the solutions with Benedict's solution. Do not heat each solution for more than 2 minutes.

(7) Test also 2.0$cm^3$ of yeast solution with Benedict's solution. Record your results in the table below;

**(O- soaked for 24hrs; P –soaked for 48 hrs, Q soaked for 72hrs)**

**Solution**

| Extract / solution | Test tube | Contents | Observation from Benedict's test |
|---|---|---|---|
| O | 1 | O + yeast | A brown precipitate at the bottom of a green liquid |
| | 2 | O control | A brown precipitate at the bottom of a green liquid |

| | | | |
|---|---|---|---|
| P | 3 | P + yeast | A yellow / green liquid with a yellow / brown precipitate |
| | 4 | P control | A yellow / orange/ brown precipitate formed |
| Q | 5 | Q + yeast | A light green liquid with a brown precipitate |
| | 6 | Q control | A dirty brown precipitate formed |
| Sucrose | 7 | Sucrose + yeast | A brown / orange precipitate formed |
| | 8 | Sucrose control | A blue solution persists |
| Maltose | 9 | Maltose control | A yellow / light yellow/ orange / brown precipitate formed |
| | 10 | Maltose + yeast | A brown precipitate formed |
| Yeast | 11 | Yeast | A light blue solution formed |

(a) Comment briefly on the results of the experiements:

***Solution:***

*Extract O, P and Q contain reducing sugars in increasing quantities (i.e. reducing sugar content increases in the order Q>P>O).*

*Sucrose is a non – reducing sugar but yeast contains a substance that converts / hydrolyses it to reducing sugars.*

*Yeast itself does not contain a reducing sugar but it affects the reducing sugar maltose.*

(b) On the evidence of your observations, what physiological changes are taking place in the seeds?

*Stored starch is being hydrolyzed / broken down by hydrolase enzymes to reducing sugars to be used for respiration to provide energy for germination.*

(c) Using the results from sucrose and maltose solutions and those of the seed extracts, identify the substance (s) being formed in the germinating seeds.

*Maltose, Glucose, Sucrose*

(d) How are the substances you have identified in (c) above affected by yeast.

*Yeast contains the enzyme maltase; which hydrolyses maltose formed to glucose.*

*Yeast also contains the enzyme sucrose which hydrolyses sucrose to glucose and fructose.*

*Yeast also contains an enzyme which catalyses the alcoholic fermentation of sucrose to ethanol.*

2. You are provided with specimen A and B which are seeds of different plants at same time of germination. Examine them carefully and answer the questions that follow.

(A – maize grains B – Cow pea seeds both soaked for 4 days).

(a) Make a well labeled drawing of A in the space below

**Drawing showing structure of specimen a**

(b) (i) Examine the plumule and radical of specimen A and identify the epicotyls and hypocotyls respectively. Measure and record their length and determine the ratio of epicotyls length (L1) to hypocotyl length (L2).

Repeat the procedure above with specimen B.

**Record your results in the table below:**

| **Specimen** | **Length of epicotyls (L1) / cm** | **Length of hypocotyls (L2) / cm** | **Ratio L1: L2** |
|---|---|---|---|
| A | 1.0 | 0.1 | 10:1 |
| B | 0.1 | 2.0 | 1: 20 |

(ii) Give an elaborate account of the significance of the above results.

*In A, the epicotyls is longer than the hypocotyls. This implies that the epicotyls grow faster than the hypocotyls, thrusting the plumule upwards through the ground but leaving the cotyledons below the ground (hypogeal germination). Endosperm tissue serves to noursish the growing plant.*
*In B, the hypocotyls is longer than the epicotyls. Thus, the hypocotyl grows faster than the epicotyls with the result that the cotyledons are trust up above the soil surface (epigeal germination). In this position, they are exposed to light and usually turn green and photosynthesis to nourish the growing* plant.

3. **You are** provided with five (5) lots of germinating maize seeds, at different stages of germination.

Examine them carefully and answer the questions that follow;

(a) Make a longitudinalsection of the seed from Z; Draw a well labeled drawing of one section in the space below.

**Drawing showing the longitudinal section of Z**

(b) Measure the length of the root of two seedlings from each lot and calculate the average length in centimeters (cm). Record your results in the table below.

| **Seedling** | **Average length of root / cm** |
|---|---|
| Z | 0.0 |
| Y | 2.3 |
| X | 4.3 |
| V | 11.6 |
| W | 22.2 |

**DISSECTION EXAMINATIONS.**

The dissection question in the examination tastes for among other things;
(i) The ability to follow a given set of instructions, to display a particular region or regions.
(ii) Identifying all the relevant parts of the display as per the instructions;
(iii) Making an accurate representative drawing of the display as per instructions.
The drawing could even be a combined one as result of two or more separate instructions.
Candidates thus require good drawing skills in addition to interpretation skills; otherwise they risk to be penalized by loss of marks for including irrelevant materials.
Marks are awarded for the following;
The title; the drawing should have a detailed title clearly stating what is represented or what was displayed.
Take care to include the name of the specimen or animal in the title, the region displayed, the sex if urinogental systems are displayed, and any relevant information e.g. side (left to right)
Good titles begin with; diagram showing… and not dissection showing…
The general outline; this is the appearance of the skin in case of the frog and rat or the cuticle as displayed. Where a small region has been displayed show only the outline in that region.
Take care to ensure the outline is complete and continuous.
The shape proportion and position of the organs and other structures displayed.
Draw in outline form shapes similar to the way the organs appear, keep them in the correct position and take note of the relative size of the different organs i.e. the proportion and maintain these as in the animal.

Your drawing should accurately bring out this even if it is larger or smaller than the specimen i.e. apply similarity and enlargement skills you learnt earlier in elementary mathematics.
Appropriate labeling; label relevant parts only taking careful note of the spellings and indicate left (or L) or right (or R) before the label to indicate the side where organs/structures are poured e.g. left kidney. A labeling line should connect the part labeled with the label.
Neatness; keeping your drawing neat by avoiding unnecessary rubbing, crossings of labels etc., will earn you a mark or two.
Magnification; Always state the magnification of your drawing.
NB. Drawing and labeling are awarded different marks for each relevant structure, including any irrelevant label results in the lossof all marks on drawing and labeling.
Confusing terminology in the instructions/procedures
Examiners tend to use languages that may confuse the candidates.
Take note of the following examples when interpreting the instructions.
**In dissection procedures**.

-blood vessels supplying a region are arteries.
-blood vessels draining a region are veins.
-Anterior blood vessels-all blood vessels in the region above the heart ie throat & neck.
-Posterior blood vessels-all the blood vessels below the heart.
-Displace to the left/right refers to the left/right of right the animal respectively
-Displace to your right refers to the candidates left/right respectively.
-Displace to one side- displace to either side of the animal according to the candidate choice.

**THE CIRCULATORY SYSTEMS**.
Identification of blood vessels;
Bright red-arteries.
Pale/dark red-veins.
Note the position branching, organs supplied/drained and names of all the blood vessels.
Drawing – keep outlines as parallel as possible.
-Do not close the junction.
-Close blood vessels at the free end.
-Show clearly which one is above the other in case of overlap.
-Keep proportion in mind the difference in size shown by the size of the space between the outlines.
-Branching vessels should be smaller than the main vessels.
-Blood vessels leading to organs should be drawn up to the organs outline.
-Do not shade to differentiate arteries from veins.
- Be original-copying the guide will only help you to fail.
Labeling- Label in correct spellings.
-Add L or R or right to the label where it applies.
-Label only blood vessels requested for in the instructions.
Use these words correctly always.

Fur -Thick covering of soft upright hair on the skin of a mammal.
Hair - A thread like outgrow from the skin of a mammal of plant surface
Bristle - A shift hair.
Whisker – a long bristle on the face.
Vibrissa - a whisker on the face of a mammal usually near the nose or mouth.
Nose - a prominent structure on the front of the face of mammals.
Nostrils - one of the paired openings in a nose or snout.
Nares - one of the paired openings on the surface of the head leading to the nasal cavity. (Internal nares connect nasal cavity to the mouth.
Snout - along projecting nose pointing forward.

NB:

- Alimentary canal includes the mouth to anus in the cockroach and rat. While in toad/frog, it's from the mouth to the cloacal aperture.
- Digestive system involves the alimentary canal and accessory organs.

- Digestion in a cockroach occurs in the dullet to the mid gut.
- Digestion in a toad occurs from stomach to the ileum.
- Digestion in a rat occurs from the stomach to the ceacum.

- Draw organs unless not told to draw

# COCKROACH

**Classification**
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Dictyoptera
Family: Blattidea
Genus: Periplaneta
Species: americana /africana

**Reasons for being classified in phylum Arthropoda are**

- It has metameric segmentation
- Each segment bears a pair of jointed appendages used for locomotion
- Has exoskeleton made of chitin

**Characteristics for phylum anthropoda for survival**

- Exocuticle/ exoskeleton is thick for protection.
- Waxy/ glossy exoskeleton to minimize water loss.
- Exoskeleton to reduce friction when entering a crevice and escape from predators
- Body is segmented for flexibility.
- Jointed appendages to increase flexibility during movement/ locomotion.

**Reasons for being classified in class inscta are**

- It has a well-defined head, thorax and abdomen
- Has one pair of antennae
- Has three pairs of legs on thorax, one pair per segment
- Thorax has three segments i.e. prothorax, mesothorax and metathorax

**Reasons for classification in order Dictyoptera.**

- Have long thread-like antennae.
- -Has a pair of anal cerci.
- -Has biting mouth parts.
- Has long, narrow, tough terminal and broad membranous wings.

NB: Reasons for classification as a member and broad membranous wings.

## THE HEAD

**Features on the head**

- Pair of antennae that are long for sensitivity.
- Compound eyes are large, curved outwards for wide view.
- Mandibles are sharp for cutting/ crushing food.
- Maxillary palp are long to reach out for food.
- Labial palp are hairy for sensitivity.
- Labial palp are segmented for flexibility to push food into the mouth.
- Labium/ upper lip large, curved to prevent food from falling out of the mouth.

**Shape and position:**

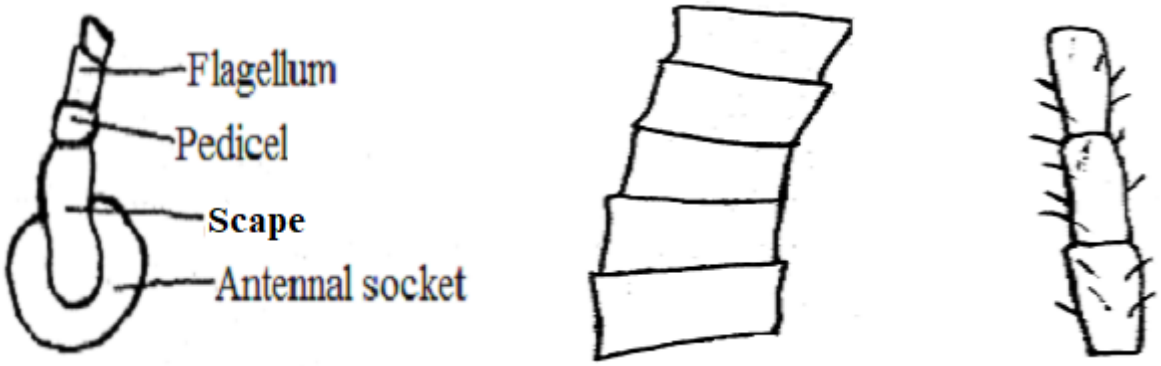
The head is small and when viewed from the front (anterior) is almost pear-shaped. From the side, it is much narrower.It is placed at right angles to the trunk. It is separated from the trunk by a short neck and limited in movement posteriorly by an enlarged tergum of prothorax. The compound eyes are kidney-shaped, coma shaped narrower at side than at the top of the head large and broad dorsally, black in colour and are situated dorsal-laterally. This position of the eyes gives the animal a wide field of view in its habitat. In front of the compound eyes lie the long flexible antennae.

**Adaptations of Antennae to the functions**

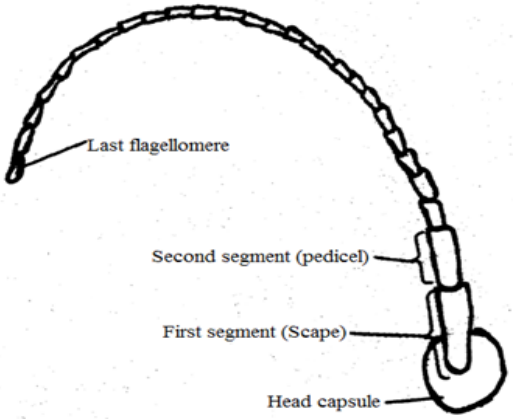
- They are segmented to make them flexible thus moved easily from one side to another
- They are long thus reaching a far distance around the insect
- The tip is tapering to increase on the sensitivity.
- Are hairy to increase sensitivity.

- Are jointed to enable them to be flexible to reach in all directions.
- Are thin and tapering to ease their movement

**Antennal segments** **Proximal segments** **Distal segments**

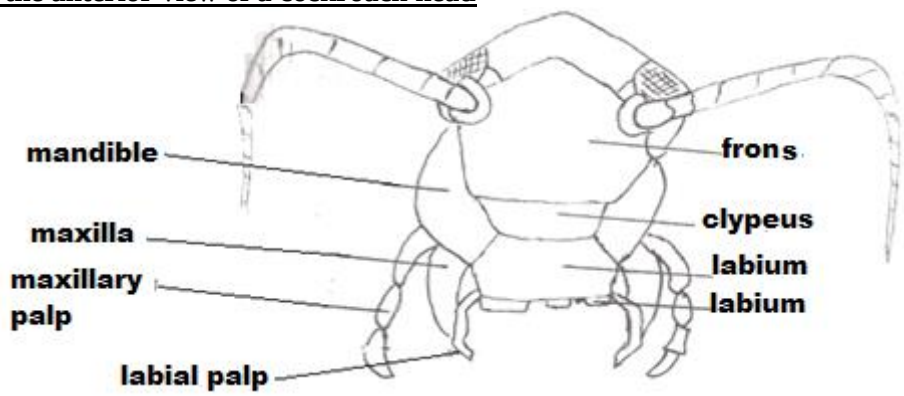



**Drawing of antenna**

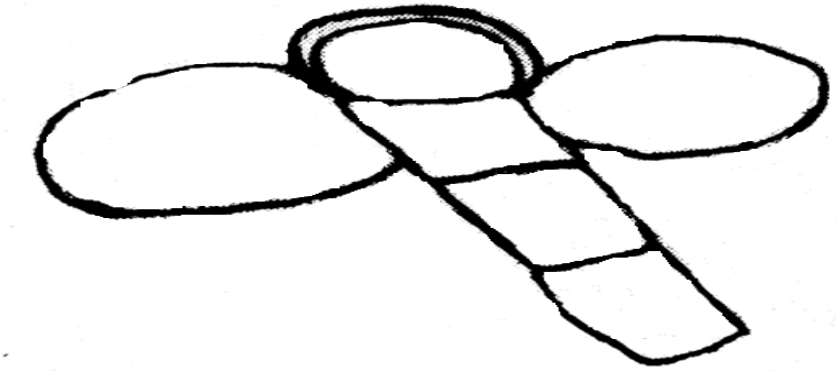



Proximal segments are shorter, wider. Distal segments are longer, narrower. Both are hairy.

**Drawing of the anterior view of a cockroach head**




(a) Using a hand lens, examine the left compound eye of the specimen including the first three segments of one antenna, from the base. Draw the structure observed. Do not label



**Eye**

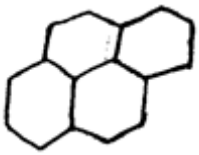
**Description of the arrangement of the eye units**

Six – sided/ hexagonal/ polygonal, placed side by side/ adjacent to each other, regularly arranged, numerous/ many, compact/ closely packed/ no space between each unit.

**Significance of arrangement of the eye units**

- Increases field of view.
- Increases sensitivity.

**Drawing showing four adjacent eye units of a cockroach**



**Mouth parts**

The mouth parts are hinged at the sides of the ventral side of the head. There are three pairs, the mandibles, maxillae and two second maxillae partially fused to form alabium.

**The Mandibles (JAWS)**

Used for chopping / biting/ chewing of food

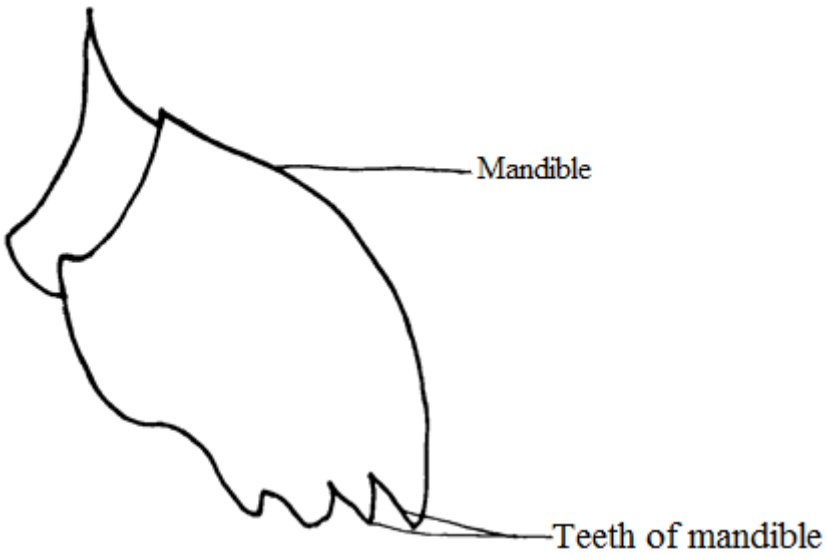
Mandibles are two stout strong, dull colored, heavily sclerotised / hard structure articulating with the sides of the head capsule by means of a small knob or condyle and a groove called the ginglmus. They swing transversely across the head. They have /bear promint teeth like projection/ toothed structures/toothed sharp edge on the inner edges/ margins which bite against each other. The toothed edge is for cutting and crushing of food materials. On the inner side of each mandible is small transparent, less heavily sclerotised, thin portion/ plate called prostheca carrying hairs on its rim.

Functions; Mandibles are used for crushing and cutting up/chopping /biting /tearing/chewing of food. They work sideways to accomplish this and them prossess sharp toothed edges for biting and chewing food.

**Adaptations**

a) They are stout, strong with toothed sharp edges on the inner surface for cutting and chewing food.
b) Sharp with jagged /serrated cutting edge for cutting and chewing food.
c) Strong / hard for biting /tearing /chewing food and also for defense.
d) Have muscles for sideways movement during cutting and crushing the food.
e) Serrated /curved /toothed /sharp /rigid mandibles or jaws for biting /cutting /chewing /crushing of food.

**Drawing of a Mandible**




**The maxillae**

**Function**

Manipulation of food during mastication/ chewing of food

**Maxillae (First maxillae)**

These occur immediately behind the mandibles and each consists of a basal portion of two segments or podomeres; the cardo which attaches the maxilla to the head capsule and the stiples which follows and is bent at an angle, (right angle) to each other. From the stiple/stem arises a five jointed/segmented, hairy long maxillary palp on the outer side which is sensory in function/tasting organ/olfactory organ and on the inner side a bipartite portion (double structure) composed of an outer hooked galea and inner most claw like lacinia. At the base of the palp is a small sclerite the palpifer. The galea is hooked in shape, while the lacinia. Terminates in a sharp blade claw like projection and has its inner margin covered (fringed) with strong /stout bristles.Both the lacinia and galea assist in holding and pushing food into the mouth.

It is made up of the

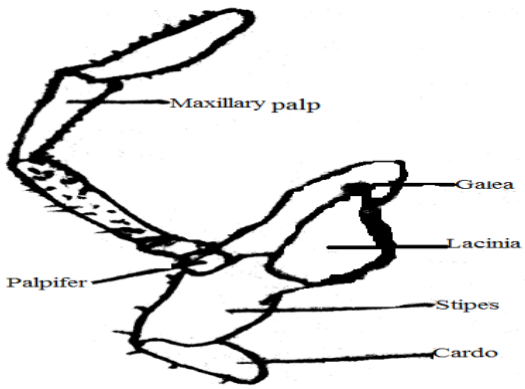
Maxillary palp, Lacinia, Palpier Stipes, Cardio, Galea.

**Function**; Maxillae are hairy modified to form a biting blade. They bite/break down food already masticated by the mandible.

**To this function they are adapted by**

a) Long and hairy segment /jointed maxillary palps for feeling /sensing/tasting food /tasting organ/olfactory/holding/grasping /pushing chewed food into the buccal cavity /mouth.
b) Hooked lacinia /sharp pointed lacinia for holding chewed food/ pushing food into the mouth.
c) Hooked lacinia /sheath like galea for holding food/pushing food into the mouth.
d) Jointed/ segmented for easy bending to hold food firmly /directing food into the mouth.
e) Sharp cutting galea and lacinia for cutting food.
f) Have sensory hairs for tasting /sensing food /sensitivity to taste outside / increase sensitivity to the food.
g) Maxillary palps are jointed /segmented for flexibility when feeding / manipulating food / for pushing /grasping food.
h) Has sharp cutting edges for cutting food.
i) Lacinia and galea are hooked for holding food.
j) Maxillary palp, lacinia and galea hold the food during feeding
k) Galea is hooded / cupped or scoop-like for protecting lacinia when not in use
l) Long maxillary palp pushes food into the mouth at a distance

Carefully cut off the whole left and right maxillae. Observe each maxilla using a hand lens. Draw and label




**Labium** (Lower lip/second maxilla)

The labium is a jointed, thin, hairy broad based and large lower lip forms the lower boundary of the mouth.

It collects, holds and pushes food into the mouth and also prevents food from falling out of the mouth.

It is a median structure derived from fusion of a pair (two) of appendages, the broad basal portion, submentum and mentum. It is made up of three proximal appendages/segments called sub mentum, and prementum. It articulates by the proximal border of the submentum with the head capsule.

From the mentum arises thee paitred structure, prementum; each half of which is composed of an outer labia palp and inner bipartite portion (two endites) of gossa and paraglossa.

The labia have fewer podemres/ segment (4) than that of the maxilla (5). The labia palp is olfactory in function /works as a tasting organ / sensing food and also serves to hold and push food into the mouth. To this function, it is adapted by:

a) Having sensory hairs for tasting food /increase sensitivity of tasting food.
b) Jointed /segmented for easy bending to hold food firmly /increasing flexibility in movement /holding food.

The bipartite inner portion is made up of an inner glossa and outer paraglossa which correspond respectively with lacinia and galea of the first maxilla and they all assist in holding food and pushing it into the mouth.

The glossa and paraglossa together are collectively known as ligula and help in food manipulation /assist in holding food, chopping /cutting it into pieces and pushing it in the mouth. To this function they adapted by having sharp edges for cutting food especially for glossae.

Generally the labium collects, holds, and pushes food into the mouth and also prevents food from falling out of the mouth.

**Adaptations**

a) Large and broad and has a large surface area for preventing food from falling out of the mouth and also collecting ,holding and pushing food in the mouth.
b) Its labia palps have sensory hairs to increase sensitivity /for tasting food.
c) Its labia palps are jointed /segmented to increase flexibility in movement /holding.
d) Has glossa with sharp cutting edges for cutting food.
e) The labial pulp is jointed to increase flexibility in movement

This is made up of three proximal segments called;

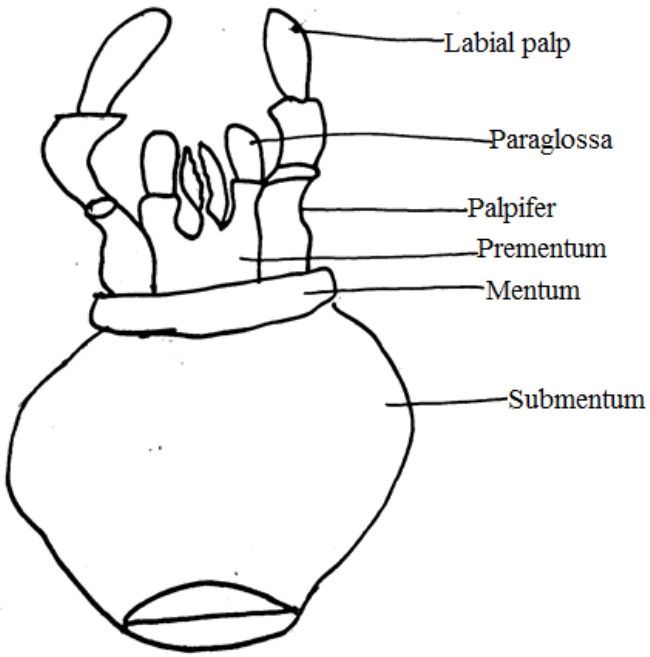
-Submentum.

- Mentum.

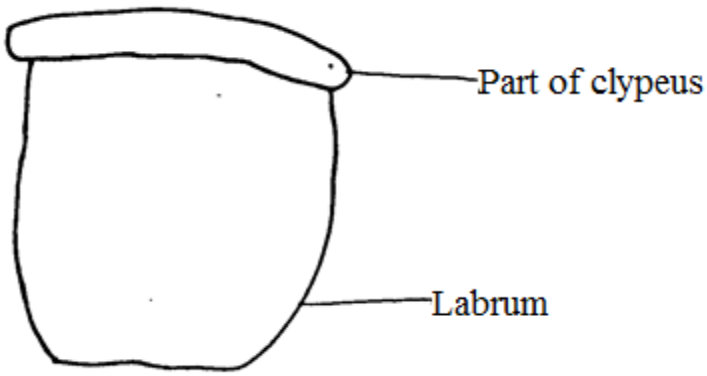
Prementum, consisting of a pair of endopodites known as labial pulps and two endities having distally, a glossa and paraglossa, similar to the lacinia and galea of the 1st maxillae.

**Function:**

- The labial pulp is olfactory in function and also serves to hold and push food into the mouth.
- The glossa serves to chop/cut food into pieces




**Labrum**




**Comparison of labium and maxilla**

- Both have jointed palps for flexibility to hold food.
- Both are hairy to increase sensitivity/ for tasting food.
- Have long palps for grabbing food at a distance.
- Both have sharp parts (glossa/lacinia) for cutting food.
- Both have hooded structures (paraglossa/galea) for holding food.
- Maxillary palp is longer than labial palp to grab food at a distance than labial palp.

**THE THORAX AND ABDOMEN:**

**(i) The thorax:**

The thorax is divided into three segments which include; prothorax, mesothorax and metathorax, in that order from anterior to posterior, each consisting of four schlerites i.e. a dorsal tergum, a ventral sternum and two small lateral pleura.

a) There are three (3) pairs of thoracic walking legs, a pair of each small segment.

Each leg consists of nine podomeres.

- The proximal podomere, the coxa, is wide and flattened.
- Then follows a small triangular trochanter, a large femur and tibia, and adistal tarsal consisting of one large and four small podomeres.

The most distal segmehe (podomere) of the tarsal (the pretarsus) bears a pair of claws between which is a glandular pad also called the arolium.

This produces an adhesive substance which assists the cockroach in gripping on slippery structures. On the lower surfaces of each tarsal podomere (segment) bear soft pads called plantulae which like the arolium, produce an adhesive substance.

b) The mesothorax and metathorax bear a pair of wings each. Those on the mesothorax are brown, opaque and hard and offer protection to wings on the metathorax. Mesothoracic wings are called outer wings due to their position while the metathoracic wings are called inner wings for a similarly reason.

The wings on the metathorax are large, membranous and transparent. They are supported by branching network of veins. They are used for flight. The wings

Wings are cuticular outgrowths form the region between tergum and pleuron in the anterior regions of the mesothoracic and met thoracic segments consists of double sheets of cuticle fused together and supported by new network of strengthening nerves or nervures each containing a nerve, a trachea and blood.

There are two pairs of wings with two longitudinal dark stripes. Wings are found on mesothorax and metathorax only. The prothorax never bears wings.

The anterior /mesothoracic /outer wings are brown /dull colored, long narrow, veined, opaque,, more heavily cutinized /thickened /sclerotized therefore very hard /stiff /tough/thick, curved ,leathery ,with a network of veins ,found on the mesothorax and offer protection or cover onto the wings on the metathorax /foleded membranous posterior pair,, and because of this ,they are also called wings on the covers or elytra (elytron) . Duee to their position, they are also known as the outer wings or tegimina.

Functions of the outer wings /elytra /forewings are; protection against mechanical damage /injured and also protection of the inner wings, and for camouflage (hiding), support /strength, gaseous exchange and circulation.

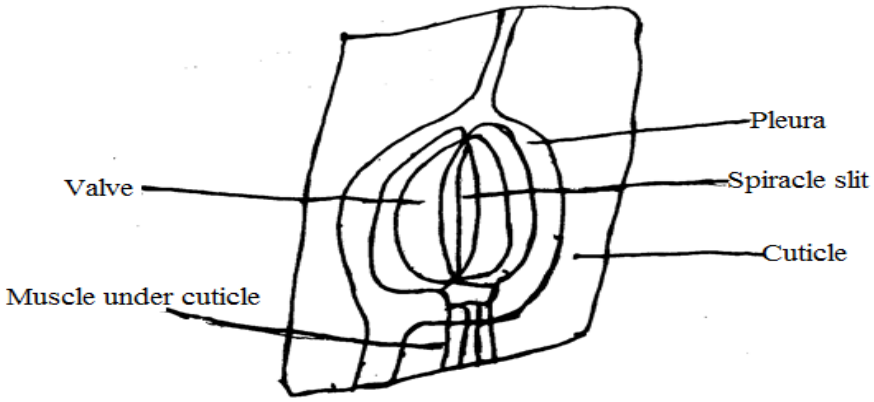
To these functions, it is adapted by being;

a) Hard for protection /cover of the hid wings
b) Brown /dull colored for comufllage (hiding).
c) Has veins for providing strength//support /for gaseous exchange /gaseous ccirculation.

Two pairs of spiracles exist on the thorax; one pair between the prothorax and mesothorax and the other between s the mesothorax and the metathorax. Thoracic spiracles

Spiracles are narrow slit/external openings of the tracheae in soft rounded patches of cuticle (pleural) along the side of the body of an insect /cockroach though which air enters the body. There are two parts of thoracic spiracles; one pair between the prothorax and mesothorax and other between the mesothorax and meta thorax situated in the pleura. Thoracic spiracles are large slits, oval in shape and each lies in the pleuron on appearing as a small slit like aperture in an oval sclerotised area.

**A general structure of the spiracle**




**Abdomen**

Features of the abdomen

The abdomen is flattened dorso- ventrally, soft and membranous. It consists of (10) segments, although only the first seven segments are easily visible, the remainder being telescoped within the hinder end. Each segment has a sclerotised tergum and sternum but the pleura are narrow and soft.

Pleura are soft membranous structure joining the tergumm and sternum.

The $7^{th}$ segment /tergum hides or completely overlap the $8^{th}$ and $9^{th}$ segments dorsally. The $10^{th}$ tergum is flat and broad, transparent bilobed structure at the end of the body. From its antero lateral corners; a pair of jointed sensory cerci project. The posterior end of this tergum is deeply notched. A pair of spiracles occurs on the first eight segments. None of the anterior /visible bears appendages.

Except for the reproductive appendages, the abdomen bears only a pair of jointed hairy tapering appendages known as the anal cerci which are sensory in function. These anal cerci are found on the $10^{th}$ abdominal segments in both sexes. The cockroaches have no external genitalia but can be distinguished into male and female basing on structures on posterior segment of the abdomen. Therefore, the terminal region of the abdomen differs in two sexes.

In the males, the more posterior sterna are modified to form accessory genital organs, in addition to the anal cerci on the $10^{th}$ segment, 9th segment/sternum bears a pair of two slender unjointed bristle like structures known as the anal styles. These are used to identify the males. These are attached to the sternum. The male has even segmentation of anternanae.

In females, the $7^{th}$ segment /sternum is greatly enlarged and longitudinally divided to form the boat like structures. Boat shape /blunt kneel shaped projection, the podical plates which house a chamber known as the oothecal chamber. These carry the oothecal (eggs case). The posterior sterna are also modified to form genitalia. The posterior surface of the abdomen is covered by two triangular paraproct extending between the anus and the cerci. The female has uneven segment of the antennae.

**Part of the abdomen as viewed under lower of a** microscope.

**Abdominal spiracles**

Spiracles are narrow slit in soft rounded patches of cuticle (pleura) through which air enters the body insect. There are eight (8) pairs of spiracles on abdomen, each pair is located in soft pleura .Spiracle are controlled by valves operated by special abdominal /thoracic muscles (there is total of ten pairs of spiracles on the whole animal/cockroach)

Though the spiracles have the same basic structure, an abdominal spiracle differs from the thoracic spiracle I the following respect; those on the thorax are larger than those on the abdomen and oval in shape while abdominal spiracles are annual/round in shape and smaller.

| Thoracic | Abdominal spiracles |
|---|---|
| 1. Large in size ( larger slit in pleura) | Smaller in size( smaller slit in pleura) |
| 2. Oval in shape | Annular /round in shape |
| 3. Thoracic tissues are more deeper | Abdominal tissues are less deeper. |
| 4. Have more supporting tissues | Have less supporting tissues |
| 5. Have stiff hairs | Have no stiff hairs |
| 6. Have valves | Have valves |
| 7. Have elaborate opening and closin mechanism | Remain permanently open |

**Drawing of the thoracic spiracles** **abdominal spiracle**

Major function of the spiracle is to allow breathing to take place (inhalation and exhalation)

Below the spiracles are the tracheoles which are sites of gaseous exchange.

**Comparison of thoracic and abdominal spiracles and their significance**

| **Structure of thoracic spiracle and sizniflcance** | | **Structure of abdominal spiracle and** | |
|---|---|---|---|
| **Relatively larger** | **To allow in much inhaled rich in oxygen needed by respiring tissues** | **Relatively smaller** | To minimize loss of water vapour during exhalation |
| **Has valves** | **To reduce entry of dust along with air.** | **Lacks valves** | To allow exit of waste |
| **Non-hairy aperture** | | **Hairy** | |
| **Oval shaped** | | **Round-shaped** | |
| **Fewer (2 pairs)** | | | Many (8 pairs) |

**Description of structure of tracheal trunk**

- It is ringed/formed by ringed structure.
- It is hollow/tubular.
- It is long.

**Significance**

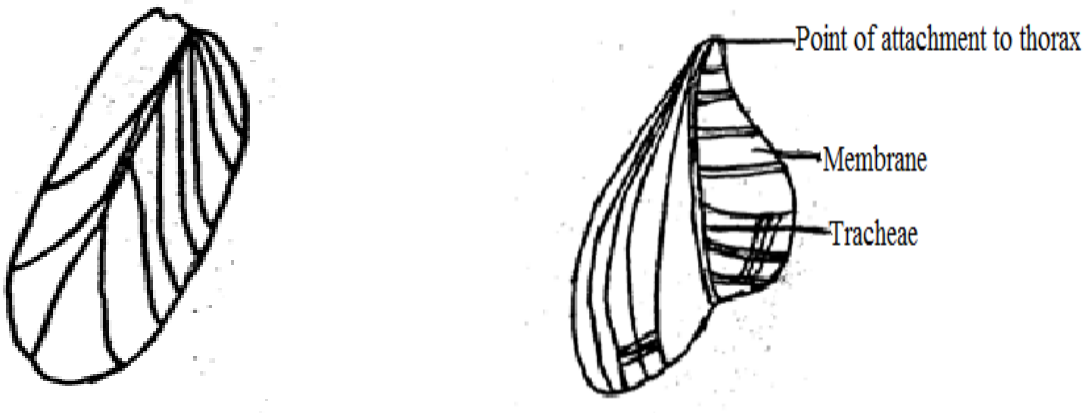
- Ringed to keep it open for passage of respiratory gases.
- Hollow/tubular to allow passage of respiratory gases.
- Long to convey/reach respiratory tissues at a far distance/ all parts of the body.

| Description of wing Position on the Body | Significance |
|---|---|
| Two pairs of wings, laterally attached near the anterior end of segments, outer pair on the mesothorax, and the inner pair on the metathorax<br>The left outer wing partly overlaps the right outer wing | Lateral attachment of wings enables their Spreading flight |

**Outer and inner wings**

| | Description of structure | Significa |
|---|---|---|
| Outer / fore | -sti ff / hard<br>dense<br>-translucent<br>-Waxy<br>-Srnaller surface area | for sufficient protection from<br>to offer extra strength during<br>to reduce light penetration to the body which would result into<br>to reduce evaporation of water from |
| Inner / hind | -<br>-dense<br>-broad<br><br>Translucent<br>Flexible | - To reduce weight during<br>-to offer extra strength<br>-to provide a large surface area for generating much lift<br>-to reduce light penetration to the body which would result into<br>-it enables their folding to be tucked under fore wing |

**Outer wing** **Inner wing**




**Hind wings/ inner wings**

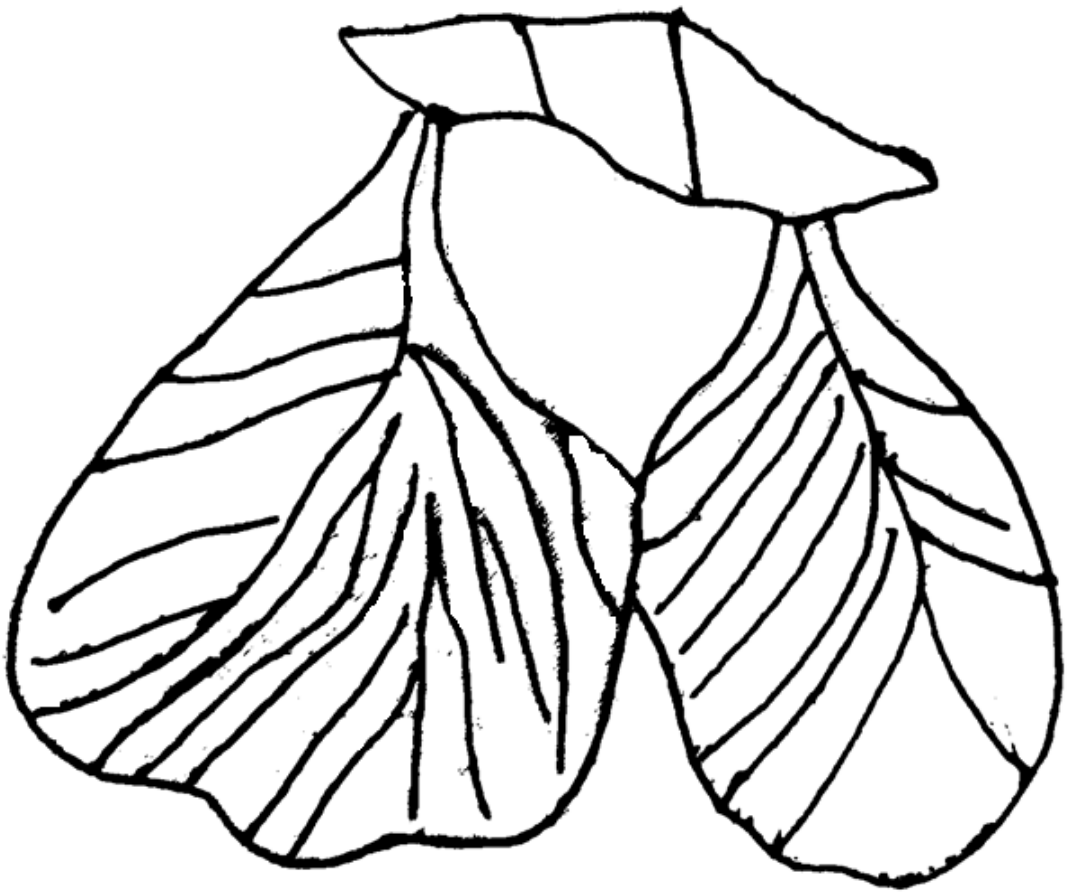
It's thin/ membraneous, broader posteriorly but narrows towards its base, notched at the margin and with network branching pattern of veins, folded.

**Outer wings/ fore**

Long, narrow, hard, straight, net veined.

Place the specimen on a dissecting dish, lying on its ventral surface and facing away from you. Spread out the light wings carefully and fix the well.

(i) Examine both wings of specimen K. draw but don't label



(ii).State how each of the wings is adapted to its function

- *Long for protecting the whole abdomen and thorax against mechanical injury*
- *It's hard to offer sufficient protection of thorax and abdomen for mechanical damage/ injury*
- *Translucent wing to reduce light amounts reaching the thorax and abdomen to prevent desiccation/ drying*
- *Has veins for extra support*

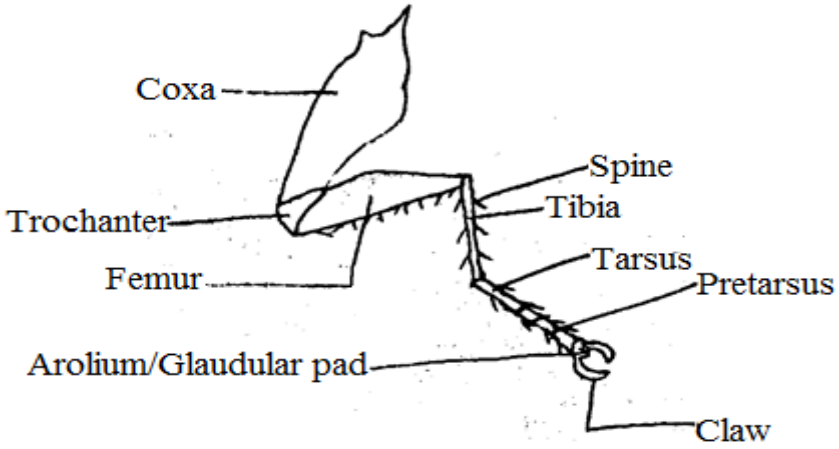
**WALKING LEGS**

Legs are jointed , slender, strong, of equal lengths and have well developed claws and arolia; an adaptation for running.The cockroach has strong legs of almost equal length; these are three [3] pairs of thoracic walking legs; a pairs on each thoracic segment, the first pairs being the smallest and the third the largest; all bear hairs. Each leg/ limb consists of nine pedometers/ segments/ five[5] parts; coax , trochanter, femur, tibia and tarsus/ made up of a basal long wide and flattened proximal portion/ podomere called the coxa articulating with the sclerites of the thoracic segments; attaching the legs o the body/ large flat coxae at the roots of legs of size adapted for running. The coxa is followed by a very small triangular trochanter which is freely movable on the coxa but fixed to the femur which follows it. The femur is long and large/ broad and succeeded/ followed by a thin long tibia and the distal portion of the limb is termed the tarsus [foot]; made up of five movable segments [or pdomeres] with different lengths and sizes [one large and four small podomeres], the last one[pretarsus] being slightly longer than the rest and bears a pair of curved sharp claws between which is delicate hairly covered glandular pad also known as the arolium/ pulvillus. On the tibia are numerous stout spines, the tibial spurs or bristles for protection. Tarsal podomeres have many fine hairs while on their lower edges/ surfaces are soft adhesive pads called plantulae which produces an adhesive substance like the arolium and this helps the animal/ cockroach to grip on slippery surface/ structures/ substratum. The claws on the other hand help the animal to grip firmly on rough surfaces. A combination of these, the cockroach is able to run very fast/ grip on any surface and even upside down on ceiling, etc. Both devices [claws and arolium/plantulae] aid in maintaining a grip on rough and slippery surfaces. The hind legs are characteristically slightly longer than the rest to provide the necessary propulsive force during locomotion.

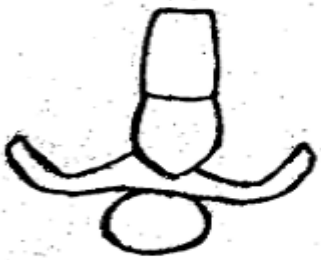
**Adaptations of hind limb to its function**

1 They are jointed/ segmented for flexibility during movement/walking/ clawing.
2 Each has strictly glandular pad/arolium which secrets a strictly liquid to give firm grip on a slippery/smooth surface.
3 Each has a pair of claws for firm grip on surface.
4 Has bristles for defenses in case of external attack.
5 The limb is hairy for sensitivity during locomotion/movement.
6 It is long in order to stretch to distant places during locomotion.

**Structure of the hind leg of a cockroach**

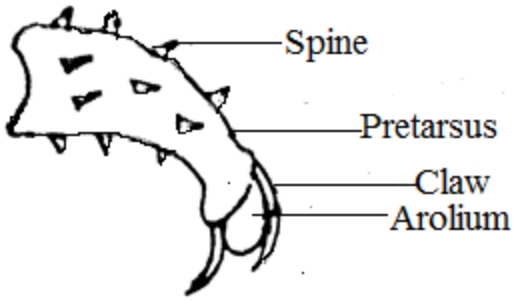



**Dorsal view of last two segments of foot**

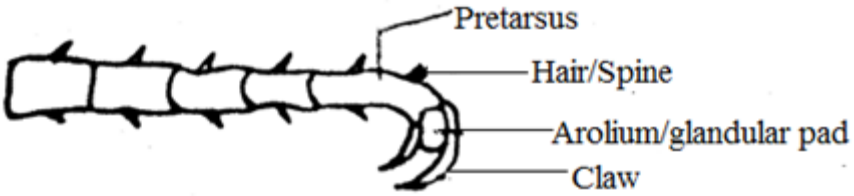


**ventral view of last two segments of foot**

**Drawing of a pretarsus and its associated structures**




**Drawing of the tarsus of the hind limb**




**NB**

- Pre-tarsus: long, curved, pointed claws, in between the pairs of claws is a swollen/ protruding, bulging, soft, hairy grandular arolium.

**SHAPE AND APPEARANCE OF THE BODY**

**a) Shape.**

- The body is flattened dorsal-ventrally and is tapering from posterior to anterior.

**Significance**.

- Flatness allows the insect to insinuate itself into small cracks and crevices where they are almost inaccessible to predators.
- The tapering nature makes the insect streamlined and helps reduce air resistance during motion on land.

b) **Appearance.**

- The animal is colored a rich brown on the dorsal surface, though beneath the wings, and on the ventral surface, it is almost yellow.
- The waxy nature of its body surface prevents desiccation as it is water repellent.

**HABITAT AND HABITS:**

**Habitat.**

- Dark cracks and crevices of walls especially in the vicinity of warm places such as fire places and boilers.

| *Habitat:* | *Justification for the habitat* |
|---|---|
| Cracks of walls | Dorsal-ventrally flattened body enables insinuating in narrow cracks |
| Dark warm damp places e.g. pit latrines | Body colouration is darker dorsally, lighter ventrally for blending the dark habitat to camouflage from predation. |

**Habits.**

- They are nocturnal, emerging to feed only at night.
- They devour a variety of organic materials including household property (paper and cloth).
- Cockroaches run very swiftly, but very rarely fly.

**Adaptations of a cockroach to its habitat**

***Body shape****:* (i) dorsal-ventral flattening enables fitting into cracks to avoid predators (ii) streamlined shape reduces air resistance during flight.

***Colour****:* darker dorsally, lighter ventrally for camouflage in the habitat to avoid predators.

***Body surface****:* is covered by glossy exoskeleton to reduce evaporation of water.

***Mouth parts****:* (i) mandibles are serrated for cutting food (ii) Maxilla and labium are jointed for flexibility when pushing food (iii) Maxillary palps are hairy for increased sensing of fooc

***Antennae****:* (i) long to sense at a distance (ii) Segmented for flexibility to reach in all directions (iii) Thin to reduce air resistance during movement

***Wings****:* (i) outer wings are hardened to protect flight wings (ii) outer wing are smooth for slipping through cracks easily (iii) Inner wings have many veins for support in night (iv) inner wings are larger for generating a big lift force in flight

***Limbs****:* (i) Are jointed for flexibility during movement (ii) Each bears arolium between claws, which is adhesive for gripping slippery surfaces (iii) Each bears a pair of claws tor gripping on rough surfaces (iv) hind limbs bear bristles to prick and scare away predators

**The spines** on the legs scare away predators.

**Legs** have thick coxae that give the organism a strong propulsive force for the organism to run on land, away from predators and to search for food.

**The plantulae**, claws and a rolia ensure satisfactory grip on any type of surface, so that running is not impeded.

**SEX DETERMINATION:**

Cockroaches have no external genitalia but can be distinguished into male and female basing on structures on the posterior segments of the abdomen.

The abdomen consists of ten (10) segments, though not all of them are visible.

Each segment has a sclerotized tergum and sternum but the pleura (soft membranous structures joining the terga and sterna) are narrow and soft.

The first seven (7) segments are easily visible in both sexes, the tergum of the $7^{th}$, almost completely by over lapping $8^{th}$ and $9^{th}$ terga.

The $10^{th}$ tergum is flat and broad. From antero-lateral corers, it consists of a pair of jointed sensory cerci. The posterior end of the $10^{th}$ tergum is deeply notched.

In the male, the more der jointed bristled styles.
Posterior sterna are modified to form accessory genital organs. The 9th sternum bears a pair of slen

**THE EXTERNAL FEATURES OF THE SPECIMEN FOR SEX IDENTIFICATION**
**Sex external features**

| Male | Female |
|---|---|
| - Thin/membraneous smooth gently notched last tergum. Tergum. | - Thick/rigid deeply notched hairy last |
| - A pair of thin/slender, long, unsegmented pointed styles. | - podical plates. |
| - Narrow abdomen | - Broad abdomen. |
| - Uneven segments of antennae | - Even segments of antennae. |
| | - elongated narrow opening of othecal chamber. |
| | - A pair of thick, curved, large lateral podical plates |

In the female, the 7th sternum is greatly enlarged and divided longitudinally to form a blunt keel-shaped projection. This houses the Othecal chamber. The posterior sterna are also modified to form genitalia
**Sex internal features**

| Male | Female |
|---|---|
| - Mushroom shaped gland. | - Ovary/ovarioles |
| - Ejaculatory duct. | - Oviduct. |
| - Pointed/sharp gonapophyses | - Vagina |
| | - blunt/rounded ended gonapophyses |

| Measurements of size of Cockroach | Significance |
|---|---|
| Body length *(include wings, exclude antenna and legs):* 3.2 - 4.0<br>*Width (wings in their normal resting position)*<br>Width of widest part of body: 1.2 em - 2.0 cm<br>Ratio of length: width at widest part is 2 : 1<br>Head width: 0.4 cm - 0.5 em<br>Body width at posterior: 0.4 - 0.7 cm<br>Ratio of width of head: widest part : posterior is about I : 3 : I | Offers a streamlined shape that reduces / minimizes<br>air resistance during flight. |
| Thickest part of body: 0.3 - 0.5 cm | Thinness of body enables fitting into narrow to avoid predators |

**THE CUTICLE**
The whole body together with the limb is enclosed in a cuticle of chitin and tanned proteins.The outer most layers are very thin complex and the most important of them is the waxy layer[of hard wax or a soft grease] responsible for water proof ing the cuticle and outer cement layer protective to the wax. In each segment the cuticle is thickened and hardened in regions to form plates, four of them, tergites/tergum in the dorsal/ tergum region, sternites/ sterum in the ventral sternum region. It is dark brown in colour for camouflage and in the thorax particularly pleurites in the lateral pleuron region. In the thoracic region each tergite/tergum in the dorsal /tergum region, sternites or sternum in the ventral sternum region. Is dark brown in colour for camouflage and in the thorax particularly pllleurites in the lateral pleuron reion .in the thoracic region each tergite is termed notum.Between the individual sclerites of each segment and between the boarders of contagious segment are thinner flexible articular membranes.
However, the sclerites of a segment may fuse for example in the head, the outlines of the sclerite of segment are indicated merely by sutures, the whole complex above made of two empecranical plates(epicranium) and ganae at the sides

Functions of the cuticle

1. Protection, because is very hard.
2. Water conservation, because it hard waxy/soft greasy.
3. Camouflage, because of the brown colour.
4. It is a water proof surface, because of being waxy.

**EXOSKELETON**:

The entire body is covered by a tough exoskeleton of chitin. Chitin provides both strength and elasticity. The wax layer on top makes the body smooth, water proof and prevents the loss of evaporation. The exoskeleton is in form of hardened plates called sclerites jointed to each other by flexible membrane.

**The exoskeleton** or cuticle is secreted by the epidermis. It contains chitin a nitrogen – containing polysaccharide which resembles cellulose the strengthening material of plant cell walls.

Chitin has high tensile strength i.e. it is difficult to break by pulling from both ends. The properties of the exoskeleton can be altered by combining chitin with other chemicals e.g. addition of mineral salts;

**The exoskeleton** is flexible and is important at joints.

- Support particularly on land
- It provides an anchor for the muscles internally particularly those involved in locomotion including flight.
- Protection from physical damage.
- Addition of a layer of wax from special glands in the epidermis thus preventing desiccation on land.
- It has a low density which is important for flying.
- Flexible joints are possible between joints
- It is transparent in some places allowing entry of light into eyes and camouflage in water
- It can be modified to form hard jaws for biting, piercing, sucking or grinding.

**Disadvantages of exoskeleton are,**

- ✓ Final body size is limited because as body size increases the surface area; volume ratio decreases.
- ✓ It restricts growth, so periodic molting (ecdysis) is required if the animal is to grow.
- ✓ NB. The head of a cockroach has the following features
- ✓ A pair of long flexible antennae in front of the compound eyes.
- ✓ A labrum forming the roof of the buccal cavity or upper lip.
- ✓ A pair of kidney shaped compound eyes located dorson laterally.
- ✓ Two maxilla with fairly long maxillary pulps placed immediately behind the mandibles.
- ✓ A pair of large mandibles on lower sides of the head

**NB.**

The legs have fairly many joints about 8 joints to increase their flexibility and allow rapid motion in the habitat.

**NUTRITION:**

Like other insects, the alimentary canal of a cockroach is divided into 3 parts; the foregut, midgut hind gut.

- The buccal cavity
-Pharynx, esophagus
-Crop and gizzard.

The pharynx is short and leads into a narrow esophagus which gradually becomes dilated to form the crop. This extends from the thorax to the 1st two (2) abdominal segments.

In the crop, much of the digestion takes places by means of enzymes regurgitated from the mid gut (mesenteron). Its dilatation gives large surface area of exposure of the food to digestive enzymes.

The gizzard is a short conical chamber with thick muscular walls. Its lumen is considerably reduced by folding of the wall. The six principal folds have heavily schlerotized thickenings, culminating in pointed teeth, as shown below.

**SALIVARY GLAND**

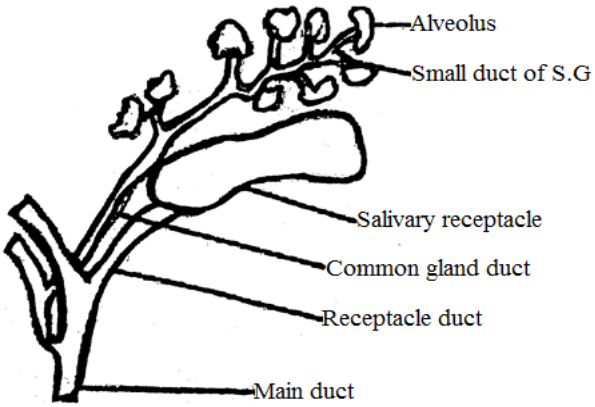
It is found in prothoracic region and it consists of salivary receptacle, salivary gland and salivary duct. Salivary glands are divided into numerous, round and small alveolar shaped secretary parts.

Numerous secretary parts increase the surface area for secreting digestive juice (saliva). The common duct of salivary gland branches into many small ducts which spread all over the salivary gland. This arrangement increases the surface area for collecting saliva.
The main common duct for receptacle branches into large ducts each duct collects the saliva into the salivary receptacle which is structurally elongated and large inorder to store much saliva.

**ADAPTATIONS OF SALIVARY GLAND**

- All ducts fuse into one main duct to control the flow of saliva.
- It consists of large salivary receptacle for storing more saliva.
- It consists numerous ducts to easily collect more saliva.

**Drawing of the salivary gland under a microscope**




**THE GULLET**

It is tubular and elongated structure it is made up of muscular wall with a smooth inner lining the long part of it is found in the thoracic region the contraction of muscular wall moves the food to the smooth inner lining eases movement of the food.

**THE CROP**

The gullet dilates to form the crop, it is found in the abdominal region it is enlarged. Cornical shaped and consists of elastic muscular wall with smooth folded inner lining and wide lumen. Starch digestion occurs in the crop by means of salivary amylase produced by salivary glands.
Its function is storage and for prelimmary digestion and absorption of food.

**ADAPTATION**

-Smooth inner lining for easy passage of food.
-Folded inner lining is to increase the surface area for digestion of food.
-It is elastic and folded to easily stratch and accommodate/store food

**THE GIZZARD**

It is ashort conical chamber with thick muscular walls. Its lumen is narrow and reduced infoldings of highly scierotized/ hardened thickening ending in pointed teeth.
Its inner lining is folding and ridged/ rough

**ADAPTATION**

-Thick muscular wall to generate powerful contraction during crushing of the food
-Folded inner lining to increase the surface area for digestion of food.
Toothed/six ridges for physical/mechanical digestion of the food.

**DIGESTIVE/MESENTERIC CAECUM**

They are eight/many, tubular, long, cylindrical, flexible and anterior tapering structures projecting into the mid gut.
Their function is secretion of digestive enzymes for digestion of food and absorption of digested food.

**ADAPTATIONS**

They are many, long and tubular for increasing the surface area for absorption of soluble food.

**THE MID GUT**

It starts from just behind the gizzard and ends in front of the ileum. It is a site for digestion ans absorption of food.
It is twin walled, long, tubular organ attached to the gizzard. It is where most of the digestion and absorption of digested food takes place.

**ADAPTATIONS.**

- Lacks cuticle to facilitate absorption of soluble food.
- The thin inner wall eases absorption of digested food.
- It has many digestive caecra to increase the surface area for absorption of soluble food and for release of digestive juices.

**HIND GUT**

- It consists of ileum, colon and rectum.
- It contains waste materials there is neither digestion nor absorption of digested food. Its only water absorbed from the colon to increase water conservation. The function of the colon is to allow water absorption and for to passage of wastes. The colon is long to increase surface area for water absorption.
- It has a large lumen for easy passage of wastes.

**ILEUM**

It is short and thin, it bears numerous thin tubules called malpighian tubules which do not have any digestive function.
It is used for removal or excretory waste products.
From the haemolymph and empty into the gut where it is removed together with the feaces. It is still used for absorption of digested food.

**ADAPTATIONS**

- It is narrow to allow food stay longer in the mid gut to maximize digestion and absorption.
- Internally the ileum is folded longitudinally and possesses many thin backward pointing setae to control passage of undigested food material and uric acid.

**COLON**

It is wide, long and smooth inside.

**ADAPTATION**

- It is wider and longer to accommodate undigested food and uric acid.

**RECTUM**

It stores wastes contraction of its wall leads to removal of unwanted materials from the body through the anus.
It is short and wide with six pronounced longitudinal ridges internally forming the rectal glands.

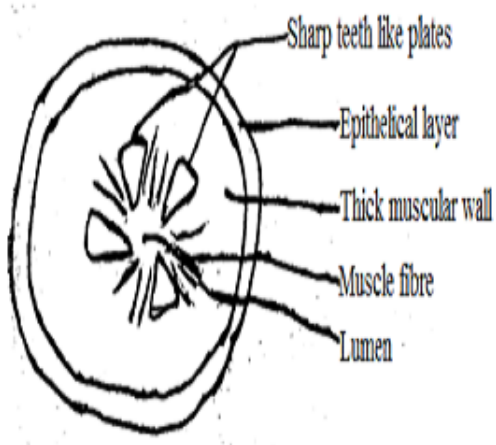
**ADAPTATION**

- It has rectal glands for water absorption.
- It has short and wider lumen to increase storage of the feaces and uric acid temporary.

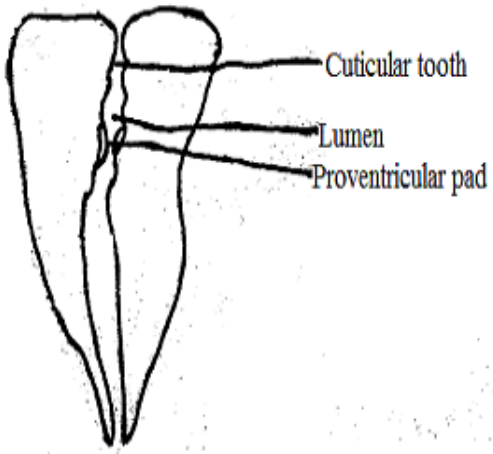
**NB**; The hind gut is thicker than the fore gut and mid gut to create powerful peristalsis which aid removal of feaces and solid nitrogenous.
When asked to draw a tissue plan of section observed under a microscope, only draw tissue lay out without showing details i.e. tissue plan of the description of the dicotyledonous stem.

Carefully make a transverse section of the gizzard and mount in balsam. Remove section from balsam, place on a glass slide and cover with a cover slip. Mount it on a microscope and view under both low and high power. Draw and label.

**Drawing of transverse secction through the gizzard:**




**Longitudinal section through the gizzard**



NB.
**Crop** is 24.0mm, Gizzard 2.0mm, midget 20.0mm while the rest of the gut is 23.0mm.
**The gizzard** is short; an active grinding region with internal ridges of cuticles covered by teeth, and is highly folded.
**The midgut** is fairly long to increase surface area for food chemical digestion and absorption.
**The rest of the gut** is long to provide a large surface area for absorption of food materials and water.
**Most** of the digestion occurs in the midget, ileum, end of midget, digestion caeca
**The crop** is long for storage of food. Physical digestion also occurs and partial chemical digestion by amylase occurs, so if it gives time for this to occur.

**NB**: The gizzard has six internal teeth for chewing, thick muscular walls and a straining mechanism of setae to ensure that only fine particles pass on to the mid gut.
The fore gut is also known a stomodaeum, middle gut as mesenteron and hind gut as proctoaeum.
**What** is the function of structures labeled on your drawing above?
The sharp teeth like plates are used for chewing food and breaking it further into fine particles moving to the mid gut. The thick muscular wall made of muscles which provide stroming mechanism setate to ensure the fine particles of food ground by the shape teeth move to the mid gut
**Remove** both the crop and gizzard. Cut them open longitudinally. Wash out the contents and examine the inner surface using a hand lens.

i. Describe the appearance of the inner surface of
   - **Crop** smooth and folded surfaces
   - **Gizzard** rigged/ rough / teeth like / sharp folded surface

ii. How are the inner surface of the crop and gizzard related to the functions of the two organs

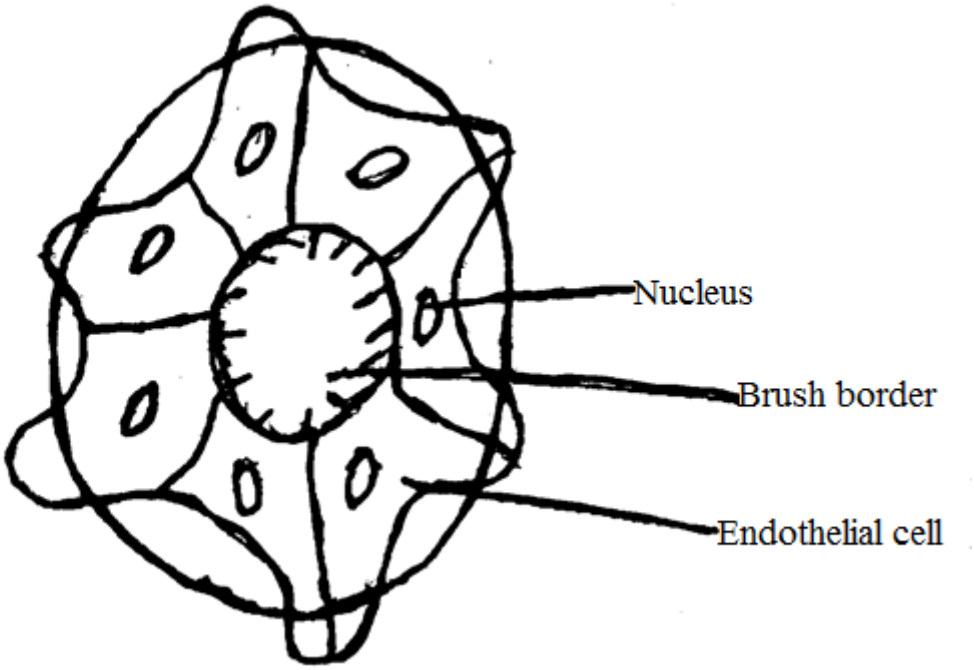
**Crop** is folded to ease the stretch to accommodate / store food / increase the surface area for digestion
**The crop** is smooth for easy passage of food
**Gizzard** is toothed/ rigged for mechanical digestion / break down food physically
**Folded gizzard** to increase surface area for digestion
**Walls** are muscular to generate powerful contraction during grinding of food

**DISSECTION OF THE MOUTH PARTS**

To separate the mouth parts for easy examination proceed as follows.
(i) Cut off the head and boil it gently in sodium hydroxide (preferably 10% or 2m).
Caution: Sodium hydroxide is corrosive; wash your hands in case of contact immediately with plenty of water until they no longer feel slippery.
(ii) This helps to remove the muscles attached to the mouth parts and to loosen them. Notice that while boiling, the head tends to `bump' i.e. move up and down.
(iii) Place a pin in the test tube to reduce the bumping and continue boiling while occasionally observing the head off the flame.
(iv) When it sinks to the bottom of the test tube quickly then it is boiled enough.
(v) Pour off the sodium hydroxide and wash the head thoroughly in water and transfer it to a microscopic slide.
(vi)Keeping the head in position and using a dissecting needle insert through the neck, use fine forces to separate the mouth parts by pulling each near its base in the following order.
First the labium, then maxillae, hypopharynx, mandibles and finally labrum.
(vii) To make a permanent amount, dehydrate them by soaking them in a series of alcohol solutions beginning with 30%, 50% 70%, 90% and finally absolute alcohol.
(viii) Clear in clove oil (or natural oil of cedar wood) and amount un stained in balsalm.
For a temporary mount just mount in balsalm and observe under low power.

**THE EXCRETORY SYSTEM**.
The excretory system is made up of the Malpighian tubules. Each Malpighian tubule is an outgrowth from the proctodacum and is lined by a glandular epithelium with characteristic brush border.
You need to refer to theory text books to appreciate how these tubules sample as their look bring about the excretion of uric acid the main nitrogenous excretion of insects.
Draw and label the secretory and absorptive structures displayed

**Drawing showing a T.S of a malpighian tubule**.




**Locate** the malphigian tubules and examine them. Describe their structure.

- Long , brush boardered, extremely slender, numerous , blind ended , octoderm out growth like

**How** is the structure of the malphigian tubules related to their functions?

- Possession of the blind ends ( distal half ) which penetrate the haemocoel
- Thin and numerous to increase the surface area for absorption of nitrogenous waste products
- Long to increase on the surface area for absorption of nitrogenous waste products

**THE RESPIRATORY SYSTEM**

This consists of a system of air tubes known as trachea which open to the exterior via spiracles and which branch repeatedly and from a network ending inferior non cuticularised tubes known as tracheales conveying air to all cells of the body.

You will not be able to study the entire trachea in situ and therefore it is only necessary to appreciate their structure by a microscopic examination of the large trachea.

Notice that these look silvery in appearance.

Proceed as follow;

(i) Remove one of the large trachea and
(ii) Stain it with picro carmine then
(iii) Mount in dilute glycerin and
(iv) Observe on a microscope.

**Note** under low power the spiral chitinous lining and the cells which secrete this lining and their nuclei:

Additional notes;

The tracheal have a cuticular lining since they are continuous with the exo skeleton and like it are shod at each ecdysis (mouth). Their lining has spiral thickening which prevent them from collapsing while allowing them to bend when parts of the insect move relative to each other. The wall of each trachea is completed by epithelium which secretes the lining.

The tracheoles penetrate the individual cells, lack this lining and are not broken down and renewed at each ecdysis. They remain throughout the life of the insect but can grow to meet physiological demands.

**THE REPRODUCTIVE SYSTEM**

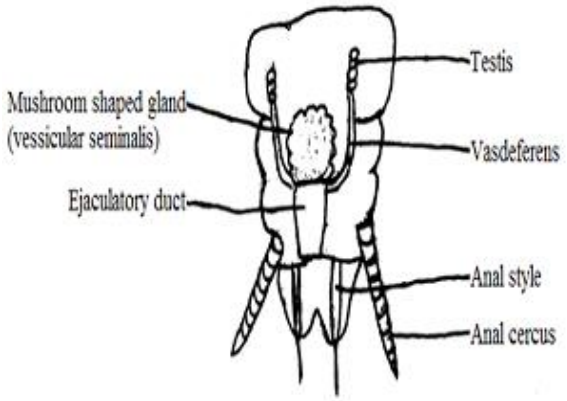
The identification of males from female cockroaches has already been mentioned in the opening paragraphs of this section.

(i) **The male reproductive system;**

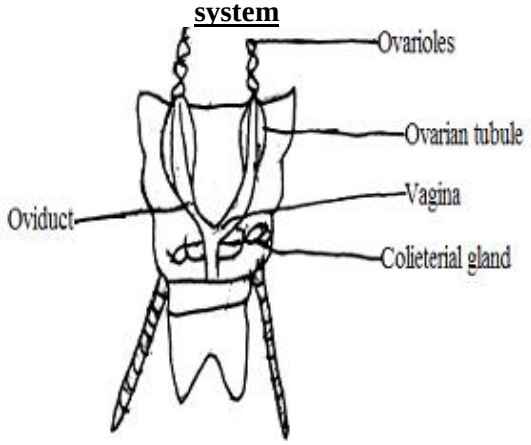
There are two testes threadlike in shape placed dorsa laterally in the $4^{th}$ and $5^{th}$ segments from which lead very fine vasa deferetio (sing vasdeferens).

The testes are never easy to find (and you may never find them actually) for they are obscurely embedded in the fatty tissue and worse still in the older males they tend to disappear altogether for by this time the spermatozoa are concentrated in the diverticular ducts ejaculatorios (ejaculatory duct) which leads to the exterior via the genital pore below the anus. Ventral to the ejaculatory duct in elongated conglobate gland (again you will have to take great care to see this gland).
Just before the vasa differential join, each dilates (widen) into a vesicle the vesicular seminalis from which arise a large number of blindly ending diverticular (finger like processes) the whole arrangement forming what is termed the mushroom shaped gland.
**Dissect** to show the structures used in reproduction. Draw and label

**Drawing showing the male reproductive system**

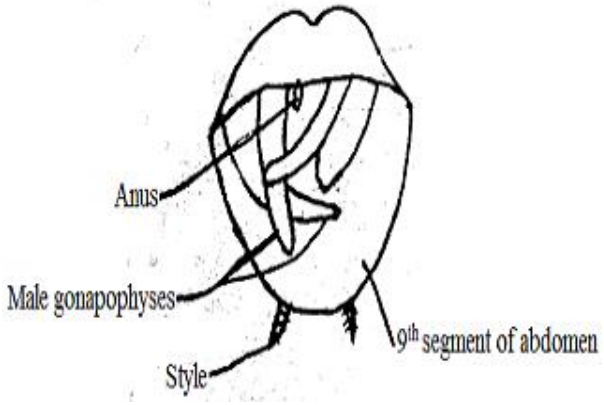



**Drawing showing the female reproductive system**

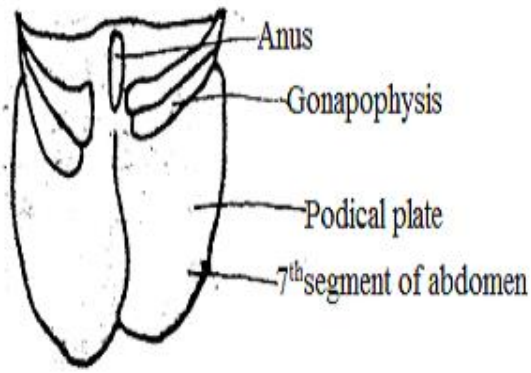



(ii) **The female reproductive system**.
There are two ovaries each with eight like lobes known as ovarioles their anterior ends are narrow and beadlike (due to the small developing eggs in them).While the posterior ends are swollen (due to the large eggs they contain) in fact 16 eggs. One from eachovariole are liberated at a time and laid in a single ootheca or (egg case). Two short wide. Oviduct i.e. from the ovaries and join to form the vagina which opens to the exterior by a vertical pore in the genital pouch on the 18$^{th}$ abdominal sternum just posterior to the other filamentous (they serve to store spermatozoa received during copulation). Occupying most of the space around the oviducts and spermathecae are two branching glands known as the collateral (not collateral) glands. The ducts of which open close together between the bases of the gonaphyses. The collateral glands secrete the coaguiting material which forms the eggs capsule (ootheca).
**Observe** the posterior region of the specimen, using forceps lift the 10$^{th}$ abdominal tergum to expose the inner structures of specimen. Draw and label the inner structure of specimen K within the posterior region
**Lift** and cut off the last upper segment at the posterior end of the abdomen. Observe the structure exposed in this region under low power magnification.

**Male**




**Female**




**Suggest** two advantages of the location and arrangement of the structures drawn
**Male**

- Posteriorly faced to direct deposition of sperms into female genital tract
- Many to hold firmly the posterior end of abdomen of female during copulation

**Female**

- Many (three pairs) to enable successful egg position into ootheca
- Close to ootheca to support it

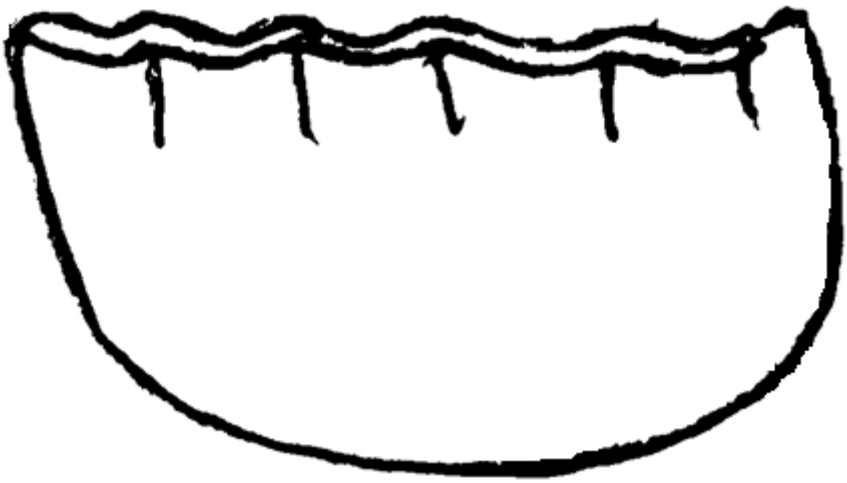
**Structures on the last tergum**


**Examination of an ootheca,**

Find an ootheca usually glued to the underside of furniture (occasionally you may come across a female cockroach still carrying one).

Observe it externally and then open it up longitudinally .Externally you will find it is brown, shaped like a money purse, internally you find two longitudinally arranged rows of eight eggs each.

**Drawing of an ootheca**



**THE NERVOUS SYSTEM**

**The central nervous system**

To study the complete nervous system, it is necessary to remove the whole of the alimentary canal if it has not already been the epicranial plates on the head.

Note the white cerebral ganglia and the short, wide caecum esophageal connectives (around the esophagus) which lead from them and join to form mouth parts. From these, a double longitudinal connectives extending from the sub-esophageal ganglia and traversing the neck to the first thoracic ganglia (prothoracic ganglia ) then follow the mesothoracic and metathoracic ganglia and six abdominal ganglia of which the first five lie in the first five abdominal segments and the last some short distance behind.

Note that the thoracic ganglia are large while the abdominal ones are small but with the sixth ganglia larger than the rest. It supplies all the posterior end of the body. Note also that the two nerve chords are widely separated in the thorax and close together in the abdomen. Nerves to the antennae and eyes originate from the cerebral ganglia (these nerves are certainly not easily seen)

The peripheral nervous system.

From each ganglia arise nerves that form the peripheral nervous system

**Drawing showing the nervous system of the cockroach.**

**Additional notes;**

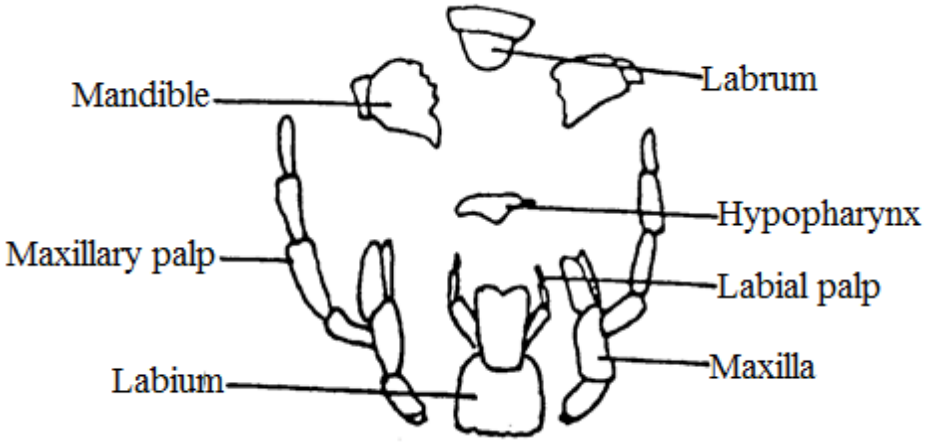
The sympathetic nervous system consists of an oesophageal sympathetic system connected to the brain and the heart and fore part of the intestine. To this system are attached behind the brain the corporallata which are endoerine glands. The ventral sympathetic system is a longitudinal nerve between the longitudinal connectives giving rise in each segment a pair of nerves serving the spiracles. The caudal sympathetic system arises from the last abdominal glanglia and serves the posterior part of the gut and reproductive system.

**Drawing of salivary glands**

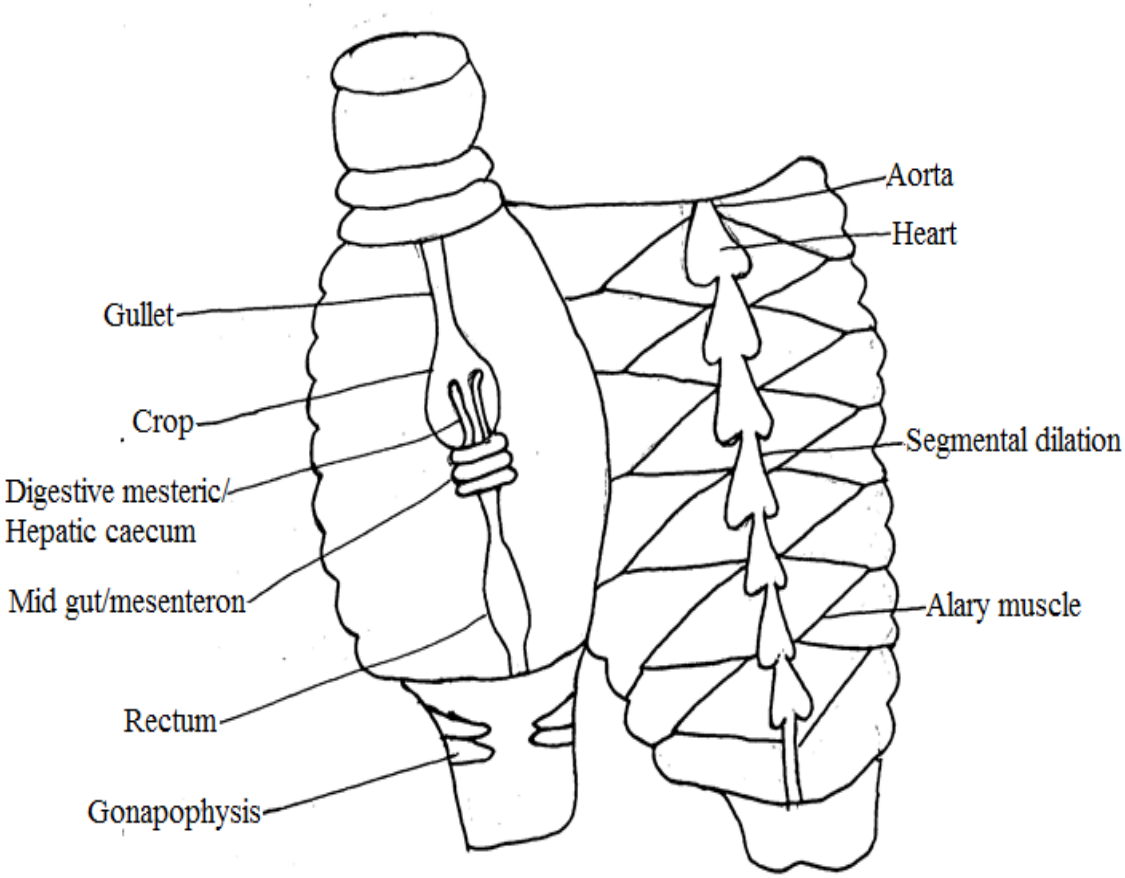
**Procedure: of viewing mouth parts**

1) Hold the head of the cockroach in between the thumb & the index finger & take out the labrum with the
help of BB forceps.
2) Lift up the antennae & hold them in between the thumb & index finger. Insert a pin at the base of the labium& separate it from the tissue that lies underneath it. Remove the labium with the help of BB forceps
by cutting it at its base with angular scissors.
3) Catch hold of the curdo & remove the first maxilla with the help of BB forceps.
4) Cut the membrane below the mandibles & take them out.
5) Observe a small flap like tongue in the centre. Hold it with BB forceps & remove it intact.
6) Place all the parts on a slide & add a few drops of dilute KOH solution to dissolve the muscles.
7) Arrange the mouth parts onto slide.
8) Observe the slide thus prepared under a dissecting microscope & note: The mouth parts include the labrum, a pair of mandibles, a pair of first maxillae, a pair of second maxillae & a Hypopharynx.

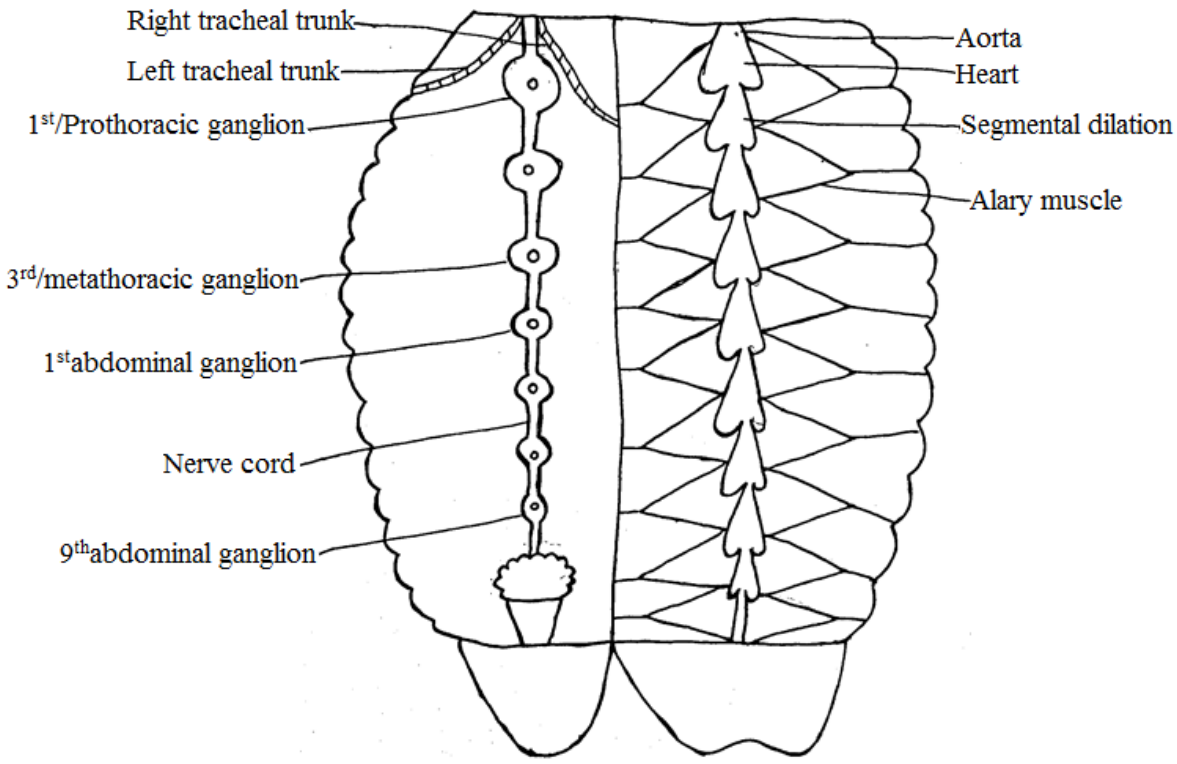
**Drawing of the mouth parts**



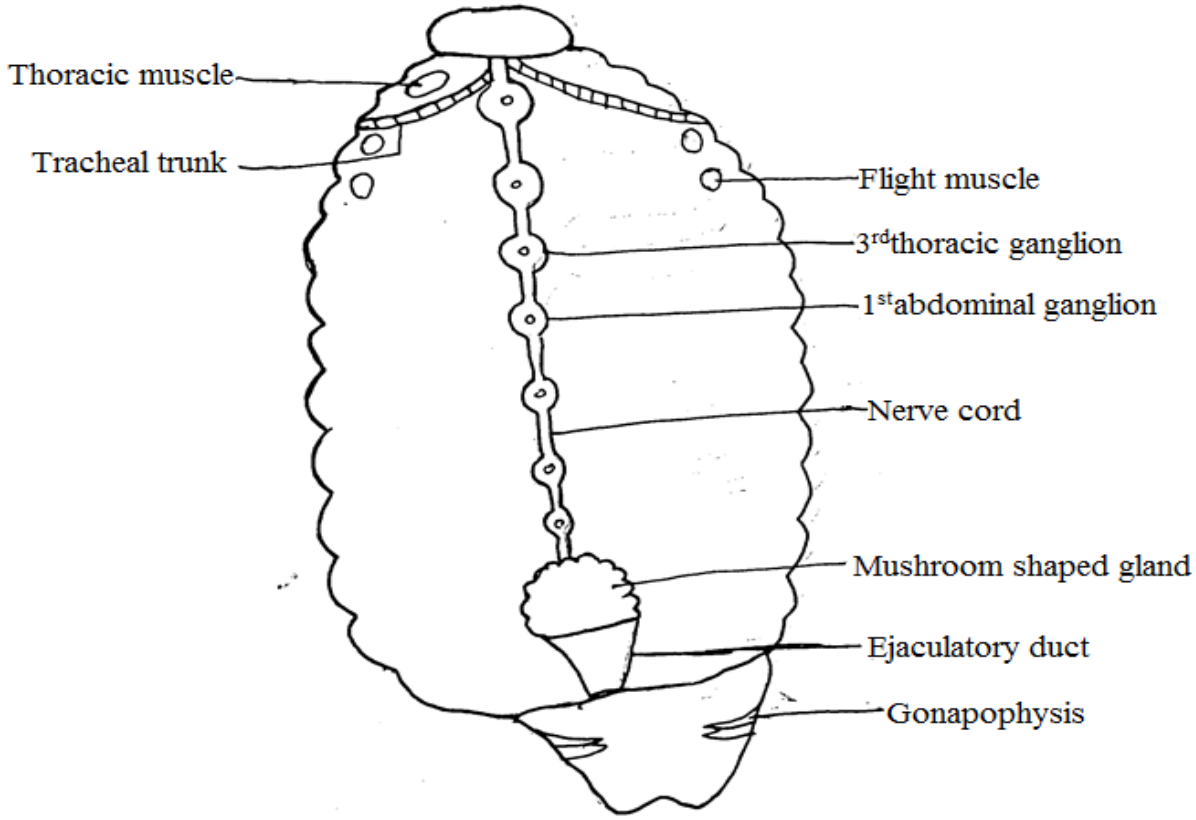
**Pin** the specimen with the dorsal side uppermost. Dissect along the left lateral line of the abdomen. Displace the dorsal cuticle and clear any fat tissue. Without displacing any other structures, draw and label your dissection



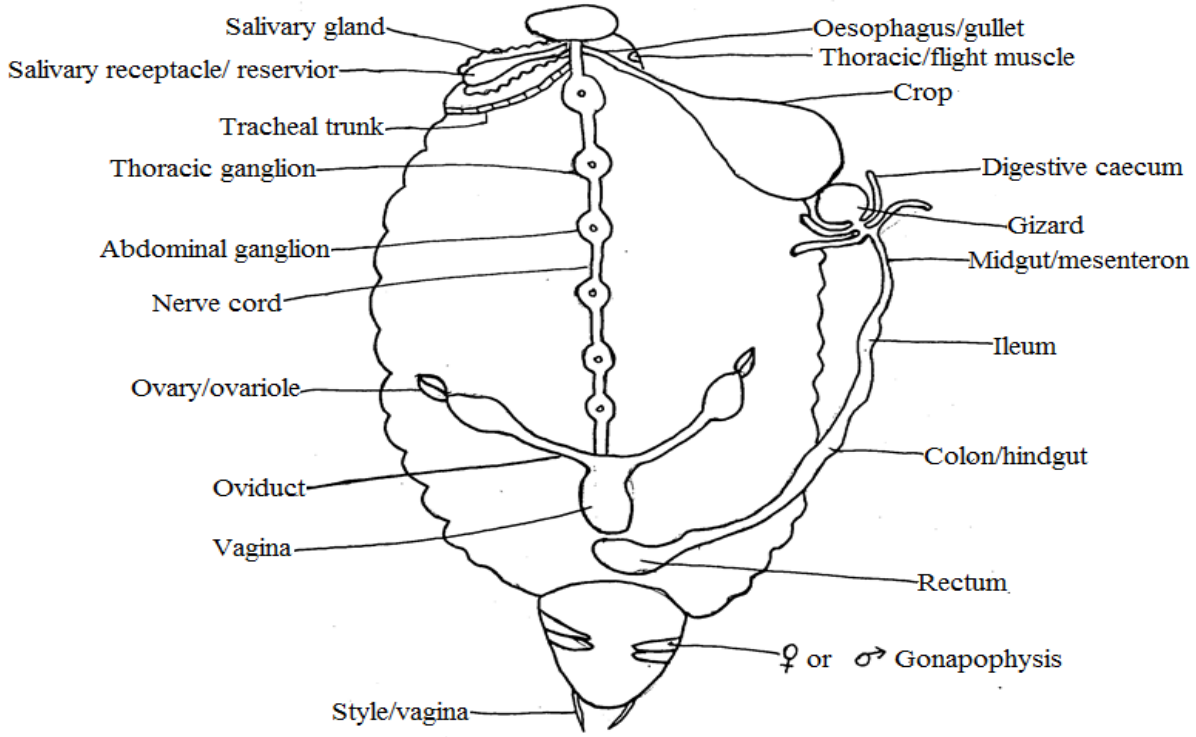

**Cut** off the wings, legs and antennal of the specimen. Open it up by cutting along its left side of the abdomen and thorax. Pour a little water to completely cover it. Discard the digestive system of the specimen leaving the reproductive structures in their un disturbed stat. draw and label the non-buoyant internal structures of specimen while the reproductive structures are intact



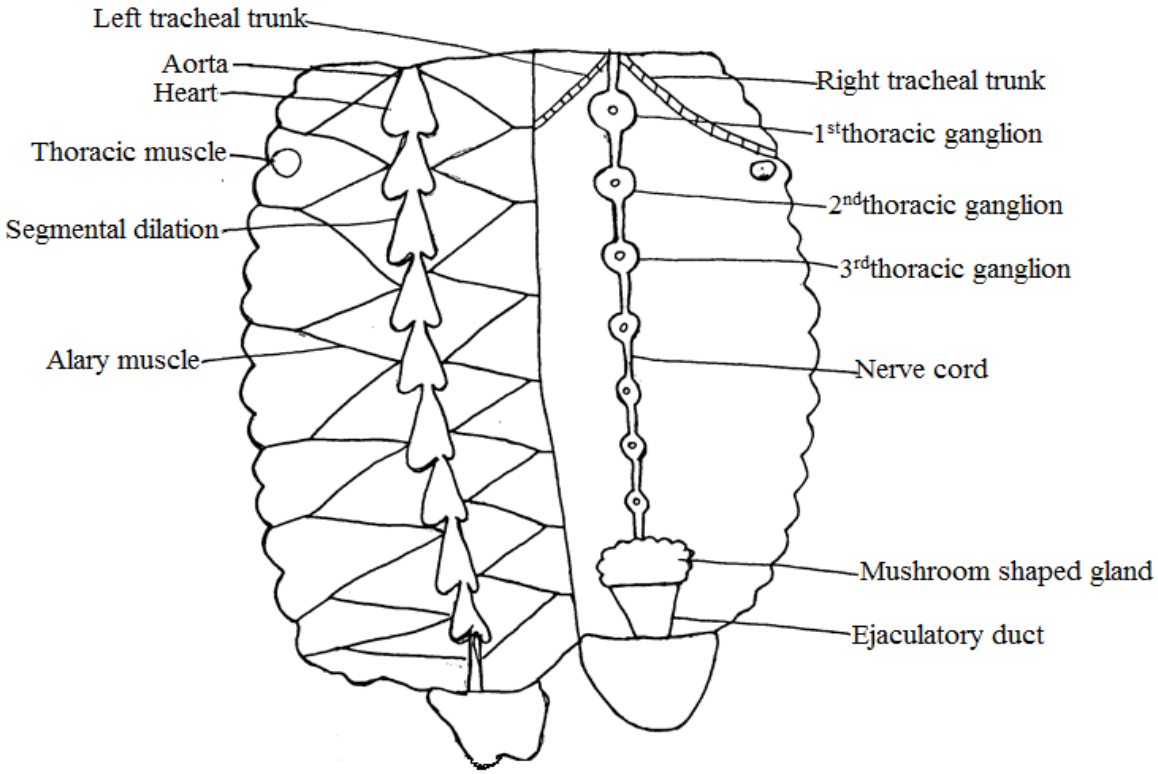

**By further** dissection, cut and remove the whole alimentary canal to clearly display the structures on the ventral cuticle draw and label the structures associated with the ventral cuticle, anterior to the last abdominal segment



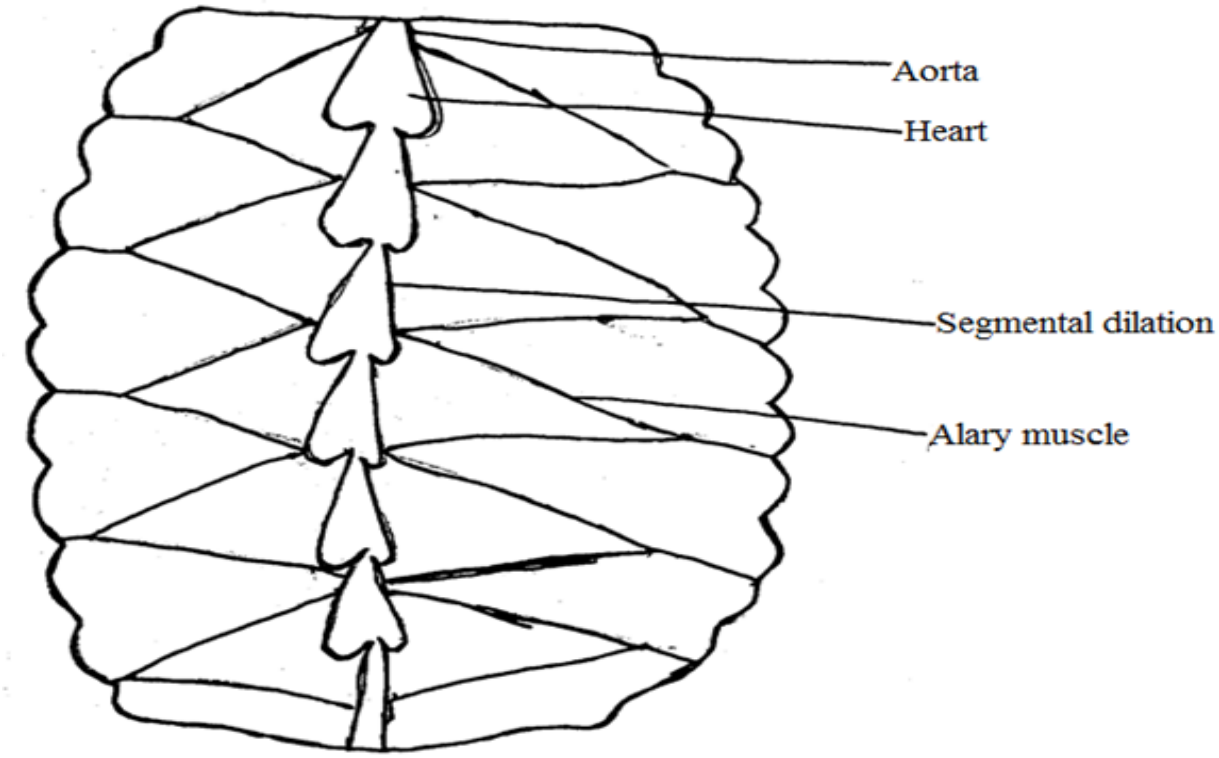

**Place** the specimen dorsal side uppermost to expose the structure within abdominal cavity
(i) Displace the structure to display the salivary glands on the left of the specimen
(ii) Displace the alimentary canal to the right of the specimen. Remove all the unnecessary tissue to display all the parts of the alimentary canal and the structures on the ventral cuticle. Draw and label.



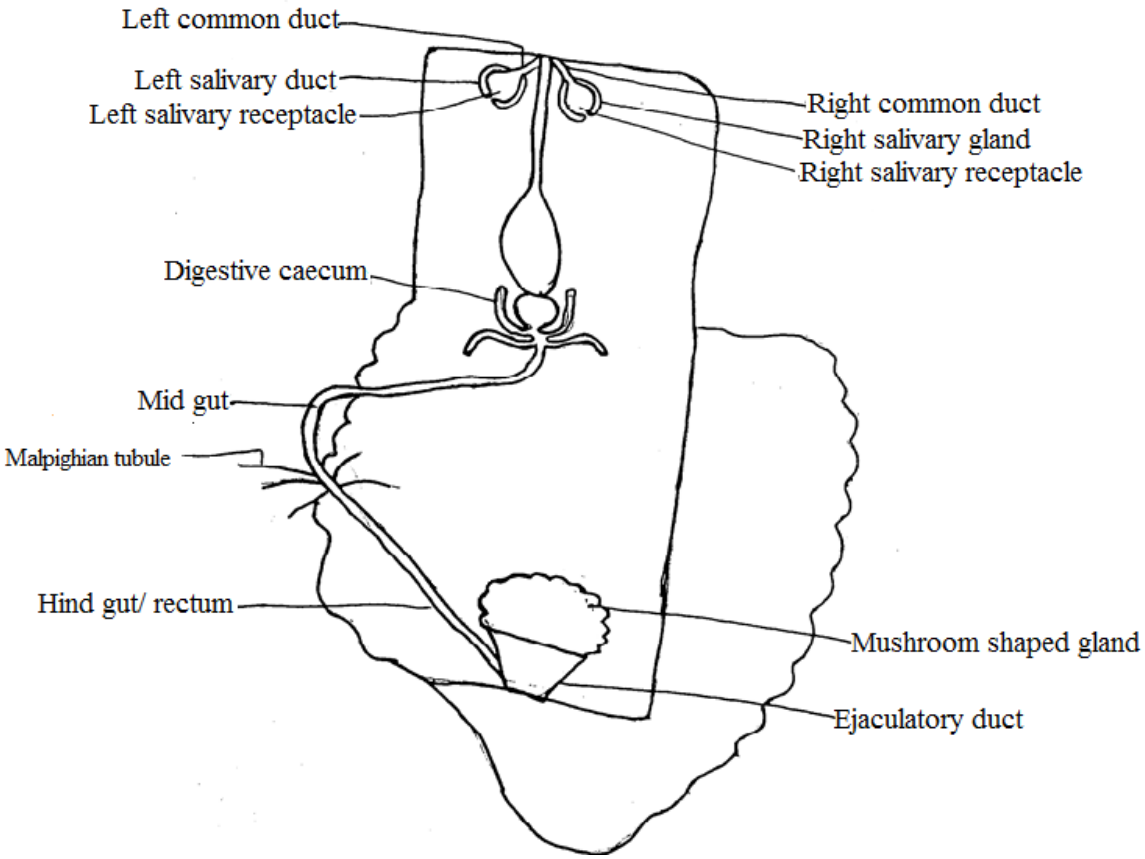

**With the posterior** end facing you and dorsal part uppermost, cut along the right side of the specimen to open it up. Remove the fats to clearly display the internal structures Discard the digestive system to display the internal structure on both the dorsal and ventral cuticles. Draw and label the internal structure displayed



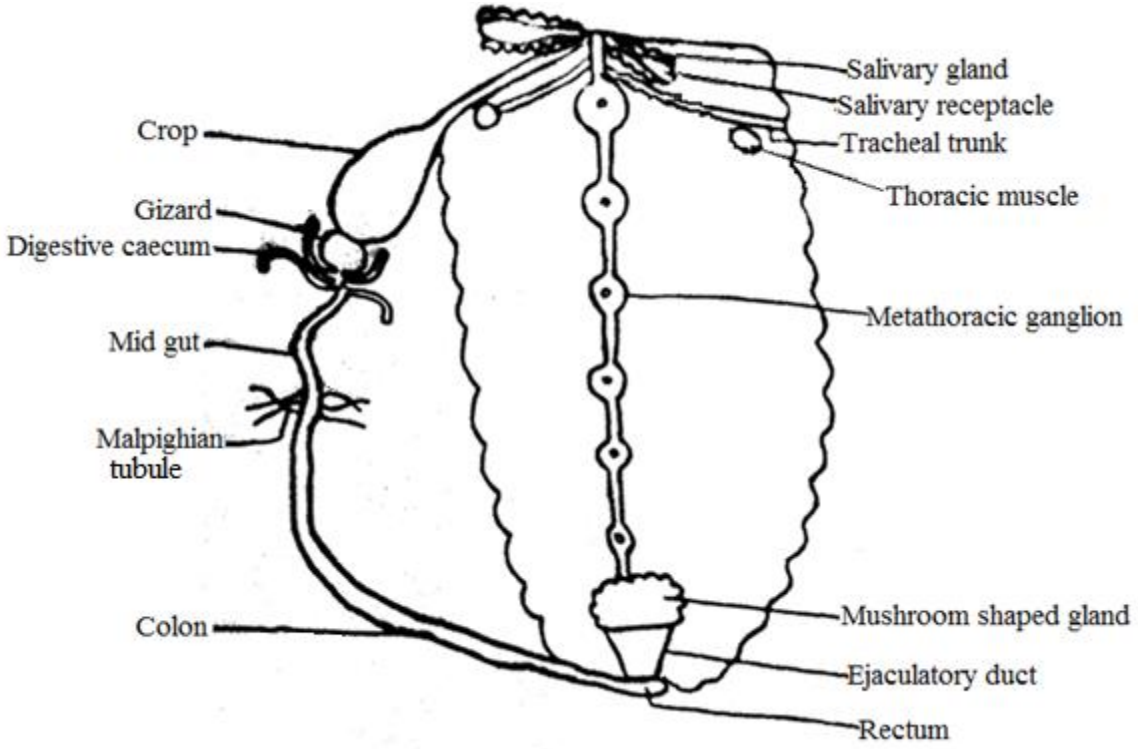

**Also draw** and label the system found on the dorsal cuticle of the specimen/cut along one lateral line of the specimen to display the heart. Draw and label the circulatory system.



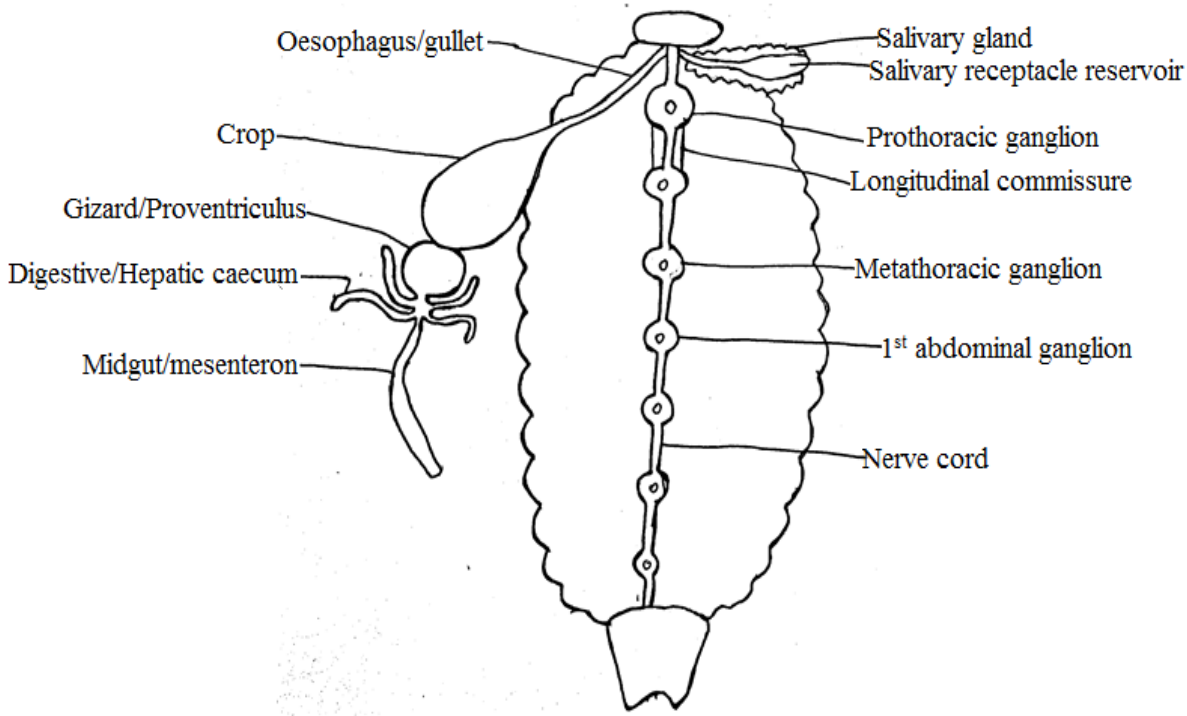

**Place** the specimen on the dissecting tray with dorsal surface uppermost. Cut along the left lateral side of the abdomen to open up the abdominal cavity. Also cut along the right lateral side of thorax to open the thoracic cavity. Fix the crop with a pin in its original position. Immerse the dissection in water. Displace the alimentary canal in the abdominal cavity to the left.



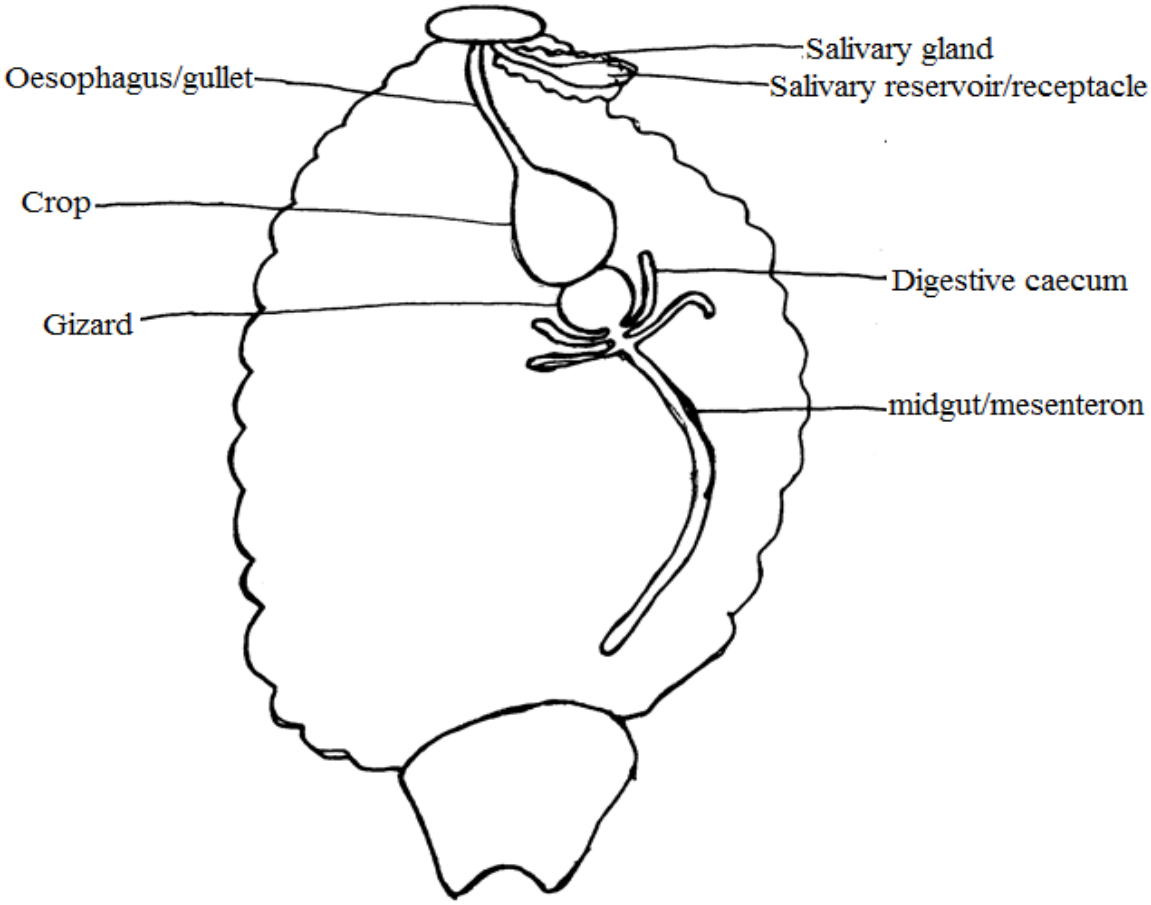

**Dissect** the specimen to remove the whole dorsal cuticle. Discard this cuticle. Then clear off the fat to display the structures on the ventral cuticle. Displace only the intestines to the left of the specimen. Draw and label the visible internal structures



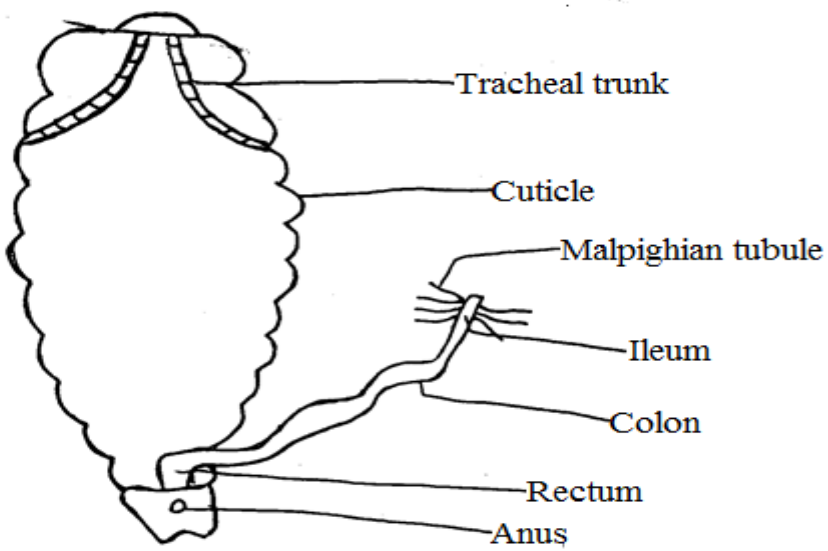

**A drawing of specimen** with the salivary glands displaced to the right and the alimentary canal to the left to show the structures of food storage, digestion and the ventral nerve cord



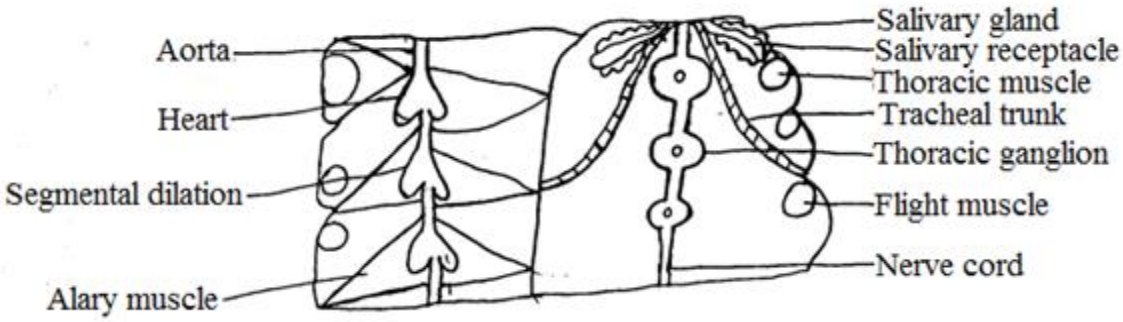

**Now proceed** to display the structures responsible for food storage and digestion and displaced to one side. Draw and label




**A drawing showing the structures for the removal of undigested and excretory materials from the body of a cockroach**

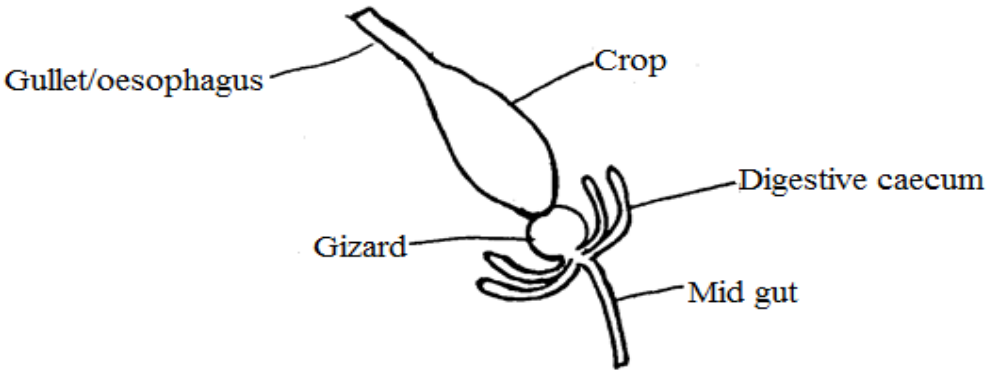



**A drawing showing structures in the thoracic region/ thoracic tergum and sternum/ dorsal and vetral cuticles of a cockroach with the gut/ alimentary canal cut out**



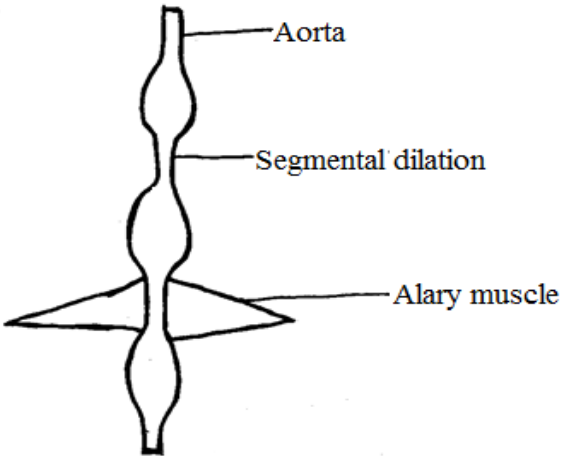

**NB:**

- Gonapophyses are on the dorsal cuticle thus are seen and drawn only if not told to do so.
- Salivary glands are seen even if the head is cut off because they are not in the head.
- Digestive ceaca open into the gizzard, they donnot just touch the gizzard.

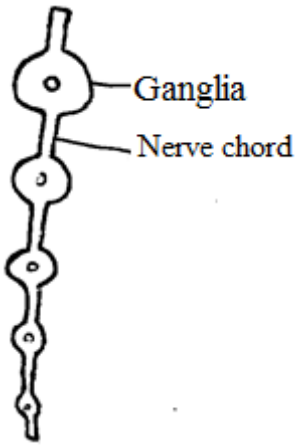



- Food is absorbed by the digestive ceaca into the mid gut and the food ends into mid gut. No food in the hind gut.
- Malphighian tubules are single lined not double lined


- A cockroach has only one Aorta, the other are segmental dilation not Aorta




In total there are 13 segmental dilation i.e. 10 in abdomen and three in thoracic.
The ganglia go on reducing in size




**Cockroach questions**

1. You are provided with specimen O which is freshly killed,
   (a) Classify the specimen in the following taxa.

   | | | | |
   |---|---|---|---|
   | Kingdom | …… | Family | …… |
   | Phylum | …… | Genus | …… |
   | Class | …… | Species | …… |
   | Order | …… | | |

   (b) State the features that are characteristic to that make the specimen O belong to:
   i. Phylum
   ii. Class
   iii. Order
   (iv) Family
   (v) Genus
   (c) Turn the specimen dorsal side upper most and examine the wings when pulled outwards, describe the structure of
   (i) Outer wings
   (ii) inner wings
   (d) Make a labelled drawing of the outer and inner wings
2. You are provided with specimen S.

(a) Examine the hind limb and describe how it is adapted to its functions (03 mks)
(b) Carefully cut and remove the right hind limb of specimen S when placed dorsal side upper most, draw and label. (05 mks)
(c) Cut off the pre-tarsus from the hind limb of the specimen S observe it under low power microscope, draw and label the pre-tarsus and its associated structures. (05 mks)
(d) How are the structures observed in C above suited to carry out its functions. (03 mks)

3. You are provided with specimen A.

(a) Using a hand lens examine the head of the specimen. Using any four observable features on the head, explain how each of them enables the animal to survive in its habitat. (04 mks)
(b) View the anterior part of the head using a hand lens, draw and label ($11\frac{1}{2}$ mks)
(c) Carefully cut off the whole left maxilla when placed ventral side uppermost, observe using a hand lens, draw and label. (03 mks)
(d) Give three adaptations of the maxilla to its function. (04 mks)
(e) Cut and examine the tarsus of the hind limb of the specimen under low power microscope. Draw and label the tarsus with its associated structures. (05 mks)

4. You are provided with specimen C.

(a) Pin the specimen C dorsal side upper most and cut off its wings.
(i) Draw and label the structures of the head and thorax including the limbs. (08 mks)
(ii) List the last abdominal tergum with forceps, and cut it off, draw and label the observed structures on the last segment. (04 mks)
(iii) From the observed structures in (ii) above state with reasons the sex of the specimen.

5. You are provided with specimen X.

(a) Dissect the specimen along the right lateral of the abdomen, displace the dorsal cuticle and clear any fat tissue. Gently displace the alimentary canal to the right of the specimen. Draw and label the exposed digestive system and structures associated with the sternum, anterior to last abdominal segment. (18 mks)

(b) Dissect the specimen along the left lateral line of the abdomen, displace the tergum, cut out the alimentary canal remove any excess fat tissue to display the structures of the sternum and tergum draw and label. (13 mks)

6. You are provided with specimen Z.

(a) Give any five observable structural adaptations for its mode of life. (05 mks)

(b) Basing on the external features, identify the sex of the specimen. (01 mks)

(c) Draw and label the features that have enabled you to identify its sex. (04 mks)

(d) Carefully remove the wings and draw and label the dorsal view of the specimen. (15 mks)

(e) Dissect the specimen to display the alimentary canal and its accessory structures, also display the heart and its associated muscles. Display the alimentary canal to the right. Draw and label the displayed parts. (16 mks)

7. You are provided with specimen C.

(a) Cut off the head of the specimen, carefully cut off the labium and one maxilla, observe the respective labium and maxilla under low power objective lens of a microscope.
Compare the suitability of the observed structures in relation to their function. (05 mks)

(b) Pin the specimen with dorsal side uppermost.

(i) Dissect the specimen along the left lateral line of the abdomen and thorax. Displace the dorsal cuticle and clear away any fat tissue. Displace the alimentary canal to the left. Draw and label the alimentary canal up to the point of absorption of the digested food and all the structures associated with the sternum, anterior to the last abdominal segment.(19 mks)

(ii) Basing on the internal structures from your dissection state with reasons the sex of the specimen. (02 mks)

(c) By further dissection cut out the tracheal trunk from the specimen. Observe it under low power of a microscope.

(i) Describe its structures. (02 mks)

(ii) What is the significance of your observation in (i) above to the specimen. (02 mks)

8. You are provided with specimen H.

(a) Examine the last tergum of the specimen from the ventral view.
Draw and label (06 mks)

(b) With the dorsal side uppermost, dissect the specimen to display the structures used for the removal of undigested and excretory materials from the specimen's body. Draw and label. (10 mks)

(c) Cut off the gut and remove unnecessary tissue to display the structures in the thoracic region deflect the dorsal cuticle to the left. Draw and label. (15 mks)

9. You are provided with specimen D.

(a) Cut of the head of the specimen, then cut off one eye with as little tissue under it as possible. Place the eye on the slide with the cut side facing downwards. View under the low power of a microscope.

(i) Describe the arrangement of the eye units. (05 mks)

(ii) Draw four adjacent eye units, don't label. (06 mks)

(iii) What is the significance of the arrangement of the eye units. (02 mks)

(b) With the dorsal side upper most, dissect the specimen to remove the digestive system. Display the structures remaining on the ventral cuticle. Draw and label. (12 mks)

10. You are provided with specimen O which is freshly killed.

(a) Using a hand lens, examine the whole specimen.

(i) Explain how two external features characteristic of its phylum enables it to survive in its habitat. (02 mks)

(ii) Give three descriptive features of the structures posterior to point of attachment of anal cerci that define the sex of the specimen provided. (03 mks)

(b) Using low power of the microscope, examine the pre-tarsus of the hind leg of specimen O. Describe the structures at the distal end of the appendage. (02 mks)

(c) Carefully spread out the hind wing of specimen O.

(i) Using a hand lens examine the hind wing and describe its structures. (02 mks)

(ii) Cut of the head of one of the specimen O provided. Examine it with its posterior end uppermost. Draw and label. (09 mks)

(d) With the dorsal side upper most dissect the second specimen along the left lateral line to display structures.

(i) Of the alimentary canal used for digestion and absorption excluding structures for elimination of solids and nitrogenous wastes.

(ii) On the ventral cuticle. Draw and label. (22 mks)

11. You are provided with specimen k which has been freshly killed

a) Examine the head of the specimen and use it to establish three diagnostic features characteristic of the phylum taxonomic level of the specimen (2 marks)

Phylum

Diagnostic features

b) Remove the whole of the labium. Observe using a hand lense.draw and label fully (8 marks)

c) Cut off the wings of the specimen observe it from the ventral side using a hand lense.draw and label. (8 marks)

d) Display the specimen on the dissecting tray with the ventral side facing the wax. Dissect the specimen by cutting along one lateral line to clearly display

i) All parts of the alimentary canal

ii) Internal structures associated with the abdominal cuticles. Draw and label your dissection on the same drawing. (17 marks)

12. You are provided with specimen k which is freshly killed.

a) With the help of a hand lense, examine the head of the specimen. Using any four observable features on the head, explain how each of them enables the animal to survive in its habitat. (04 marks)

b) View the anterior part of the head using a hand lense.draw and label. (11 marks)

c) Cut off the head of the specimen then cut one eye with as little tissue under it as possible. Place the eye on the slide with the cut side facing downwards. View under the low power of a microscope.

i) Describe the arrangement of the eye units (05 marks)

ii) Draw your adjacent eye units. Do not label. (06 marks)

iii) What is the significance of the arrangement of the units? (02 marks)

d) With the dorsal side upper most, dissect the specimen to remove the digestive system. Display the structures remaining on the ventral cuticle. Draw and label. (12 marks)

13. You are provided with specimen k

a) Place the specimen ventral side uppermost and cut off its antennae limbs. Observe the head and the first thoracic segment. Draw and label.

b) Turn the specimen dorsal side uppermost and examine the wings when pulled outwards. Describe their structure

i) Outer wings

ii) Inner wings

c) Cut off wings. Cut along the right lateral line of the body from the anterior part of the thorax up to the $8^{th}$ segment. Turn the dorsal cuticle to the left and clear any fat tissues. Carefully displace only exposed structures on the ventral cuticle. Draw and label your dissection showing

i) All internal structures on both cuticles
ii) Parts of the digestive system use of storage, digestion and absorption
14. You are provided with specimen **Q**
a) Examine one of the specimens and state any two external features in each case to classify the specimen into its phylum and class
i) Features of the phylum (2 marks)
ii) Features for class
b) Using a hand lense and examine the left compound eye of the specimen including the first three segments of the antenna, from the base. Draw the structures observed. Do not label. (05 marks)
c)i)pin one specimen with the dorsal side uppermost. Dissect along the left lateral line of the abdomen. Displace the dorsal cuticle and clear any fat tissue. Without displacing any other structures, draw and label your dissection. (16 marks)
iii) By further dissection, cut and remove the whole alimentary canal to clearly display the structures associated with ventral cuticle, anterior to the last abdominal segment. (11 marks)
15. You are provided with specimen k
a) From your observation of the external features, state with reasons the sex of the specimen.(2 marks)
b) Place the specimen ventral side uppermost. Draw and label the end of the abdomen (5 marks)
c) Using a hand lenses examine one antenna and draw. Do not label. (2 marks)
d) Place the specimen dorsal side uppermost and dissect to expose the structures within the abdominal and thoracic cavity
i) Displace the structures to displace the salivary glands on the left of the specimen
ii) Displace the alimentary canal to the right of the specimen. Remove all the unnecessary tissue to display all the parts of the alimentary canal and structures on the ventral cuticle. Draw and label.
(24 marks)
16. You are provided with specimen k
a) i) examine the antennae and describe how they are adapted to their function. (3 marks)
ii) Carefully cut the whole left maxilla. Observe using a hand lense.draw and label. (06 marks)
iii) Give three adaptations of maxilla to its functions (3 marks)
b) Place the specimen dorsal side uppermost, cut along the left lateral line of the specimen to display the heart. Draw and label the circulatory system. (8 marks)
c) i) remove both the crop and the gizzard related to the function of the two organs. (4 marks)
ii) Describe the appearance of the inner surface of the
Crop
Gizzard
iii) How are the inner surface of the crop and gizzard related to the functions of the two organs?
(4 marks)

Crop
Gizzard
d) Place the specimen on a dissecting tray with dorsal side uppermost. Cut along the left lateral side of the abdomen to open up the abdominal cavity. Also cut along the right lateral line of the thorax to open up the thorax cavity.fix the crop with a pin in its original position. Immerse the dissection in water. Displace the alimentary canal to the left. Draw and label the secretary and absorptive structures displayed.
e) Dissect the specimen to remove the whole dorsal cuticle. Discard this cuticle .then clear off the fat to display the structures on the ventral cuticle.diplace only the intestines to the left of the specimen. Draw and label the visible internal structures. (19 marks)
17. You are provided with specimen k

a) Cut off appendages at their proximal ends, remove all the wings including the tegimina.describe the structure of the animal's body. (10 marks)
b) Lay the specimen dorsal side uppermost cut off the elytra and wings close to their base. Lift the $10^{th}$ abdominal tergum.draw and label the visible structures of the specimen. Describe the structures on ventral cuticle. (4 marks)
18. a)i) you are provided with freshly killed specimen q.lay the animal ventral side uppermost. Observe the structures posterior to the trochanter of the hind limb. Draw and label. (10 marks)
ii) Count the number of abdominal segments in this region. (10 marks)
b) Lay the animal dorsal side uppermost..Cut through the left lateral line of the abdomen and thorax, leaving the anterior most segment of the specimen intact. Lift the dorsal cuticle and displace it o one side of the specimen. Cover the dissection with water and clear away. The fat bodies and displaces the alimentary canal to the right of the specimen. Draw and label the structures on both cuticles. (18 marks)
19. You are provided with specimen k
a) Cut off the antenna from its base
i)measure and record the length of the antenna and the rest of the body. (2 marks)
ii) What is the significance of the ratio in promoting the survival of the features (2 marks)
b) i) identify the sex of the cockroach, draw and label those external features which you used to determine the sex of the specimen. (4 marks)
ii) Remove the wings of the specimen.pin down the specimen with dorsal side uppermost. Lift the free edge of the tergum in the middle of the right lateral side of the abdomen. Cut the anterior edge of the terga and remove all the terga except those posterior to the middle of the abdomen. Avoid damaging the organs. List all the visible organs after removing the terga. (4 marks)
iii) Make a fully labeled drawing of the digestive system. (8 marks)
20. You are provided with specimen k
a) Using a hand lens examine the antennal socket and four proximal segments of the antenna.
i) Describe the structural features of this part of the antenna (2 marks)
ii) Draw and label this part of the antenna. (5 marks)
b)cut off the tegmina posterior wings, antenna and limbs, place the specimen dorsal side uppermost, cut through its right lateral side and dissect to expose the structures within the abdominal and thoracic regions. Displace the salivary glands to the right of the specimen. Displace the alimentary canal to the left. Remove all unnecessary tissue to display the alimentary canal and the structures on the ventral cuticle the gut. Draw and label structures exposed in your dissection. (18 marks)
21. You are provided with specimen k
a) Using a hand lense examine the compound eye, fenestra, antennary pit and antenna. Describe their structural features. (6 marks)
b) Examine the head region search for the mouth parts, describe their relative positions and associated structural features (6 marks)
c) Using a lower microscope. Examine the ventral view of the pretarsus
i) Describe the structure of the pretarsus. (3 marks)
ii) Draw and label. (4 marks)
iii) Place the animal ventral side uppermost. Draw and label the posterior end of the abdomen together with its associated structural features. (3 marks)
d) Place the specimen dorsal side uppermost, cut through the left hand edge of the exo-skeleton of the abdomen and dissect to expose the structures within the abdominal region. Displace the alimentary canal to the left of the animal. Remove the unnecessary tissue display all the parts of the alimentary canal and structures on the dorsal cuticle. Draw and label. (8 marks)
22. You are provided with specimen k

a) Using a scapel cut off the third leg of the specimen. Examine the inner view of the leg using a hand lense.draw and label. (10 marks)
b)i)examine the tarsus, draw and label. (4 marks)
ii) Outline the adaptations of the tarsus to its functions. (04 marks)
c)i) search for the spiracles. Describe their location and structures. (3 marks)
ii) Draw thoracic spiracle (4marks)
iii) Outline the differences between the thoracic and abdominal spiracle. (3 marks)
d) Using a microscope, examine the antenna carefully
ii) State three adaptive features of the antenna. (3 marks)
iii) Make a large label drawing of the antenna. (6 marks)
23. a) you are provided with specimen A, examine the mouth parts and describe the structural features of the mouth parts. (10 marks)
b) Draw and label
i) Mandible (4 marks)
ii) Maxilla (4 marks)
iii) Labium (4 marks)
c) Lay it on a dissecting board, dorsal side uppermost. Cut along the left lateral line except the posterior three terga. Displace the alimentary canal to the right. Draw and label the structures exposed on both the ventral and dorsal cuticles. (17 marks)
24. You provided with specimen y.examine it carefully and answer the questions that follow.
Display the animal on a dissecting board with the dorsal side uppermost. Cut along one lateral line of the abdomen, except its three anterior most segments and displace the dorsal terga to the left and the alimentary canal to the right. Draw and label the structures exposed on the ventral and dorsal tergum that are used for removal of insoluble nitrogenous waste products, sexual reproduction, coordination, breakdown and absorption and transport of digested nutrients and oxygen (22 marks)
25. a) you are provided with specimen A Which is freshly killed.
Cut off the head and boil it in caustic soda/alkali (sodium hydroxide) until when the head sinks. Cool the alkali and remove the head. Isolate carefully the first maxilla, second maxilla (labium) and the mandible
i) Draw and label these structures. (12 marks)
ii) How are these structures drawn adapted to their functions/roles? (10 marks)
b) Proceed to dissect and display all the structured lying on the dorsal cuticle. Draw and label. (8 marks)
26. You are provided with specimen k
a)i)cut off the wings and legs of the specimen. Examine the dorsal and ventral parts of the abdomen. Give three differences and similarities between the two cuticles. (6 marks)
ii) Explain how descriptions in a (i) above relates to the mode of life of the animal. (6 marks)
b)i) pin the specimen in the wax dish with the ventral side towards the wax. Dissect along the lateral line and remove the dorsal cuticle completely from the specimen. Turn this cuticle so that the internal structures are seen. Draw and label structures on the dorsal and ventral cuticles without displaying any. (12 marks)
ii) Explain how the cuticle can be of advantage or disadvantage in animals life.
27. You are provided with specimen x.use the specimen to answer the following questions
a) Cut off limbs completely to expose the thoracic segments clearly. Turn the specimen so as it faces you. Draw and label the interior half of the specimen
b) Dissect the specimen as follows
i) Pin the specimen with dorsal side uppermost

ii) Cut along the lateral line of the abdomen to the right hand side except the posterior most segments and displace the dorsal cuticle to your left. On the same drawing, draw and label the structures exposed on the dorsal and ventral cuticle

28. You are provided with specimen E

a) Using a magnifying lense, examine the structures found on the head region of specimen E

i) State four features observed from the head region used to classify the specimen (4 marks)

ii) Using low power magnification, observe the left compound eye and the first three segments at the base of the antenna. Make the accurate drawing don't label (6 marks)

iii) Give three descriptions of the compound eye and relate each description given to the role of the compound eye in the specimen. (6 marks)

b) Detach all the legs by carefully cutting at the point of attachment to the thorax. Then observe structures found in the interior half of the specimen using magnifying lens.

i) Make an accurate drawing showing the structures in the anterior half of the specimen from the ventral view. Label only segment structures. (15 marks)

29. You are provided with a freshly killed specimen k

a) Using a hand lens examine the dorsal view of the head. Draw and label. (7 marks)

b)i)place the specimen dorsal side uppermost cut one lateral line of the specimens to display organs that comprise the vascular,nenrouse,reproductive and excretory system. Draw and label the structures exposed in your dissection with the dorsal cuticle displaced to the right and alimentary canal to the left of the specimen. (18 marks)

ii) Cut through the right lateral side of the abdomen and the two posterior most segment of the thorax, leave the prothorax intact. Displace and hold the dorsal cuticle to one side of the specimen. Cover the dissection with water and clear away the fat bodies. Draw and label the exposed structures on both cuticles. (17 marks)

30. You are provided with specimen k

a) With the dorsal side uppermost, dissect the specimen to display the structures used for the removal of undigested and excretory materials from the specimens' body. Draw and label. (10 marks)

b) Cut out the gut and remove unnecessary tissue to display the structures in the thoracic region. Deflect the dorsal cuticle to the left. Draw and label. (14 marks)

31. You are provided with specimen k

a) Cut all the wings and limbs of the specimen. Then place the specimen on its back and examine the lower half of the abdomen using a hand lense.

i) Draw and label the structures observed. (6 marks)

ii) List two differences you expect to find in a specimen of the opposite sex. (2 marks)

b) Measure and cutoff 0.5 cm length of the fore limb from the end towards the foot. Observe from the inner view under low power magnification of a microscope.

i) Draw but don't label. (5 marks)

ii) State three ways the part of the limb drawn in b) i) is structurally adapted for its function. (3 marks)

c) i)pin the specimen with its dorsal side uppermost.dissct to completely remove the dorsal cuticle in the abdomen. Carefully clear off any unnecessary tissue. Draw and label the visible structure at the stage of dissection. (13 marks)

ii) Dissect further to display the whole alimentary canal. Proceed to cut and remove it. Draw and label the internal structures attached to the ventral cuticle. (12 marks)

32. You are provided with specimen k

ii) Cut off the wings, legs and antennae of the specimen.pin the specimen with the dorsal side uppermost. Dissect the specimen to remove the dorsal cuticle on the abdomen and display structures on the ventral cuticle that are associated with the reproduction and the posterior half of the gut displaced to your left. Draw and label your dissection (16 marks)

33. You are provided with specimen k, which is freshly killed.
i) Using candle wax, place your specimen with dorsal side uppermost. Cut along the ventral line to displace the dorsal cuticle of the abdomen to the right. Draw and neatly label your dissection. (10 marks)
ii) Continue to dissect to remove the thoracic dorsal cuticle. Displace the digestive system and associated organs to the left of the specimen. Draw and label your dissection including only structures attached to the ventral cuticle. (15 marks)
34. a) Cut off the wings and limbs from their point of attachment of specimen K. Place the specimen with the dorsal side uppermost. Continue to carefully cut off the last tergal segment. Examine the exposed last sternum structures and those associated on the lateral side. Draw and label.
(b) Dissect the specimen along the left lateral line of the abdomen on a wax dish and turn the dorsal cuticle. Remove any fat tissues with the aid of water. Displace the exposed parts of alimentary canal to the left to expose structures.
(i) Responsible for digestion; absorption of nutrients and removal of undigested food materials.
(ii) Within the ventral cuticle anterior to last segment and those of dorsal cuticle. Draw and label structures in (i) and (ii).
35. (Requirements: Microscope & glass slides, Razor blade, dissecting kit)
a) You are provided with a freshly killed animal. Use it to answer the following questions.
Using razor blade, remove the head of the specimen, boil it in a potassium solution in order to macerate its muscle tissues. Remove the tube from the flame at frequent intervals and observe the head. When it sinks quickly and remains at the bottom of the test tube it has been boiled enough. Wash the head with head with water.
(a)(i) Remove the labium by using fine forceps by holding it near its base and pull gently. Be careful not to damage other mouth parts. Put it on a microscope slide and observe. Draw and label.
(ii) What is the function of the labium to the specimen?
(iii) How is the labium adapted to its function?
(b) Remove the maxilla using a fine forceps by holding it near its base and pull gently. Place it on a slide. Observe it under a microscope. Draw and label.
(c) (i) State the function of the maxilla.
(ii) How is the labium adapted to its function?
(d) (i) In the same way remove the mandible. Put it on a microscope slide. Observe it under a microscope, draw and label.
(i) What is the function of the mandible?
(ii) How is it adapted to its function?
(e) Place the specimen dorsal side uppermost and dissect to expose the structures within the abdominal region.
(i) Displace the structures to displace the salivary glands on the left of the specimen.
(ii) Displace the alimentary canal to the right of the specimen. Remove all unnecessary tissues to display all the parts of the alimentary canal and the structures on the ventral cuticle. Draw and label.
(iii) Also draw and label the system found on the dorsal cuticle of the specimen.
(iv) For the same specimen, dissect to show the structures used in reproduction. Draw and label.
(v) Carefully make a transverse section of gizzard and mount in balsam. Remove section from balsam, place on glass slide and cover with a cover slip. Mount it on a microscope and view under both low and high power. Draw and label.
36. You are provided with specimen K.
(a) Examine the specimen and name the external features which are characteristic of the class to which the specimen belongs.
(b) From your observation of the external features, state with reasons the sex of the specimen.

(c) Place the specimen ventral side uppermost. Draw and label the end of the abdomen.
(d) Using a hand lens examine one antenna and draw. Do not label.
(e) Place the specimen dorsal side uppermost and dissect to expose the structures within the abdominal cavity.
(i) Displace the structures to display the salivary glands on the left of the specimen.
(ii) Displace the alimentary canal to the right of the specimen. Remove all unnecessary tissues to display all the parts of the alimentary canal and the structures on the ventral cuticle. Draw and label.

37. You are provided with specimen B which is an animal. Use it to answer the questions below.
(a) State;
(i) The habitat of the specimen and its adaptation to living in its habitant.
(ii) The habits of the specimen and its adaptations to these habits.
(b) (i) Remove the head from the specimen. Examine it thoroughly remove using a hand lens provided. Make a labeled drawing of the lateral view of the head region showing the features of biological significance to the specimen.
(c) Remove one antenna from the head of the specimen. Mount it on a glass slide and observe it under a low power microscope. Using the features on the antenna, state;
(i) The sex of the specimen

ii) The function of the antenna

d) i) remove the anal circus from the specimen. Mount it on the side and observe under a low power of a microscope. State one similarity and one difference between the anal circus and antennae

ii) Remove the hind limb of the specimen and from it obtain a portion from the tibia to the claws. Mount this portion on a slide and view it under a microscope. Describe any three observable features of the limb stating how they are adapted to carry out their functions in the specimen.

iii) Make a well labeled drawing showing the features stated c (ii) as shown under the low power microscope.

e) Using a pair of scissors, cut off all the wings and of the specimen and remaining limbs.pin the specimen on the dissecting board with the dorsal side uppermost. Dissect to the specimen to display the reproductive system. Make a well drawing of your dissection in the space provided.

## STUDY OF INSECT MOUTH PARTS, HAIR AND LEGS.

We shall look at some of the common insects like the Bee (order Hymenoptera), Housefly (order diptera), Drosophila (order diptera) Ant (order Hymenoptera), termite (order isoptera) and butterfly (order Lepidoptera).

Of particular interest are the variations in the general features foreaxample:-

| | |
|---|---|
| Antenna | Length and shape, knobbed or not, hairy or smooth |
| Head | Shape |
| Compound eyes | Large or small, colour |
| Mouth parts | Type and size of the parts. |
| Wings | Number, size, type; hard or membranous |
| Abdomen | Number of segments hairy or not, appendages e.g. Cerci, style, stings present or not and their size. |
| Legs | Hairy, with spikes or not, shape and length of parts, or absence or presence of arolium.<br>Other structures like wax spines, pollen brushes as seen in the honey bee |

The table below shows sokme of the characteristic features of common insects

| **INSECT TYPE** | **CHARACTERISTIC FEATURES** |
|---|---|
| Cockroach | - a pair of long jointed antennae<br>- a pair of large black compound eyes |

| | |
|---|---|
| | - a pair of mandibles<br>- a labrum<br>- a pair of labial pulps on a labium<br>- anal style(in males) podical plates in females<br>- anal cerci<br>- spines on hind legs<br>- two pairs of wings: outer opaque and membranous inner wings. |
| House fly. | -a pair of short antennae<br>- a pair of large compound eyes<br>- a pair of short pulps<br>- a proboscis expanded at the tip (funnel shaped)<br>- a hairy body<br>- a pair of membranous wings<br>- a pair of halters (balancers) |
| Worker bee | - a pair of membranous wings<br>- a hairy body<br>- a hymen between the thorax and abdomen<br>- a pair of short antennae<br>- Hind leg and pollen baskets and comb<br>- a small labium<br>-a pair of large compound eyes<br>- a long labium that is pointed form a lapping tongue. |
| Soldier termite | - a large (prominent) head with eyes<br>- a pair of large mandibles<br>- a pair of very short antennae<br>- a small labium. |
| Butterfly | -a pair of large club shaded / knobbed antennae<br>-a pair of large compound eyes<br>-a pair of maxillary pulps<br>-a long coiled proboscis<br>- wings are larger than the rest of the body. |
| Sugar ant | -a pair of long antennae<br>-a pair of long maxillary pulps<br>-a pair of short labial pulps<br>-a pair of small compound eyes<br>-a pair of mandibles<br>-a labium<br>-a hymen |
| Weevil | -a pair of hard outer wings<br>-a pair of membranous wings<br>-a pair of short pulps<br>-a pair of small compound eyes. |

**NB**: Mount the legs in Canada balsam or glycerin and observe under low power. Identify the characteristic features and practice drawing

**DRAWINGS OF THE HIND LEGS OF SOME COMMON INSECTS.**

a) Drosophila b) Honey Bee

**THE MOUTH PARTS OF INSECTS.**

These are appendages around the mouth of insects adopted for feeding.

The basic parts are;

. Labrum (upper lip).Mandibles (jaws), Maxillae.Labium (lower lip), Pulps.

**Functions of the parts.**

| | |
|---|---|
| Mandibles | biting and tasting food |
| Pulps | tasting food |
| Maxillae and Labium | pushing food into the mouth |

**NB**

The basic plan (primitive plan) is that adopted for chewing and bitting as seen in the cockroach and grasshoppers. The variation in the mouth parts is evidence of the adoptive radiation of insects to exploit a variety of habitats and food types therein. These include,

Piercing and sucking mouth parts.

**Modification**:

.Labium forms a sheath enclosing other mouth parts.
.Mandibles and maxillae are slender, sharp stylets.
.Labium is elongated and tubular to form the proboscis.
.Have a hypaphyrnx through which the anticoagulant is released.
.Sucking only e.g in Lepidoptera and some diptera.

**Modifications; Butterfly**

.Mandibles are absent as they do not chew.
.Maxillary from a long sucking tube the proboscis.
.Maxillary pulps absent or rudimentary
Labium present but small.

**NOTE**

When not in use the proboscis is coiled under the thorax.

**Modifications**;

**House fly**

.Labium forms a soft proboscis expanded at the tip into two pads of the labella.
.a number of minute food channels spread laterally over each labellum.
.and leads to the mouth (pseudo tracheae).

NB

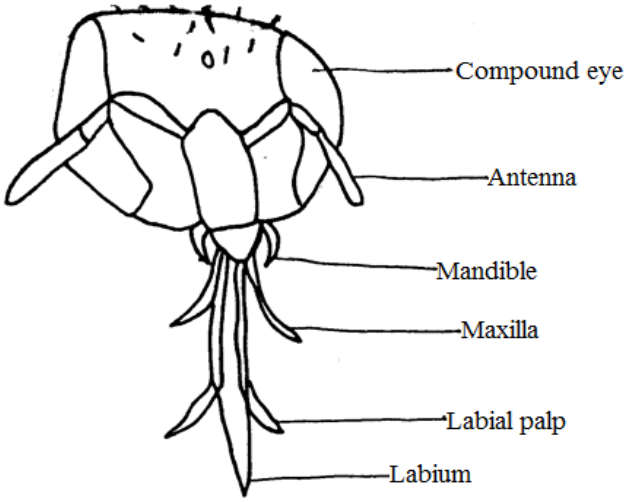
The size of these channels ensure that only liquid food and very tiny particles

The size of these channels ensure that only liquid food and very tiny particles can be sucked.

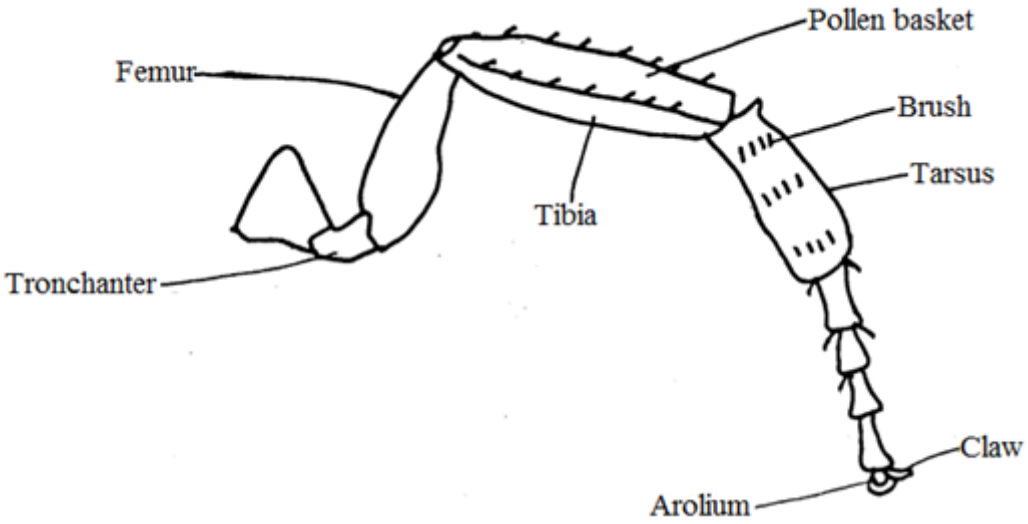
Modifications;

**Bees**

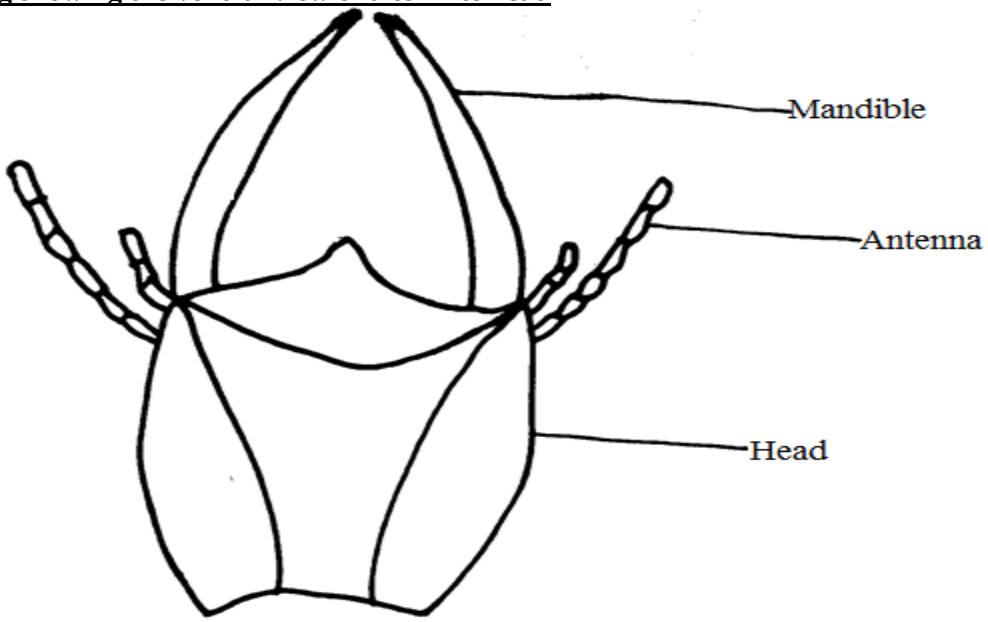
.Blunt mandibles used for molding wax
.Maxillae are blade like with bristles.
.Maxillae pulps are vestigial.
.Labial pulps are elongated.
.Paraglossa are vestigial
.Gloss are fused to form a long sucking tube with an expanded tip.



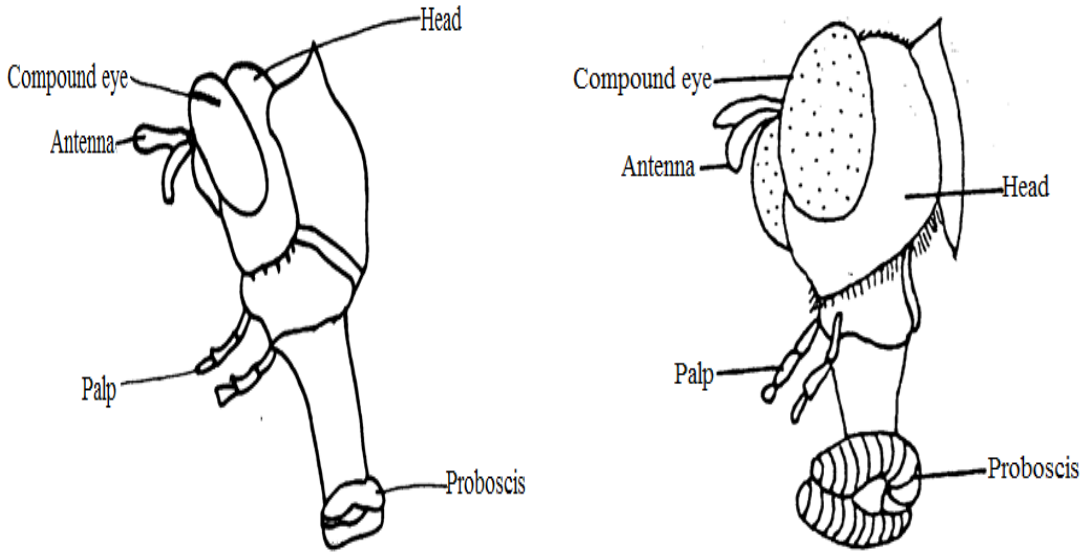
Drawing showing the leg of the bee



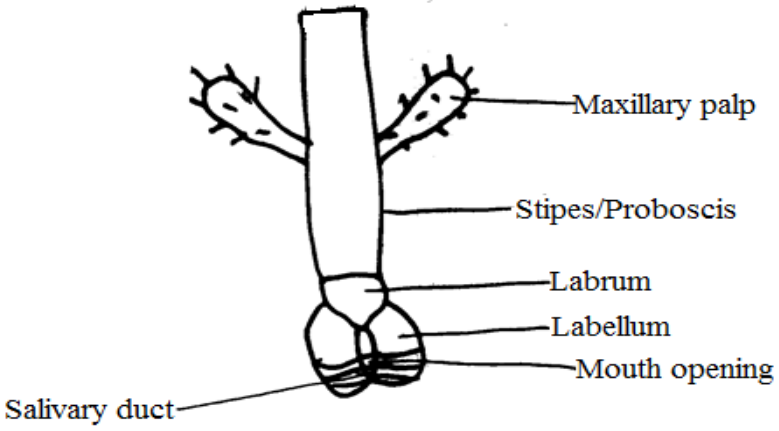

**A drawing showing the ventral view of a termite head**



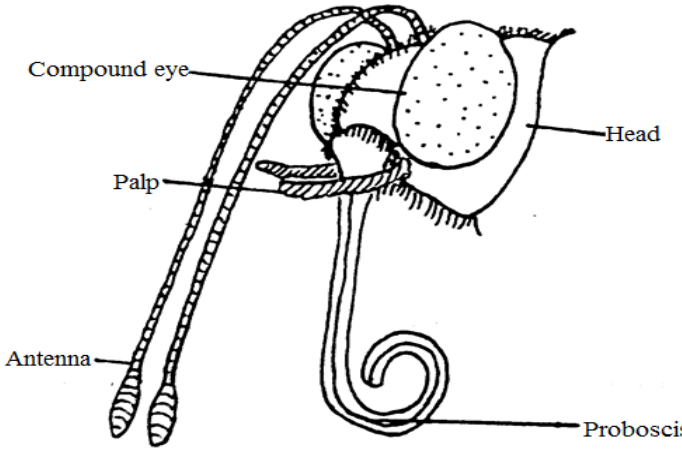

**Head of housefly**



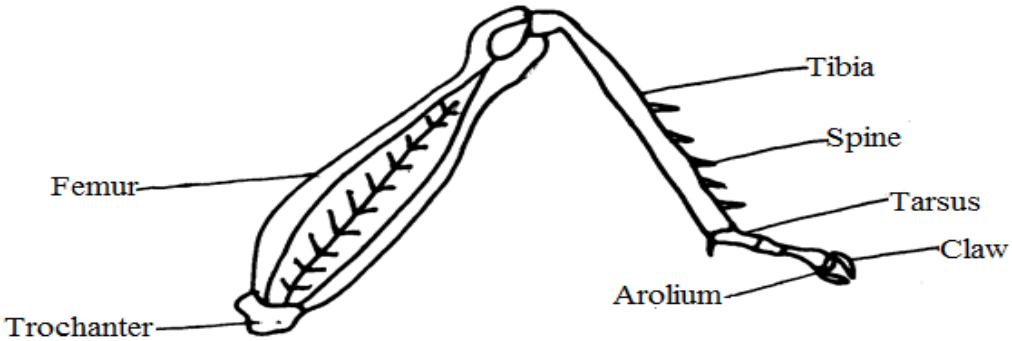
**Transverse section through the mouth of a housefly**



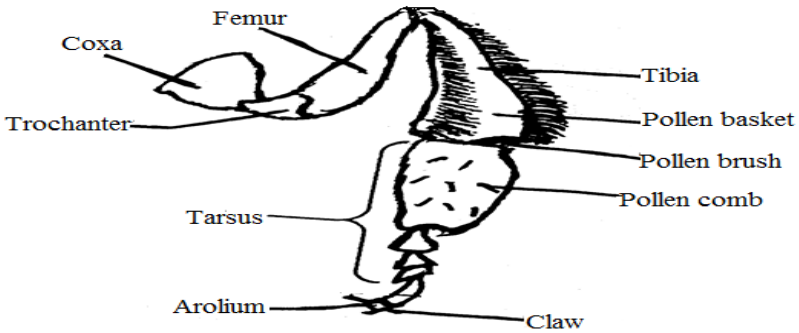

**Head of butterfly**




**Hind leg of a grasshopper**

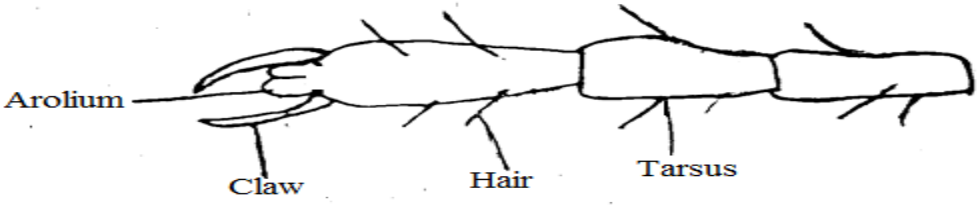



**Hind leg of a worker bee**




**Drawing of the three segments/Podomeres of the tersus of a cockroach under low power**


**Drawing of the three segments/Podomeres of the tersus of a blow fly under low power**




| | **Housefly** | **Worker bee** | **Worker termite** | **Grasshopper** | **Tick** |
|---|---|---|---|---|---|
| Order | Diptera | Hymenoptera | Isoptera | Orthoptera | Acarina |
| Diet<br>Reason | **Fluids**;e.g. feaces<br>• Proboscis is expanded at the tip to suck fluids. | **Fluids**; e.g. nectar<br>• Glossa is narrow at tip for sucking. | **Solid substances** e.g. wood<br>• Mandibles are sharp for cutting. | **Solid substances** e.g. grass.<br>• Mandibles are sharp for cutting grass | **Fluids;** e.g. **blood**<br>• Chericerae have hooks for piercing animals |
| Ecological role, and how suited | Transmission of germs that cause diseases.<br>• Hairy body enables attachment of germs | Pollination<br>• Pollen baskets on hind legs for attachment of pollen | Destruction of wood<br>• Hard mandibles for cutiing wood. | Destruction of vegetation<br>• Sharp mandibles for cutting grass. | Parasite on mammals.<br>• Chelicerae have hooks for piercing skin for mammals |
| Habitat | • Pit latrines<br>• Rotting garbage | • Bee hive | • Termitarium OR<br>• Termite mound | Green grass | Bodies of mammals. |
| | **Housefly** | **Worker bee** | **Worker termite** | **Grasshopper** | **Tick** |
| Head-general | Ovate/Triangular shaped hairy | Triangular shaped hairy | Rectangular, smooth dorsal surface, brightly coloured, dorsal-ventrally flat. | large | Fused thorax abdomen |
| One eye | Large, dull coloured oval shaped, dorsal laterally positioned | Large, dull coloured, comma-shaped, dorsal laterally position. | No eyes | Large, dull coloured, smooth, protrude, oval shaped, dorsal laterally positioned. | Small |
| | **Housefly** | **Worker bee** | **Worker termite** | **Grasshopper** | **Tick** |
| Antennae | Short, hairy, segmented, with bristles. | Short, hairy, segmented, bent | Short, not hairy segmented, blunt ending | Short, thin, pointed, jointed | No antenna |

| | | | | | |
|---|---|---|---|---|---|
| Mouth parts | Proboscis is expanded at the tip<br>Large labium<br>Maxillary palp short, hairy | Hairy,<br>Proboscis is pointed and curved at the end, mandibles are two, small, blunt for moulding pollen/wax. | Mandibles are 2, short, pointed , strong, curved, sharp,<br>Labial palps are two, jointed, short, hairy. | Mandibles are two, hard, large, serrated.<br>Maxillae are two, hairy<br>Labrum is one, thin, hard,<br>labium is one, hairy. | Two palps ,chelicerae, hypostomen 1, barbed needle-like. |
| Thorax | Segments, hairy, striped, halters are 2, short, attached on the third thoracic segment. | 3 segments, hairy, segmented | 3 segments | Thick, box-like, consists of 3 fused segments. | Fused with head and abdomen |
| Wings | 2 transparent, network veined | Four, flattered, membranous, inner wings have hooks on the top edge | Wingless/no wings | Are 4, forewings two, leathery, narrow, veined inner wings two, thin/membranous, broad and veined | No wings |
| Limbs | 6 hairy, jointed, have glandular pad between the 2 claws.<br>Hind limbs are long | Six jointed hairy legs, hind leg long, has pollen basket on tibia, pollen brush | 3 pairs, jointed, smooth, almost equal size. | Has 6 legs, jointed for flexibility, pointed spined for protection.<br>Hind legs are long, have large femur forcreating a lift force, have curved claws for gripping | Eight jointed , hairy |
| Abdomen | Segmented, hairy, pointed posteriorly, short | Segmented, narrow, has a sting at the posterior end. | Segmented smooth | Segmented, terminal segment has cerci | Fused with thorax and head |
| **Specimen** | **Butterfly** | **Sugar ant** | **Cockroach** | **Millipede** | **Weevil/bettles** |
| Head region | Two long club-shaped/knobbed antennae<br>Two large compound eyes<br>Two long maxillary palps long coiled proboscis | Two, short antennae<br>Two small sized compound eyes<br>Two serrated mandibles<br>Two short segmented labial palps | Has two, long, thin, tapering antennae<br>Has two large serrated mandibles<br>Two long, segmented maxillary palps, two segmented labial palps curved labrum | Sharp mandibles, pair of long segmented antennae<br>Has eyes/oceli<br>Has curved labrum | Has rostrum/snout/boring mouth parts |
| Thorax wings | | No wings | 4 veined, wings outer wing thick, long and narrow, inner wing thin and broad/large | No wings | Two pairs, hard/thick outer wings, longer thin inner wings |

| | | | | | |
|---|---|---|---|---|---|
| Limbs | 6 jointed legs with curved claws and sticky glandular pad | 6 jointed legs with curved claws and sticky glandular pad | Long with pointed spines, curved claws, large sticky arolium | Many jointed limbs with curved claws | 6 jointed legs with claws and glandular pad |
| Abdomen | | Tapering posteriorly | Flattened and has a pair of segmented hairy anal cerci | | Tapering posteriorly. |

1. You are provided with specimens **W, X, Y** and **Z.**

**(a)** Using a head lens, examine specimen **Z** and state how the features of its head are suited for its role in the community it lives. **(02 marks)**

- Pointed, long , curved, sharp mandible for defence
- Hard mandibles for define
- Big head to scare enemies,hard Head for defence
- Thin, segmented antenna for easy swing (flexible)
- Segmented palps for flexibility,swelling, manipulating food head for defence

**(b)** Examine the wings of specimens W and Y using hand lens and state three structural differences between them in **Table 1**. **(03marks)**

**Table 1**

| **Wings of specimen W** | **Wings of specimen Y** |
|---|---|
| Outer wing/ membranous than inner wing<br>Outer/inner/ hind wing/elytra membrane/ thin. | Outer wing border than inner wings<br>All wings membranous. |
| Inner wing folded<br>Inner wing notched | Inner wing not folded<br>Inner wing not notched |
| Outer/ inner wing has many veins | Outer/ inner wing has few veins |

(c) (i) Observe the tibia and tarsus of each specimen using the low power of a microscope. State two descriptive features on the tibia and tarsus of each specimen in **Table 2.**

**(i)** Observe the abdominal appendages on each of the specimens and state your observation in **Table 2.** **(12marks)**

**Table 2**

| **Specimen** | **Descriptive features on** | | |
|---|---|---|---|
| | **Tibia** | **Tarsus** | **Abdominal appendages** |
| W | Very many, pointed, thick,<br>Very long bristles, spines<br>Many, pointed, tapering, short hairs | Many, pointed, thick, short spines<br>Pointed curved claws<br>Thick. swollen/round arolium | Segmented, hairy 2 cerci<br>Slender, tapering, pointed 2styles |
| X | Few, pointed, tapering ,thick long bristles, spines<br>Very many, pointed, thin short hairs | Long, pointed, thick, short spines<br>Thin, pointed, hairy short hairs, bilobed, hairy, round thick arolium | Lacks |
| Y | Many, thin, pointed, short spines, bristles<br>Very many, shirt, than hair<br>2wings, thick, panels spurs. | Few/thin/ pointed, short spines<br>Many is points short | Short, slender thin, pointed sting |
| Z | Few, pointed, short, tapering hair | Few,thin,pointed hair long,curved,pointed claws rounded arolium | lacks |

(d) Using the feature on the tibia alone, contract a dichotomous key to identify the specimens.

**1.** (a) Tibia with spines …… 2
(b) Tibia without spines (hairs only)…….. z
**2.** (a) Tibia with few spines …….. X
(b) Tibia with many spines …… 3
**3.** (a) Tibia with thick spines …….. w
(b) Tibia with thin spines …… Y

**(e)** In the space below, draw and label the last three segments of the tarsus of the hind limbs of specimens W and X, when viewed under low power of a microscope.
**(08marks)**

**TOAD/ FROG**

| **Classification** | **Frog** | **Toad** |
|---|---|---|
| Kingdom | Animalia | Animalia |

| | | |
|---|---|---|
| Phylum | Chordate | chordata |
| Class | Amphibia | Amphibia |
| Order | Anura | Anura |
| Family | Ranidae | Bufonidae |
| Genus | Rana | Bufo |
| Species | temporaria | regularis |

**Reasons for being classified in phylum chordata**

- Has a dorsal, longitudinally running rod, the notochord this lies between the dorsal nerve tube and the gut. It increases internal support and locomotory power.
- Presence of dorsal, hollow nerve chord.
- Presence of post-anal tail i.e. tail starts posterior to anus.
- Limbs formed from more than one body segment.
- Presence of pharyngeal (visceral) clefts.
- Has bilateral symmetry.
- Has triploblastic coelomate.

**Reasons for being classified in class Amphibia**.

- Soft moist skin with no scales.
- Visceral clefts present in aquatic larva (tadpole) only.

**Order Anura bacuase**

- External ear drums.
- Hind limbs are elongated and enlarged for leaping.
- Hind limbs have aweb of skin between the digits.

**SEX IDENTIFICATION**

There are no external genitalia thus distinguishing between the sexes is not obvious. However, males and females can be distinguished by the following characteristics.

**Characteristics of females.**

-Broad abdomen, bloated with eggs especially during the breeding skin.
-Skin underlying the throat is creamy white/grey.

**Characteristics of males.**

-Slender bodied (narrow abdomen).
-Skin underlying the throat is usually white.
-Have a rough black, warty patch on `the inside of the first or pre-axial finger on the fore limb called the nuptial pad.

**NB**.

Nuptial pad should only be written when comparing two specimens.

**ADAPTATIONS FOR SURVIVAL IN HABITAT.**

An amphibian lives on both land and water comfortably due to its external and internal features.

**Adaptations to Terrestrial life**.

These include,

-Moist skin for gaseous exchange.
-long hind limbs to provide strong propulsive force for jumping longer distances.
-Limbs for locomotion that is jumping, limping.
-Skin coloured brown, grey or green for camouflage.
-protruding eyes to increase on field of view.
-pointed claws for grasping on rough surfaces.
-Poison glands in skin to protect them from their predators.

**Adaptations to Aquatic life.**

-Eyes bulging dorsa laterally in position so that they can be exposed while the rest of the body is submerged in water.
-Hind limbs bigger, stronger and longer to provide strong propulsive force during swimming.
-Streamlined body to prevent water resistance while swimming.
-hind limbs have webbed feet which increase surface area for water while swimming.
-Nostrils anteriorly positioned so that breathing can proceed without exposing the rest of the body

**THE SKIN /NATURE OF THE SKIN**

The externally, the skin is damp (moist), soft warty and slimy (slippery to touch), and hard to prick, yellow /green (for frog) or grey/black or dark brown patches on dorsal surface, with poison glands all over the body. Skin color is lighter on the ventral sides and males have white throats (frog). The skin is kept moist and slimy by secretion of mucous glands present in the integument.

**Significance /adaptations**

1. It is soft /thin and moist /damp to allow gaseous exchange while submerged under water and also in moist terrestrial habitats (moist skin surface makes the skin an important respiratory organ)
2. It is warty /rough and slimy ( slippery to touch ), to allow animal to escape predation as it is not easy to hold /grip fast on ( for easy escape from predators)
3. The color (green for frog and black or dark brown patches for toad) on dorsal part helps them to blend with the background /camouflage efficiently in their environment, escaping predation /for protection /unpalatable to large carnivorous animals /deep brown body surface for camouflage.
4. It is tough and hard to pick, for protecting the delicate internal organs from injury/external damage.
5. It contains numerous poison glands all over the with two main concentrations on the head, which secretes a milky substance (poisonous fluid) that protects the animal from predators defense/ to be unpalatable /keep off predators.
6. The ventral /lower side is slight blown to bend it with the sky when in water for further protection from its predators in water.

**Attachments to the body wall (internal structures)**

Internally, the skin is loosely attached to the underlying body wall/muscle by loose areolar connective tissue, at intervals only; the intervening spaces occupied by the large lymph sacs/fluid filled large spaces (swollen with large lymph sacs where the skin does not touch the body) and has numerous blood vessels/mucous glands and several nerves. This loose attachment increases gaseous exchange over the skin. The loose attachment is mainly on the ventral abdominal region/lower trunk region. The skin is also firmly attached to the body wall at the head, throat region, and at the limb joints (pectoral/ fore limbs and pelvic or hind limbs) for support during locomotion and to hold the skin on to the body of the animal.

**Significancy of loose attachment:**

- Loose attachment with fluid filled spaces increases gaseous exchange over the skin
- Loose attachment with large lymph sacs which allow destination of the body wall;
- Also allows movement of the skin freely on to the body wall, without rapture of internal organs and increase gaseous exchange of the skin.
- Thin surface/numerous blood vessels make the skin an important respiratory organ/ for exchange and transport away of the respiratory gases.
- Mucus gland/ simple saccular glands secrete watery mucus which keeps the skin in a moist condition, enabling the absorption of oxygen and elimination of carbdioxide

**NB**

**Attachment of the skin to the body wall**

- The skin is firmly attached to the body wall at fore limbs, hind limbs and throat region while it is loosely attached within lower trunk/abdominal region.

**Significance of skin attachment**

- Loose attachment has fluid filled space, for gaseous exchange/dissolution of gases, while firm attachment to support/hold the skin onto the animals body.

**NATURE OF THE SKIN AND ADAPTATIONS**

- It is thin to ease diffusion of gases.
- It is moist to ease gaseous exchange by dissolving the gases
- It has numerous capillaries on inner surface to increase the surface area for gaseous exchange and transport way of gases.

**PATTERN OF BLOOD CIRCULATION ON THE SKIN**

The pattern of blood vessels is that the one/two main blood vessels. The musculo cutaneous vein emerging from the armpit/ attachment of the forelimbs, big sized divides into numerous blood capillaries which are spread all over the skin inner surface. The nature of blood vessels is that they are closely attached to the inner surface of the skin to reduce/ shorten the diffusion distance hence easing gaseous exchange / for efficient gaseous exchange.
Form a network (highly branched) to increase the surface area for gaseous exchange /diffusion of gases over the skin /also increases surface area for supplying large amounts of nutrients such as oxygen, sugars to the skin.
To increase transport /flow /draining of blood away from the skin leading to increased gradient/ diffusion of gases.

**NB**

**Description of pattern of blood circulation**

- One main blood vessel/musculo cutaneous vein from the base of the fore limbs, the large size blood vessel branches/ramifies into many smaller blood vessels, capillaries and forms a network which spread over the skin.

**Significance of pattern of blood circulation**

- Increased surface for increased gaseous exchange and diffusion of gases and to increase transport/flow/draining of blood away from the skin, leading to increased diffusion gradient.

**NB:**

The musculo – cutaneous vein emerges from the arm pits and branches into smaller blood vessels distributed over the inner surface of the skin.

**Adaptations of the skin for gaseous exchange**

- It is moist for easy diffusion of respiratory gases /air.
- Thin walls for easy diffusion of gases, well supplied with blood capillaries for easy transport /diffusion or gases /air.

NB. Other respiratory surfaces are the lungs and buccal cavity lining have the same adaptations

**Adaptations of the dorsal skin in the trunk region for survival on land**

- Has poison glands for protection.
- Dull brown coloured for camouflage.
- Large surface area for gaseous exchange.

**Structural difference between the dorsal and ventral skin surface**

| **Dorsal skin surface** | **Ventral skin surface** |
|---|---|
| - Few glands. | - Numerous glands. |
| - Dark colouration. | - Pale colouration |
| - Larger swellings/glands. | - Smaller swellings/glands. |
| - Tightly held onto the body wall. | - Loosely held onto the body wall |

**Relevancy of the structural differences**

- Dorsal surface is more exposed to danger than the ventral surface therefore the dorsal surface is more highly protected than the ventral surface.

**BODY**

The body is about 10.11cm /18cm long, when fully grown and is squat, being flattened dorso-ventrally. The animal has no neck, the head being connected directly to the trunk and there is no tail therefore the body is divided into two regions /parts .The head and trunk ,neck and tail are absent in the toad and the frog .

**THE HEAD** (shape and position)

The head is broad and triangular in shape, with its apex in front and base posterior (behind) and joined to the trunk directly there being no neck .It is dorso-ventrally flattened /compressed, tapering /narrowing to the snout/anteriorly, and is bluntly rounded ending into a wide mouth and broader at the rear /posterior ( the head is narrow in front and broad behind, the anterior narrow ,blunt end is known as the snout ) . It bears the mouth, nostrils, eyes and tympanic membrane/ear drum.

**Significance of shape and position of the head**

Triangular shape and position of the head gives/ offers the animal a streamlined shape; that reduces resistance to its motion /movement (to ease movement) in water while swimming /on land during burrow

**NB**

**Shape of head and its significance**

- It is triangular with apex anterior and base posterior joined to the trunk directly to reduce air resistance during locomotion.
- It is dorsal ventrally flattened to offer a streamlined shape to the animal for reducing air resistance during locomotion.

**Significance of the structure and position of the eyes**

- Are large, spherical and dorsal laterally positioned on the head for a wide field of view.
- Has slightly movable upper eye lids and lower transparent nictitating membrane for protecting the eye ball.

**TONGUE**

It is for rolling of food during swallowing; and has taste buds for tasting food;

The tongue is a muscular, long, elongated, flappy/flat, broad flexible, soft structure formed /found on the floor of buccal cavity .its anterior end is free and capable of slight protraction while the posterior end is attached to the floor of the buccal cavity along the greater part of its length. The surface of the tongue is rough due the presence of many small projections called the taste papillae. These taste buds are used to taste food.

- The tongue is elongated /long to suitably roll food swallowing.
- It is broad to increase the surface area that can expose more taste buds for tasting food.
- The rough surface of the tongue facilitates manipulation of the food to form a bolus that can easily be swallowed.
- The tongue is muscular to effect movement during rolling for swallowing.
- The tongue is flappy/flat and flexible for easy rolling of the food.
- It is slippery and moist for easy swallowing of food.

**Adaptations of the tongue**

(a) Long to capture distant prey, elastic to stretch where the prey is /to reach the prey at a distance and retract back after capturing the prey.
(b) Long enough and elastic to trap insects /prey at relatively far distances for food.
(c) Flattened to increase the surface area for trapping the prey /fly insects for food.
(d) It has numerous glands that secrete sticky mucus to easily trap the prey.
(e) It is forked anteriorly to easily trap the food and increase the surface area which exposed.
(f) Sticky to trap small animals/flying insects easily for food, which are not able to escape once the fall on the tongue /sticky to prevent prey from escaping after capture.
(g) Muscular: it is muscular (the hypoglossus muscles which pass forward to the root of the tongue into it and up to the tip), to flick/flip/shoot out the tongue over a wide arc when contracted to allow physical gripping of prey and easily trap the insect.
(h) Located on the anterior end of the lower lip so that it can easily be flipped out of the mouth for easy capturing of prey.

**NOSTRIL/ EXTERNAL NARES**

The nostrils are a pair of small rounded holes/openings (external nares) located anteriorly on (at the anterior) the head and above the mouth. These nostrils lead into the nasl sacs/open into the olfactory sacs. They are used for perceiving odours (smell) and to take in air during breathing /Nostrils are for breathing /passage of gases or air.

**Significance**

- The position allows breathing /passage of air(gaseous exchange) when the rest of the body is submerged in water/during movement in water or on land.
- They are also strategically placed to detect smells of food and /or enemies in the environment before the rest of the body come close.
- They are open /hollow for breathing /passage of air.

- Dorso- posteriorly located on the anterior tip of the head for aerial contact with air while the animal is submerged in water or when on land.

**THE EYES**

The eyes are two ( a pair ) big, round ,dark coloured ,largely /prominent and protruding /bulging ,placed /lying /positioned dorso-laterally on the head lie almost dorsal but facing laterally) .They are covered with poorly developed eyelids (thick folds of skin ) the upper eyelids being stiff and immovable /slightly movable , while the lower one represents /forms a third membrane which is thin,transparent and movable called the nictitating membrane (third eyelid) that can be drawn up over the eye and is used to clean ,moisten and protect the eye.

**Significance /importantance**

(a) The significance of structure and position (dorso lateral location) of the eye is to provide the animal with a wide field of vision/wide vision; in its habitat, which is advantageous to its being carnivorous/predator/ suit its carnivorous /predator way of life / to view objects at the surface of water while swimming /to maintain aerial contact when the animal is submerged in water.
(b) The nictitating membrane moistens, cleans and protects the eye from injury without interrupting the continuity of version /during swimming.
(c) Round, large, and protruding eyes for wider field of view /clear vision.

**EXTERNAL EAR DRUM /EARS /TYMPANIC MEMBRANE**

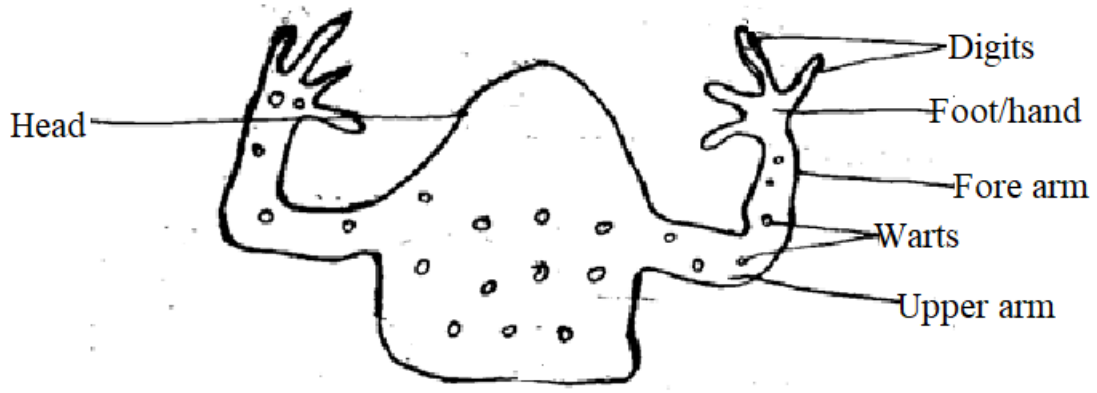
The external ear drum /tympanic membranes are smooth, large, prominent, round /circular, thin, shiny, grey patches of tough membranous tissue /skin, which are usually moist and tightly /tensely out stretched skin located dorsolaterally behind the eyes.

They pass the sound waves /vibrations to an ear bone which passes them to the fluid filled inner ear. The external ear drum is for hearing /to convert sound waves into hearing.

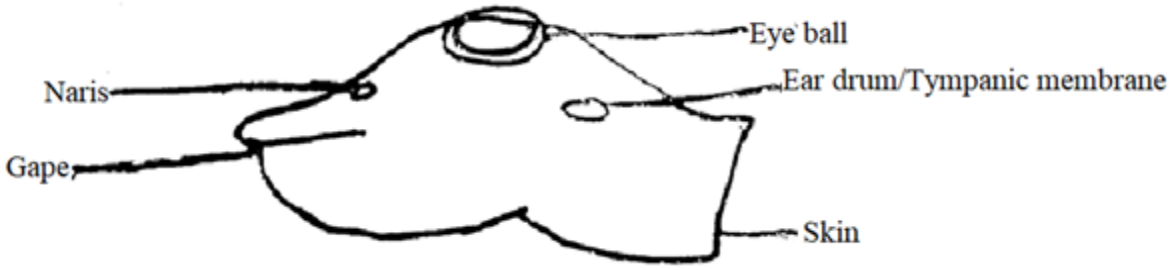
**Significance**

(a) Position allows them to receive sound vibrations from a wide field of that for easy hearing making it possible for the animal to detect fellows, obstacles, and enimies in the environment.
(b) Tough structure /nature of the skin allow them to resist the pressure exerted by water and other external obstacles without rupture.
(c) Round to increase surface area for detection of sound waves
(d) Tough skin to with stand strong waves while swimming.
(e) Large surface to provide a large surface area to capture sound waves
(f) Thin, membranous, circular, shiny, tightly, outstretched to vibrate when receiving sound waves.

**A drawing of the structure on the anterior venacava surface of a toad including the laterally attached surface of the fore limbs**

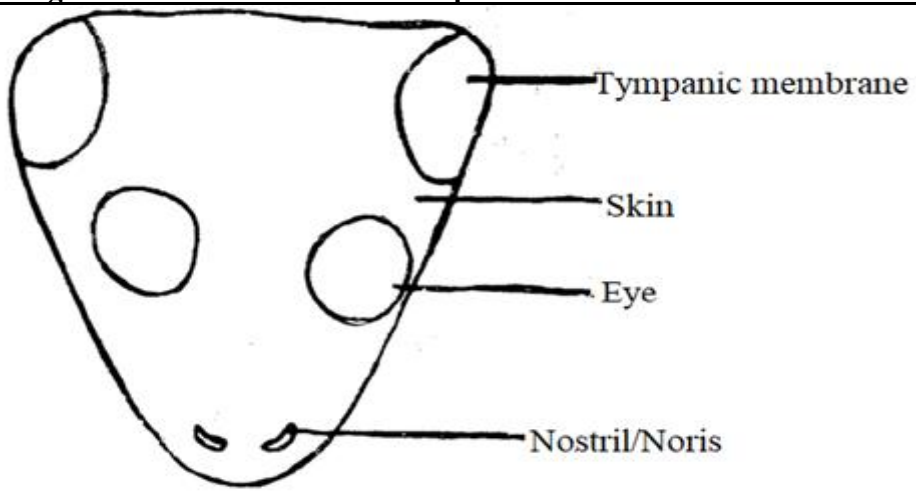



**A drawing showing the structural features of sensitivity and feeding located on the left handside of the head**




**The shape and position of the head**


**Drawing showing the dorsal view of the anterior part of the head structures fro sensitivity**




**THE LIMBS**:

The limbs are of un equal size and this reflects their different functions. They are arranged on the pentadactyl limb plant typical of all land vertebrates.

The front legs are used mainly to support the head and chest and break the force of fall on landing. They are consequently short and shout.

Each consists of four (4) parts an upper arm (bronchium) which in the ordinary position is directed backwards and downwards from the shoulder joint, a fore arm directed downwards and forwards from the elbow the wrist (carpuls) and the hand (manus) ending in four short tapering digits directed forward and are not webbed.

The hind limb is for providing propulsive force or forward thrust both for jumping on land and swimming in water.

It accomplishes the jump by sudden straightening and swimming by alternate kicks which push the webbed toes against the water.

The hind limbs are consequently much larger and longer. They also consist of four parts i.e. the thigh (femur), shrunk, tarsus (ankle) and pes (foot) consisting of five long slender digits united by webs.

**Description of the attachment of the hind limbs**

The hind limbs are attached on the lateral ventral surface of the pelvic region of the trunk of the specimen.

**DIFFERENCES BETWEEN THE HIND LIMB AND FORE LIMB**

| Hind Limb | Fore Limb |
|---|---|
| - Longer. | - Shorter. |
| - Has five digits. | - Has four digits. |
| - The digits on the hind foot are webbed. | - The digits of the fore foot are not webbed. |
| - Has two prominent joints . | - Has one prominent joint. |
| - Has longer digits. | - Has shorter digits. |
| - Its foot is longer. | - Its foot is shorter. |
| - Its z – shaped. | - Its L – shaped. |
| - More muscular. | - Less muscular. |

NB: Avoid answers like the left feet are webbed.

A drawing of the left hind limb including the exposed superficial muscles of the thigh of a toad fully stretched out from the dorsal view

**Similarities between fore and hind limb**

- Both have digits.
- Are jointed.
- Have poisonous glands.
- Have phalanges in digits.
- Digits are variable in length

**Adaptations of the hind limb for survival of the specimen (Toad) in its habitat (remember these can be both structural)**

- Jointed for flexibility.
- Dark brown on the dorsal surface and creamy white on the ventral surface for camouflage.
- Webbed digits to increase surface area for pushing against water to provide propulsive force during locomotion.
- Numerous mucus glands to secrete mucus that dissolves respiratory gases to facilitate gaseous exchange. Digits are different sizes for firm grip/ increase grip.
- The limb is long with a muscular thigh to provide propulsive force during locomotion.
- Numerous poison glands/swellings which secrete poison for defense.

**Adaptation of the fore limb**

- Fore limbs are short and stout, holding the body clearly off the ground during rest.
- Fore limbs are short and stout to absorb shock during hoping.

**Adaptations of the limbs to their functions**

(a) The fore limbs are short and stout, to hold/support the front body (head and chest) clear off the ground during rest, and for shock absorption on landing after a jump.
(b) The hind limbs are long for jumping/hopping/leaping longer distance.
(c) The hind limbs are muscular and folded into three regions to provide/generate a propulsive force or a forward thrust to the body during jumping /hopping on land and swimming /locomotion in water.
(d) The hind limbs have webbed toes/digits to provide a large surface area against which a forward thrust /propulsive force is generated (for pushing the animal forward) during swimming/leaping.
(e) The hind limbs have long-nailed toes which dig deep into ground to provide stability to animal during jumping on land.
(f) Jointed limbs for flexibility during locomotion / movement
(g) The hind limbs have long claws for firm griping on land.

**Fore limb structure. Significance**

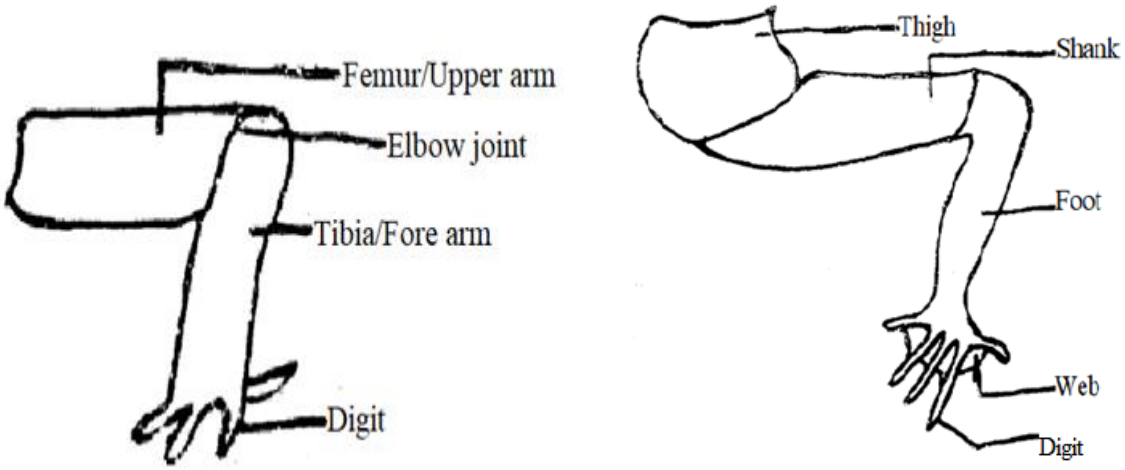
- Jointed for flexibility during locomotion.
- Short stout to absorb shocks during landing.
- Four webless digits for digging burrows for hiding.

**Fore limb location**

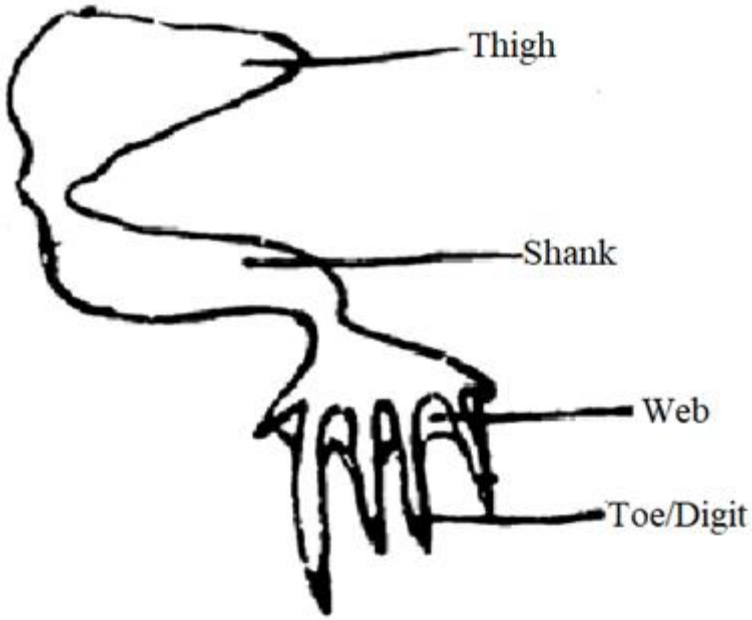
- Ventral – laterally attached to support the body above the ground.
- Attached onto the anterior part of the body to raise the head above the ground.

**A drawing showing the structure of the left fore limb and hind limb**

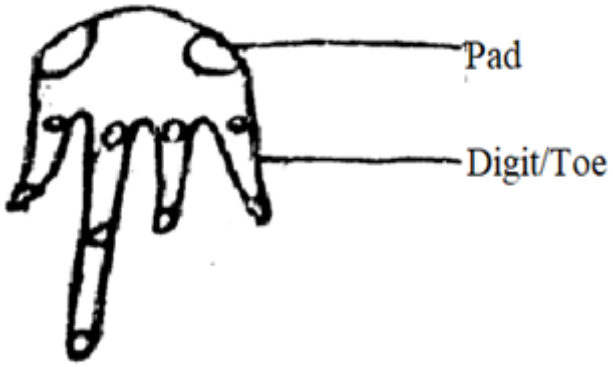
**Fore limb** **Hind limb**



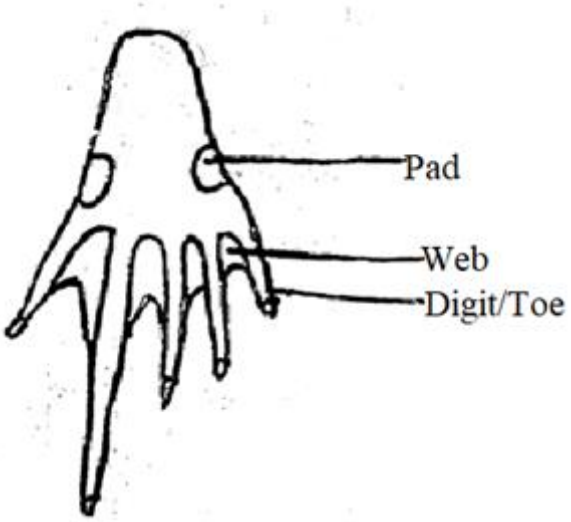

**A drawing showing the ventral side of the hind foot**




**A drawing showing the ventral side of the left fore limb of a toad**



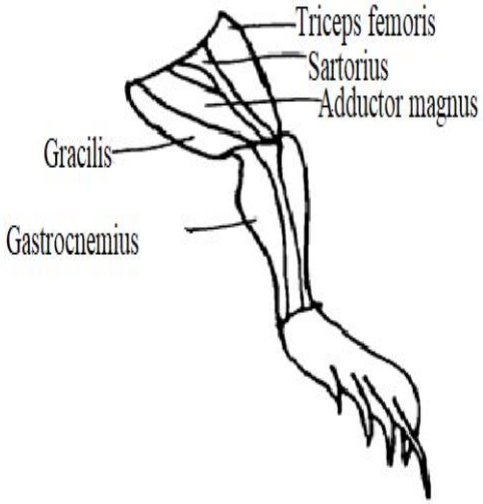

**A drawing showing the ventral side of the left hind foot of a toad**



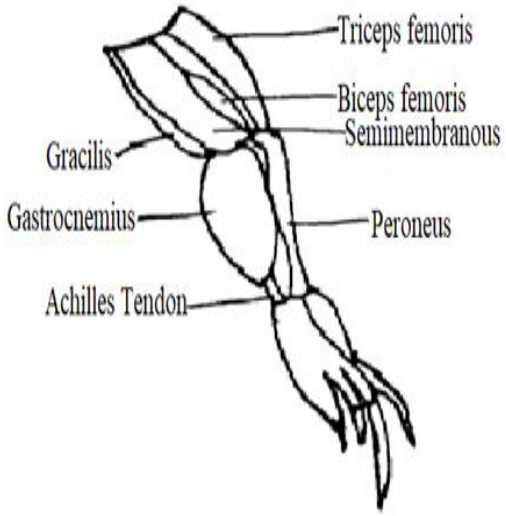

**Muscles of the hind Limb**

There are four/five muscle blocks arranged parallel to each other. The muscle blocks overlap.

**Ventral view of the hind limb**

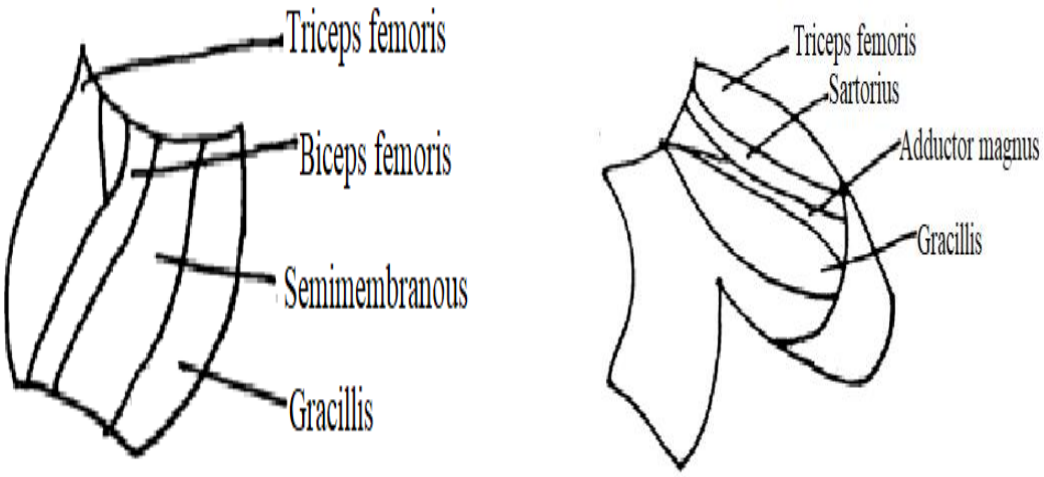



**Dorsal view of the hind limb**

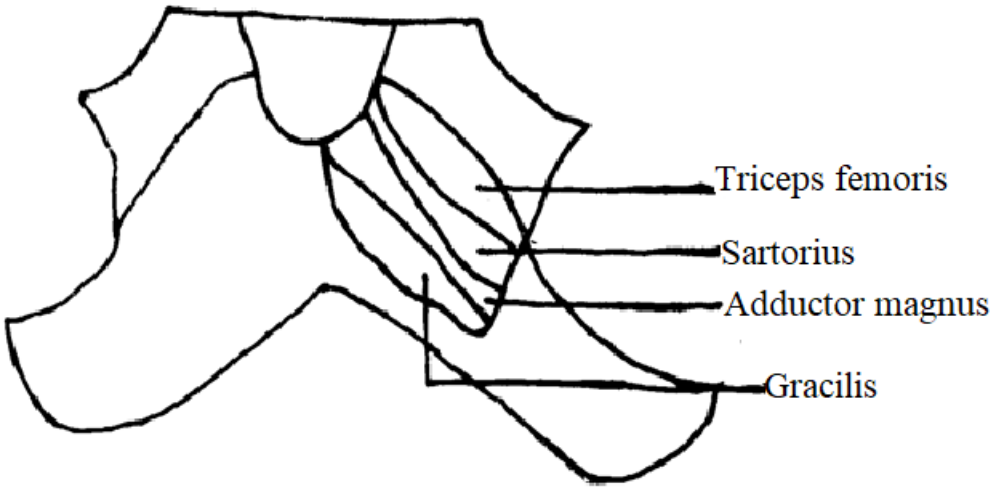



**Drawing of the muscles of the hind limb observed from the:**

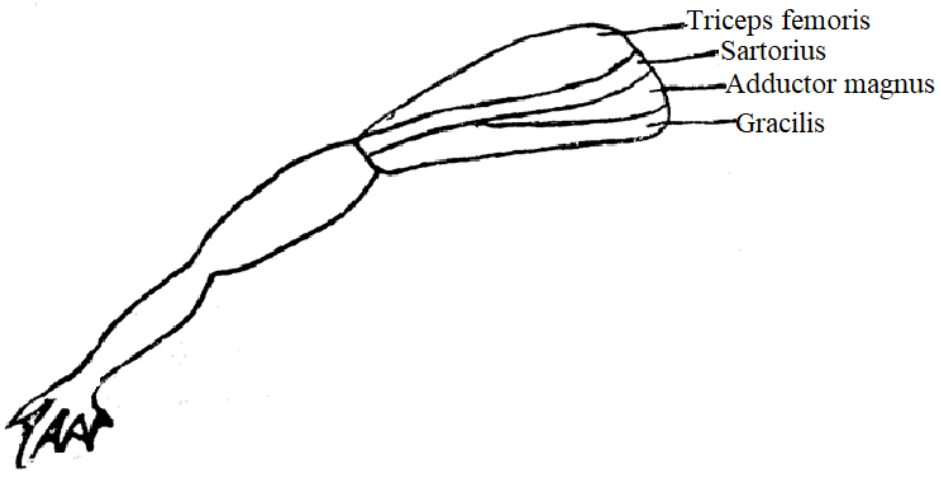
**Dorsal View** **Ventral view**



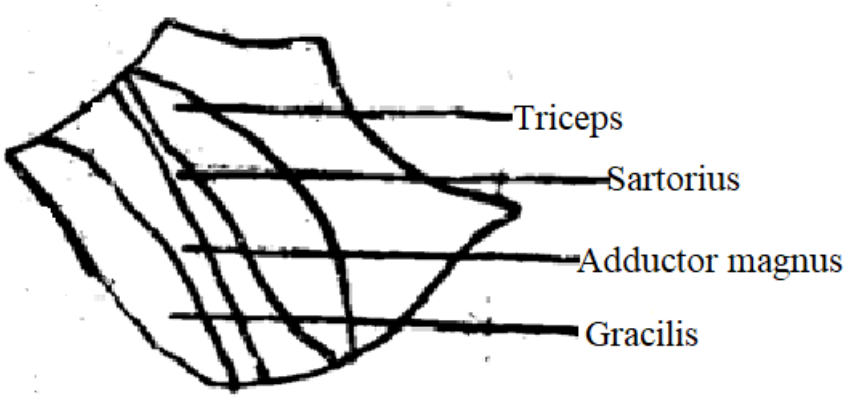

**Drawing of the main superficial muscles of the thigh**




**A drawing of the right hind limb showing observable thigh muscles which is fully structured**




**A drawing showing the muscles of the thigh of the left hind limb of a toad**




**Toad muscles can be summarized as GAST i.e. from inside to outside**

Gracilis
Adductor magnus
Sartorius
Triceps fenoris

**Structural efficiency of the triceps femoris**

The triceps femoris is a large, muscular, spindle shaped attached to the tendons, on the bone, to easily contract and relax, to allow flexibility of the limb.

**THE ALIMENTARY CANAL**

It consists of the mouth, buccal cavity, pharynx, esophagus, stomach, duodenum, ileum and rectum.

a) **Mouth and Buccal cavity:**

The mouth is terminal and very wide, extending back as far as the tympanic membrane on each side. This provides a wide gap for the ingestion of large pieces of food material.

The buccal cavity is flattened and contains the teeth which are small, sharp-pointed and conical. It has a ridge of teeth arranged in a single series around the edge of the upper jaw attached to the premaxilla and maxilla known as the maxillary teeth.

There are also a group of teeth on the vomers on the roof of the mouth and are known as vomerine teeth.

The teeth do not have pulp or nerve-tissue and are conical in shape.

They are homodont i.e. all are similar in shape.

These teeth are not for chewing but they prevent smooth or slimy prey e.g. millipedes, slugs, insects and worms from writhing out of the mouth.

There are no teeth on the lower jaw and are polyphodont i.e. can be replaced when damaged indefinitely.

There are two pale instrussions in the roof which indicate the positions of the eye ball, these are important during swallowing by exerting a downward pressure.

On the front of the roof of the mouth between the vomers and the upper jaw are small opening called the internal nares (posterior nares) which are guarded by valves and through which air enters the buccal cavity.

The whole surface of the buccal cavity is ciliated and plentiful with mucus glands which are present especially on the tongue and on the roof.

**Adaptation of the buccal cavity to perform its functions**

- Sharp teeth for firm grip/killing of the prey.
- Wide gape allows for ingestion of large pieces of food materials.
- Internal naris for entry and exit of respiratory gasses.
- The tongue for capturing the prey.
- Flattened tongue increases surface area for trapping the prey.
- Eustachain tube for equalization of pressure.
- Glottis for passage of respiratory gases to and from lungs.
- Pair of large eye balls that press against the prey for easy swallowing.

**N.B**

The mouth is anteriorly located on the head has a wide gape.

**Mouth has the following**

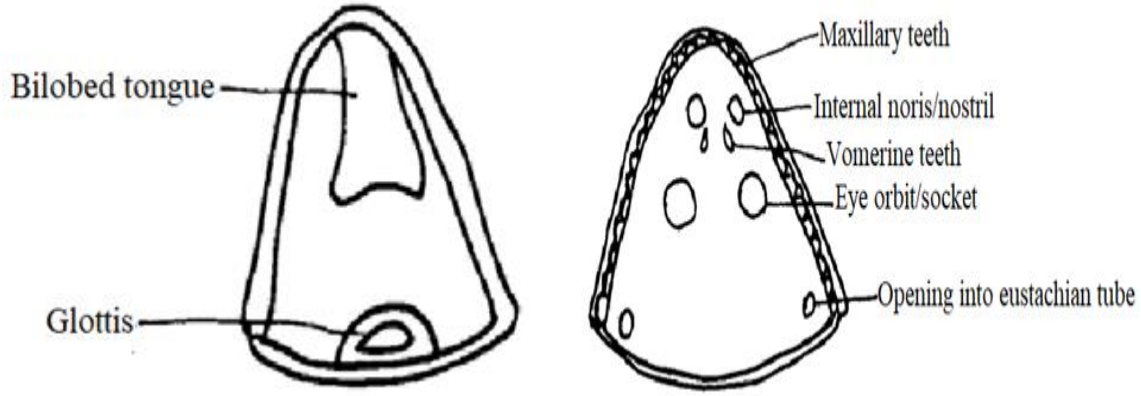
- Terminal, very large, extends to tympanic membrane. This provides wide gape of ingestion of large food and prey.
- Numerous maxillary teeth which are uniform, small, pointed, conical shaped and curving backwards.
- Internal roof has nares through which air enters the buccal cavity. They are two, small rounded with valves.
- Vomerine teeth protrude out of the roof of the mouth above the eye balls. They are found in frogs.

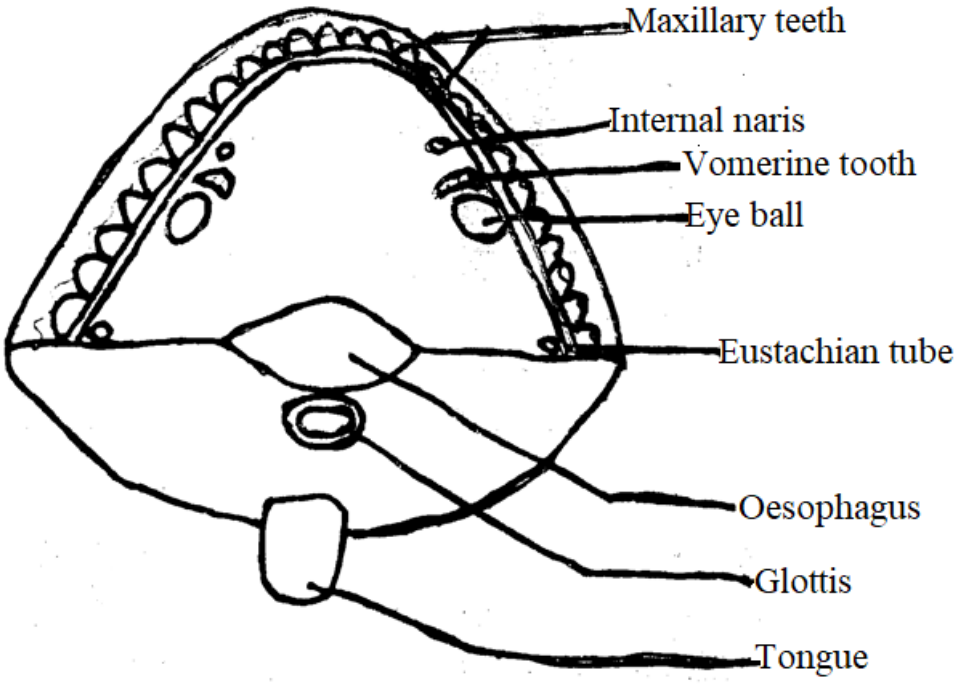
**Structures on the roof of a toad/frog from nutrition**

- Vomerine teeth
- Eye ball aid in swallowing because they are depressed
- Opening into oesophagus (floor).

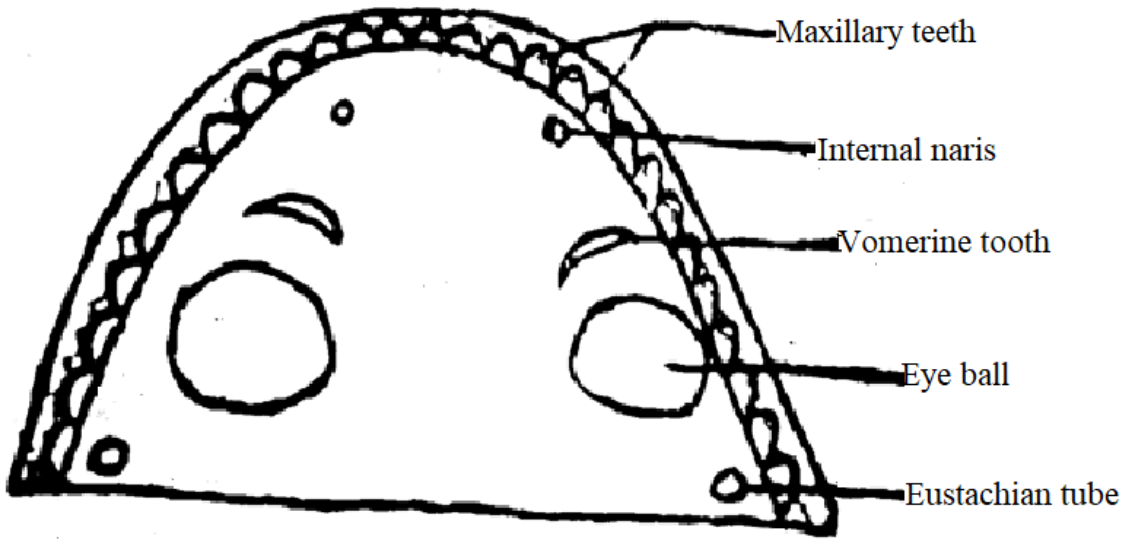
**Draw showing the internal structure of the Buccal cavity and pharynx.**

**Structures on the floor/ lower jaw** **Structures on the roof/ upper jaw**




**A drawing showing observable features on the roof of buccal cavity**




**Digestive system**

- The oesophagus is short, narrow, tubular within it has longitudinal folds which close entry of air into the stomach.
- The stomach is elongated and thick walled, internally it is folded longitudinally to allow distension and increase surface area foe secretion of gastric juice. There are two constrictions, one anterior is the cardiac sphincter controlling exit of food.
- The pancreas is cream coloured and lives in the mesentery between the stomach and the duodenum.
- The gall bladder is an oval shaped sac lying between the main lobes of the liver. It has the bile duct as outlet.
- The gall bladder is an oval shaped sac lying between the main lobes of the liver. It has the bile duct.
- The ileum is very coiled, narrow, tubular with thin walls.
- The rectum is short, thick walled, enlarged, wide between the colon and cloaca. It is used for temporary storage of wastes before elimination.

**Structure in relation to function of different parts of the alimentary canal**

**(i) The esophagus**

It is short and has longitudinal faults which close it to prevent entry of air into the stomach and yet allows dilation when food is being swallowed.Cilia of the buckle cavity pharynx and esophagus constantly swaft the mucus backward into the stomach. This assists in swallowing and ensuring that small food particles are not retained in the interior regions of the alimentary canal.

**(II). STOMACH**

It is a large white bean shaped /avoid /curved/ sac like situated behind the diaphragm slightly towards the wards left side of the animal /lying transversely across. The posterior part of the stomach which receives the esophagus is called the cardiac stomach whereas the part that joins the intestines is the pyloric stomach. The posterior part of the stomach is convex while the anterior part is concave in curvature.

The opening of the esophagus into the cardiac stomach is called aperture guard by the cardiac sphincter. The pyloric part of the stomach leads into the intestines by an aperture, the pyloric aperture guarded by thick ring like value called the pyloric sphincter.

- Both sphincters participate in the physical digestion of food as their smooth muscles contract and relax to release the food either in the stomach or in the duodenum.
- The cardiac stomach is proportionately larger than the pyloric stomach. Therefore it is suited for the temporary storage of food .Its inner surface is smooth and in addition its walls are elastic, muscular, transparent, and thin walled.

- It is smooth to reduce on friction.
- Elastic to accommodate enough food.
- Thin walled to easily stretch and accommodate enough food.
- It is muscular for peristaltic movement. There is low physical and chemical digestion in the cardiac stomach since it is less glandular, and food appears more of solid.
- The pyloric stomach is proportionately smaller than the cardiac stomach .It is highly folded to increase surface area for secretion, muscular thick walled for the peristaltic movements, it is a region of great physical and chemical digestion and contents appear form of a watery paste called the chyme

**FUNCTIONS OF THE STOMACH**

The stomach acts as;

1. A temporary store of food, giving chance for action of enzymes.
2. A site of digestion of food.
3. A site of absorption of digested food.
4. A site of secretion of enzymes.

**Adaptations**

- The inner lining of the stomach is highly folded and smooth. This increases the surface area for digestion and absorption of digested food and also for secretion.
- The folds also allow extension of the stomach for increased storage of food.
- Smooth to reduce on friction.
- The stomach is elastic to accommodate enough food,
- It is muscular for peristaltic movements.
- The anterior end of stomach consists of the cardiac sphincter which controls the inflow food of the chyme in duodenum.
- The stomach wall has many blood capillaries to increase the surface area for absorption of digested food.
- The stomach inner walls feel slippery because of screted mucus that protects stomach mucosa from the aggressive nature of both the protein digesting enzymes ad hydrochloric acid.

The stomach walls contain the gastric gland that secrete or release gastric juice and mucus. Gastric juice is rich in /contains proteolytic enzymes /proteases, pepsin and rennin also hydrochloric acid (Hcl).

The contains enzymes work best in acidic media therefore the PH of stomach of there is highly acidic with a PH 1.5-2.5, the action of these enzymes is inhabited by alkalines media.

The mucus protects the stomach mucosa from aggressive nature of both the proteases and hydrochloric acid.

**Note**; if you are told to crush the stomach wall in a motor using a pestle and make a filtrate, this contains proteases and dilute hydrochloric acid.

**(iii). SMALL INTESITINES**

The small intestine is differentiated between a U shaped duodenum and then the coiled jejunum and ileum. It is about 1- 1.2 metres long to increase the surface area for digestion and absorption of food materials.

**DUODENUM**

It is a short tubular structure which bends into a U shape. It is the first part of the small intestine , it runs backwards , then turns in front forming a 'U" shaped loop, Between the two limbs of the duodenum found an irregular ,membranous ,pinkish gland and called the pancreas .The function of the duodenum is used for digestion and absorption of food .From the pancreas, a pancreatic duct arises which is joined by the bile duct from the liver lobes open into the upper /proximal loop /limb of the duodenum to release bile and the pancreatic juice that enhance digestion of food.

Bile which is produced by the liver contains bile salts which are concerned with physical digestion of fats/liquids (emulsification of fats) and providing an alkaline condition for the action of digestive enzymes in the pancreatic juice .So the PH of duodenum is between 8-9.

The pancreatic enzymes work best in alkaline media and their action is inhibited by acidic medium.

**Ileum**

It is a very long greatly coiled tubular structure /organ made up of thin wall, it is greatly attached to by many /numerous capillaries which are the tributaries /branches of hepatic portal vein. It is

used for chemical digestion and absorption of digestion food. It is here that the final digestion and absorption takes place. The ileum wall contains glands that secrete enzymes like maltase, sucrose, etc. for digestion of food **.It is adapted to function by**;

- Having numerous blood capillaries to increase the surface area for absorption /it has a rich supply of blood vessels particularly the tributaries /factors/branches of branches of the hepatica portal vein which has transport the soluble products of digestion to the liver for metabolism.
- Having thin wall to ease diffusion of digested food.
- Being very long (has great length /elongated) and coiled increase the surface area for digestion and absorption of digested food materials into the body.
- Its wall is thin that reduces the distance of diffusion of materials into the blood stream.
- Contains inward folding called villi that increase the surface for absorption of large amounts of food materials.

**iv).The Gall Bladder**

It is an avoid sack lying between the main lobes of the liver. It's out-let is the bile duct which runs through the pancrease i.e. the hepatal-pancreatic duct into the duodenum.

The gall bladder stores bile juice secreted by the liver and is secreted into the duodenum used for emulsification of fats i.e. increasing their surface area for enzyme action

**Drawing showing abdominal contents of an amphibian in situ**.

**Cloaca**

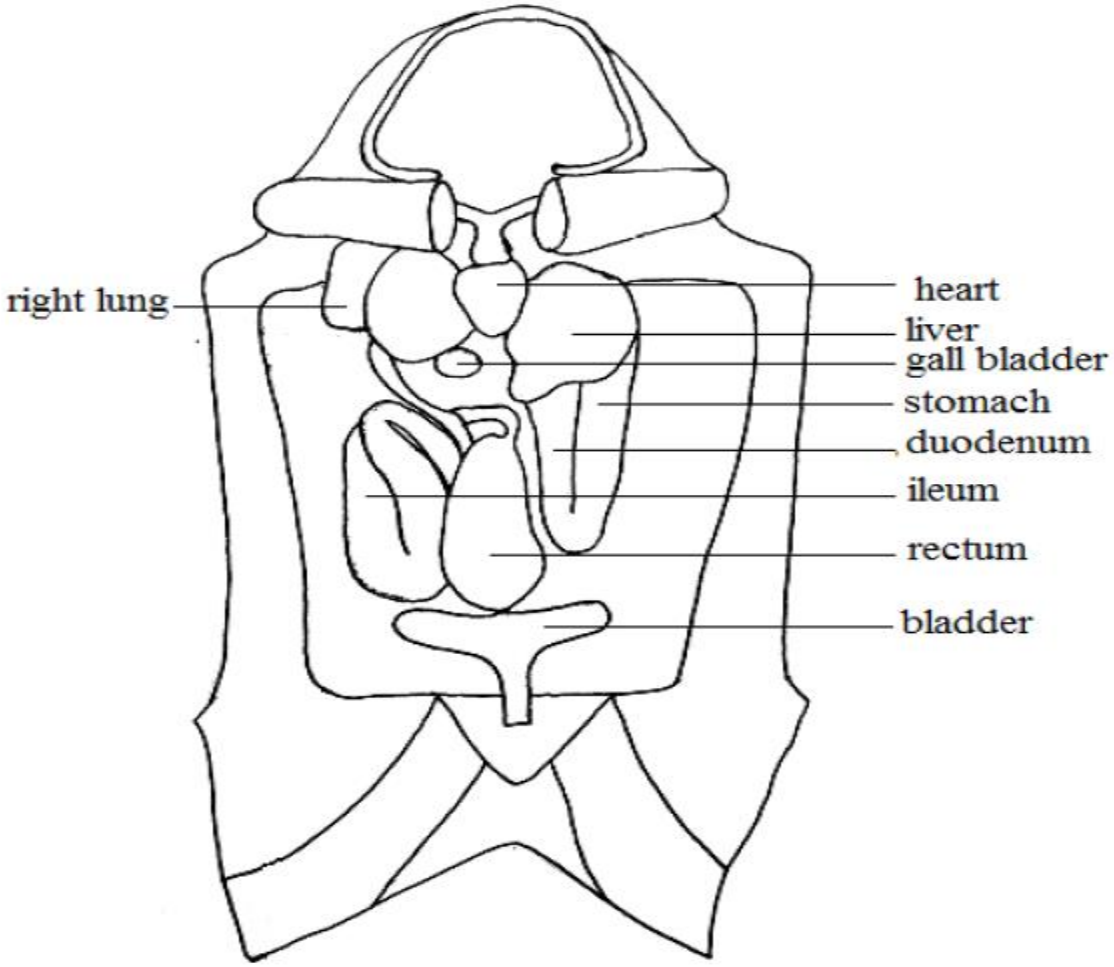
It's a narrow lumen, muscular elastic wall, smooth inner lining moist and constricted cloaca opening aperture.

It has an opening which is dorsal laterally located at the posterior end of the middle line of the body trunk.

**Adaptation of the cloacal opening**

- Its opening is moist for easy egestion.
- Its opening is narrow to regulate egestion.
- It has elastic muscular wall to allow passage of large materials.
- It is tubular to allow passage of materials
- It has smooth inner lining for easy passage of materials

**Drawing showing organs in situ of a toad**




**THE SYMPATHETIC NERVOUS SYSTEM AND SPINAL NERVES**

The nerves are easy to identify from their white colour and thread-like appearance, most of them arise from the central nervous system.

a) **The autonomic/ sympathetic system.**

There are ten pairs of sympathetic ganglia situated at the sides of the dorsal aorta posterior and along the systemic arches interiorly. Each ganglion is joined to its corresponding spinal nerve by ramus communicants and the respective pairs are also joined by transverse connections.

b) **Spinal Nerves**

There are ten pairs of spinal nerves. The first nine (9) emerge from the intervertebral foramina and the $10^{th}$ pair from small foramina in the urostyle. Each mixed nerve gives off three branches.

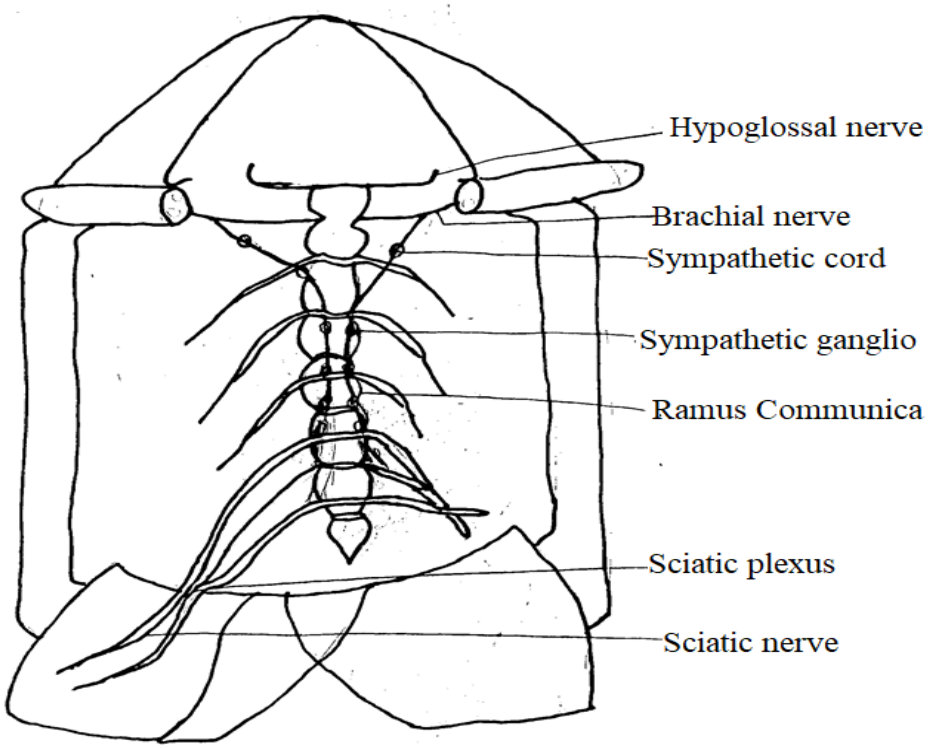
(i) A short dorsal branch to the skin and muscles of the back.

(ii) A large ventral branch to the skin and muscles of the abdomen and where applicable to the limbs.

(iii) A short ramus communicants to the autonomic/sympathetic chain.

**NB** The bonny vertebral column and the ten pairs of spinal nerves numbered I-X in the diagram and the sympathetic nervous system especially the sympathetic cords on either side of the aorta, alongside systemic arteries.

**Drawing showing spinal nerves and Sympathetic/Autonomic nervous system of a toad/frog**




**THE URINOGENITAL SYSTEM**

Though there are no external sexual organs, the urinogenital systems of male and female toads/frogs are clearly distinguished internally.

To expose the urinogenital system it is necessary to first remove the alimentary canal by cutting through the esophagus, the mesentery, holding the alimentary canal with forceps and the rectum.

**NB**

The system is clear only when the alimentary canal is removed. The lungs, kidneys, ureter, urinary bladder and cloaca form the excretory system.

| | **Part** | **Description and location** |
|---|---|---|
| - | Ureter | Slender duct from the kidney. |
| - | Kidney | Dark, one each side of the dorsal aorta or posterior venacava. |
| - | Bladder | Thin – walled transparent bi – lobed structure opens into the cloaca. |
| - | Cloaca | Small medium chamber and opens to the outside through an aperture. |

**<u>The male Urinogenital System</u>**:

There are two red flat oval-shaped kidneys.

The yellow tests partly hiding the kidneys ventrally.

The kidney duct which also serves as a genital duct and is known as the urinogenital duct (Wolffian duct) from the kidneys to the cloaca.

It enters the cloaca via the urinogenital papilla that after leaving the kidney, the duct bears a sac known as vascular seminal is or seminal vesicle which is temporarily store of sperm during mating.

The bladder is thin walled and bilobed. The tests are attached to the kidneys by folds of a supporting tissue the mesorchium which are continuous with the peritoneal epithelium that cloaks the ventral face of each kidney and lines the entire body cavity.

Ducts from the tests known as vasa efferentia lie in the mesorchium.

Attached to each test alogged bodies of a brightly yellow coloured flat bodies or corpora adipose which are food reserves during aestivation.

On the ventral face of each kidney is an elongated yellow adrenal gland.

**Reproductive system**

| | |
|---|---|
| Testis | Paired, yellow, oval bodies, attached onto ventral side of the kidney. |
| Vasaefferentia | Convey sperm |

**The Female Urinogenital System**

The kidneys are largely hidden by ovaries and their ducts i.e. the ureters also known as the wollfian ducts enter the cloaca via a urinary papilla.

The ovaries are logged and are supported by a tissue the mesovarium.

The oviducts are long coiled tubes also known as mullerian ducts which also lead to the cloaca and bear swelling near the posterior ends known as ovaries.

During the breeding season these may be distended with eggs

**NB**

**Reproductive system**

| | |
|---|---|
| Ovaries | Pair of large irregularly folded structure. |
| Oviducts | Long, white above the ovaries, posterior each widens to form large thin walled chamber the ovisac/uterus |
| Cloaca | Medium sac, opens to the outside via an aperture |

**How to trace the internal organs**

- The urinary bladder is a thin walled bilobed sac at the posterior end of the coelom which opens ventrally into the cloaca.
- The heart is a conical reddish organ enclosed in a white membrane the pericardium.
- The rectum is a short wide tube in which the small intestine leads. This opens into the cloaca.
-The lungs are spongy pink organs on either side of the heart.
-The spleen is a small red globular organ attached by mesentery to the anterior end of the rectum.
- The liver is a large reddish brown organ which consists of two large lobes with the left subdivided into two.
- The gall bladder is a small dark green sac lying between the liver lobes.
- The stomach is a muscular sac on the left of the animal and the esophagus leading into the pharynx.
-The duodenum is continuous with the stomach and is the first part the intestine. It begins at a point where there is a small constriction known as the pylorus.
-The pancreas is a white gland lying in the mesentery between the stomach and duodenum.
-The bile duct leads from the gall bladder and running a cross the pancreas.
-The hepatic pancreatic duct which leads from the pancreas into the duodenum.
-The genital organs, in the males the testes are two yellow oval bodies ventral to the kidneys. In the females the ovaries and the coiled oviducts may be distended with ova in the breeding season.
-The ileum in a coiled tube between the coils of which is the vascular membrane known as the mesentery.

**THE VASCULAR SYSTEM**

The veins are identified by their dark red colour while the arteries are bright red in colour .most of the veins are moved fast during dissection heart is conical thus veins should be studied first.

**THE HEART**:

The heart is conical in shape with the apex directed backwards and has a single thick-walled ventricle at the free end with two auricles anterior to it.

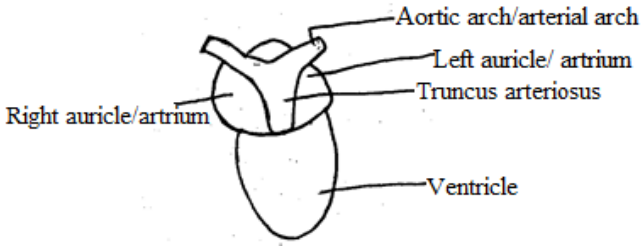
The truncus arteriosus arising from the right upper side of the ventricle on the ventral side which passes between the auricles and divides into three blood vessels at their upper edge. These are the aortic arches.

The siaus venous is triangular in shape at the apices of which the two anterior venacava and the posterior venacava enter the heart.

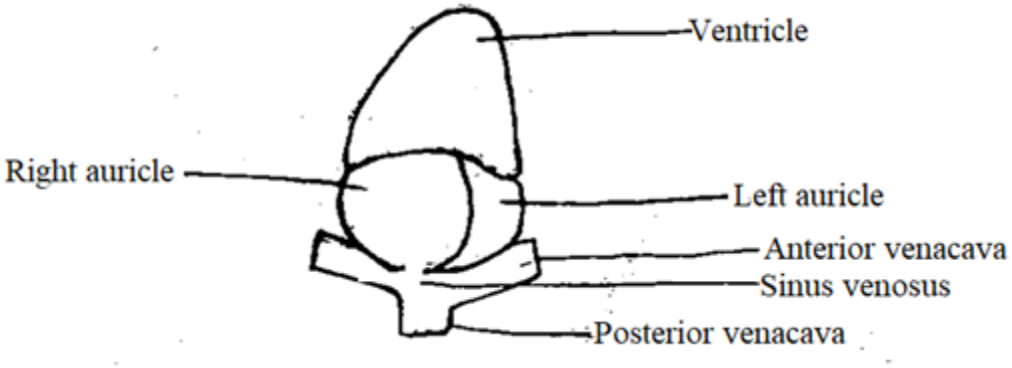
The siaus venous leads into the right auricle and the pulmonary veins formed by a branch from each lung lead into the left auricle.

The heart has three chambers.

**Ventral view/ undisplaced heart**




**Drawing showing the heart of a toad/ frog when turned arteriorly including the bases of the veins/ displaced/ dorsal view of the heart**




**THE VENOUS SYSTEM**

These include veins, blood vessels that return blood from all parts of the body back to the heart i.e. drain all parts of the body.

Blood returns to the heart via three main vessels i.e.

- Sinus venous
- Left anterior venacava
- Right anterior vena cava

The veins can easily be traced from the heart for here they are larger.

It is more convenient to study the anterior and posterior parts of the system separately.

Turn the heart upwards and locate the anterior venacava and posterior venacava. The anterior venacava originates from;

(a) External jugular vein made by joining of mandibular (draining lower jaw) and lingal vein (draining the tongue).
(b) Innominate vein the middle of the three veins. It is formed by union of internal jugular vein (draining the jaw) and subscapular vein (draining the shoulders).
(c) Subclavian vein is the largest of the three. It comes from the arm. It is formed by joining brachial vein draining the arm and the muscular cutaneous vein draining the skin and body wall

The posterior venacava originates from,

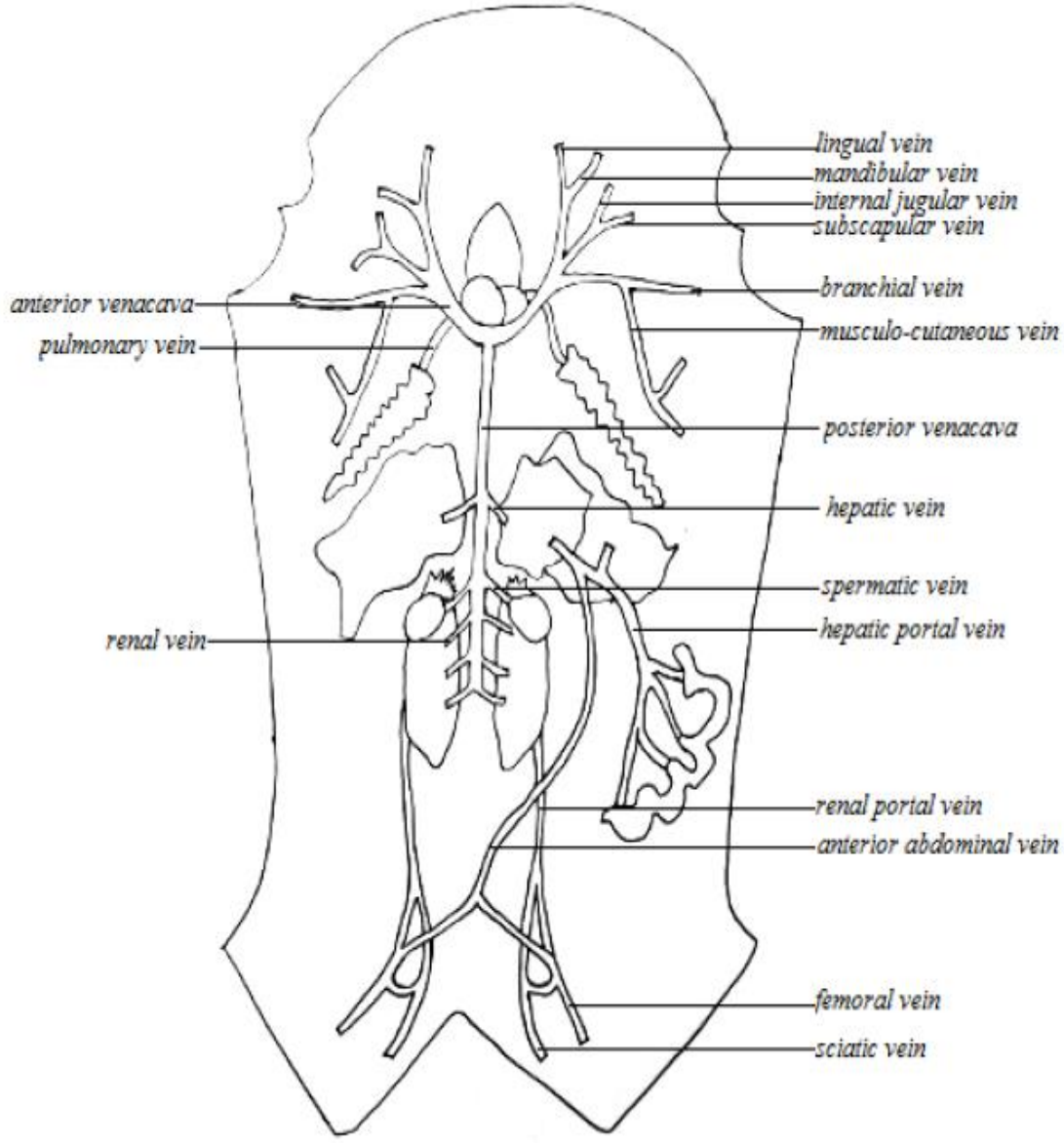
(a) Hepatic vein draining the liver.
(b) Renal veins 4 in number draining the kidney.
(c) Spermatic vein draining the testis or ovarian vein draining the ovaries, though sometimes they join one of the renal veins.

**Other vessels**

| **Vein** | | **Part it drains** |
|---|---|---|
| Pulmonary | : | Lungs to the left auricle. It is obscured by posterior venacava and the liver. These have to be removed first. |
| Renal portal | : | Hind limbs, it drains blood from the femoral vein (hind limb) and sciatic vein inside the thigh to the kidney. |

| | | |
|---|---|---|
| Pelvic | : | From the femoral vein to the ventral abdominal. |
| Ventral Abdominal: | | From union of the right and left pelvic vein. |
| Hepatic portal vein | : | Formed from a fusion of,<br>Gastric vein draining the stomach.<br>Duodenal vein draining the duodenum.<br>Intestinal vein draining the ileum.<br>Splenic vein draining the spleen.<br>Rectal vein draining the rectum. |

**Drawing of main veins of a toad**




**A) THE ANTERIOR VEINS**:

Trace the anterior vena cava and its branches i.e. the blood vessels leading into it.

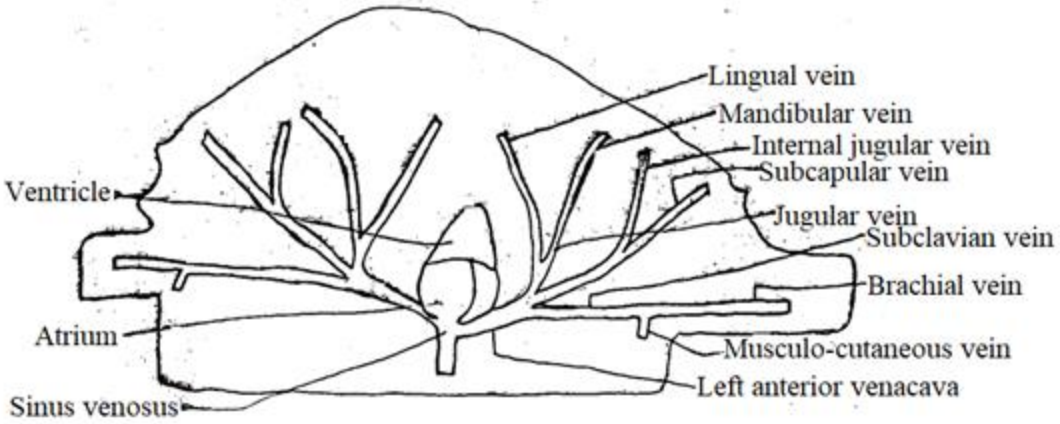
After the auricles it receives;

(i) The external jugular vein which is the most anterior of the three veins joining at this point. It is self- formed by the union of two other veins the mandibular innermost from the lower jaw and the lingual vein outmost from the tongue.

(ii) The innominate vein which is the middle of the three veins which run along the angle between the shoulder and jaw. It is formed by the union of two smaller veins the internal jugular vein from the angle of the jaw and the subscapular vein from the shoulder.

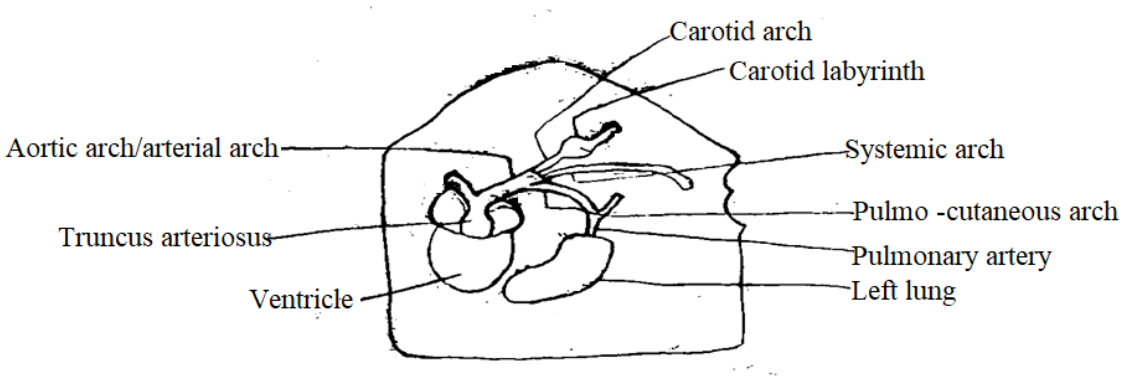
**(ii)** The subclavion vein is the posterior and largest of the veins joining the anterior vena cava. It comes from the arm where it is formed by the union of two veins, the brachial veins from the arm and the musculaocutaneous vein from the skin and body wall.

**a) <u>Drawing showing blood vessels that drain/ remove/ carry blood from the head and other anterior structures of the body including those that drain the fore limbs back to the heart displaced anteriorly</u>**




**b)Venous drain.**

**<u>A Drawing of the main blood vessels that supply the left thoracic region of a toad</u>**




**B) THE POSTERIOR VEINS.**

The posterior vena cava leads into the sinus venosus where the two hepatic veins from each lobe of the liver are received.

(i) Venous drainage of the alimentary canal.

Blood from the alimentary canal returns to the heart via the hepatic portal vein which joins the posterior vena cava, in the substance of the liver via short hepatic veins in sinus venosus which finally returns the blood to the heart.

The hepatic portal vein is formed by union of gastric vein from stomach and pancrease.

Intestinal/mesenteric veins, the splenic veins and anterior abdominal vein.

Due to its position, the hepatic portal vein can be identified by following the anterior part of the anterior abdominal vein up to the liver.

**C) Venous drawing of the hind limbs and kidneys**.

Blood from the hind limbs flows back to the heart via two roots.

One through an outer femoral vein and an inner sciatic vein. These join inside the body cavity to form the renal portal vein which passes along the outer boarder of the kidney on the respective side. Another is an alternative route for blood for the femoral vein which passes along the pelvic vein which joins its fellow, ventral to the pelvic girdle to form the anterior abdominal vein. This passes ventrally forward in the mid-line of the body just beneath the skin to join the hepatic portal vein immediately before its entry into the liver.
From the kidneys, blood passes inwards by renal veins to join the posterior vena cava which returns blood direct to sinus venous and eventually back to the heart.

## THE ARTERIAL SYSTEM

Arterial system

Arteries are much paler than veins, to study the arterial system, the veins must be removed.

| | | |
|---|---|---|
| Carotid arch | Lingual/external carotid<br>Internal carotid | Tongue, lower jaw<br>Eye, pharynx, palate |
| Systemic area | Subclavian artery<br>Systemic artery | Fore limbs<br>Posterior circulation |
| Pulmo – cutaneous arch | Cutaneous artery<br>Pulmonary artery | Skin<br>lungs |

- The coeliaco – mesenteric artery branches off the left systemic artery before forming the dorsal aorta. It divides into the coelic artery and mesenteric artery.
- The coelic artery divides into:

a) Gastro – duodenal artery divides into gastric artery (supplying the stomach) and duodenal artery (supplying the duodenum).
b) Hepatic artery that supplies the liver.

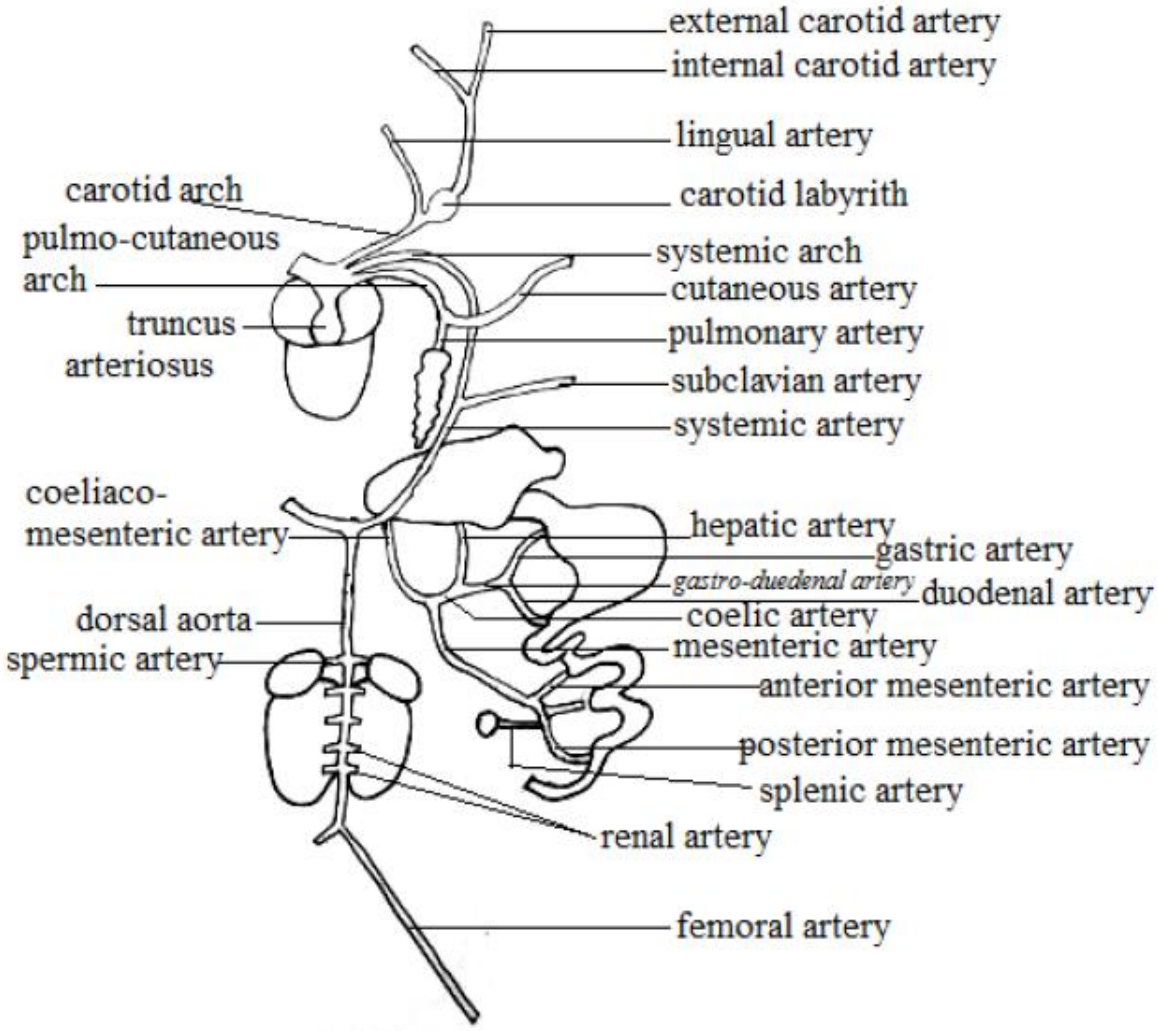
- Mesenteric artery divides into:

a) Anterior mesenteric artery to the intestines.
b) Posterior mesenteric artery to the lower intestines and rectum.
c) Splenic artery supplying the spleen

- Dorsal aorta branches into:

a) Renal arteries (usually five – 5) supplying left and right kidneys.
b) Lumbar arteries to the dorsal muscles.
c) Genital arteries.
d) Lliac artery which also branches into femoral artery and sciatic artery

**Drawing of main arteries of a toad**




a) Blood supply to the alimentary canal.
b) Immediately posterior to the function of the systemic arches, the median coeliaco-mesenteric artery proceeds ventrally to supply the alimentary canal and its accessory glands.

It divides into coeciac artery and mesenteric artery.

-The coeciac artery gives off hepatic artery to supply the liver and gall bladder and gastric artery to supply the stomach and pancreas.

-The mesenteric artery forks into anterior mesenteric and posterior mesenteric arteries to supply the intestines and the spleen

**b) Blood supply to the kidneys, genitals and hind limbs.**

From the dorsal/abdominal aorta, small branches, renal arteries pass to the kidneys and paired genital arteries pass to the reproductive organs, from the most anterior pair of the renal arteries.

The aorta forks into paired iliac arteries which eventually pass into the hind-limbs, where they are called sciatic arteries.

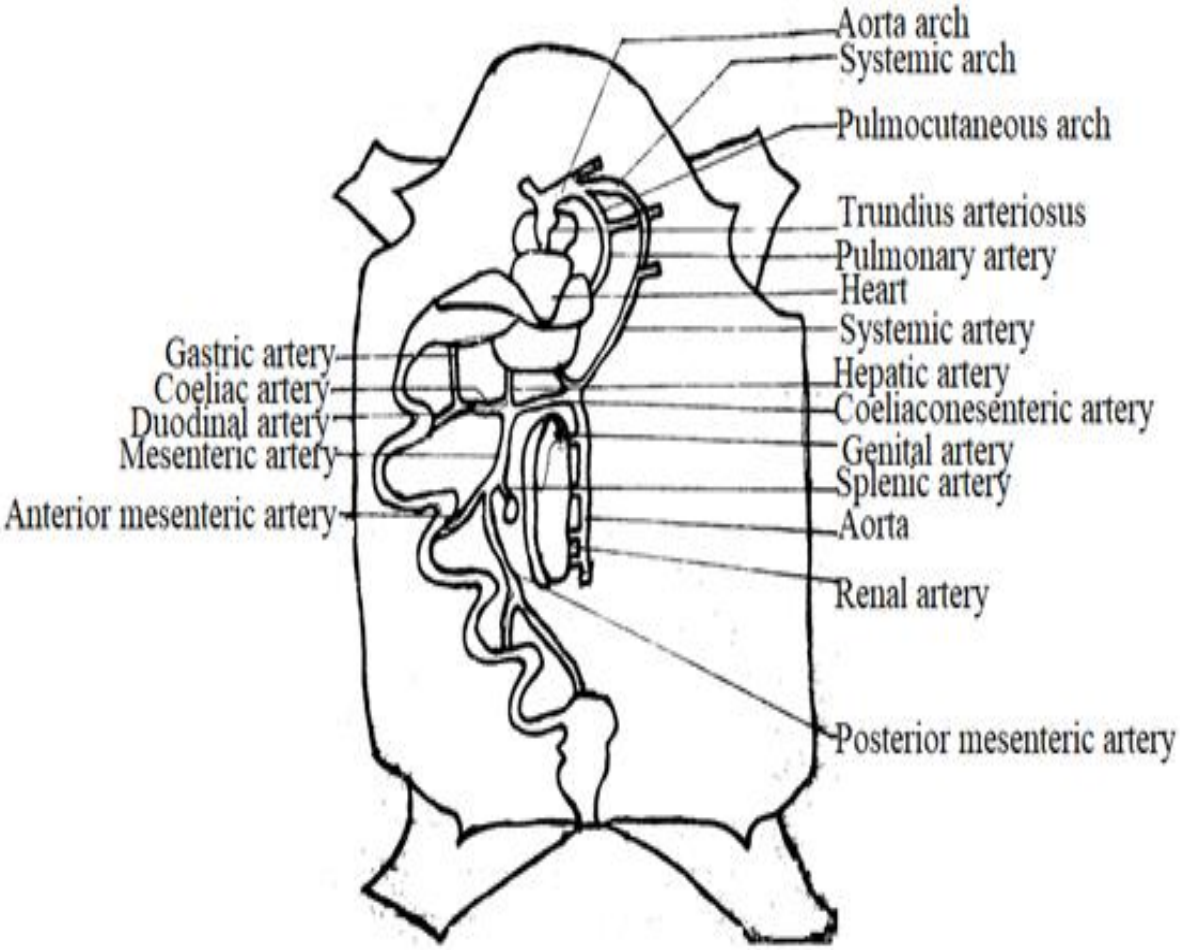
**c) Blood supply to the rest of the body (below the head.**

The rest of the body below the head, blood is transported through the aortic/systemic arch.

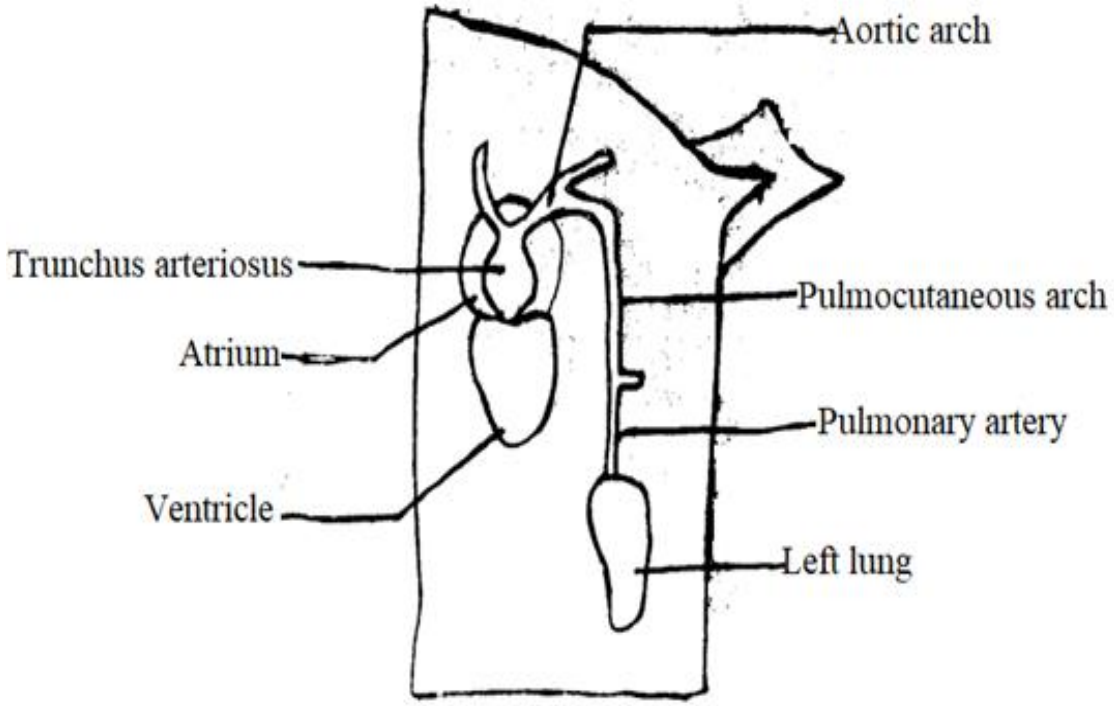
The arch first splits to give a subclavian artery which continues as a brachial artery to supply the fore limb.

The other branch joins the fellow on the opposite side to form the abdominal/dorsal aorta dorsal i.e behind the liver.

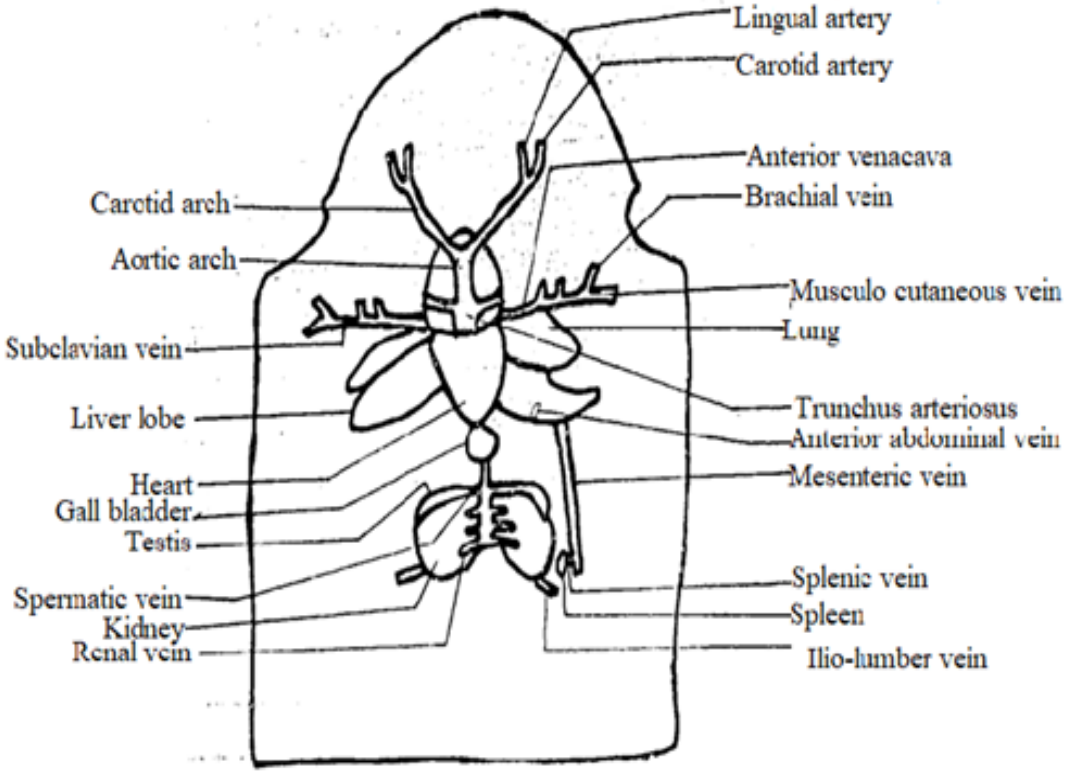
**A drawing showing blood vessels that empty blood to the organs in the lower trunk when the alimentary canal, left lung and left kidney are displaced to the right side**



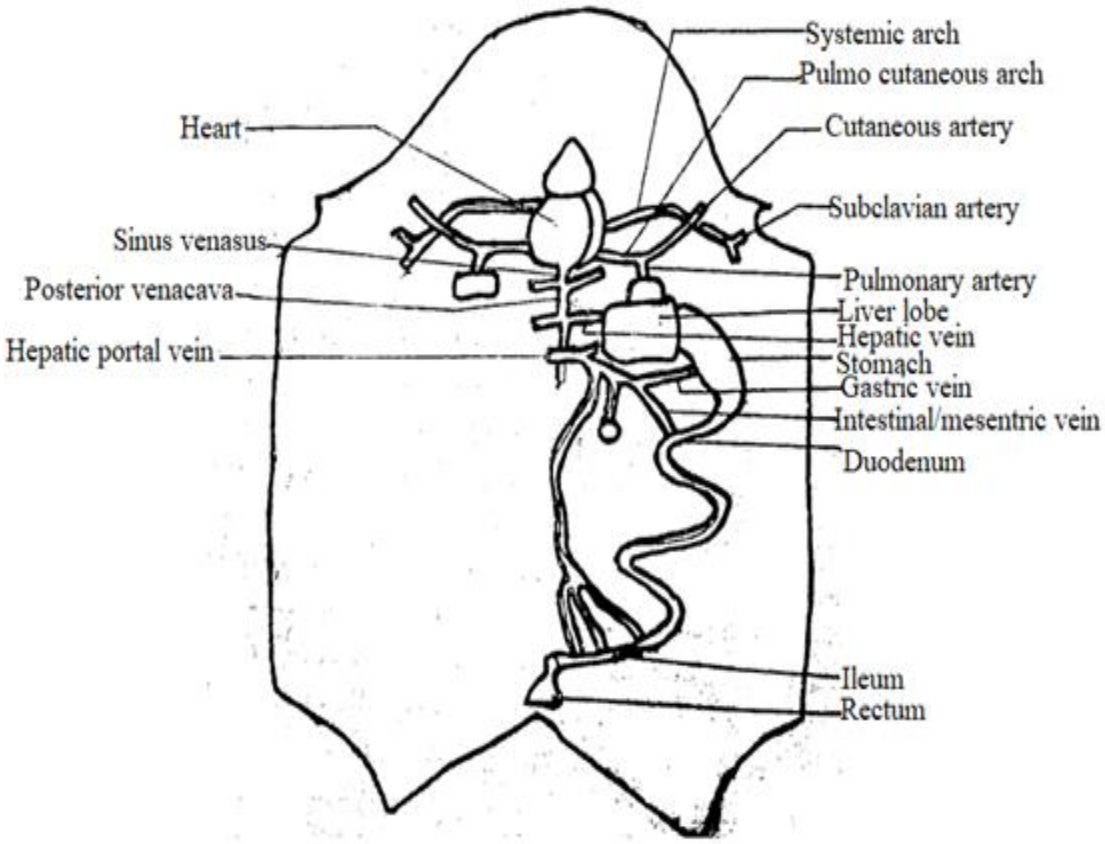

**A drawing showing blood vessels/ arteries taking blood to the left lung**



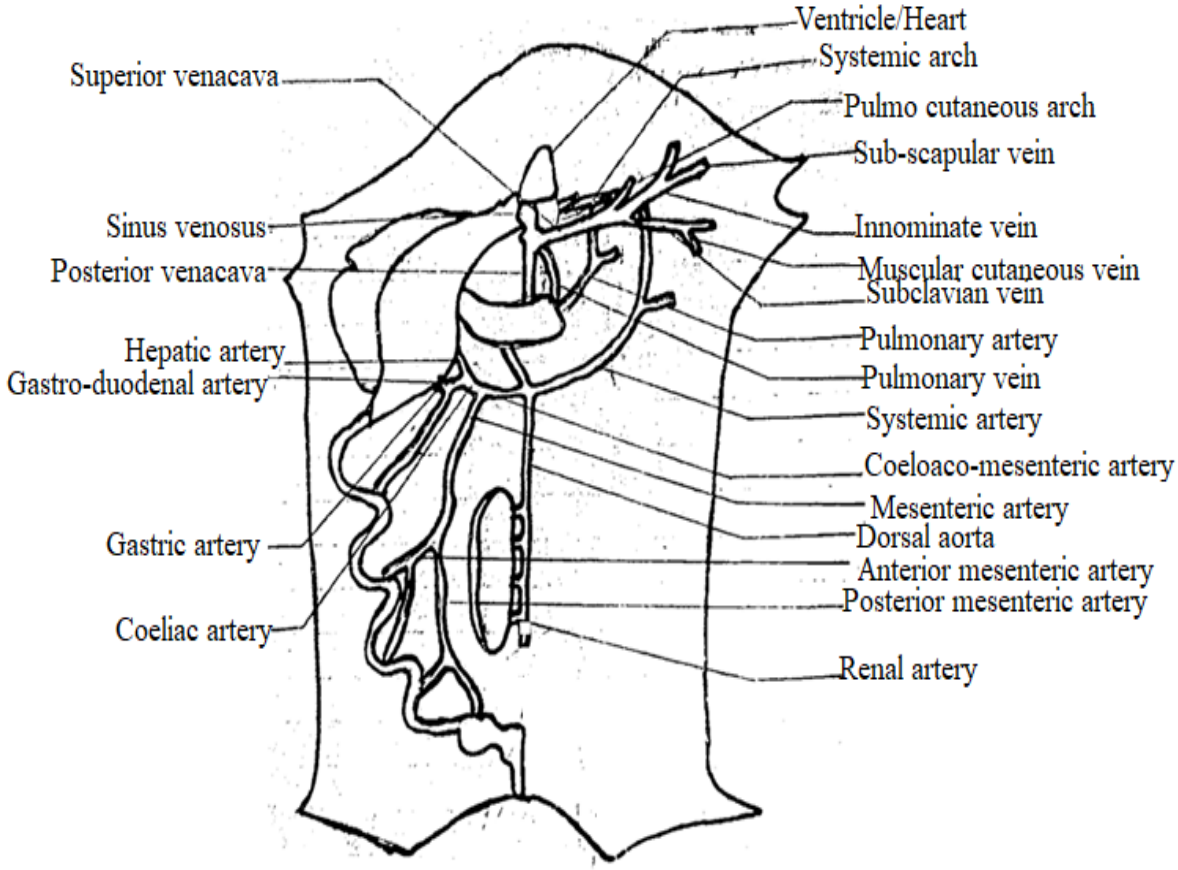
**A drawing showing the observable vessels that carry blood from abdominal region and fore limbs back to the heart, to the head region from the heart and visible undiplaced organs of a toad**



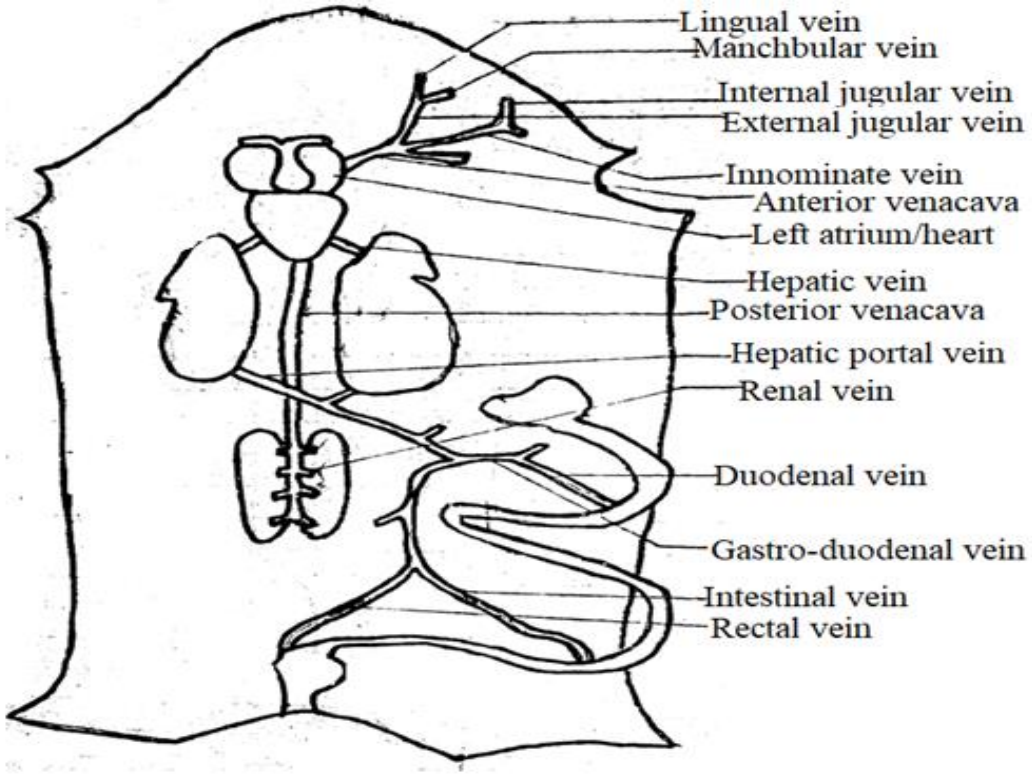

**A drawing showing blood vessels that drain blood from the alimentary canal and its associated organs back to the heart and blood vessels that take blood from the heart to the thoracic region of a toad**



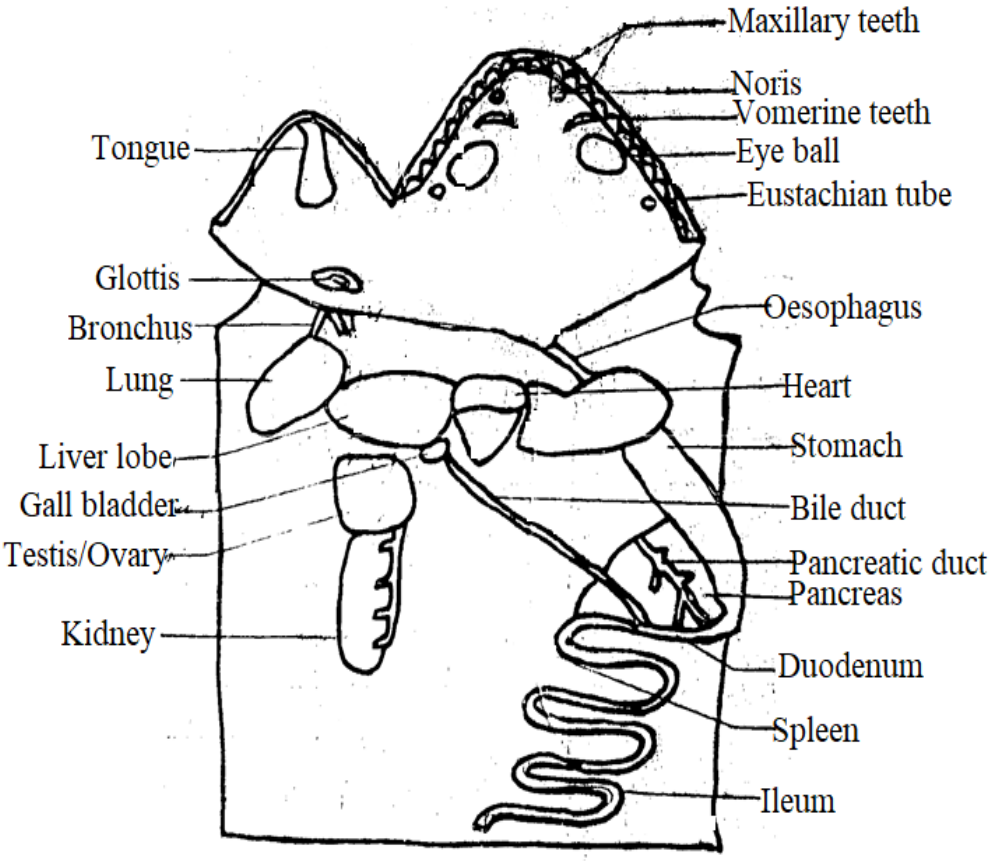
**A drawing showing showing the main blood vessels returning blood from the trunk region to the heart turned over and blood vessels supplying the structures for absorption of nutrients and excretory organs of a toad**



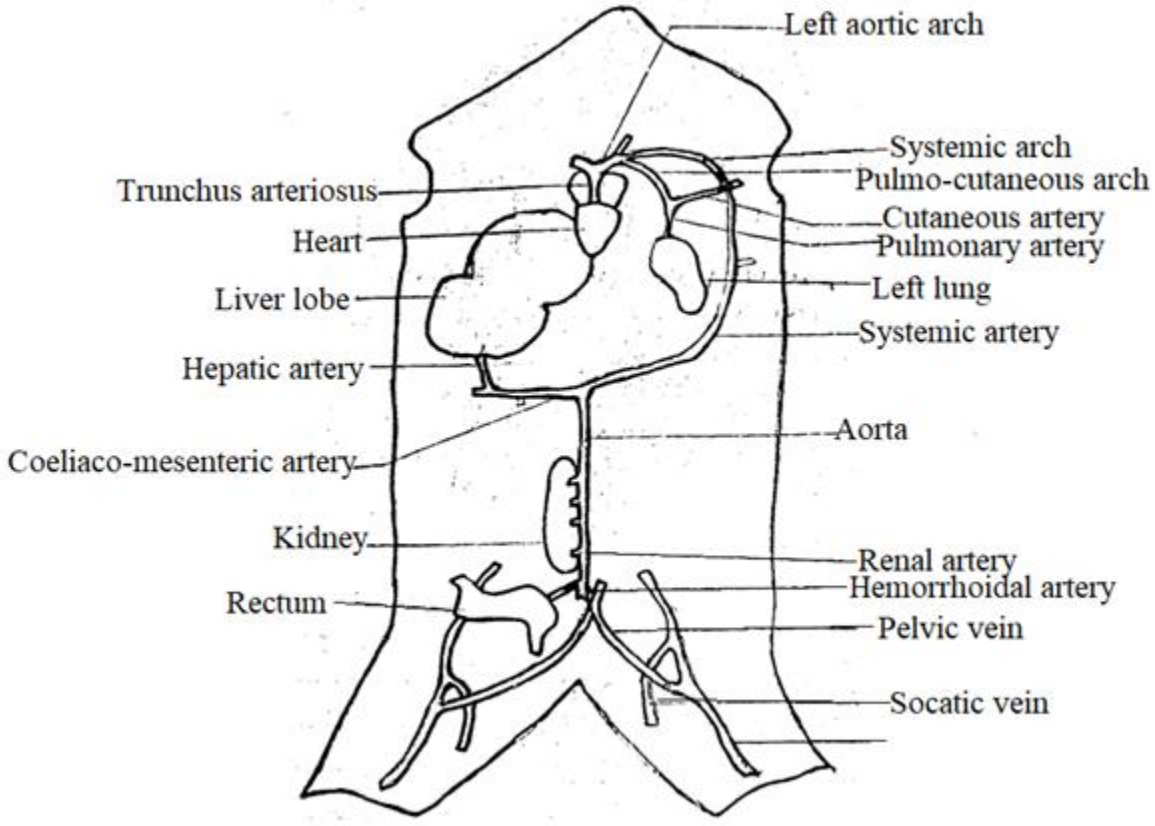

**A drawing showing the blood vessels that carry blood back to the heart from the head region, intestines and kidneys of a toad with the heart undisplaced**



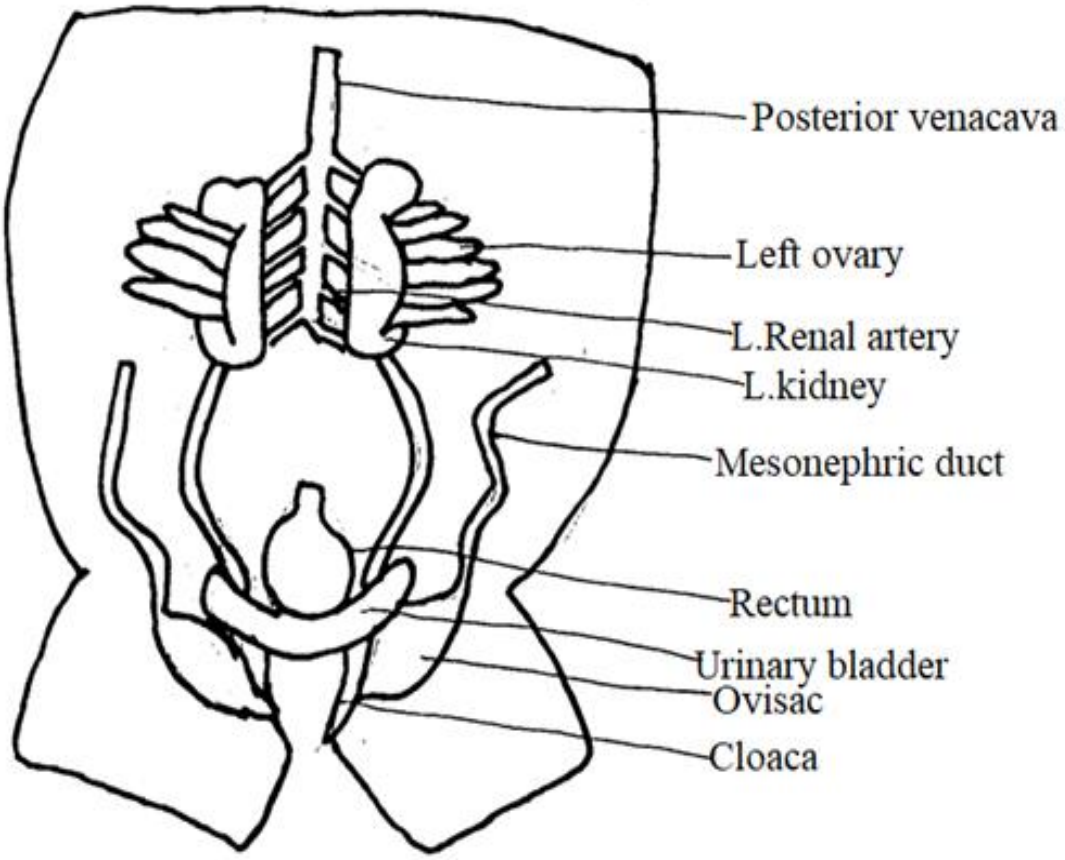
**A drawing of all the structures seen lying wholly anterior to the bladder with alimentary canal displaced to the left the buccal cavity opened and mesentery not damaged**



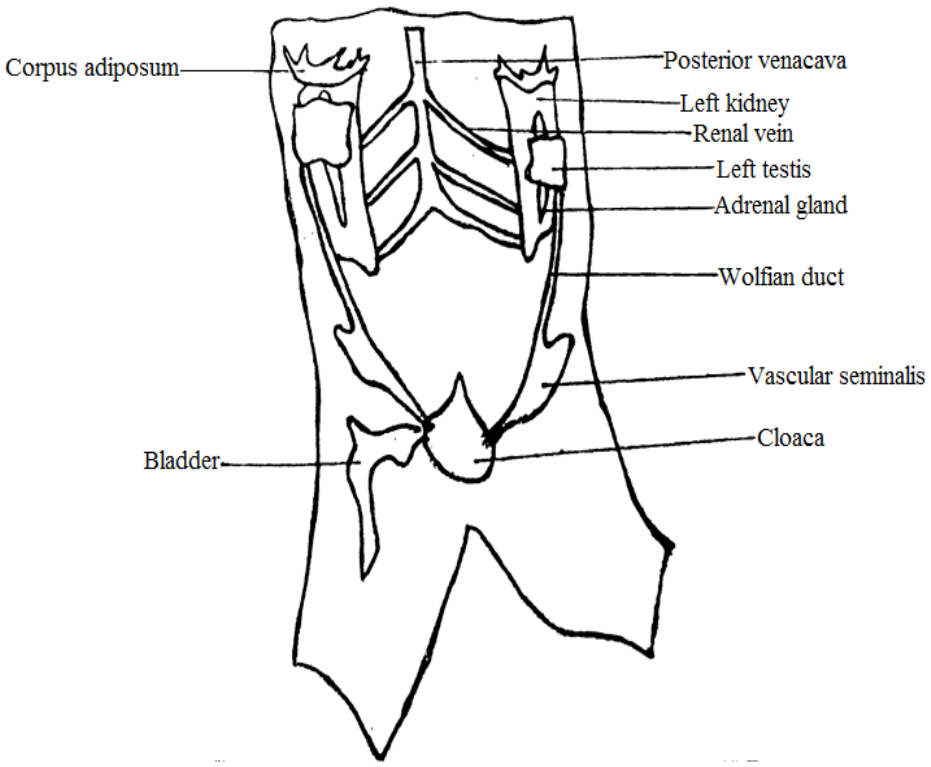

**A drawing showing blood vessels supplying structures responsible for removal of wastes and blood vessels draining the hind limbs and pelvic region with the heart in dorsal view**



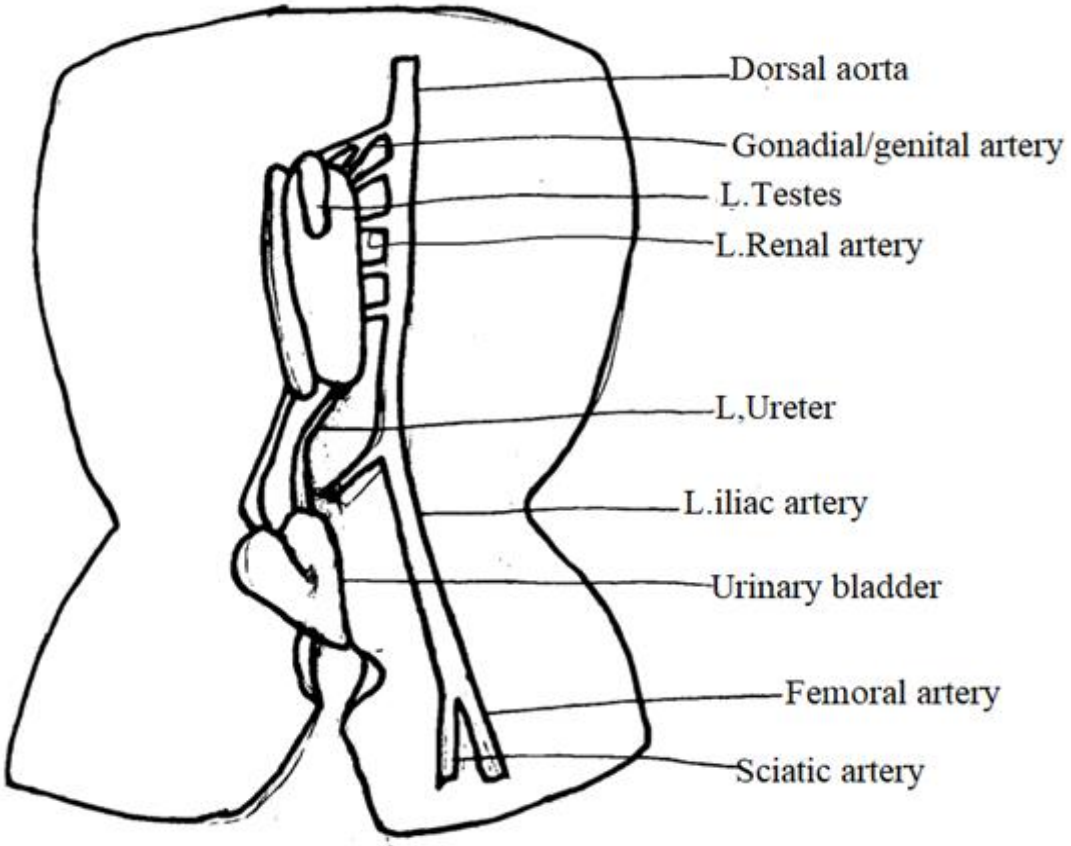
**Drawing showing female urinogenital system of a toad**



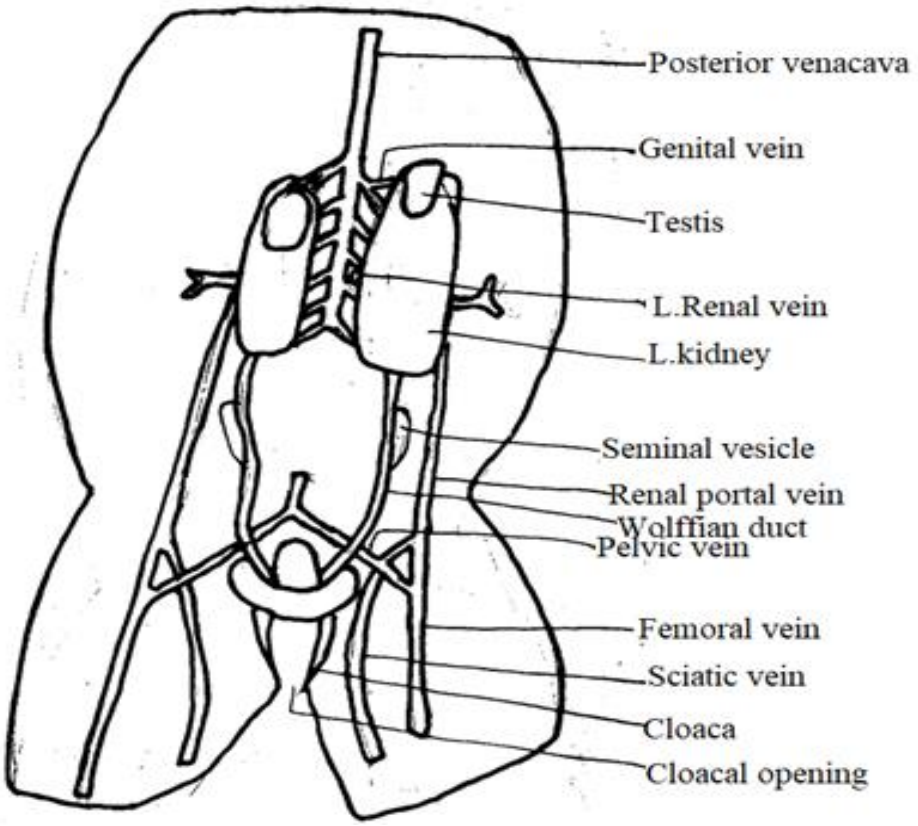

**Male urino-genital system**



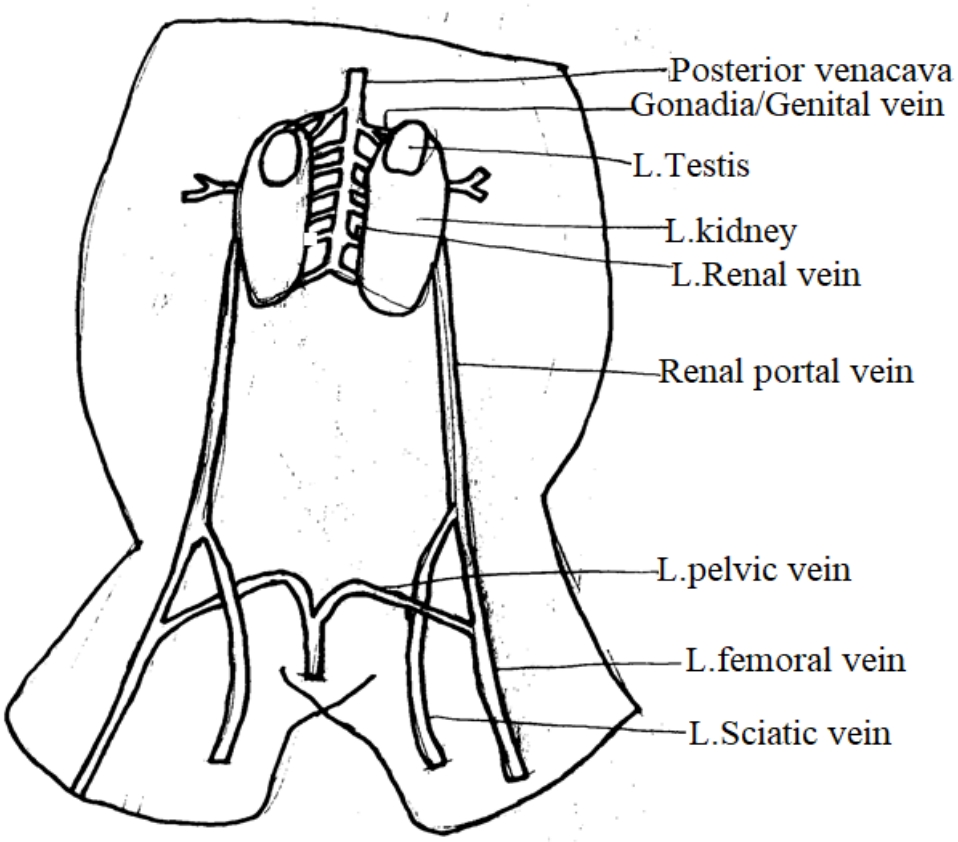

**Drawing showing blood vessels that supply urinogenital system and hind limbs of a toad**




**Drawing showing male urinogenital system and blood vessels draining hind limbs and pelvic regions of a toad**




**Drawing showing blood vessels draining hind limbs and the urinogenital system of a male toad**




**NB:** The renal veins of a toad are four and the kidneys are elongated.

**HEAD MUSCLES AND THE VENTRAL SIDE**

a) Mylohyoid /sub maxillary muscle it runs from the mid line to the edge of the lower jaw. It forms the floor of the buccal cavity. The muscle helps in the swallowing of food and elevates the throat in breathing.

b) Depressor mandibularis it is a depressor muscle which lowers down the lower jaw to open the mouth.

c) Deltoid

**VENTAL TRUNK MUSCLES**

a) **Pectoralis muscle**; it is large/broad, flat and fan shaped muscle radiating from the forearm to the centre of the side. It arises/originate from the sternum and fascia of the body wall/ rectus abdominis and inserts on the humerus. It is a powerful abductor muscle of the upper arm. It flexes, adducts and rotates the arm.

**NOTE**; this is a thoracic muscle but since the animal does not have the thorax, it is taken as an abdominal muscle.

**Linea Alba**; A white line of connective tissue present in mid ventral line

**b) External Oblique Muscle;** inserted on the linea Alba. It supports the abdomen, reduces the abdominal cavity in breathing to compress the lungs. Constricts the abdomen and supports the viscera.

**c) Rectus abdominis muscle**; it is a large muscle which covers the ventral midline from sternum to the pubis /pubic border (runs along the lower part of the trunk). It is separated /divided longitudinally in the centre by the linea alba/middle line into two bundles situated on either side of the middle line and transversely by tendinous intersection. The muscle supports abdominal viscera (abdomen) and flexes the back.

**Xiphoid cartilage (or xiphisternum**), a small triangular piece of cartilage in the centre of the rectus abdominis muscle.

**Anterior abdominal vein;** a bluish vein in the lower part of the body wall along the mid ventral line.

**FORE LIMB MUSCLE:**

The two muscles on the ventral surface;

a) Triceps brachii; it is an extensor muscle. It extends or straightens the fore limb
b) Biceps; it is a depressor muscle and it bends the forearm

**HIND LIMB MUSCLES:**

a) **Triceps femoris;** it is the muscle that forms the bulk of the muscle tissue in the thigh. It helps to draw the entire hind limb forward and extends the leg. Its origin is that three divisions; one head on the acetabulum and two on the ilium and they all insert on tibiofibula
b) **Sartorius; it** flexes the shank and adducts the thigh. It runs from the pubis to the tibiofibula.
c) **Adductor magnus;** it originates from the ilium and inserts on the femur. It adducts the thigh and the leg
d) **Gracilis major and Gracilis minor;** originates from the ischium and inserts on the tibiofibula. They all adduct thigh and flex or extend the shank, according to their position

**MUSCLES OF THE SHANK/LEG**

**a)** **Gastrocnemius muscle of the calf;** it is large spindle shaped muscle arising/originating from the lower or distal end of the femur bone and its insertion in the sole of the foot, the insertion being affected by the long tendo Achilles or Achilles tendo. It flexes the shank and extends ankle and foot.
**b)** **Tibialis anterior longus/ Tibialis anticus longus;** originates/arises/runs from the femur, divides into two bellies and inserts by two tendons on the ankle bones. it extends shanks, flexes ankle
**c)** **Tibialis posterior / Tibialis posticus;** originates from side of tibiobula and insert on the ankle. It extends foot when flexed, flexes foot when fully extended
**d)** **Extensor cruris;** originates from the femur and inserts on the ventral surface of the tibiofibula and extends the shank.
**e)** **Peroneus;** originates from the femur and inserts on the distal end of tibiofibula, head of the calcaneus. It extends shank, when foot is extended, extends it farther, when flexed, flexes it farther.

**DEEPERLYNG MUSCLES'THE THIGH OF AFROG/TOAD FROM THE VENTRAL SURFACE.**

On the ventral surface, if Sartorius is removed to reveal the insertion of the **Adductor femoris** and this also cut away from its origin, reveals the muscle;

a) **Semitendinosus**; long muscle, made up of two bands with different origins. One from the ischiu near the acetabulum, the other from the ischial symphysis. The two parts pass into a insert on tibiofibula. Removal of semitendinosus, reveals the
b) **Psoas muscle**; a group of small muscles related to the proximal portion of the femur originates from the hinder ventral part of the ischium and inserts on the anterior face of the femur about half way along its length.
c) **Pectineus muscle**; arises from the pubis and attached to the ventral side of the femur a little nearer to the body than psoas.
d) **Retractor femoris**; a tripartite muscle taking origin on theischium and inserts on the posterior face of the femur.

**MUSCLES OF THE THIGH/HIND LEG OF THE TOAD/FROG FROM THE DORSAL SURFACE:**

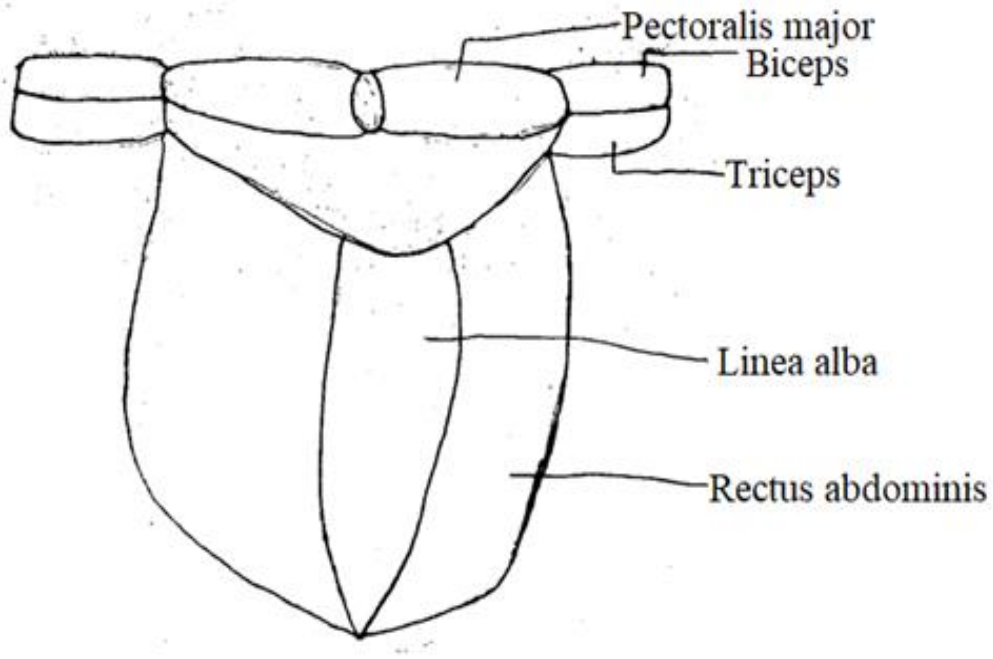
On the dorsal surface, the two dorsal components of the **extensor cruris**, occupying the anterior half of the thigh. Along the inner border of the extensor cruris is seen the **Biceps femoris**, posterior to which lies the broad **semimembranosus**. Along the inner border is found the edge of the **gracilis.** Biceps femoris originates from the crest of the ilium and inserts on the head of the tibiofibula. In this semimembranosus arises from the ischial symphysis and inserts on the head of the tibiofibula. In this view, part of the iliacus muscle can also be seen.

**DEEPER MUSCLES:**

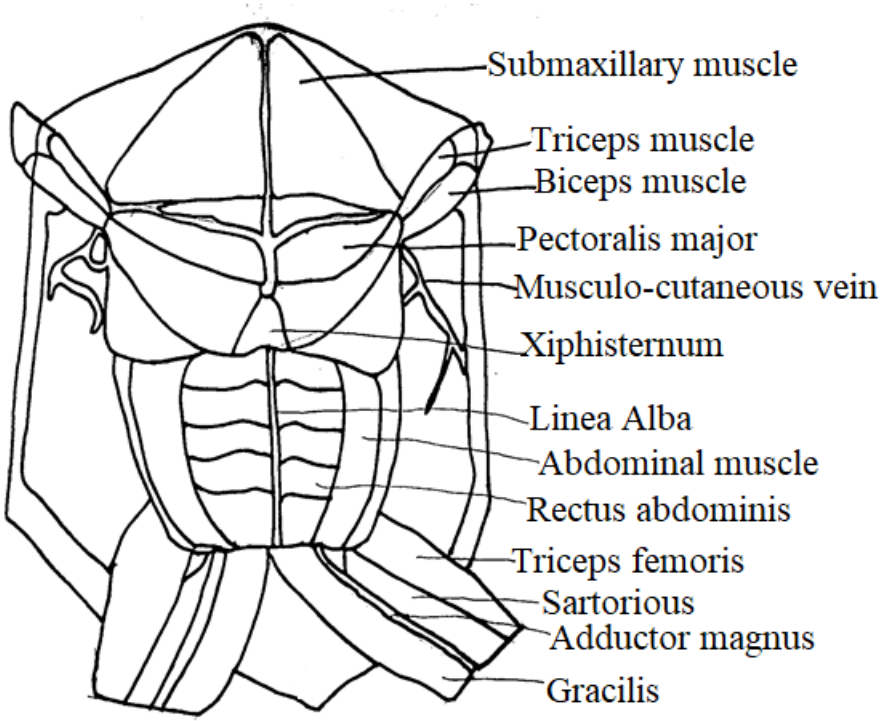
Removal of the extensor cruris, biceps femoris, and semimembranosus from the dorsal side of the thigh, shows the **gluteus**, the **caudofemoralis**, and the posterior component of the **retractor femoris** .the **iliacus muscle** is now fully seen originating from the dorsal border of the ilium and inserts into the posterior face of the femur.

When all the muscles above are cut away, only one muscle remains; the **Obturator internus**, which has a wide origin around the **acetabulum** and inserts on the dorsal side of the femur.

**A drawing of the trunk region muscles from the ventral view including those of the fore arm in the upper region of a toad**




**A drawing showing the main superficial body muscles and muscular arrangement of the ventral side and hind limbs of a toad**




## Toad Questions

1. UNEB 2016 QN 1. You are provided with specimen R which is freshly killed. Examine the fore and hind feet of the specimens.

(a) Draw and label the ventral side of the left fore foot and the left hind foot of the specimen. Both drawings should be at the same magnification. (7 marks)
(i) Fore foot
(ii) Hind foot
(b)Dissect the specimen to display the heart and the blood vessels that carry blood from the head region, intestines and kidneys and back to the heart. Without displacing the heart, draw and label your dissection. (36 marks)
2. You are provided specimen P which is freshly killed.
(a) Examine the specimen and give five observable adaptive features that enable the specimen to survive in its habitat. (5 marks)
(b) Dissect the specimen to display the;
(i) Blood vessels taking blood to the left lung of the animal. Draw and label. (16 marks)
(ii) Blood vessels returning blood from the right side of the head and chest region of the animal to the heart. (22 marks)
3. UNEB 2015 QN 1. You are provided with specimen K which is freshly killed.
(a) (i) Measure the length of the fore and hind limbs and record the result in table 1. Express the results as a ratio of the length of fore limb: length of the hind limb. (2 marks)

Table 1.

| Length | Fore limb | Hind limb |
|---|---|---|
| | | |
| | | |

Ratio

(ii)State the significance of the ratio. (1 mark)
(b) Examine the hind limb and state three ways it is adapted for the survival of the specimen in its habitat. (3 marks)
(c) Examine the head of the specimen and draw and label the dorsal view of the anterior part of the head to show the structures for sensitivity. (5 marks)
(d) Dissect the specimen to expose the heart. Turn the heart to display the main blood vessels;
(i) Returning blood from the trunk to the heart.
(ii) Supplying the structures for absorption of nutrients and excretory organs. Draw and label. (27 marks)
4. (a) You are provided with specimen R. classify it into the following groups. (1 marks)

(i) Kingdom
(ii) Phylum
(iii) Class

(b) Observe the head of the specimen and state how it is adapted to its habitat. (3 marks)
(c) Dissect the specimen R to display the main superficial muscles of the left thigh of the specimen. Draw and label the muscles. (9 marks)
(d) Continue to dissect the specimen to display,
(i) The blood vessels that drain from the alimentary canal and its associated organs back to the heart, with the alimentary canal displaced to your right and the heart turned upwards and pinned through the ventricle.
(ii) The blood vessel that take blood from the heart to the thoracic region of the animal. Draw and label your dissection showing (i) and (ii) (26 marks)
5. UNEB 2007 QN 1. You are provided with specimen T which is freshly killed.
(a) Pin the specimen with the ventral side uppermost. Dissect and remove the skin, taking note of how it is attached to the underlying body wall.
(i) Describe the attachment of the skin to the body wall. (3 marks)
(ii) Suggest the significance of the way the skin is attached to the body wall as described in (a)(i) above. (3 marks)

(b) Observe the main blood circulation on the skin.

(i) Describe the pattern of blood circulation on the skin. (4 marks)
(ii) Give the significance of the pattern of blood circulation described in (b)(i) (3 marks)

(c) Dissect the specimen further to display;

(i) Blood vessels carrying blood from organs located on the left half of the abdominal cavity back to the heart.

(ii) Structures used for the elimination of unwanted materials from the body. With the heart displaced anteriorly, draw and label the blood vessels and structures displayed in (c)(i) and (ii) on one diagram. (27 marks)

6. You are provided with specimen K which is freshly killed. Open up the buccal cavity of the specimen and proceed with your dissection to display the rest of the internal structures. Carefully displace the alimentary canal to the left of the specimen without damaging any mesentery. Draw and label all the structures seen lying wholly anterior to the bladder. (25 marks)

7. a) Carefully examine the external features of the head and describe its structure. (10 marks)
   b) Using dissecting instruments open the buccal cavity and describe the structural features in this part of the body (10 marks)
   c) Explain three ways the structural features of the buccal cavity suit their function.
   d) Dissect the specimen to display the arterial circulation on the left side lying posterior to the heart plus the associated structures. Draw and label when the heart is displaced. (20 marks)

8. You are provided a freshly killed animal.
   a) Describe the following structural features of the head.

i) mouth (2 marks)

ii) ear drum (2 marks)

iii) eye (4 marks)

iv) poison glands (3 marks)

bi) Describe the structural features you used to identify the sex.( 3 marks)

ii) Dissect and remove the skin from the ventral sides of the animal's head, abdomen and limbs. Search for the superficial structures, draw but DON'T label. (8 marks)

c) Dissect the animal to display the blood vessels draining the left side anterior to the heart, with the heart turned forward. Draw and label. (16 marks)

9. You are provided a freshly killed toad.
   a) Describe the structure of the foot of the posterior limbs. (3 marks)
   b) Explain how the structure of the foot is related to its function ( 2 marks)
   c) Dissect the animal to display the heart and the gut. Turn the heart forward and search for the vascular system draining the gut, spleen and associated structures. Draw and label. ( 18 marks)
   d) By further dissection search for blood vessels that supply blood to the head, skin and stomach. Leave the heart undisplaced. Draw and label.( 15 marks)

10 a) Explain five ways the animal is adapted to live in its habitat. (5 marks)
   b) Dissect the specimen to display the:
   (i)The main routes of blood flow supplying the left anterior region of the specimen.
   (ii)The main routes of blood flow draining the right hind limb of the animal to the heart, with the heart pinned forward through the ventricle. Draw and label your dissection. (30 marks)

11) You are provided with a freshly killed toad.
   a)i) Carefully observe the animal and explain five structural features that suit the animal to live on either land or water bodies.(05marks)

ii) Describe the position and structure of the following; Webbed toes, Cloaca, Head, Tongue: (8 marks)

   b) Lay the specimen ventral side upper most. Dissect it in the usual way, and remove the skin of the head, trunk and fore and hind limbs up to the elbow and knee respectively.
      i) Draw and label the superficial structures. (13marks)
      Describe the structural features of the skin and clearly indicate, how they relate to function. (05marks)

(c) Proceed to dissect and display the internal structures. Displace the stomach further to the right, the right lung to cover part of the heart. Search for blood vessels supplying the stomach, pancreas, and the right hand side of the animal anterior to the heart. Draw and label. (16marks)

12. You are provided with a freshly killed frog.
   a) Observe the fore and hind limbs and describe their structure. (04marks)

b)i) Outline three differences between the fore and hind feet. (03marks)

ii) Draw but don't label the hind foot. (03marks)

c) Lay the animal ventral side upper most. Dissect it in the usual way to display internal structures. Turn the dish side ways and cut through the right angle of the jaw, pharynx up to oesophagus. Pin a side the floor of the buccal cavity and pharynx. Search for structures used for feeding Search for blood vessels supplying the gut. Draw and label your dissection. (22marks)

13. You are provided with a freshly killed frog.

a. i) Examine the head and describe how it is adapted to promoting the animal's survival. (05marks)

ii) Open the buccal cavity, using dissecting instruments search for a structure at the front of the floor of the buccal cavity, hold the structure, pull it and release it. State your observations and explain their significance in promoting the animal's nutrition. (03marks)

(b) Dissect the specimen and pull the skin off the body wall.

i) Describe its attachment on the body wall. (02marks)

ii) Examine the skin and explain three ways it is adapted to the process of gaseous exchange. (3marks)

c) Dissect the specimen further to display the routes of blood low:

(i) Carrying blood from the head region on the right hand side of the specimen back to the heart.

(ii) Carrying blood to the alimentary canal, displaced to the right and to the kidneys, the right turned to appear on top of the left. Without displacing the heart, draw and label your dissection. (25marks)

14) You are provided with a freshly killed toad.

a) With the mouth opened, pull out the tongue and pin it. Draw and label the head as observed in lateral view.(05marks)

b) Dissect the animal to display:

i) Blood vessels supplying the left hand lung, fore limbs, skin and head.

ii) Blood vessels draining blood from the right hand side of the animal EXCEPT the inner part of the hind limb. Turn the heart forward. Draw and label. (28 marks)

15. You are provided with a freshly killed animal labeled T.

a)i) State the sex of the animal. Give a reason for your answer.

ii) Outline 3 differences between the fore and hind limbs.

(b) Lay specimen T- ventral side upper most. Pin it and proceed to dissect, display:

i) Routes of blood flow draining blood from the left hand side of the head and lung to the heart.

ii) Routes of blood flow supplying the right forelimb, part of digestive system anterior to ileum and the urinogenital system. Displace the heart forward. Draw and label.

16. You are provided with specimen T which is freshly killed.

a) Classify the specimen according to the following taxa.

| | | | |
|---|---|---|---|
| Kingdom | Class | Family | Species |
| Phylum | Order | Genus | |

b) Observe the structural features on the head from the left hand side. Draw and label the features concerned with sensitivity and feeding. (07 mks)

c) (i) Examine the head of the specimen, describe the shape of the head and its significancy. (03 mks)

(ii) Is your specimen a toad or a frog, give a reason. (01 mks)

(iii) State the significancy of the structure and position of the eyes (02 mks)

(iv) Examine the dorsal and ventral skin surface of the abdominal region of the specimen. Outline the structural differences between the dorsal and ventral skin surfaces. (04 mks)

(v) State the relevancy of the structural differences in (iv) above. (02 mks)

(vi) Observe the limbs of the specimen ventral side uppermost. Draw and label.

(a) The structure of the left fore limb (05 mks)

(b) The left hind limb. (07 mks)

(vii) Compare and differentiate between the fore and hind limbs. (08 mks)

(viii) How is the toad adapted to terrestrial and aquatic life. (10 mks)
(ix) Open up the buccal cavity of the specimen to expose structures. Draw and label the interior of the buccal cavity when the tongue is pulled at the front. (11 mks)
(x) State the adaptations of the buccal cavity to perform its functions. (06 mks)
(xi) Dissect the specimen to display the main superficial muscles of the left thigh of the specimen. Draw and label the muscles.
(09 mks)

17. You are provided with specimen C which is freshly killed
(a) Place the specimen dorsal side uppermost. How are the following features significant in the life of the specimen in its habitat.
(i) Fore limb structure. (02 mks)
(ii) Fore limb location. (02 mks)
(b) Pin the specimen ventral side uppermost with limbs fully stretched. Dissect to remove the skin from the body up to the first joint of the limbs. Draw the right hind limb and label only the observable muscles of the thigh. (07 mks)
(c) Using forceps, open the mouth of the specimen and examine the roof of the buccal cavity. Draw and label its observable features. (07 mks)
(d) Dissect the specimen further to display the internal organs, remove the pericardium without displacing the heart, displace the alimentary canal, left wing and left kidney to the right side of the specimen. Displace the blood vessels that supply blood to the organs in the lower trunk. Draw and label. (22 mks)

18. You are provided with specimen Q.
(a) Pin the specimen with ventral side uppermost. Dissect and remove the skin, taking note of how it is attached to the underlying body wall.
(i) Describe the attachment of the skin to the body wall (03 mks)
(ii) Suggest the significance of the way the skin is attached to the body as described in a(i) above. (03 mks)
(b) Observe the main blood circulation on the skin
(i) Describe the pattern of blood circulation on the skin. (04 mks)
(ii) Give the significance of the pattern of blood circulation described in b(i) above. (03 mks)
(c) Dissect the specimen to display the blood vessels taking blood to the left wing of the animal. Draw and label. (11 mks)
(d) Further dissect the specimen to display the structures of the buccal cavity. Carefully cut off the whole alimentary canal including the bases of its capillary network. Trace the observable vessels that carry blood.
(i) From abdominal region and fore limbs back to the heart.
(ii) To the head region from the heart. Draw and label the vessels and visible undisplaced organs. (24 mks)
(e) Examine the fore and hind feet of the specimen. Draw and label the ventral side of the hind foot of the specimen. (07 mks)

19. You are provided with specimen O which is freshly killed. Dissect the specimen to display.
(i) The blood vessels that drain blood from the alimentary canal and its associated organs back to the heart with the alimentary canal displaced to your right and the heart turned upwards and pinned through the ventricle.
(ii) The blood vessels that take blood from the heart to the thoracic region of the animal. Draw and label your dissection showing (i) and (ii) on one drawing. (24 mks)

20. You are provided with specimen O which is freshly.
(a) Examine the skin from dorsal side to trunk region of the specimen. From your observation, state three adaptations of the skin from this part for survival of the specimen on land. (03 mks)

(b) Pin the specimen with ventral side uppermost. Dissect the specimen to display the muscles of the left thigh.

(i) Isolate the first muscle block on the outer part of the left thigh up to its attachment. Describe the structural efficiency of the muscle to its function. (03 mks)

(ii) Draw and label the muscles of the left thigh. (08 mks)

(c) By further dissection, display the blood vessels that

(i) Carrying blood to the structures for removal of wastes from the body of the specimen and

(ii) Drain the hind limbs and pelvic regions. Draw and label the structures displayed in (i) and (ii) above on the same drawing to include the heart in ventral view. (27 mks)

21. You are provided with freshly killed specimen T.

(a) Describe the structure of the head and relate to the significance for the survival of the organism in its habitat.

(b) (i) Examine the lateral anterior view of the head. Draw and label the observable features.
(ii) How are the features named in (b) (i) above adopted for survival of the organism in its habitat?

(c) (i) Dissect to expose organs in the body cavity in-situ. Draw and label organs that are concerned with excretion and vessels that carry blood to the head region.
(ii) By carefully loosening the tissue. Cut out the rectum and ileum with their associated capillary network to display main vessels that carry blood from remaining abdominal cavity organs and fore limbs back to the heart. Draw and label.

22. You are provided specimen K.

a) Place the specimen dorsal side uppermost with head facing you. How are the following features significant in the life of the animal in its habits?

I. Fore limb structure. (2 marks)

II. Fore limb location (2 marks)

III. Hind limb foot structure (2 marks)

b) Dissect the specimen ventral side uppermost. Carefully displaced the alimentary canal to the left loosening the tissue holding it to expose the urinary system structures within the abdominal cavity. Continue to expose vessels that carry blood.

i) From the fore limbs and exposed body cavity organs except the spleen and gonads back to heart

ii) To the head region from the heart with a displaced heart anteriorly.draw and label only the mentioned structures and blood vessels. (23 marks)

c) Unpin the specimen and place it dorsal side upper most. Continue to dissect to remove the skin from the whole left hind limb. Draw to show the observable structural features. (08 marks)

## THE RAT

**Classification.**

| | |
|---|---|
| Kingdom | Animalia |
| Phylum | Chordata |
| Class | Mammalia |
| Order | Rodentia |
| Family | Munidae |
| Genus | Rattus |
| Species | rattus {black}<br>norvegicus {white} |

**A rat is classified in class mammalia because of the following.**

**External features:**

- Presence of pinnae i.e. external ear lobes.
- Skin is covered with fur/hairs.
- Possession of post anal tail.
- Presence of pent dactyl limbs.
- Presence of a pair of nostrils.
- Presence of scrotal sacs in males and vaginal opening in females.
- Presence of nipples which lead from the mammary glands.

**Internal features**.

- Presence of diaphragm separating the thorax from the abdomen i.e. body cavity divided into two an upper thoracic cavity containing the heart, lungs and abdominal containing the intestines and the rest of the viscera. –
- Presence of heterodont teeth which are modified to perform various functions.

**Reasons for being classified in the order rodentia.**

- Well-developed ceasal teeth.
- Presence of a gap between the incisors and the cheek teeth.
- Presence of a hairless scaly tail and necked scales.

**ECOLOGICAL ADAPTIVE FEATURES**.

1. Presence of the pinnae which are dorsolaterally located on the posterior part of the head which are small and rounded with short hairs for collection or trapping of sound waves.
2. Skin is covered with fur to reduce water or conserve heat to regulate body temperature.
3. Presence of nostrils on the anterior part of the head or roof of the buccal cavity which are comma shaped for detection of smell of food, enemies or breathing.
4. Presence of whiskers/vibrissae which are long stiff hairs located at the sides of the anterior part of the head around the mouth and nostrils which are sensitive to touch or detecting size during burrowing.
5. Then the head is pear shaped and tapering anteriorly making it streamlined which enables it in movement into burrows/hidden places with little resistance.
6. Dorso - laterally located eyes on the posterior part of the head which are large with movable upper and lower lids having eye lashes and a nictating membrane. The large and therefore position enable a large field of view. The eye lashes protect the eye from entry of foreign bodies or dust.
The nictating membrane produces a fluid in the eye to wash off foreign particles.
7. Presence of a long tail to give support or balance or maintaining a raised head and chasing a way predators.
The tail is scaly so as to conserve heat and its tapering towards its end to ease flexibity.
8. Presence of two sharp pointed incisors and fingers for grip of prey or protection.
9. Presence of two pairs of pentadactly limbs for locomotion and support. The hind limbs are long folded and muscular for generation of propulsive forces during locomotion.
10. Presence of naked soles for reducing noise hence escaping from predators.
11. Presence of sharp claws on the toes for holding food or prey, digging burrows, for protection against predators predators for firm grip/ support.
12. Have many overlapping scales on the tail to reduce desiccation.
13. Has elongated, pointed claws for firm gripping on the rough surface or for digging burrows/tunnels or for holding food or for defense.

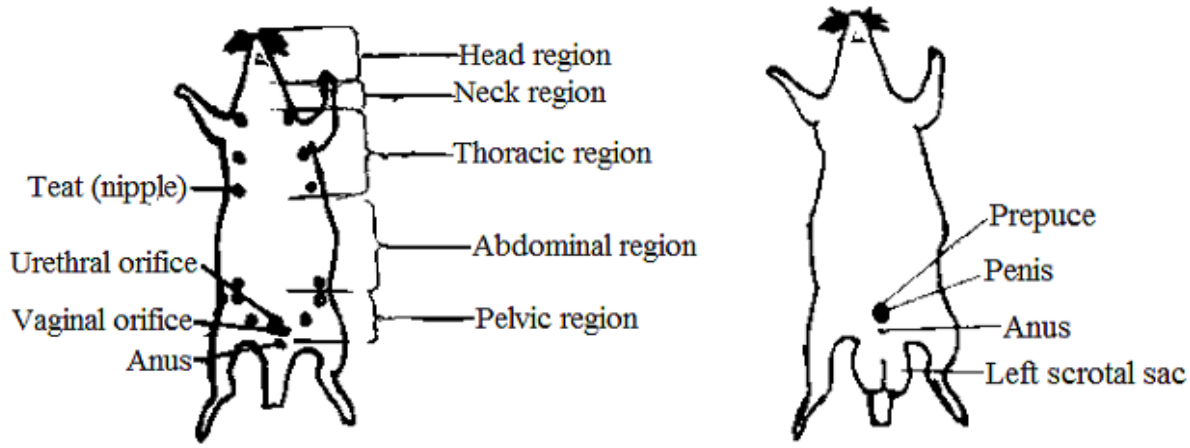
**EXTERNAL FEATURES**

**External anatomy of the rat**

The body is divided into four easily identifiable areas:

1. **Cranial region**- head;3. 2. **Cervical region**- neck; **3. Trunk** (thoracic region-chest area; abdominal region-belly; pelvic region-area where the back legs attach on body trunk); 4. **Tail**-caudal. Limbs are attached on the trunk.
   **Note:** When pressed the ventral surface of the **thorax** feels firmer than the **abdomen,** which is softer.

**Drawing of features at the ventral surface of male and female anatomical regions of rats**




| Part | Description | Significance |
|---|---|---|
| SKIN | **Location:** covers entire body | It offers protection all over mechanical injuries, entry of parasites and heat loss |
| | **Structure:**<br>1.Thick<br>2. Covered with fur. | 1.Thick to protect underlying tissues against mechanical injuries, entry of parasites<br>2. Presence of fur reduces heat loss. |

**Description of hair distribution on the skin**

Some parts have spares fur, some have dense fur while some parts lack hair (are hairless)

| Sparsely furred parts | Densely furred parts | Parts without hair |
|---|---|---|
| Pinnae, upper surface of feet, anal region, tail, mystacial pads, scrotal sac and prepuce (in males) nipples and clitoris (in females).<br>**Significance of sparse furring:** enables loss of excessive heat during hot weather | The dorsal and ventral surfaces of the trunk<br>**Significance of dense furring:**<br>(1) For insulation against heat loss<br>(2) Protects the skin against mechanical damage. | Lower surface of feet.<br>**Significance of hairless Sales:**<br>Enables gripping the surfaces during locomotion |

**Description of nature of hair:** Some of the hair is long and stiff, short, moderately long

| Parts with long, stiff hair | Parts with short hair | Parts with hair of medium size |
|---|---|---|
| Mystacial pads, dorsal to the eyes.<br>**Significance of vibrissae being long and stiff**<br>Enables tactile sensing of burrow walls in the dark | Pinnae, upper surface of feet, anal region, tail, scrotal sac and prepuce (in males), nipples and clitoris (in females).<br>**Significance of hair being short.**<br>To allow much heat loss when the body heats up. | The dorsal and ventral surfaces of the trunk |

**VIBRISSA (WHISKER) - plural: VIBRISSAE**

**Structure:** each is long, stiff, and thin.

**Location:** grow around the mouth and on the face, some pointing dorsally, others laterally, ventrally.

**Function:** Sensitive to touch, which allows the animal to judge the size of an opening that is about to pass through

**Groups of vibrissae**

**(1)** Superciliary or Supraorbital- above **the eye (2) mystacial**-where a moustache would be **(3) Genial**-on the cheek, far left **(4) submental**-beneath the chin **(5) Interramal**- between the mandibles of the lower jaw.

**2 LIPS**

**Description of lips of a rat**

1. **Upper lip: split into two medially, by**
   A cleft called **philtrum,** which extends to the nostrils. Upper lip has vibrissae.
2. **Rhinarium:** area between the nostrils Rhinarium: is moist, hairless, shinny
3. **Lower lip:** not divided, hairy

**ADAPTATION OF UPPER LIP**

1. Has a cleft called **philtrum** that exposes incisor teeth to gnaw food.
2. Many **vibrissae** for sensing tunnel diameter
3. Lower edge is **Flap**- like to hold food in diameter during feeding.

**Drawing of lips and other structures observed from ventral view of rat head**


**THE HEAD**

i. **Shape.**

The head is pear shaped and anteriorly where the mouth is small and bounded by soft upper and lowerlips.

**Significance**

a) It gives the animal a streamlined shape which helps it to move easily without interference with air resistance.
b) It also has long stiff sensitive hair called vibrissae at the sides of the mouth and nostrils which are very sensitive to touch and are of great value in darkness of the burrows.

**iii The eyes**

**Position and structure**:

Eyes are located dorso-laterally on the head. They are large and with movable upper and lower lids with eye lashes. At the inner corners of the eyes are nictating membranes.

**Significance:**

- Position gives the animal a wide field of view in the habitat enabling it to detect prey and predators from a wide area.
- The nictating membranes can be moved across the eyes to wash them of foreign particles.
- The eye lashes protect the eye from entry of dust and small insects.

**IV The nostril/ nares:**

**Structure and Position:**

The nostrils/nares are comma-shaped and located anteriorly.

**Significance**

Position gives them chance to trap and recognize smells of food and dangerous substances in the vicinity before the whole organism approaches.

**v. External ears:**

**Structure and position:**

They are small and rounded and contain very short fine hairs.

They are located dorso-laterally on the head.

**Significance:**

a) Their reduced size enables to regulate heat loss and/ or absorption from the surroundings.
b) The short fine hairs serve to collect and reflect sound waves into the auditory canal.
c) They also enable to determine the direction from which the vibrations come, by virtue of their dorso-lateral position.

**The whiskers/vibrissae /sensitive hair.**

These are few /many long bristle /stiff/sensory hairs arranged in rows located on either side of the mouth and the nostril s/ anterior end of the end of the head/snout of the head.

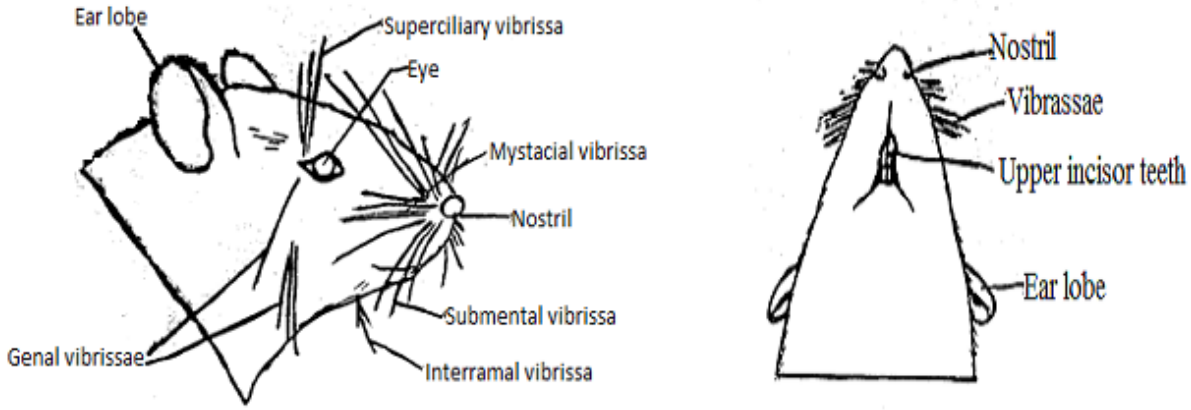
They are very sensitive to touch (sensory in function ) and are of great value in darkness when the animal is burrowing to aid them find /gauge the right diameter /width of burrow to fit in their bodies.

**Significance**

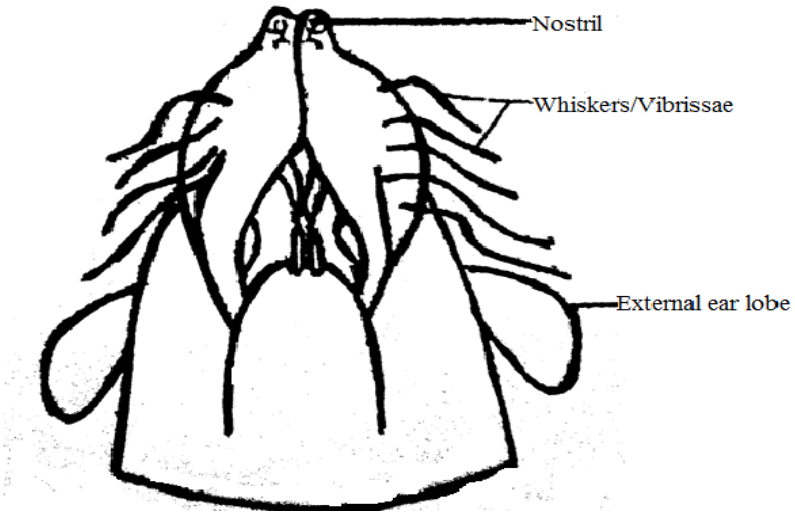
a) Whiskers are for sensitivity/ sensing touch /tactile organs serving for the sense of touching and burrowing directly size of the burrow in its darkest depths/ great value in darkness of the burrow/ length and bristle nature of the whiskers makes it easy to detect the diameter of the burrow.
b) They are also sensitive to changes in air pressure.

**NB**: Whiskers /vibrissae also exist on other, areas of the head and are named accordingly; mystical vibrissae extending posteriorly from the nostrils , sub mental on the lower jaws ,superciriliary over the eyes, interramal on the chin ,genial vibrissae a few only on the cheek.

**Drawing showing the structure of the head**




**Drawing of the ventral side of the head showing structures for sensitivity**




**The table below shows description of body parts of a rat and their significance**

| DESCRIPTION OF PINNAE(EAR LOBES | SIGNIFICANCE |
|---|---|
| **Position:** Dorso-lateral on the head<br>**Structure: (1)** each is erect **(2)** it is a flexible flap. | • Dorsal lateral to receive sound waves from all directions<br>• Staying erect maintains a posture that enables reception of sound waves and direct into external auditory meatus. |

| | |
|---|---|
| (**3)**Sparsely furred **(4)** Broad and rounded at the top, narrows at base<br>**(5)**Blood vessels form a pattern from dorsal view:<br>There is one main blood vessel originating from the base upwards and forms several branches, each of which branches dichotomously close to the tip of the pinna. There is also a smaller capillary close to the edge of the pinna. | • Flexibility enable turning to the direction of sound waves.<br>• Scanty hair allows a loss of excess heat in hot weather.<br>• Conical shape increases surface area for reception of sound.<br>• The branching pattern of blood vessels enables a rich nutrient supply to pinna tissue. It also enables loss of much heat during overheating. |

| | |
|---|---|
| **EYES:** Position: dorsal-lateral on the head<br>**Structure:**<br>Are paired, have large pupil, are covered by upper and lower eyelids, and a semitransparent, movable nictitating membrane in the inside anterior corner. | • Dorsal-lateral position enables seeing food and predators in the habitant from a wide area. |
| **Nostrils/ nares:**<br>**Position:** ventral surface at the tip of the snout, but face laterally<br>Structure: Narrow, comma-shaped paired openings | • Being at the most anterior enables detection of smells even when the trunk is concealed from predators in borrows.<br>• Narrowness enables minimize entry of chemicals<br>• Being open allows entry of chemical substances. |
| **TAIL:**<br>**Position:** At terminal end of trunk, dorsal to anus<br>**Structure:**<br>1.Elongated, up to a ratio of about 1 trunk: 1 Tail/long(20cm).<br>2.Solid, when pressed between fingers<br>3.Tapers posteriorly.<br>4. Has rows of overlapping epidermal scales all over, which face backwards/posteriorly.<br>5. Hairless, but three, short bridles project from under the edge of each scale.<br>6. Surface covered with orange-yellow, waxy grease. | • Great length and solidness enable providing body support during climbing of trees/walls.<br>• Great length also enables chasing away parasites from all over the body.<br>• Solidness enables tail to hit at and scare away predators.<br>• Taperinginteriorly reduces air resistance during locomotion.<br>• Overlapping epidermal scales reduce water evaporation.<br>• Hairless/ short bristles enable much heat loss to avoid overheating of the body<br>• Waxy grease reduces evaporation of water from the tail. |

**External features on the dorsal side of the head**

- Fur/ hair is numerous/ many, thick, short/ long/ of variable length, thin/ slender, dull coloured/ brightly coloured/ white/ grey/ yellow/ black, pointed/ sharp/ tapering.
- Vibrissae/ whiskers are numerous/ many, short/ long/ of variable length, stiff/ erect/ straight, thin/slender, tapering/ pointed/ sharp.
- Pinnae/ external ears/ external ear lobes/ outer ears are large, funnel shaped/ curved at the base/ narrow at the base/ curved/ tapers at the base, covered by/ with few/ scanty, short hair.
- Eyes are large/ protruding/ bulging/ small, oval/ curved/ convex shaped/ round/ spherical, brightly coloured/ pink / red / dull coloured/ black.

**ADAPTATIONS OF THE HEAD TO ITS HABITAT**

- Movable eye lids for protection of eye from mechanical damage.
- Many vibrissae /whiskers to increase surface area for sensitivity.
- Vibrissae of variable length to increase surface area for sensitivity.
- Large pinnae/ outer ear to increase surface area for trapping sound.
- Pinnae curved at base / funnel shaped to direct sound waves.

- Pinnae with little fur to promote heat loss.
- Open nostril to easy breathing.
- Dorso-laterally positioned eyes for wide field of view.
- Streamlined head/ tapers anteriorly to easy burro wing.

**Adaptations of buccal cavity structures**

- Incisors are hard, top is sharp to gnaw hard, top is sharp to gnaw hard food substance.
- Molar are ridged with a large surface area to grind food.
- The diastema separates chewing from gnawing for proper physical digestion to occur.
- The tongue is muscular to turn food in the mouth during chewing.
- The anterior palate is ridged for increased friction during chewing to prevent food from falling out of the mouth.
- The posterior palate is smooth to reduce friction when swallowing.

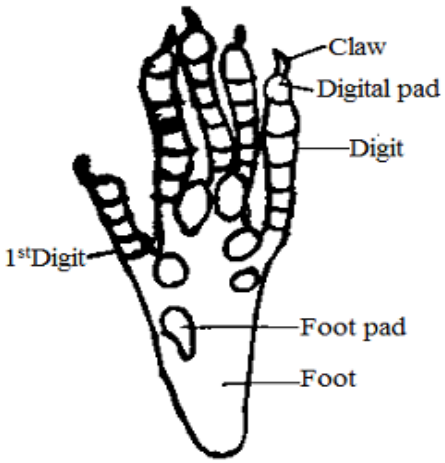
**Drawing of tail of a rat showing eight epidermal scales**

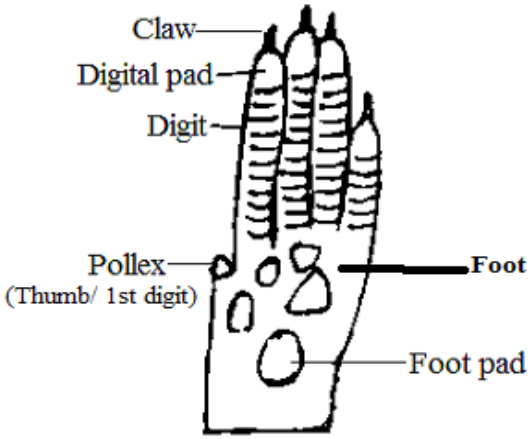
**LIMBS**

| **FORELIMBS** | **HIND LIMBS** |
|---|---|
| **Whole limb**: short, relatively muscular, upper parts are covered with thick fur.<br>**Foot:** Short with **Five digits** of variable length i.e. thumb (1st digit) is much reduced, claws on digits are sharp, curved, hard, pointed, except claw on thumb which is flattened, not sharp in **Mature rat.**<br>**Upper (dorsal) surface of foot:** sparsely furred, **ventral (lower) surface:** hairless, with foot pads **foot pads and digital pads:** Swollen, horny thickenings on medial surface.<br>**Digital pads:** located at the tips and bases of digits.<br>**Foot pads**: located on the sole of the foot, **Six** in total<br>**FUNCTION OF FORE LIMB**<br>• Holding and grasping walls, support materials.<br>**ADAPTATION OF FORE LIMB**<br>• Sharp claws prick and scare away predators.<br>• Ventral surfaces have dermal ridges, foot pads, and digital pads to grip surfaces to avoid sliding.<br>• Long digits ensure firm grip of surfaces. To avoid sliding. | Whole limb: Relatively long, highly muscular, upper parts are covered with thick fur.<br>Foot: long, has Five digits of variable length, claws on digits are sharp, curve, hard, pointed claws.<br>Upper (dorsal) surface of foot: sparsely furred Ventral (Lower) surface of foot: hairless, has foot pads, digital pads and dermal ridges on digits.<br>Digital pads: located at the tips and bases of digits<br>Foot pads: located on the sole of the foot, six in total<br><br>**FUNCTION OF HIND LIMB**<br>• Running, climbing, jumping and support<br>**ADAPTATION OF HIND LIMB**<br>• Highly muscular to generate strong propulsive force.<br>• Long to provide great thrust when jumping.<br>• Ventral surface of foot is hairless to minimize noise during locomotion.<br>• Ventral surface has dermal ridges, foot pads, and digital pads to grip the ground when running to avoid sliding. |

**Differences between the fore and hind limbs:**

| **Fore limb** | **Hind limb** |
|---|---|
| Short and stout | Long and folded onto the body |
| Less muscular | Greatly muscular |
| Ends in five digits with sharp claws | Ends in four digits with claws |




**THE TAIL**

**Structure:** The tail is; Long (about 20cm), Scaly, Hairy and Flexible.

**SEX IDENTIFICATION**

**Characteristics of females;**

- Have vulva/genital aperture on the ventral side.
- Have the small projection, the clitoris on the ventral side of abdominal region, which bear outlets mammary glands.

**The vulva** in adult rats is open, smooth, oval/circular/round opening. It is found in the middle cross length between the hind limbs on the ventral side. It is moist and open for easy passage of materials. It is close and posterior the clitoris which is a small projection/protrusion; solid; cylindrical; with a small opening at the tip and short scanty hair/fur.

**The clitoris** is pointed and close and interior to the vulva.

The nipples are in six pairs on ventral side of the thorax and abdomen. Three pairs are thoracic, one is abdominal and two inguinal (found in groin region). The teats are at the same distance from the longitudinal mid-line of the ventral side.

**Nipple**; small projection; short; cylindrical; smooth; and solid.

**Characteristics of male**

- Have a projection of prepuce covering the penis.
- Have the scrotal sacs protecting the testes.
- The dorso-posterior end is round to expanded testes on the ventral side.

**Penis** is elongated/long, covered by a loose sheath/prepuce which is cylindrical, solid, with scanty hair, slit like aperture at the tip.

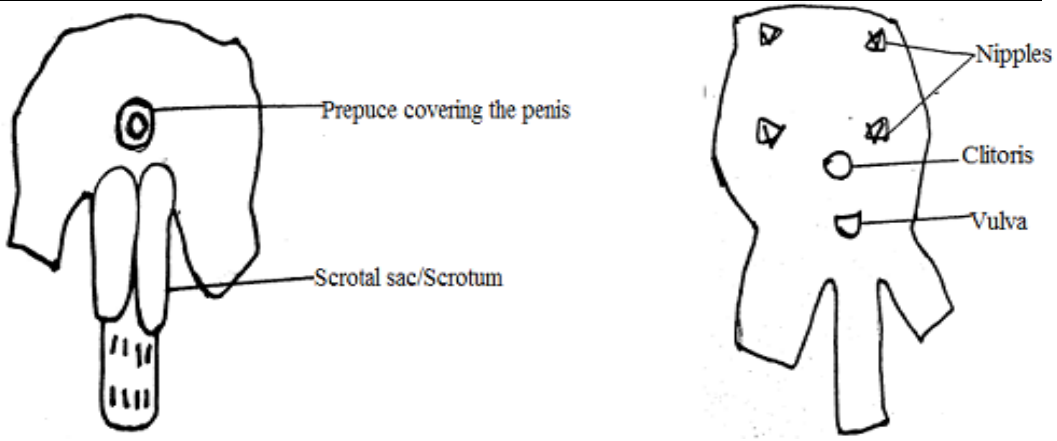
**Scrotal sacs/scrotum,** swollen, sac like, elongated, with short scanty hair and two swellings with a depression in the middle.

The scrotal sacs are enlarged/dilated and elongated to accommodate large testes.

**FEATURES FOR SEX IDENTIFICATION.**

| Male Rat | Female rat |
|---|---|
| 1. **Scrotum:** Double pouch, two scrotal sacs. Oval-shaped, large, scantly furred.<br>**Location:** posterior and lateral to urogenital aperture.<br>2. **Prepuce:** cylindrical, sparsely furred, covered with short hair, bulging<br>**Structure in relation to function**<br>**Scrotal sac:**<br>(i) Large for accommodating large tests to manufacture much sperm.<br>(ii) Scantly furred to allow much heat loss | **1. Teats/nipples/mammary papilla:**<br>**Location:** Twelve (6pairs), ventrally positioned-six (3 pairs) are located in thoracic region, two (one pair) into the abdomen, four (2pairs) in the groin/ pelvic region.<br>**Structure:** each nipple is pointed, cylindrical, hairless, short, and smooth.<br>**2. Vaginal orifice:**<br>**Location:** anterior to the anus<br>Structure : open, depression, oval-shaped, moist<br>**Structure in relation to function**<br>Vaginal orifice:<br>(i) Open to enable entry of penis during copulation<br>(ii) Moist to enable entry of penis without much resistance. |

**Drawings showing vetral view of male and female posterior region and abdominal surface**




## GLOSSARY OF TERMS

Right and left-refer to the specimen's right and left
Viscera/internal organs.
**Internal organs:** organs seen after opening body wall
**Inner structures:** seen after lifting body flaps e.g.teeth
**Superficial:** on ornearthesurface
**Deep:** some distance below the surface
**Dorsal:** toward the back
**Ventral:** toward the belly
**Abdominal cavity: -** area below (posterior to) diaphragm.
**Lateral:** toward the sides
**Thoracic cavity:** Area above (anterior to) the diaphragm.
**Mediam:** near the middle
**Transverse:** Separation between anterior and posterior.
**Anterior**: toward the head
**Horizontal:** Separating line between dorsal and ventral.
**Posterior:** toward the hind end (tail)
**Sagittal:** mid line which bisects left from right sides

**Proximate:** towards the center of the body
**Distal:** farther away from the body
**Cauda:** toward the tail end
**Pectoral:** relating to the chest and shoulder region
**pelvic:** relating to the hip region
**Dermal:** relating to the skin.
**longitudinal:** Lengthwise

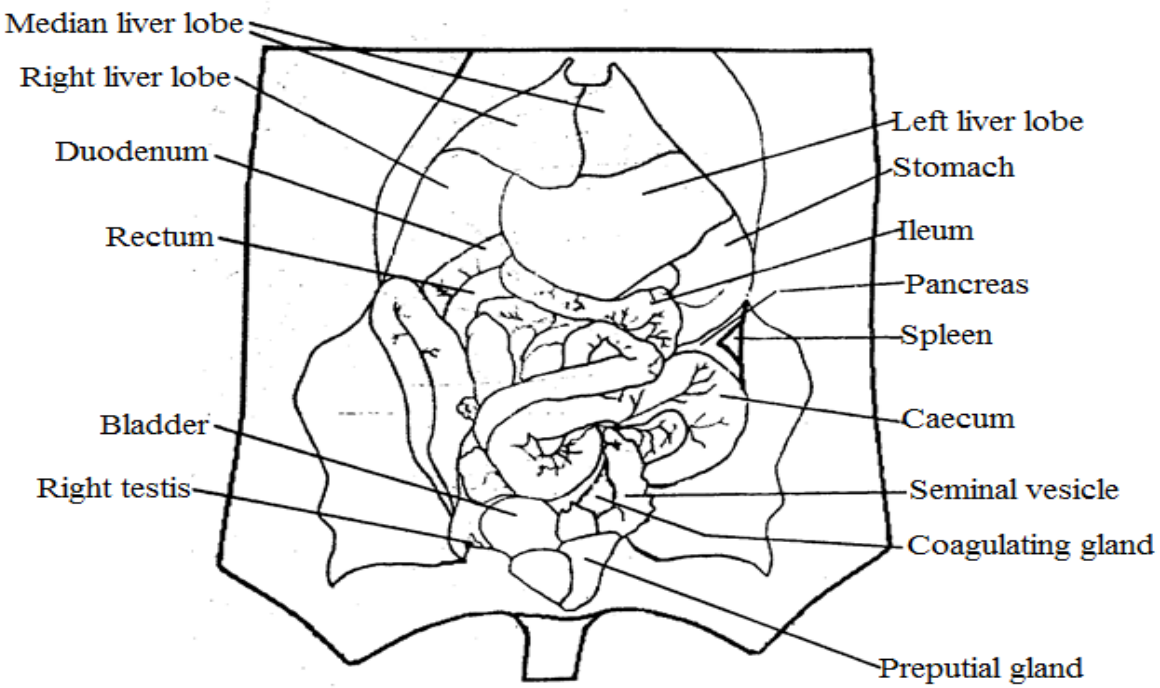
## BODY SYSTEMS

The body systems are exposed to study by opening internal cavities. Before the internal cavities are opened, the skin has to be removed first by using a blank knife scissors.
The visible structures exposed on the body wall by removing the skin are called superficial structures like the neck glands, masseter (jaw) muscle, pectoral muscles, neck muscles, shoulder muscles, intercostals muscles, abdominal muscles and cutaneous nerves and femoral vein. If it is a female, thoracic abdominal and inguinal mammary glands are exposed for the male the scrotal sacs are exposed.
**NB:** The incisor teeth and the tongue are not superficial because are not exposed by removing the skin but by the opened mouth.

### The alimentary canal

This shows greater differentiation into regions that of lower vertebrates. It consists of the month, esophagus, stomach, duodenum, ileum, caecum, colon, rectum and the anus.

**Drawing showing the alimentary canal of a rat and associated organs in situ**




**Structure in relation to function:**

**The mouth**

The mouth is small, cone shaped and ventrally located anteriorly/ on the anterior end of the head/ terminal or sub terminal in position ,below the nostrils, are bounded by a pair of soft lips ; a thin upper and lower lips. The upper lips pushed right in the centre to expose the teeth which are long, large, and curved in wards and it is said to bear a cleft /gap/harelip. The teeth that are exposed are two incisor which are protruding, large, chisel shaped, hard, long curved in wards and with sharp cuttings edge Each jaw has a pair of incisors and molars, the canine and premolars are absent. Dental formula of the rat is $\mathbf{I}\frac{1}{1}, \mathbf{C}\frac{0}{0}, \mathbf{PM}\frac{0}{0}, \mathbf{M}\frac{3}{3} = 16$

. Total number of teeth is 16. The lower incisors are longer than the upper incisors.

The buccal cavity. This is a region between the mouth and the pharynx.

It is supported by jaws both of which bear teeth.

The jaws of the rat are long and narrow with the upper jaw fixed and the lower jaw able to move sideways. Up and down even rotate to some extent during feeding. The teeth are 16 in total with no cainines and premolars. A gap where these teeth would have been, remains and is known as a diastema The upper incisors are more curved than the lower ones and are anterior to them. For this reason, the lower incisors bite inside the upper ones during feeding. The molar have several cusps the tips of which are free from enamel.

The tongue is very muscular and has a ridged and roughened surface. It is used to move food a bout in the buccal cavity to place it between the molar teeth. So that it can be chewed and to mix it with saliva. Its surface has numerous taste buds sensitive to various tastes. In the resting position the ridges of the cavity is virtually occluded. This prevents the inhalation of dust while growing. The palate separates the buccal cavity from the nasal cavities. The front part of the palate is supported by bone and is known as the hard palate, while the back part is of membrane only and form the soft palace. The edges the palate act acts as a salve to prevent food from going up the nose during swallowing.

Like the tongue, the palate has taste buds.

**Significance /function of the mouth**

The function of the mouth is for ingestion of food materials

**Adaptations**

- ✓ It is ventrally located on the anterior end of the head below the nostrils for easy ingestion of food materials.
- ✓ It is cone shaped with the sides of upper lips folded inside into the diastema for easy nibbling.
- ✓ The upper lip also has a cleft to the expose the incisors for nabbing/gnawing/cutting the food easily/biting the food.

- ✓ It has protruding sharp, chisel shaped, hard, long and curved in wards incisor teeth. Each jaw has one pair of incisors. The lower incisors are longer than the upper ones.
- ✓ Consist of the tongue, lips and teeth and the hard palate necessary for feeding.
- ✓ The tongue is elongated to suitably roll the food for swallowing.
- ✓ It is also broad to increase surface area that can expose more taste buds fro tasting food;
- ✓ The rough surface of the tongue and the hard palate facilitate manipulation of food to form a bolus that can be swallowed.

**BUCCAL CAVITY (ORAL CAVITY)**

**Procedure:** Use larger pair of scissors to cut at both angles separating upper and lower jaws, depress the lower jaw

| **Observable structures at the roof of buccal cavity** | **Observable structures at the floor of buccal cavity** |
|---|---|
| **Upper incisor teeth:** two, moderately long, curved, sharp top<br>**Upper molar teeth:** ridged, large surface area, 2 rows<br>**Anterior palate:** hard (bony), ridge, white coloured<br>**Posterior plate:** Soft, smooth, moist, red coloured | **Lower incisor teeth:** two, every long, curved, sharp<br>**Lower molar teeth:** ridged, large surface area , 2 rows<br>**Tongue:** Muscular, taper interiorly<br>**Epiglottis:** moist |

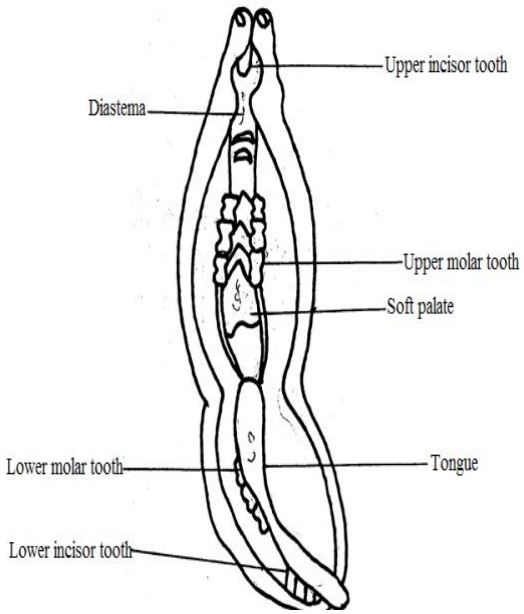
**TEETH OF RATS**

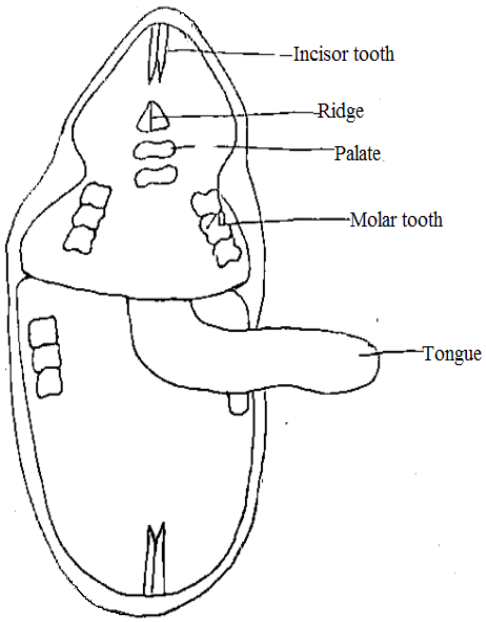
**Dentition: Heterodont** i.e. shapes of teeth differ greatly

**Description of rat's dental formula**

- Dental formula shows half the number of teeth in each jaw
- **Upper row:** upper jaw, molars are in two rows;
  Left 3, right also 3.
- **Lower row:** lower jaw, molars are in two rows; left3, rightalso3
- **Each jaw has:** 2incisors, 0canine, 0premolar and 6molars.
- **Total number of teeth:** 16
- Agap called the **diastema** separates incisors from molars.

**Drawing on roof of buccal cavity, ventral side uppermost.**




**How the features in the mouth are suited for the diet of a rat**

- Long tongue for easy rolling of the food during chewing.
- Long tongue for easy swallowing.
- Long tongue to increase surface area for rolling food.

- Broad/large tongue to increase surface area to expose the taste buds/ rolling the food.
- Sharp/ pointed incisors for easy cutting of food.
- Large/ broad/ many molars to increase surface area for the chewing/ grinding of food.
- Ridged molars for easy chewing / grinding of food.
- Hard plate for manipulation of hard/ course food.
- Wide/ broad diastema for easy movement of the tongue.
- Thick tongue for easy manipulation / movement/ rolling of food.
- Rigid palate for easy/ firm gripping/ holding of food.

**Snout**

The snout is sharp in the black rat./Rattus and blunt in the brown /white/albino/variegated rat.
In the brown/white/albino /variegated rat. Rattus norvegicus, and has no its sides a few long stiff sensory hairs called whiskers /vibrissae/sensitive hairs for sensitivity /sensing touch /tactile sensation /tactile organs serve for the sense for the sense of touch /burrowing/directing size/gauge the width of the burrow in its darkest depths.

**The Osophagus/gullet**

It is a long tube that leads through the neck and thorax to the stomach. It is muscular and lined with stratified epithelium internally.
Longitudinal folds close the lumen except when swallowing. At the distal end is a valve arrangement, the cardiac, which prevents regurgitation of food from the stomach

**Stomach**

It is a large white bean shaped /avoid /curved/ sac like situated behind the diaphragm slightly towards the wards left side of the animal /lying transversely across. The posterior part of the stomach which receives the esophagus is called the cardiac stomach whereas the part that joins the intestines is the pyloric stomach. The posterior part of the stomach is convex while the anterior part is concave in curvature.
The opening of the esophagus into the cardiac stomach is called aperture guard by the cardiac sphincter. The pyloric part of the stomach leads into the intestines by an aperture, the pyloric aperture guarded by thick ring like value called the pyloric sphincter.

- Both sphincters participate in the physical digestion of food as their smooth muscles contract and relax to release the food either in the stomach or in the duodenum.
- The cardiac stomach is proportionately larger than the pyloric stomach. Therefore it is suited for the temporary storage of food .Its inner surface is smooth and in addition its walls are elastic, muscular, transparent, and thin walled.
- It is smooth to reduce on friction.
- Elastic to accommodate enough food.
- Thin walled to easily stretch and accommodate enough food.
- It is muscular for peristaltic movement. There is low physical and chemical digestion in the cardiac stomach sine it is less glandular, and food appears more of solid.
- The pyloric stomach is proportionately smaller than the cardiac stomach .It is highly folded to increase surface area for secretion, muscular thick walled for the peristaltic movements, it is a region of great physical and chemical digestion and contents appear form of a watery paste called the chime

**Functions of the stomach**

The stomach acts as;

- A temporary store of food, giving chance for action of enzymes.
- A site of digestion of food.
- A site of absorption of digested food.
- A site of secretion of enzymes.

**Adaptations**

- The inner lining of the stomach is highly folded and smooth. The increase the surface area for digestion and absorption of digested food and also for secretion.
- The folds also allow extension of the stomach for increased storage of food.
- Smooth to reduce on friction.

- The stomach is elastic to accommodate enough food,
- It is muscular for peristaltic movements.
- The anterior end of stomach consists to form the cardiac sphincter which controls the inflow food of the chyme in duodenum.
- The stomach wall has many blood capillaries to increase the surface area for absorption of digested food.
- The stomach inner walls feel slippery because of screted mucus that protects stomach mucosa from the aggressive nature of both the protein digesting enzymes ad hydrochloric acid.

The stomach walls contain the gastric gland that secrete or release gastric juice and mucus. Gastric is rich in /contains proteolytic enzymes /proteases, pepsin and rennin also hydrochloric acid (HCL). The contains enzymes work best in acidic media therefore the PH of stomach of there is highly acidic with a PH 1.5-2.5, the action of these enzymes is inhabited by alkalines media.

The mucus protects the stomach mucosa from aggressive nature of both the proteases and hydrochloric acid.

**Note**; if you are told to crush the stomach wall in a motor using a pestle and make a filtrate, it used contains proteases and dilute hydrochloric acid.

**Small intestines**

The small intestine is differentiated between a U shaped duodenum and then the coiled jejunum and ileum. It is about 1- 1.2 metres long to increase the surface area for digestion and absorption of food materials.

**Duodenum**

It is a short tubular structure which bends into a U shape. It is the first part of the small intestine , it runs backwards , then turns in front forming a 'U" shaped loop, Between the two limbs of the duodenum found an irregular ,membranous ,pinkish gland called the pancreas .The function of the duodenum is used for digestion and absorption of food .From the pancreas, a pancreatic duct arises which is joined by the bile duct from the liver lobes open into the upper /proximal loop /limb of the duodenum to release bile and the pancreatic juice that enhance digestion of food.

Bile which is produced by the liver contains bile salts which are concerned with physical digestion of fats/liquids (emulsification of fats) and providing an alkaline condition for the action of digestive enzymes in the pancreatic juice. So the PH of duodenum is between 8-9.

The pancreatic enzymes work best in alkaline media and their action is inhibited by acidic medium.

**Ileum**

It is a very long greatly coiled tubular structure /organ made up thin wall, it is greatly attached to by many /numerous capillaries which are the tributaries /braches of hepatic portal vein. It is used for chemical digestion and absorption of digestion food. It is here that the final digestion and absorption takes place. The ileum wall contains glands that secrete enzymes like maltase, sucrose, etc. for digestion of food .It is adapted to function by;

- Having numerous blood capillaries to increase the surface area for absorption /it has a rich supply of blood vessels particularly the tributaries /factors/branches of branches of the hepatica portal vein which has transport the soluble products of digestion to the liver for metabolism.
- Having thin wall to ease diffusion of digested food.
- Being very long (has great length /elongated) and coiled increase the surface area for digestion and absorption of digested food materials into the body.
- Its wall is thin that reduces the distance of diffusion of materials into the bold stream.
- Contains inward folding called villi that increase the surface for absorption of large amounts of food materials.

**<u>Glands associated with the alimentary canal:</u>**

**1. The liver**:

It is the largest gland in the body.

It is below the lungs from the diaphragm by a double sheet of peritoneum which encloses the whole organ.

It is divided into five (5) lobes which include: from right to left;

- The caudate lobes which over laps the kidney.
- A right central lobe. ( contains the gall bladder)
- A left central lobe.
- A left lateral lobe.
- A small dorsal spigelian lobe.

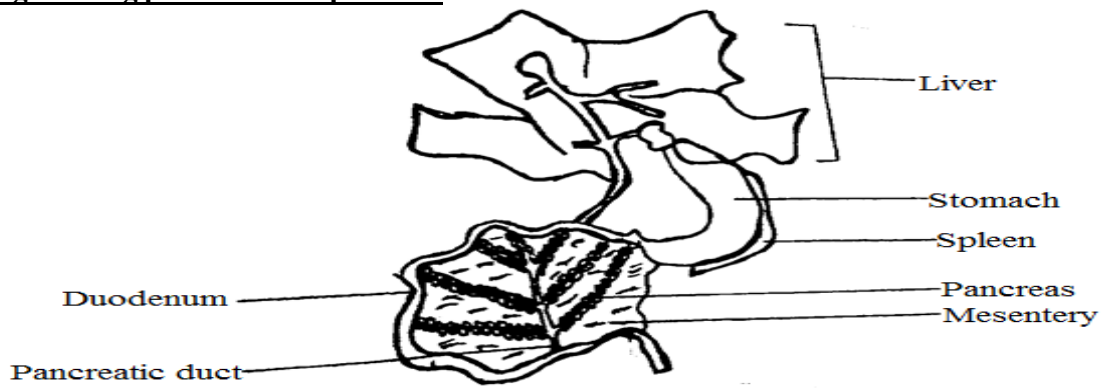
**Drawing showing the structure and position of the liver**

2. **The pancreas:**

This is an endocrine and exocrine organ that appears as small scattered masses of pink tissue, in the mesentery, between the loops of the duodenum.

Its ducts open into the duodenum, secreting pancreatic juice which contains enzymes that digest starch and fats, together with bicarbonate ions that makes the PH suitable for the enzymes to act.

**Drawing showing position of the pancreas:**




**Large intestine**

Differentiated into the caecum, colon and rectum

**Caecum**

It is a very small, short saclike portion of the alimentary canal lying between the ileum and colon .The caecum is responsible for cellulose digestion and absorption. Cellulose digesting bacteria and protozoa are present in the caecum. It is in association with cellulose secreting bacteria that secrete cellulose enzymes onto cellulose containing food chemical digestion.

The caecum terminate in (directly connected to) the smooth; thick walled bindly ending tube called the vermiform appendix which has no digestive role (appendix is an extension of the caecum with digestive food and it's not pass through the appendix therefore it is not used for chemical digestion of food and it is not part of the gut/alimentary canal.

**Colon**

It is a fairly short and elongated tubular section /portion of the alimentary canal. It bears longitudinal muscle bands the taeniae. The inner surface is smooth to reduce on friction due to secretion of mucus from crypts of lieberkuhn. It is primarily concerned with (used for) water absorption making the content to gradually solidify and also for storage wastes /feacal material.

**Rectum**

It is the last part of the alimentary canal. It gives beaded appearance due to presence of feacal pellets it. It is for temporary storage of the feacal matter/ unwanted material/ waste and also allow absorption of water to increase waste conservation and eliminating of undigested food/feace matter which is a waste product. Contraction of rectal muscles removes unwanted materials from the body. The inner surface has crypts of lieberkuhn which secrete mucus to reduce on the friction .The rectum opens to the extension through the anus.

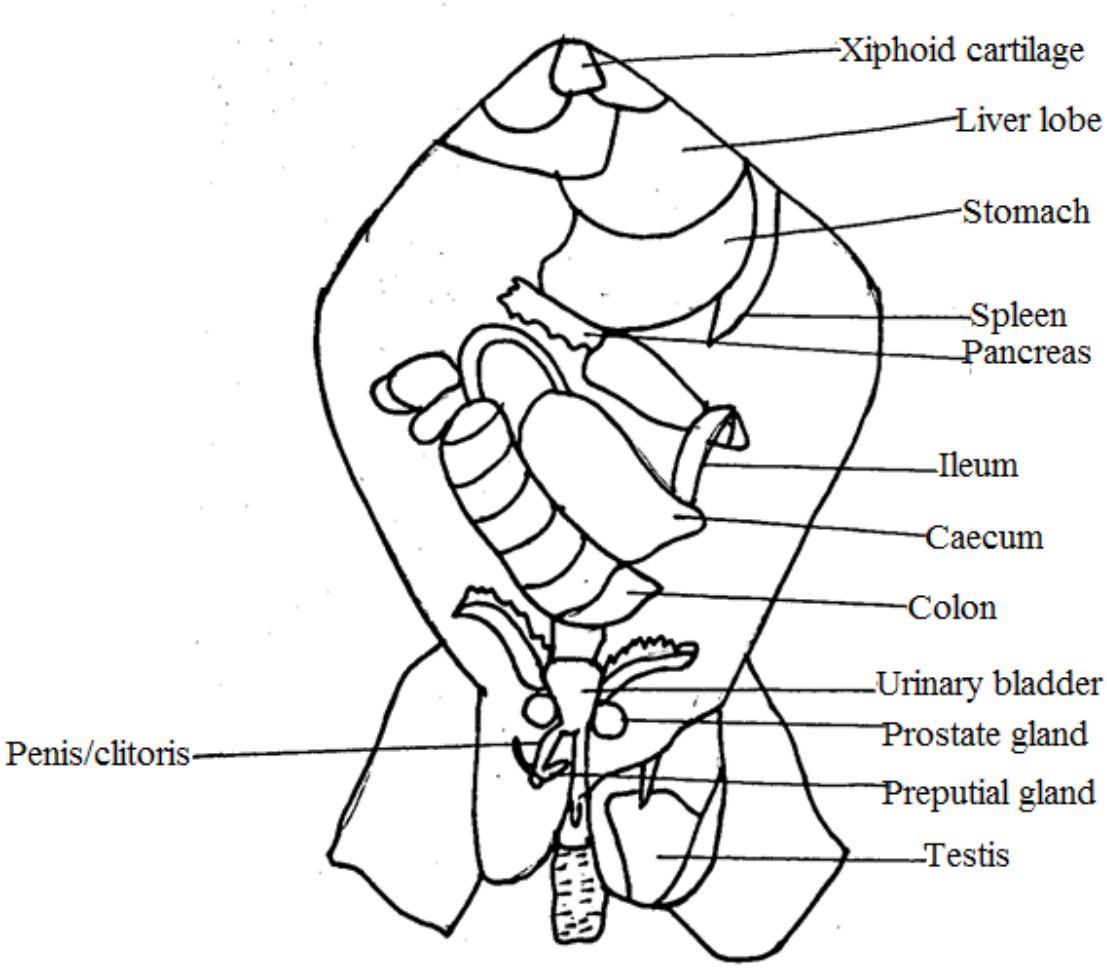
**Summary of abdominal viscera and the digestive system**

**Abdominal viscera:** structures observed on opening up the abdominal wall.

**Digestive system consists** of alimentary canal and accessory structures.
**Alimentary canal:** a tube in which food passes, and includes these parts: mouth, throat, esophagus, stomach, small intestines, large intestines, rectum and anus.
**Accessory structures**: The organs, glands and tissues whose activities enable digestion, e.g. by secreting fluids with enzymes but undigested food does not pass through them. They include: salivary glands, liver, gallbladder and pancreas.

| Part | Description of structure | Function |
|---|---|---|
| **Parietal Peritoneum** | -Very thin, shiny membrane, lines the inside of abdominal wall. | Protection of viscera |
| **Visceral Peritoneum** | -Very thin, shiny membrane covers the internal organs of the abdominal cavity. | Protection of viscera |
| **Mesenteries** | -Folds of the visceral perineums that attach the small intestine and colon to the posterior abdominal wall. | Keeps organs in place |
| **Liver** | -Large, dark brown organ, lobed, occupies much of the anterior portion of the cavity, suspended just under the diaphragm.<br>**The four lobes:**<br>(i) **Median or cystic lobe**-top most, has central cleft<br>(ii) **Left lateral lob**- large, partially covers the stomach<br>(iii) **Right Lateral lobe**-Partially divided into anterior and posterior lobules, hidden from view by the medium lobe<br>(iv) **Caudate lobe**- small, folds around the esophagus and the stomach, see most easily when stomach is raised | Manufactures bile, Regulates food in blood e.g glucose. Remove toxins, stores ions and vitamins. |
| **Gall Bladder** | -The rat does not have a gall bladder. | |
| **Stomach** | -Curved, bag-like organ, lies below the diaphragm. | Physical digestion by churning food.<br>Chemical digestion by secreting digestive enzymes e.g. pepsin |
| **Esophagus** | -Muscular tube, passes through the diaphragm, empties food into stomach | |
| **Small intestine** | -Composed of three major parts. The stomach empties its contents into the first.<br>Section of the intestine called the **Duodenum.**<br>The **ileum** is the terminal.<br>Section of all the small intestine that connects with the cecum. The middle section. | |

**Drawing showing structures lying posterior to the diaphragm without displacing any organs of a rat**




**The respiratory system**

Air passes through the nostrils where it is filtered by the nasal hairs and warmed and moistened by its passages through the turbinal epithelium and narial passage. It enters the phrynx, where excepted during swallowing, the glottis is open.

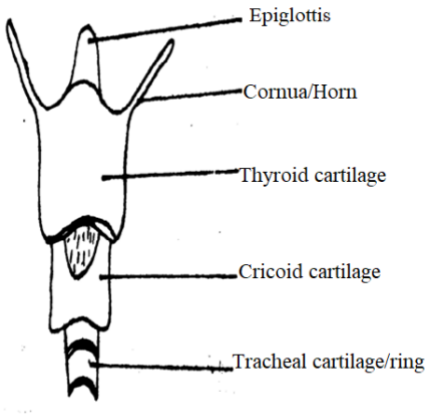
The larynx and the trachea are kept open by cartilages which in the case of the larynx are the **thyroid, cricoids** and **aryteniod** cartilages. In case of the trachea, the cartilages are a series of rings incomplete dorsally, the defect being closed by **trachealis muscle**.

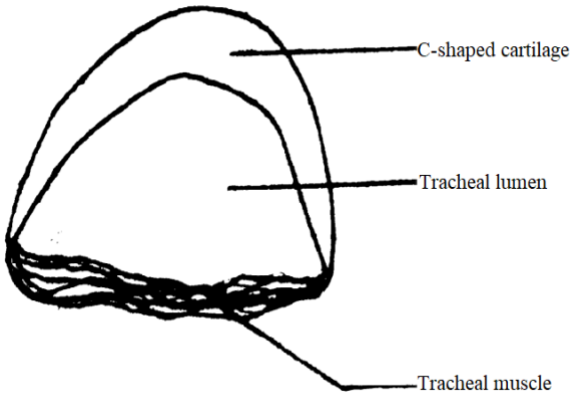
**The trachea of the rat is** Cartilaginous, Ringed, Open / hollow/ tube like, Cylindrical and Contains **c**-shaped cartilage rings ventrally and smooth trachealis muscle dorsally

**The trachea is adapted to its function**

- Ringed or having rings of cartilage to keep it open for easy passage of gases or for support/ strength.
- Being hollow ventilation /air passage.
- Having muscle connection between the cartilage for flexibility.
- The trachea is rigid to keep it open or support it in place.
- The trachea is cartilaginous with intervals of non –cartilaginous rings for its flexibility/ support strength.
- It is hairy inside to trap dust particles of or germ to reduce infection.
- It is tubular or hollow to allow air passage or for support.
- It is ringed to keep patent/open to allow air passage or for support.

**Drawing showing the structure of the larynx** **Structure of the cartilage ring**




**Relation to function:**

- The trachea is rigid to keep it open / support it in place.
- The trachea is cartilaginous with intervals of non-cartilaginous rings for its flexibility.
- The trachea is ringed to keep patent/ open.
- The trachea is tubular to allow air passage.
-

**1. Lungs**

**Structure and appearance**

Lungs are soft / sponge-like.

Red/pink in co lour.

Consist of numerous air sacs.

**Relation to function**:

- Softness / sponge-like nature allow easy distention with air.
- Red/pink co lour indicates rich blood supply, implying rapid/efficient gaseous exchange in the air sacs.
- The numerous air sacs increase surface area fore for gas exchange.

2. **Diaphragm**

**Shape and structure:**

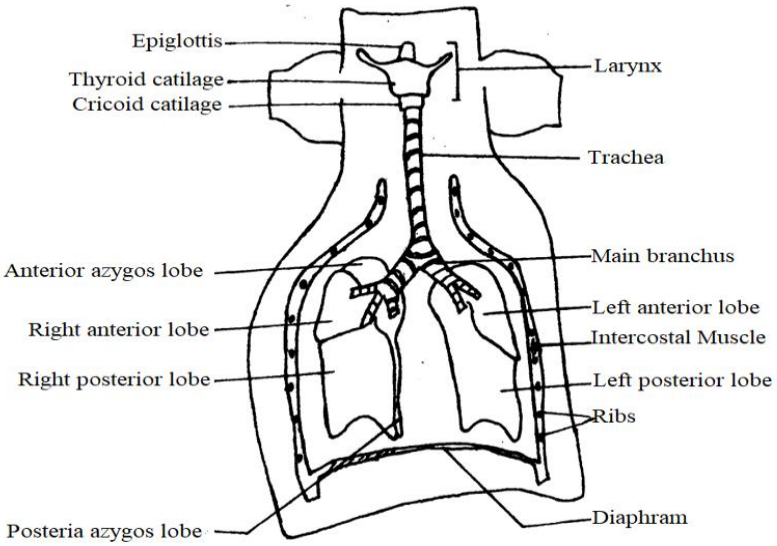
- Dome- shaped.
- Have a central tendon and a peripheral muscular position.

**Relation to function:**

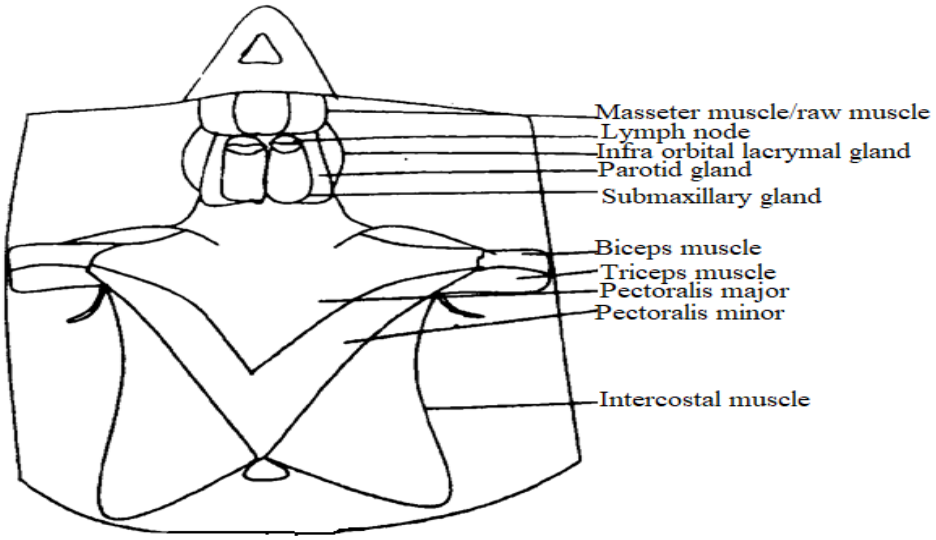
- Contraction of peripheral muscles flattens the dome, increasing volume of the thorax (decreasing thoracic pressure) to allow air into the lungs.
- Relaxation of the muscles creates a dome shape that reduces volume of the thorax, pushing air out of the lungs.

**Drawing showing the general structure of the respiratory organs of the rat in situ**

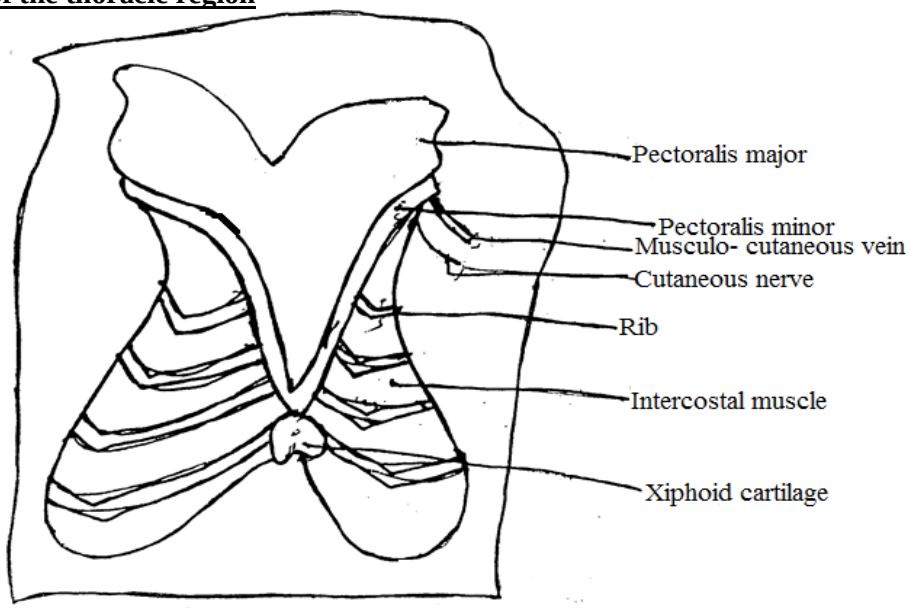
**General structure of the respiratory organs of a rat in situ**



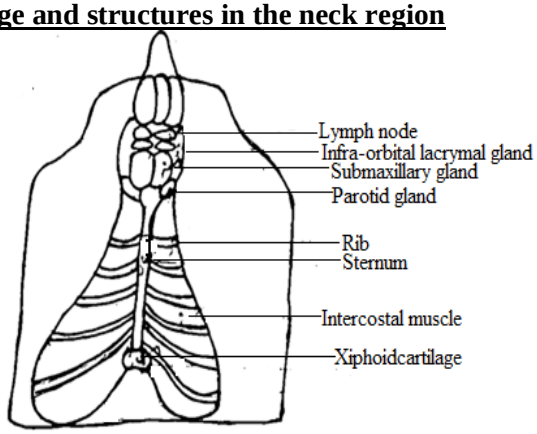

**A drawing showing the superficial structures of the neck, thoracic region and lower head region of the rat**



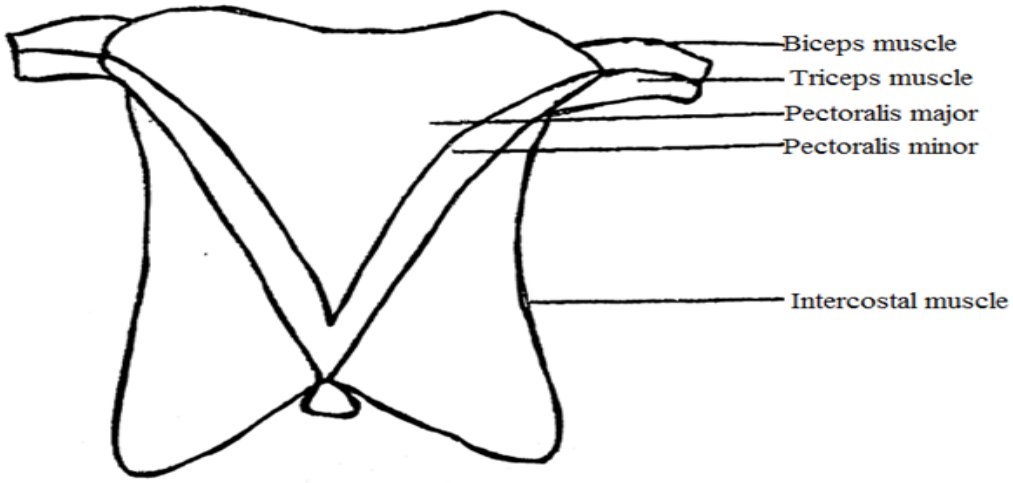

**Structures of the thoracic region**



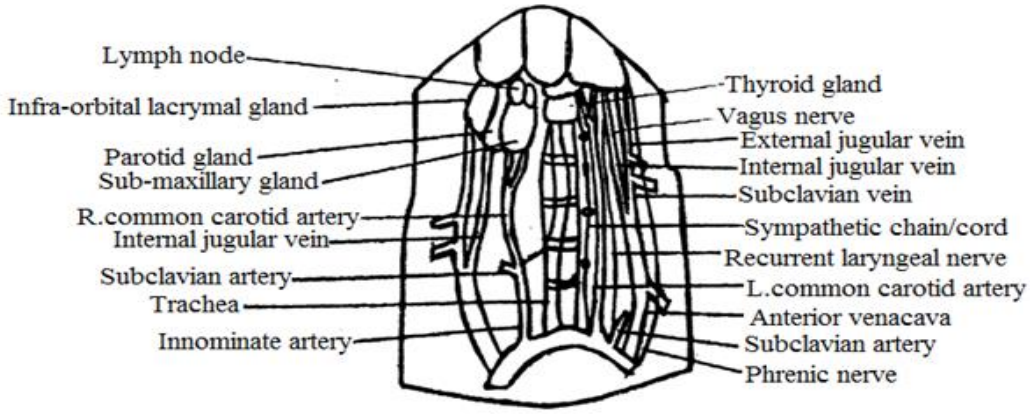
**Drawing showing the rib cage and structures in the neck region**



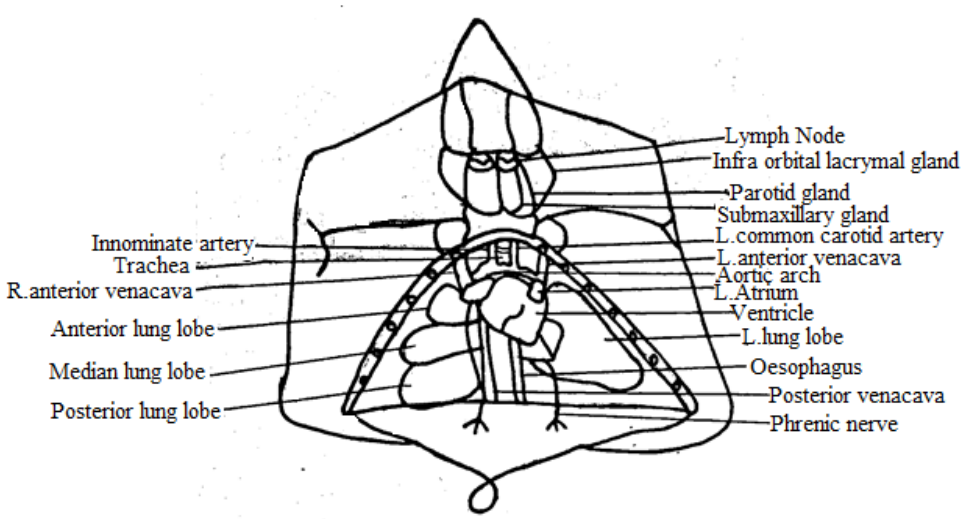

**A drawing of muscles of the thorax and forelimbs up to the elbows**



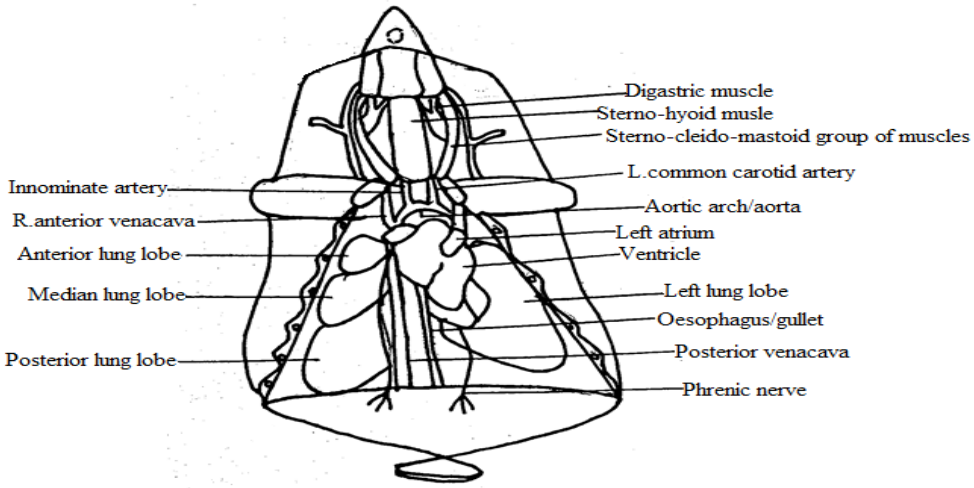

**Drawing showing structures in the neck region and accessory structures**



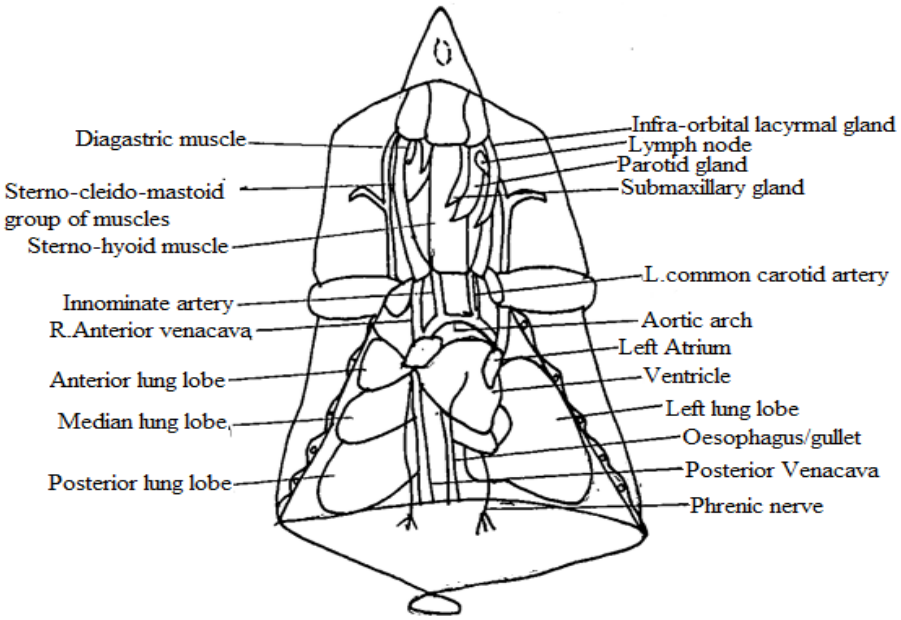

**Drawing of glands in the neck region/ throat region and visible structures enclosed in the thoracic cage after removal of thymus gland of a rat**



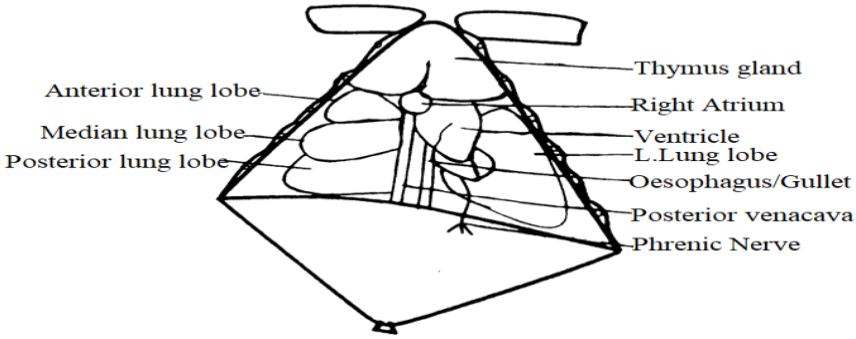

**Drawing showing muscles in the neck region and structures in the thoracic region in undisturbed state with the thymus gland removed of a rat**




**Drawing showing**



**Drawing of the structures in the thoracic region of a rat in undisturbed state/situ**




## THE BLOOD VASCULALAR SYSTEM:

It contains of arterial and venous systems. Arterial system consists of vessels that supply the body tissue and are called arteries. Venous system consists of vessels draining the body tissues back to the heart. In the rat, there is a double circulation as it is in other mammals with the heart at the centre of the system. There is;

- A **systemic circulation**, which supplies and drains all parts of the body except the lungs.
- A **pulmonary circulation** supplying and draining the lungs.

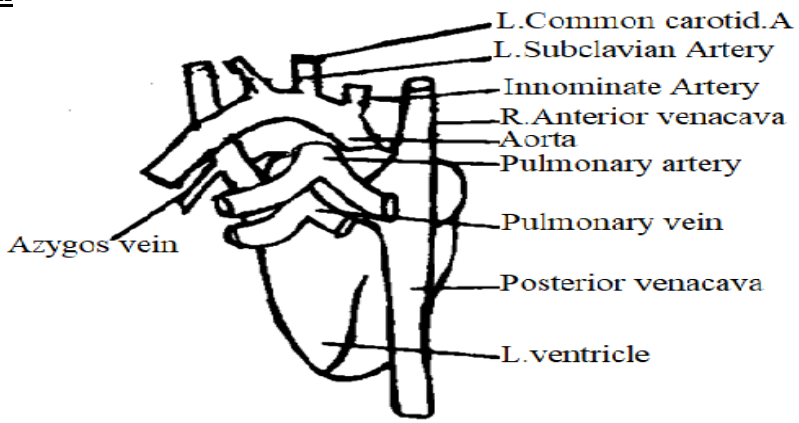
**The heart and great vessels**

**Position and shape**

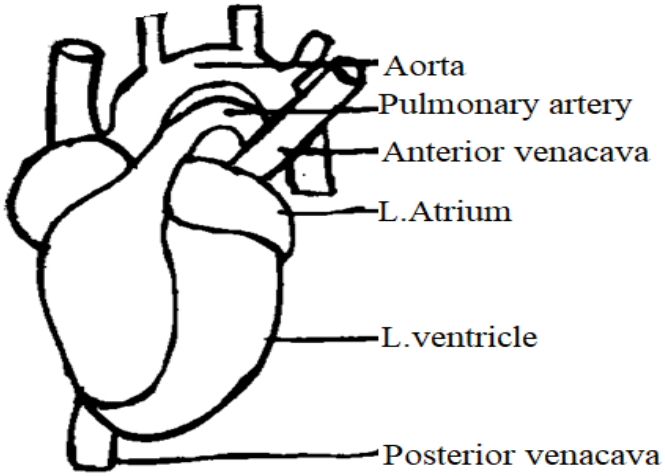
The heart lies ventrally in the thorax. It is **pear shaped,** with the apex posterior and tilted to the left and the base, anterior, giving way to the origin of the great vessels.

The heart is divided into 4 chambers with the ventricles appearing much a strong force in pumping blood

**Drawing of the ventral view of the heart and associated blood vessels with lungs removed from the thoracic region**




**Dorsal view of the heart and associated blood vessels after the lungs have been removed**

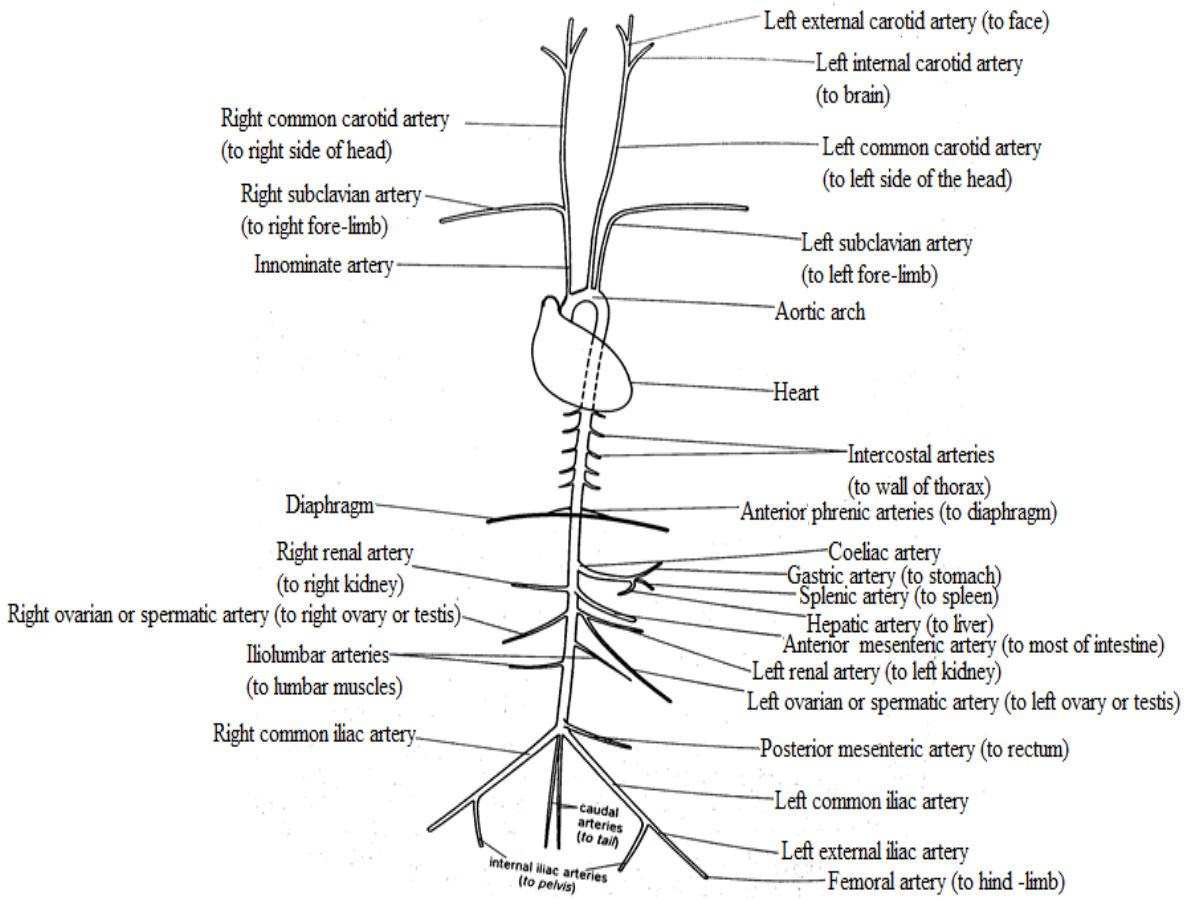



**Anterial blood supply to the different body parts**

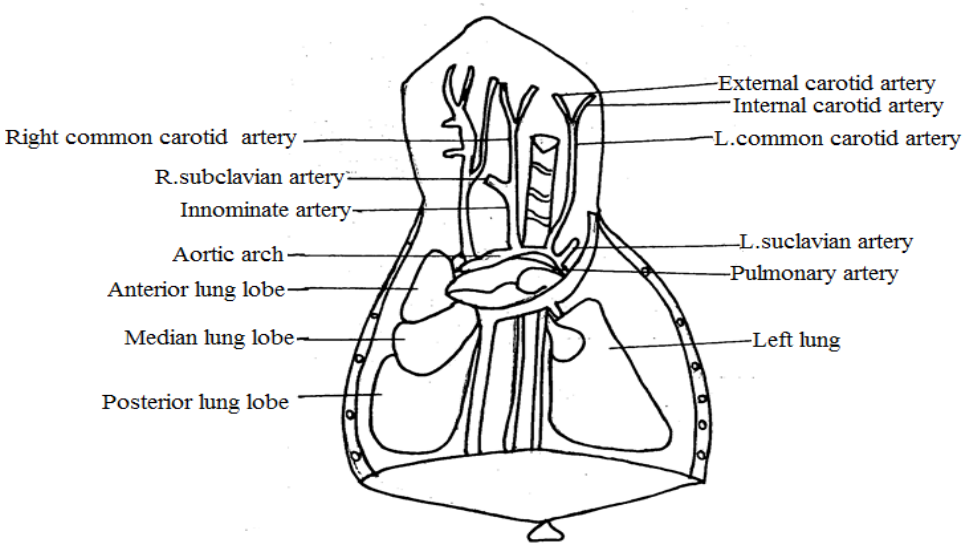
**Vessels supplying the thoracic, neck and head regions**

The aorta from ventricle of the heart, braches into three arteries, i.e the innominate artery on the right, left common carotid artery and left subclavian artery.
Innominate artery divides into the right subclavian artery and right common carotid artery. The subclavian artery turns into the right axillary artery after giving off intercosatl and vertebral artery.
The axillary artery divides into brachial artery supplying the arm and cervical arteries supplying the muscles and the neck vertebrae.
The **right common carotid artery** divides into the internal carotid artery and external carotid artery.
The internal carotid artery supplies the brain and the deep region of the head and external carotid artery supplies the external parts of head.
The **left common carotid artery** extends directly from the aortic arch and then forks into internal carotid artery and external carotid artery.
The left subclavian artery divides like the right subclavian artery which serves the fore arm via the thoracic cavity structures in situation and respiratory tract of a RAT
The aortic arch continues down beneath the left anterior venna cava to supply the organs posterior to the heart. It also gives off numerous intercostals arteries that supply the intercostals muscles.
From the right ventricle, arises pulmonary artery which supplies the lungs.
The vessels supplying the thoracic region are; aorta, innominate artery, subclavian arteries, vertebral arteries, and cervical arteries.
The right and left common carotid arteries divide into internal and external carotid arteries that supply the head.

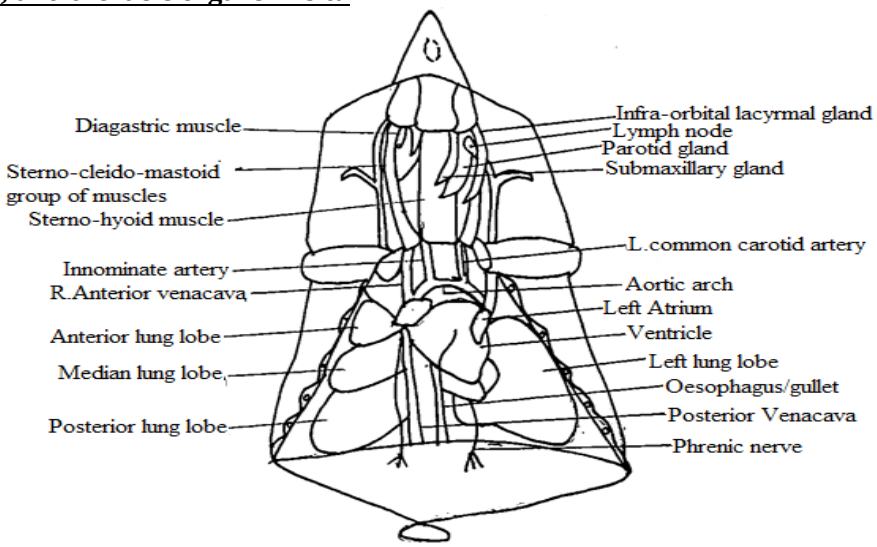
**Aterial system**




**Drawing of blood vessels supplying the thoracic, neck and head region including thoracic cavity structures in situ with the heart displaced to the right**




**Drawing showing superficial strauctures in the neck, heart displaced to the right with its main blood vessels, and thoracic organs in situ**




**THE BLOOD VESSELS THAT DRAIN THE THORACIC, NECK REGIONS, AND HEAD REGION**

The main large one vessel, the vena cava, draining into the right atrium, divided into the vessels.

- The posterior vena cava, draining into the right atrium, divided into three vessels.
- The right anterior vena cava draining the right side of the thoracic, neck and head regions.
- The left interior vena draining the left thoracic, neck and head regions.

The vessels draining thoracic region are; posterior vena cava, pulmonary vein, left and right anterior vena cava, subclavian veins, axillary veins, and cephalic veins and Azygos vein.

The cephalic vein drains the arm and shoulder region.

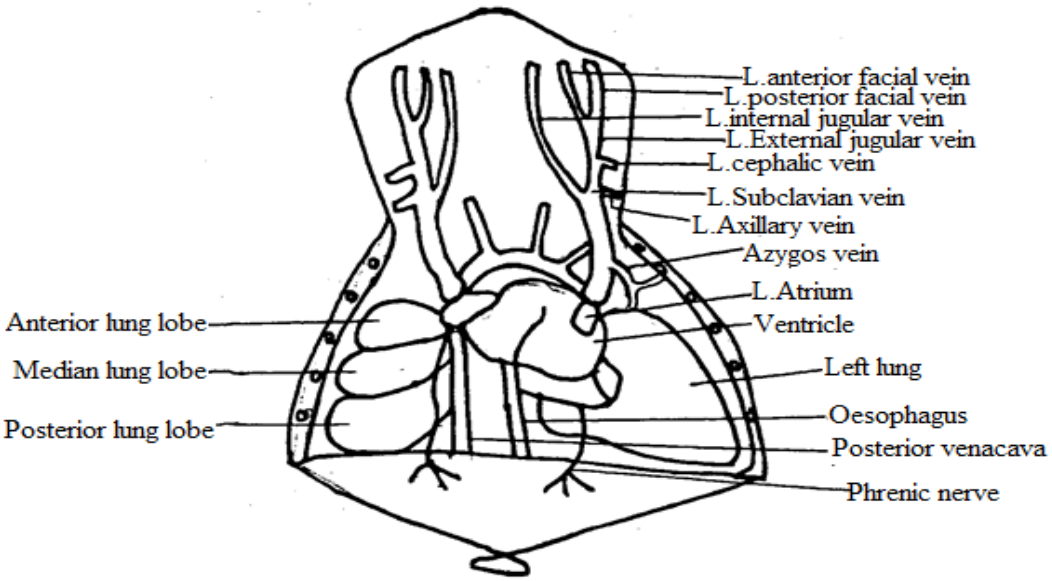
The axillary vein drains the armthrough branchial vein and the arm pit, and

The Azygos vein occurs on the left side of the thorax only and draws blood from both sides of thorax.

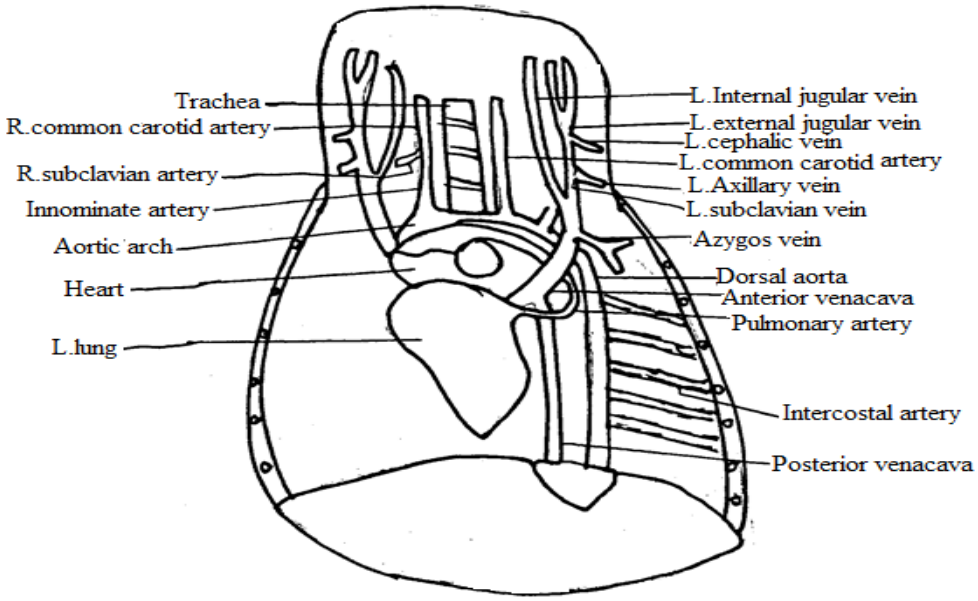
The vessels draining the neck region are; left and right anterioir vena cava, subclavian veins external jugular veins, and internal jugular veins.

Posterior facial vein drain blood from the head, the anterior facial veins drain blood from the internal parts of head and posterior facial vein drains blood from the external parts of the head.

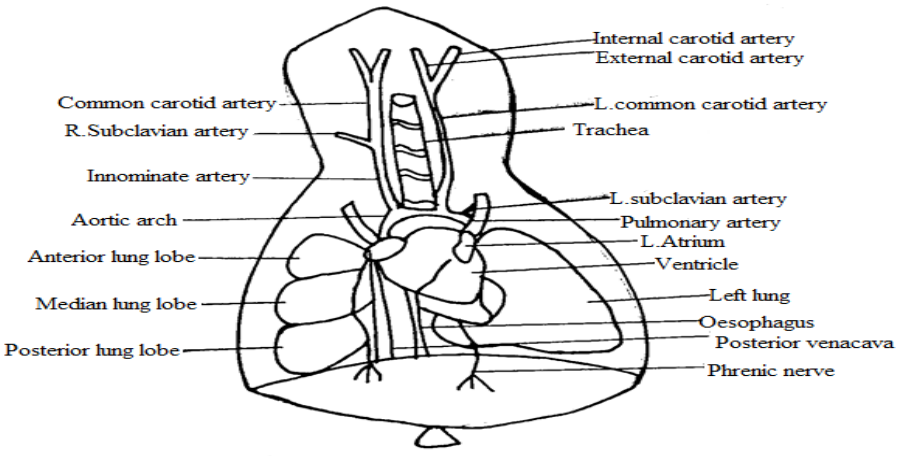
**Drawing showing blood vessels draining head, thoracic region and structures in thoracic region in undisturbed state**

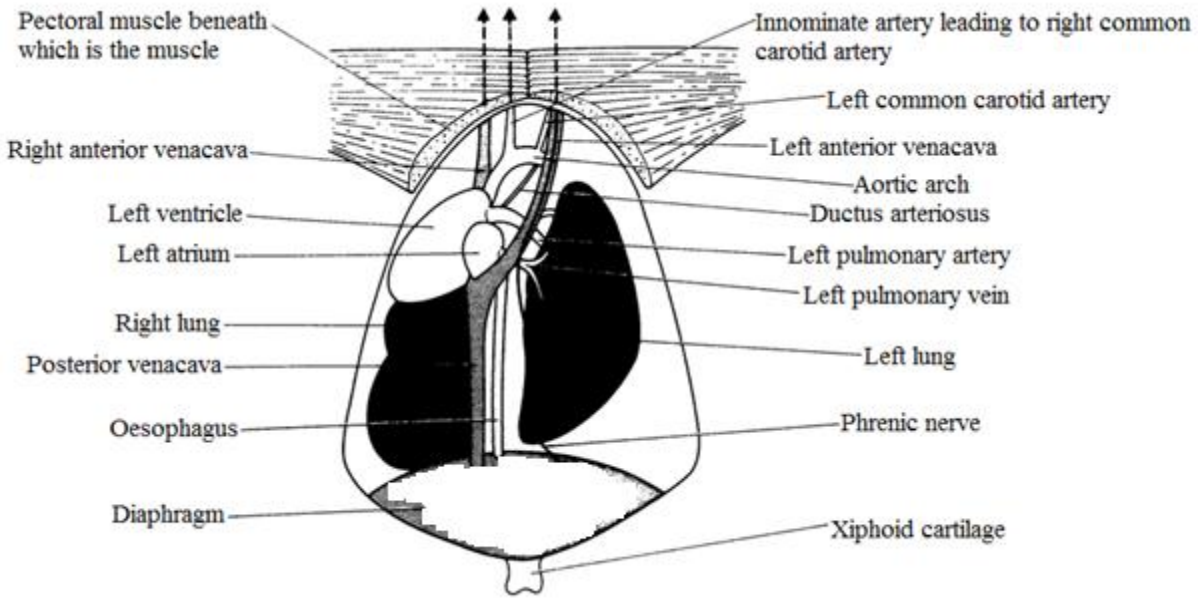



**Drawing showing structures for ventilation and blood circulation in the regions anterior to the diaphragm with the heart and left lung displaced to the right of the rat**

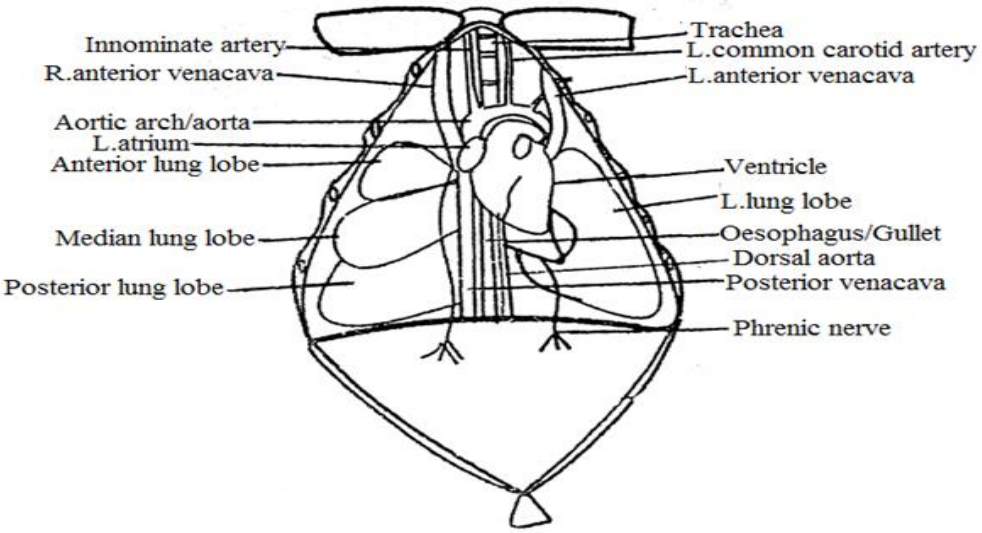



**Drawing showing the structures for blood circulation and ventilation in the regions anterior to the diaphragm without displacing the heart after removing the rib cage, shoulder and neck muscles of the rat**

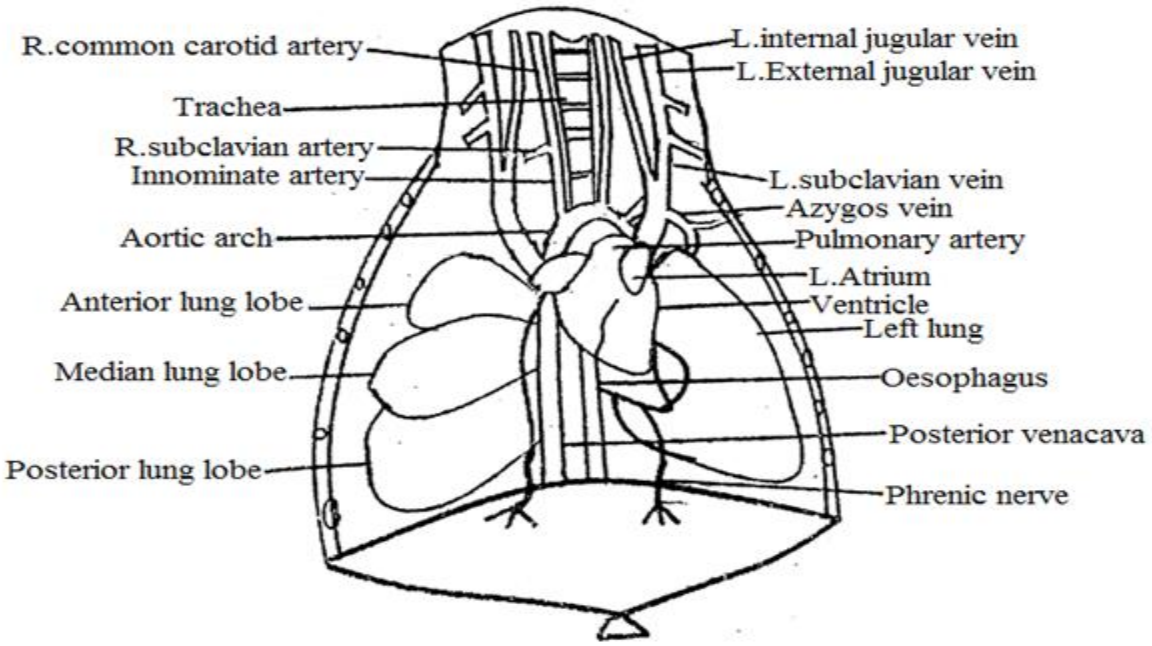





**Drawing showing structures in the thoracic region in undisturbed state and major blood vessels from the heart after the thymus gland has been displaced/ removed**

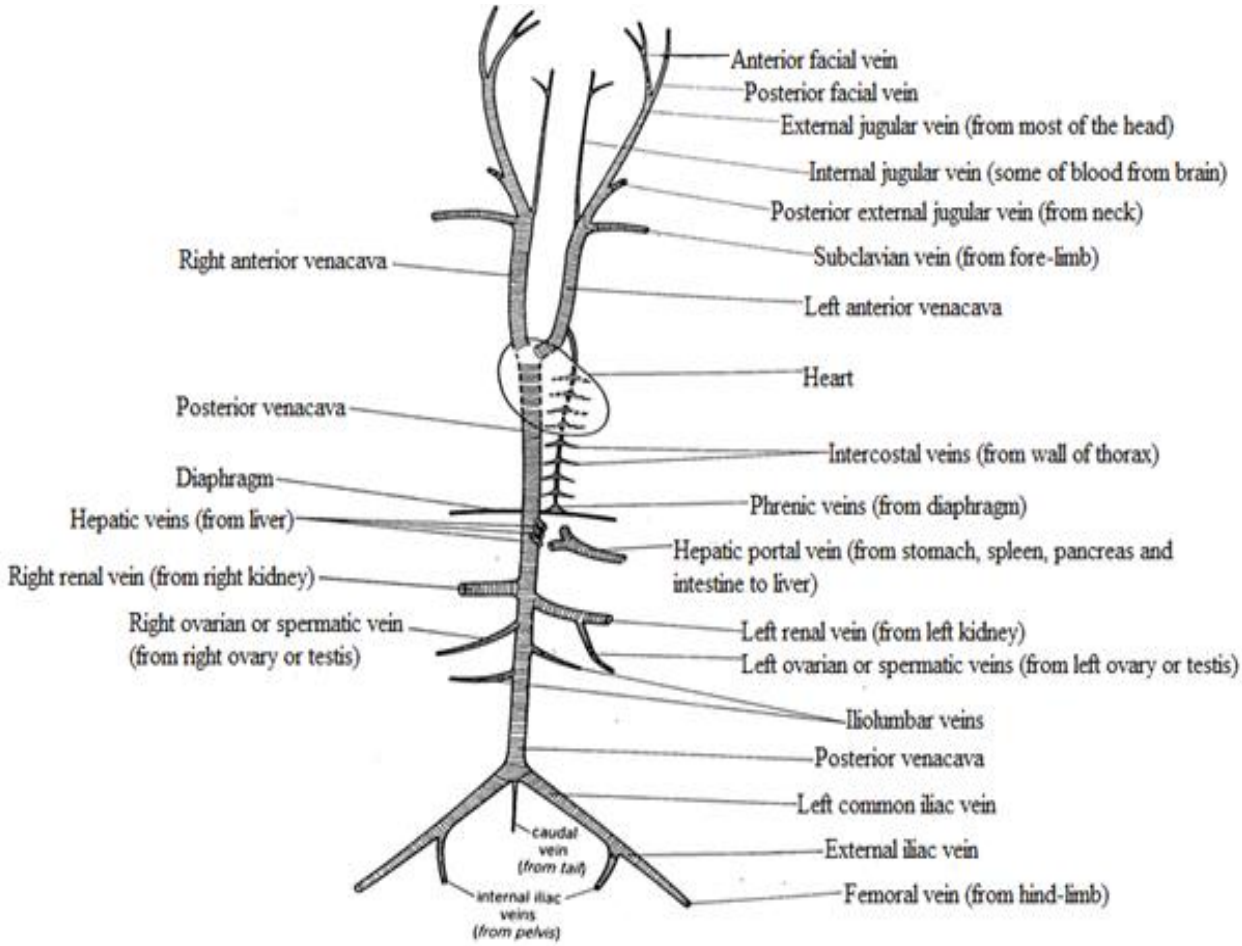



**Drawing showing structures involved in the movement of substances in the thoracic and neck region with the heart in undisturbed state**




**VENOUS DRAINAGE**

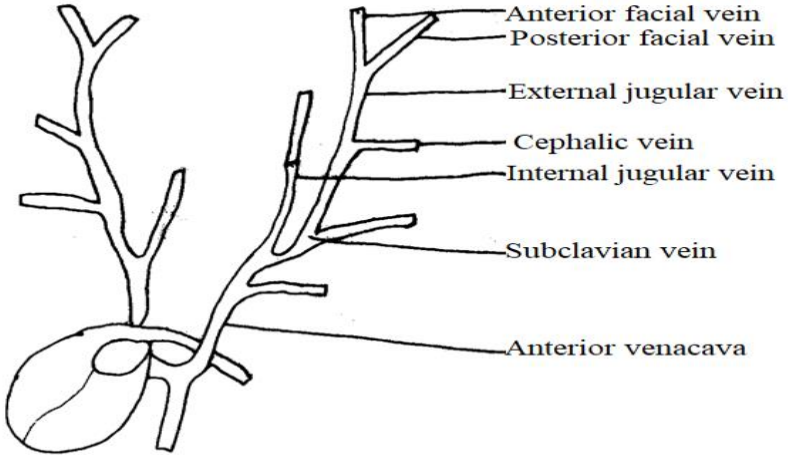
**Venous system**



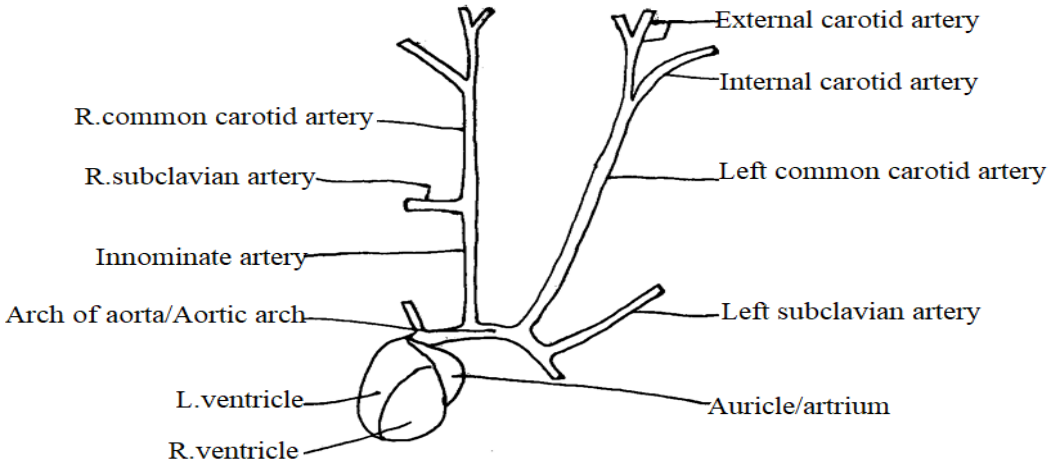

(A) Head, Neck and the fore limbs:

Blood from the head, neck and fore limbs returns to the heart via the left and right anterior vena cave with different tributaries as shown below.

**Blood vessels that return/drain blood from the head, neck and fore limbs back to the heart**




**Blood vessels that supply the head, neck and fore limbs of a rat**




(B) **The alimentary canal**:

From the alimentary canal, blood full of nutrients passes via the hepatic petal vein through the liver to the posterior vena cava via the hepatic vein to the heart.

The hepatic portal vein has several tributaries that collect blood from different parts of the alimentary canal. They include.

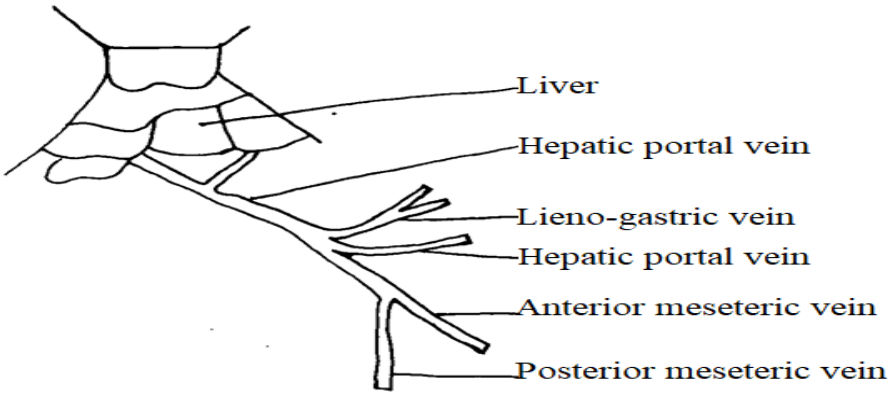
(i) **Lieno- gastric vein –** drains the stomach and spleen.

**(ii) Duodenal vein** – drain the duodenum.

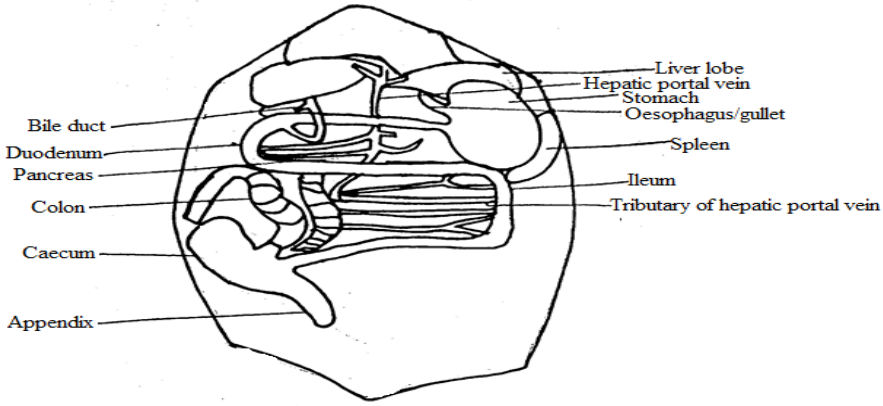
(iii) **Anterior mesenteric vein–** drains the intestines and pancreas.

(iv)**Posterior mesenteric vein** – drains the rectum and large intestine.

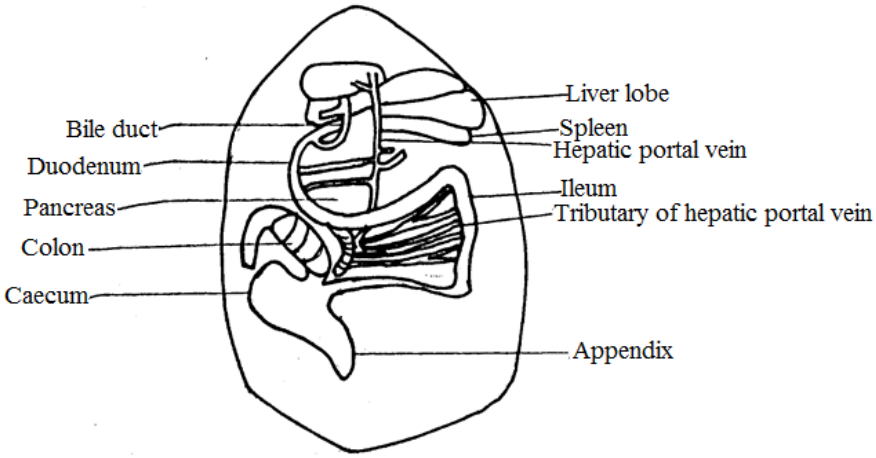
**Blood vessels that return blood froom the alimentary canal and accessory glands back to the heart**



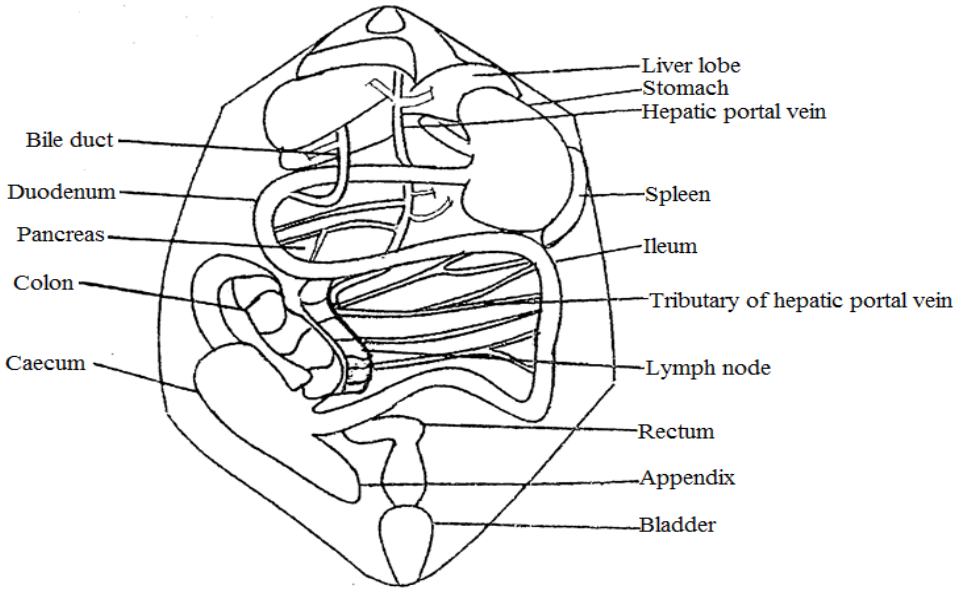

**Drawing of the alimentary canal and associated organs with the duodenum loop displaced to its right and ileum displaced to its left without destroying the mesenteries.**



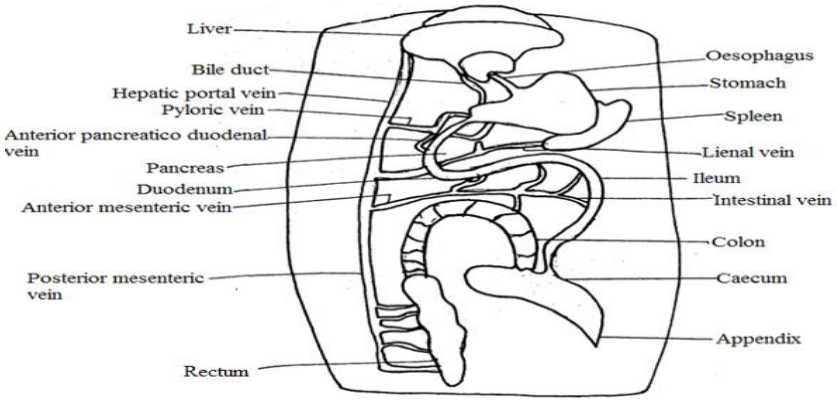

**Drawing showing the structures in the abdominal region without the stomach, with duodenum loop displaced to the right, ileum to the left, colon and rectum downward to the right and liver lobes displaced anteriorly of a rat**



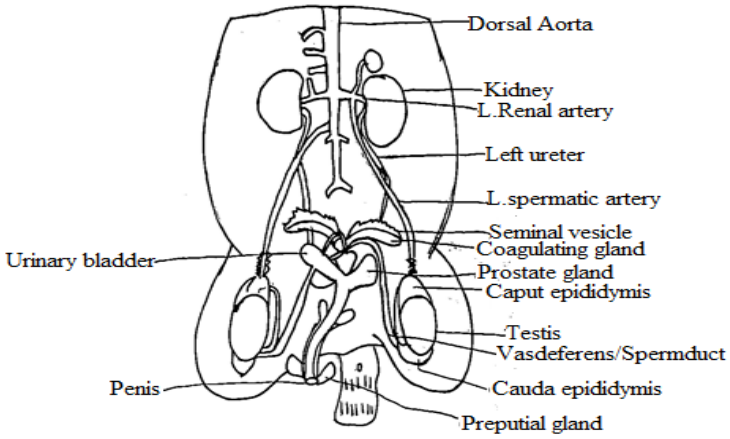

**Drawing showing abdominal structures after displacing the duodenal loop to the right with bulk ileum to the left side the colon and the caecum down wards to the right with the liver lobes displaced anteriorly**




**Drawing showing blood vessels draining digestive system of a rat**

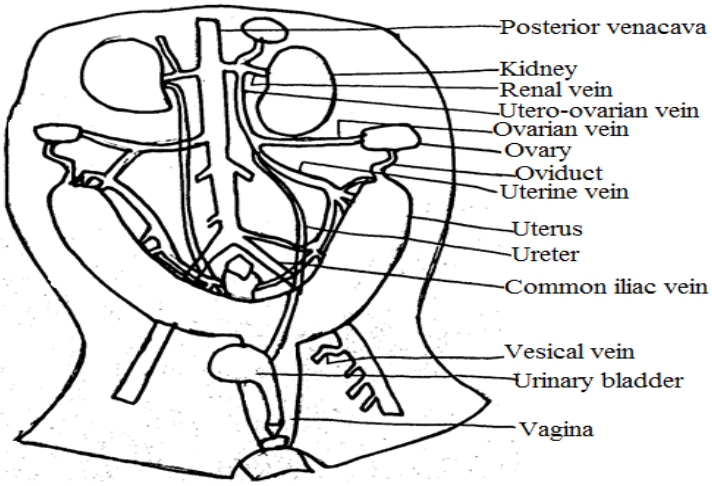



**Drawing showing blood vessels that supply the superficial system of a male rat**

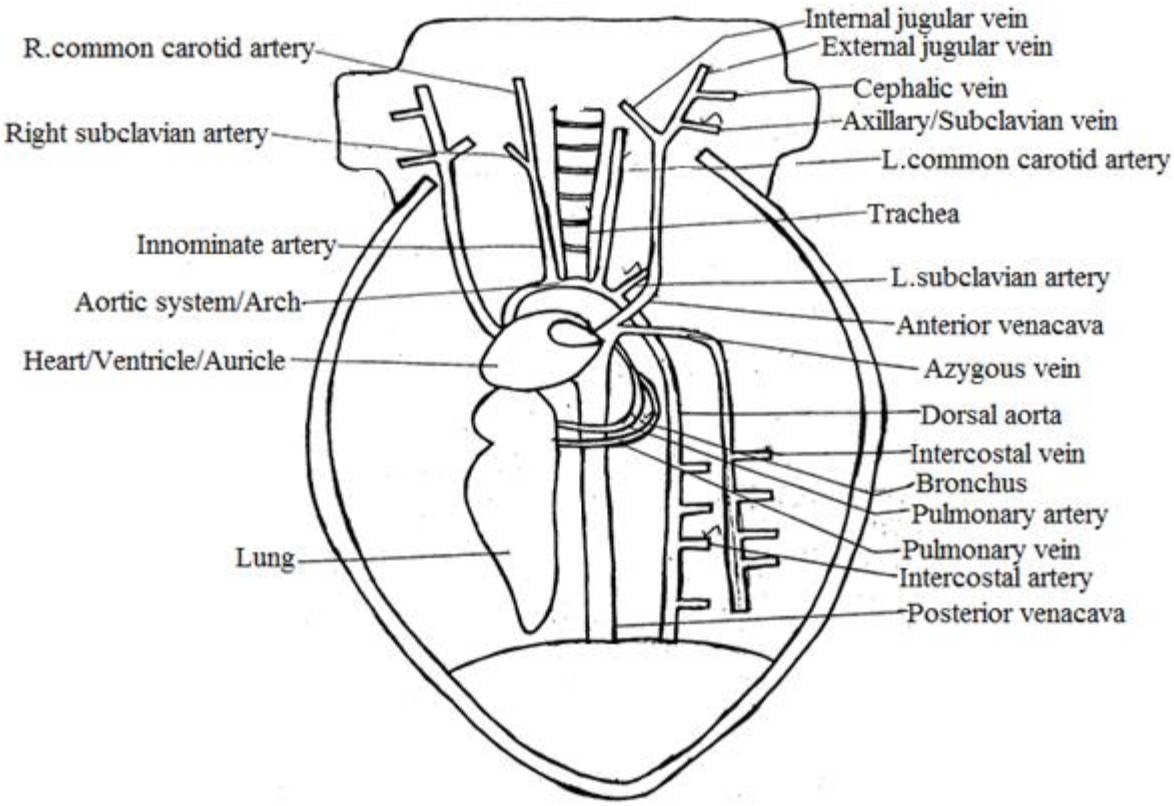



**Drawing showing the stomach and structures previously below it after returning and pulling the right of the rat**

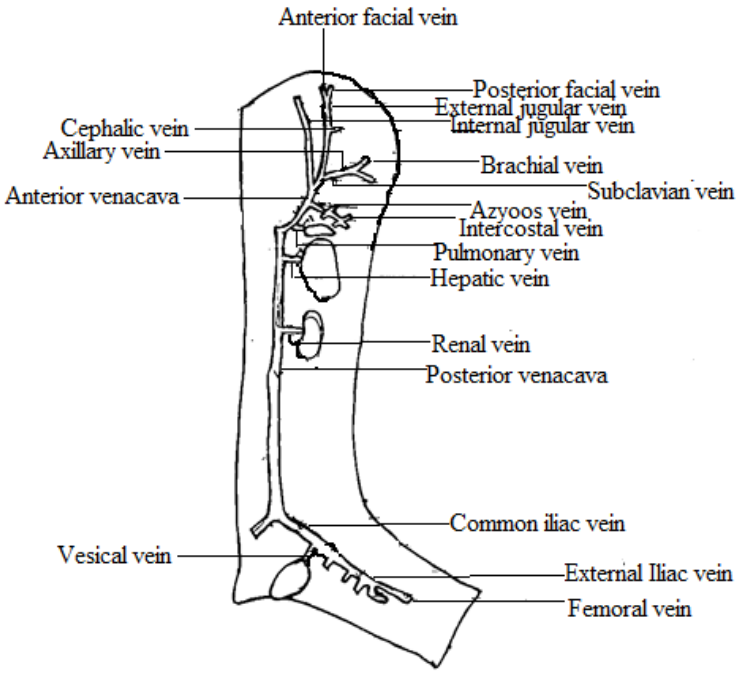

**Drawing showing blood vessels draining the urinogenital system of a female rat**



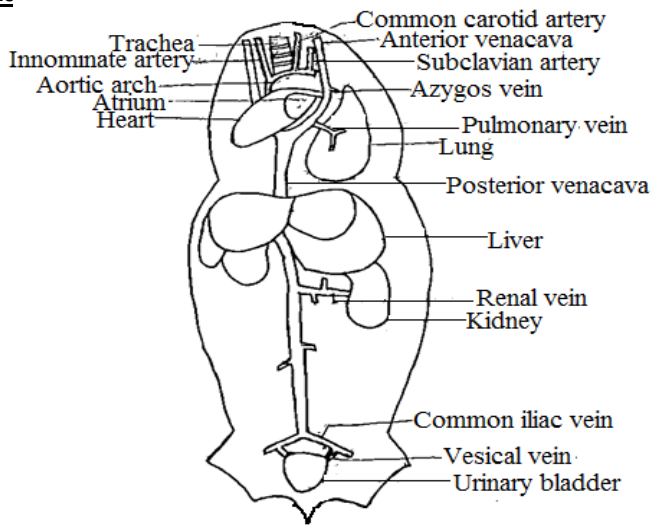

**Drawing showing the circulatory and respiratory system within the thoracic and lower neck region of a rat**



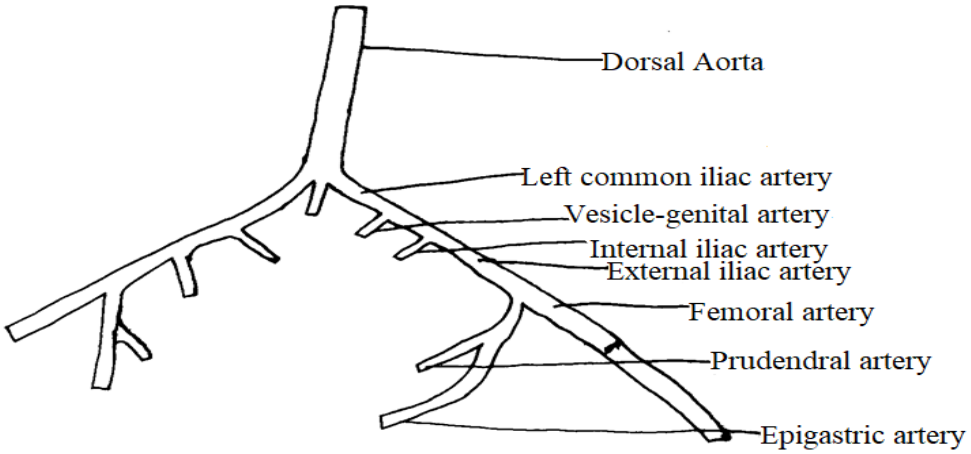
**Drawing showing blood vessels returning blood to the heart from the structures used for excretion, left hind limb, left head region, left thoracic region and left fore limb excluding the heart**



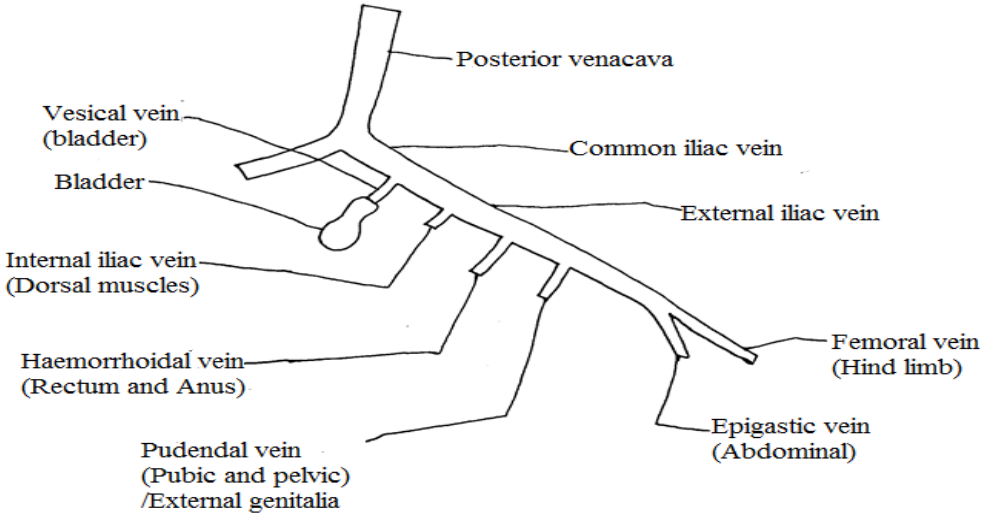

**Drawing showing structures anterior to the heart, vessels draining blood from left thoracic region and visible vessels within abdomenal region and those draining blood from urinary structures back to the heart displaced to the right with the alimentary canal, diaphram and thymus gland cut out**



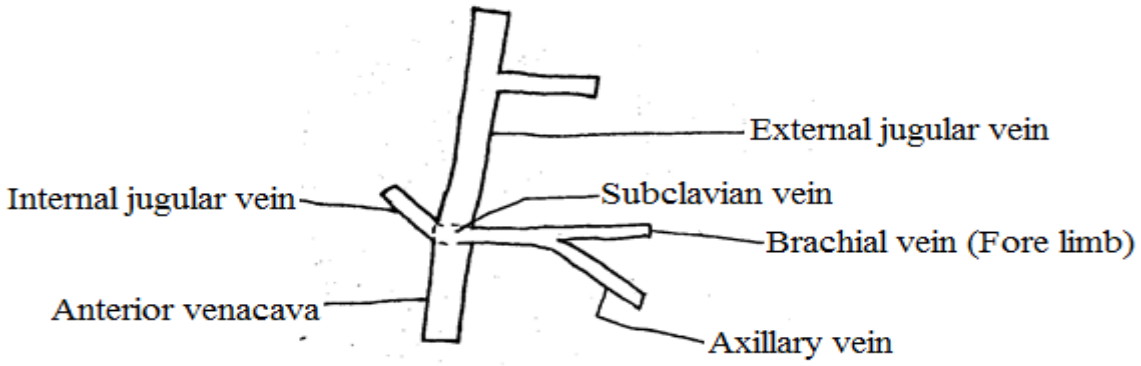
**Blood vessels that supply the hind limbs and the groin**



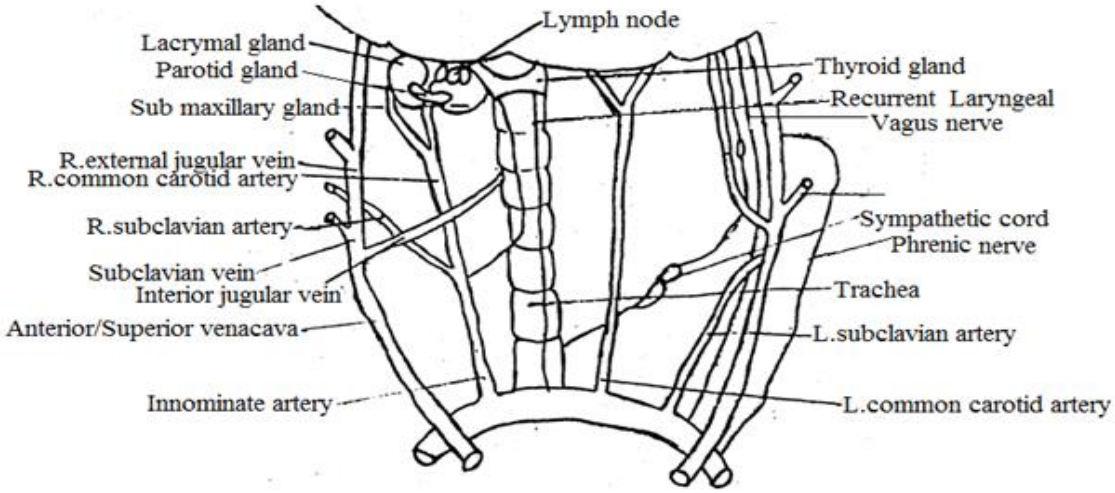

**Drawing showing blood vessels draining the hind limb, pubic, bladder and dorsal muscles of a rat**




**Drawing showing blood vessels draining the fore limb, head region of a rat**




**Drawing showing structures in the neck region**




**NB**:

- In a rat the left utero – ovarian vein branches from the renal vein.
- Right utero – ovarian vein branches from the posterior vena cava
- Right ilio – lumbar vein is below the left ilio – lumbar vein.
- Azygos vein drains the chest from the inter coastal vein. The left lung obstructs the azygos and inter coastal vein.
- The pinna trap sound waves not collect sound waves.
- When you displace the lung you see the azygos vein and when undisplaced you see the pulmonary vein. Pulmonary vein just touches the anterior vena cava.

2. **The musculature**

The study of the musculature of the rat which should include a detailed outline of the origins insertion and functions of all the rats' muscles is beyond the scope of this book and the "A" level syllabus.

It is therefore sufficient to mention a few important muscles and their functions as shown in the table below. The rest of muscles as shown on the diagrams below the table for purposes of appreciation their location

**To expose the musculature:**

(i) Place the animal, ventral side upper most, on a dissecting board.

(ii) Fix pins through the waist and stretching the body as much as possible fix pins through the ankles.

(iii) Pinch the skin in the centre of the abdomen.

(iv) Cut with scissor making a median incision upwards to the top of the thorax and down to the tail holding the skin and muscular body wall as far as possible.

(v) Pin the skin on either sides.

**MUSCULAR SYSTEM**

**Superficial muscles of the ventral surface of the rat**

| **Region** | **Muscles and their functions** |
|---|---|
| **Head and Throat** | **Master:** mastication (chewing) |
| | **Digastric:** opens the mouth. |
| | **Mylohyoid:** raises floor of mouth. |
| | **Sternohyoid:** pulls the hyoid towards the sternum. |
| | **Ternomastoid:** rotates the head |
| **Chest and foreleg** | **Pectoralis major:** -It is large, triangular covers the upper thorax. pulls arm towards the chest |
| | **Pectoralis minor:** -It is partly covered by pectoralis major. Pulls arm towards the chest |
| | **Biceps brachii:** -It is large, located on inside of the upper Flexes (bends) lower arm. |

**Epitrochlearis:** -It is a flat, thin, at medial surface of upper arm.
extends lower arm
**Triceps brachii:** extends lower arm
-Has three heads.
-Runs between the scapula and radius and ulna.

**Shoulder and lateral of fore leg.**
**Clavotropezius:** Pulls the clavicle forward.
**Latissimusdorsi**: Pulls the arm downward.

**Abdominal muscles**
**External oblique**: compresses and holds internal organs of abdomen in place
**Rectus Abdomin is:** compresses and holds the internal organs of abdomen in place.

**Hip and Medial Muscles of Hind leg**

**Gracilis:** pulls the thigh in wards.
**Rectus femoris:** extends the lower hind leg
**Vactusmedialis:** extends the lower hind leg.
**Adductor longus:** pulls the thigh towards the body.

**SUPERFICIAL STRUCTURES IN THE THROAT OF A RAT**

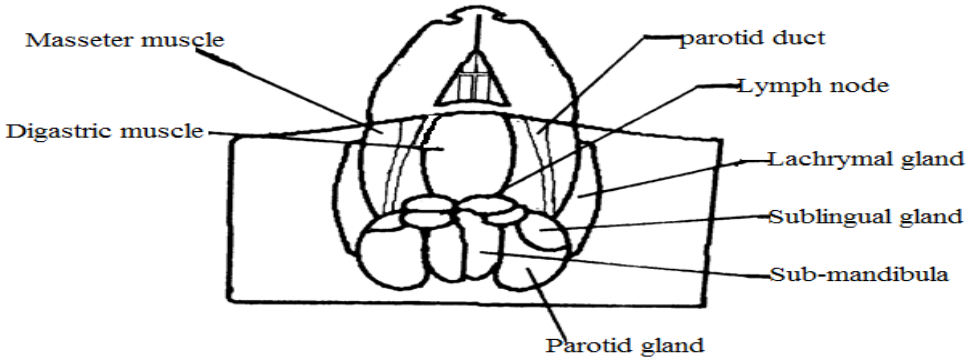
These are muscles and various glands that belong to different organ systems.

| **system** | **Structure and their organ systems** |
|---|---|
| **Digestive** | **Parotid gland**: it is the major salivary gland which secrets saliva that contains starch digesting enzyme<br>**Parotid duct:** Empties saliva from the parotid gland into the oral cavity.<br>**Sub-mandibular (Sub-maxillary) gland**: salivary gland that secretes a thick mucus.<br>**Sublingual gland**: a small salivary gland that empties into the oral cavity behind the lower incisors.<br>**Lymph nodes**: filter foreign particles from immune System and also makes leucocytes. |
| **Immune system** | **Lacrymal gland**: Secretes lacrimal fluid (tears) to lubricate and protect the eye.<br>Tears contain water, proteins (albumin), lysozyme enzyme, mucins, salts, lipids, e.t.c. |

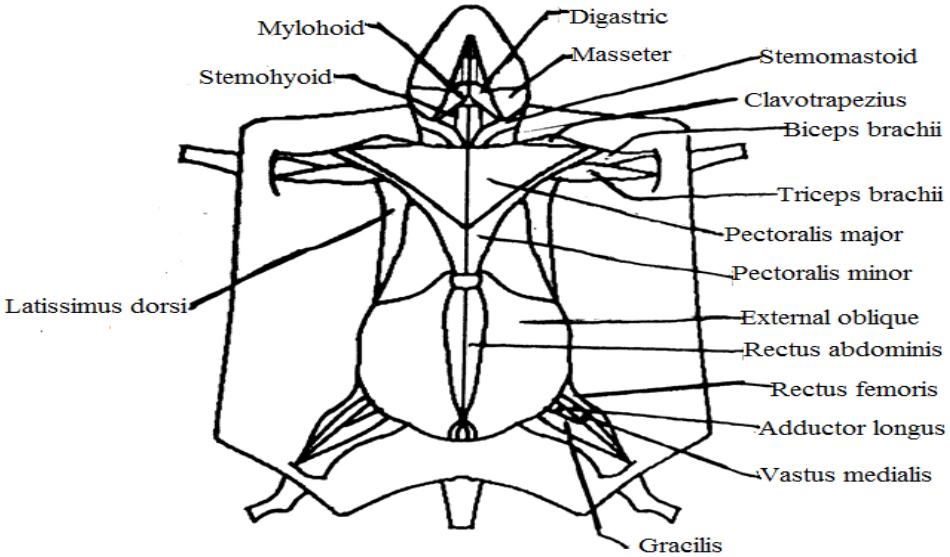
**A TABLE SHOWING THE MAJAR MUSCLES OF THE RAT AND THEIR FUNCTIONS**

| MUSCLE | FUNCTION: |
|---|---|
| The trapezium Divided into: | |
| Spino – trapezium | retracts the scapula. |
| Acramio trapezium | protracts the scapula. |
| Clava trapezium | protracts the clavicle. |
| The pectoralis | Depresses/retacts the humorous |
| The latissimus dorsi | retracts / elevates and rotates the humerous |
| The Deitoideus into: | |
| Acromio deltoideus | protracts the humorous |
| Spino deltoideus | elevates the humorous. |
| The Biceps | Flexes the lower arm. |
| The triceps | Extend the far arm. |
| The masseter | moves the lower jaw. |

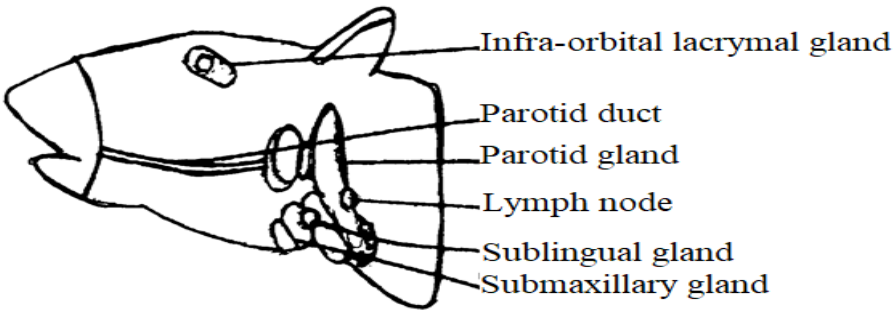
**Superficial structures in the throat of a rat**




**Superficial muscles of the ventral view**




**Drawing showing the features for secretion and passage of materials in the lateral neck and head regions of a rat**




**Terms used in the naming of blood vessels**

Blood vessels are named according to the areas and organs they serve and the side of the body they occur by adding the words left or right to the appropriate name accordingly

| **Name** | **Organs served:** |
|---|---|
| Pulmonary | Lungs |
| Coronary | Heart |
| Carotid | Head |
| Ovarian | Ovary |
| Mesenteric | Gut |
| Coeliac | Abdominal |
| Iliac | Ileum and legs |
| Femoral | Below femur |
| Jugular | Below jaw |

Ilio lumbar …… Back (lumbar region)
Subclavian …… Back clavicle
Azygos …….Inter costal muscles
Cephalic……..Head(facial region)

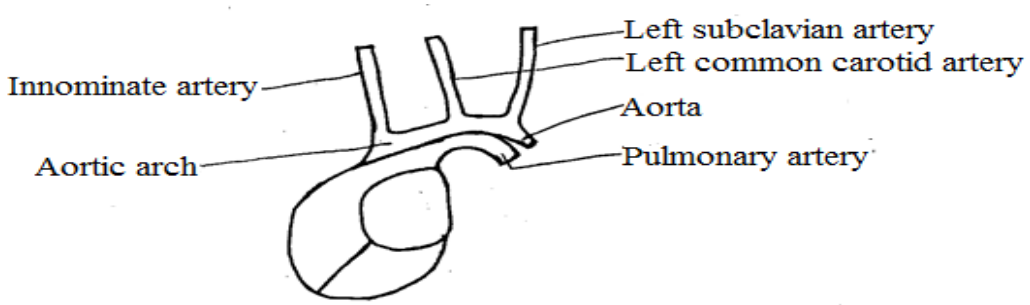
**Glands of the neck**

**The tail of the rat**

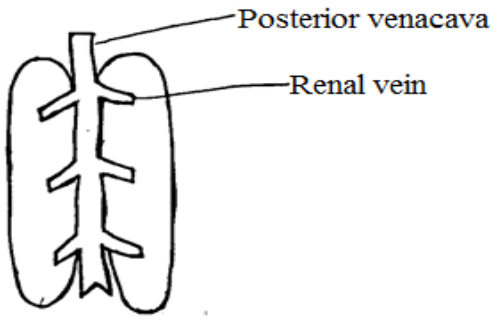
**THE PADS OF THE LIMBS**

a) **Fore limb** **b)Hind limb**

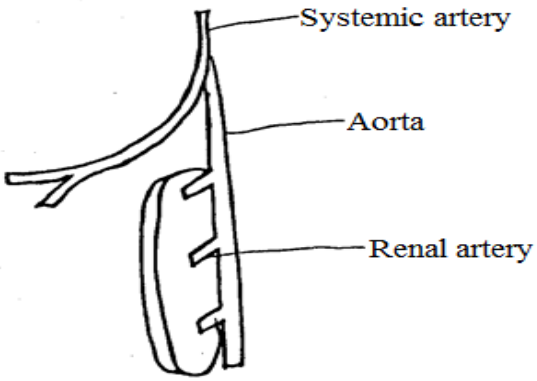
NB: Aortic arch has 3 branches i.e. innominate artery, left subchavian artery and left common carotid artery.




**Veins of a toad of the kidney**

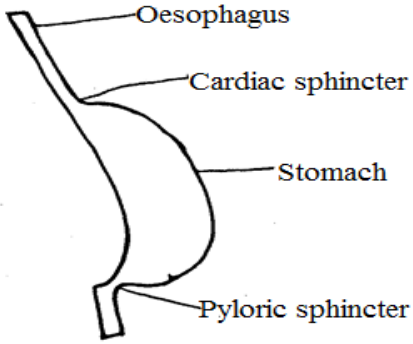



**Arterial system of a toad**

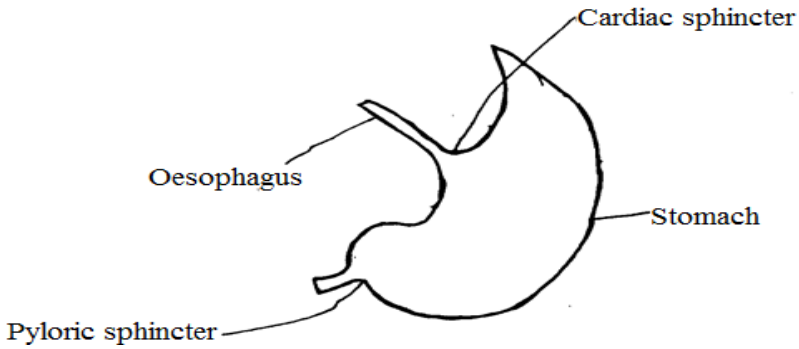



The oesophagus of a toad joins directly thus at the end into the stomach, that of a rat is in the middle. Both have cardiac and pyloric sphincters

**Toad**

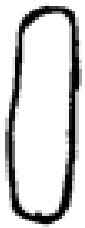



**Rat**




**The kidneys of a rat are kidney shaped**

**While those of a toad are elongated**



**NB**

- ❖ A nerve is represented with a single line and blood vessels with two lines.
- ❖ Ribs are curved and bent.

**PRACTICE QUESTIONS ON ANATOMY OF THE RAT**

1. You are provided with specimen R which is freshly killed
   (a) (a) Observe the head of the specimen from the dorsal side and describe three external features on the head.
   ($07\frac{1}{2}$ mks)
   (b) Pin specimen R ventral side upper most. Cut the masseter muscles and open the mouth wide. Pull the tongue forward and displace it to the left side of the specimen.
   (i) Draw and label structures in the buccal cavity which are used for physical break down of food into smaller particles. (08 mks)
   (ii) State how any three features observed in the mouth are suited for the diet of the animal (04 mks)
   (iii) Observe the mouth of the specimen and write down its dental formula. (01 mks)
   (c) Dissect specimen R further by cutting the rib cage to expose structures in the thorax and base of the neck. Clear away the thymus gland and deflect the heart and left lung to the right of the specimen. Draw and label the circulatory and respiratory systems within the thoracic and lower neck regions. (21 mks)
2. You are provided with a freshly killed rat.
   (a) (i) Observe the head carefully and describe five ways its external structural features adapt the animal to live its habitat**.** ***(5marks)***
   (ii) Draw and label the head as you observe it in its lateral views. Ventral view ***(03marks)***, lateral view ***(03marks)***
   (iii) Open the buccal cavity and count the number of teeth. Write the dental formula. ***2marks)***
   (b) (i) Dissect the animal to display the superficial structures in the neck. Draw and label. ***(10marks)***
   (ii) Proceed to dissect and display the structures used for reproduction, and blood vessels supplying blood to them. Draw and label. ***(12marks)***
   (c) By further dissection, display the structures used for reproduction, and blood vessels supplying blood to them. Draw and label. ***(10 marks)***
3. You are provided with a freshly killed rat.
   (a) Examine the trunk and limbs and suggest five ways the animal is adapted to cope up with the challenges in its habitat. ***(05marks)***
   (b) (i) State the sex of the animal and suggest two reasons for your answer. ***(11/2 marks)***
   (ii) Draw and label the external structures you used to establish the sex of your specimen**.** ***(03marks)***
   (iii) Describe the external structures you would use to identify the mammal of the opposite sex**.** ***(06marks)***
   (c) Proceed to dissect and display reproductive structures and blood vessels supplying blood to them. Draw and label. ***(10marks)***
   (d) By further dissection:
   (i) Open up the thoracic cavity and display the structures in the undisturbed state in this part of the body.
   (ii) Displace the liver lobes anteriorly and the stomach to your left. Draw and label the structures in the thoracic cavity and those originally obscured by the stomach on the same drawing. ***(22marks)***
4. (a) You are provided with a freshly killed rat. Examine the animal carefully and describe:
   (i) Structure and distribution of fur. ***(06marks)***
   (ii) The structural features of the tail. ***(03marks)***
   (iii) Outline the significance of your observations in **(a) (i)** and **(ii)** to the survival of the animal. ***(05marks)***
   (b) Dissect the abdominal region, and display the internal structures in this part of the body. Deflect liver lobes anteriorly, displace duodenum to the right and the rest of the

intestine (ileum) to the left. Re-arrange the structures so that the structures within the mesentery can be seen clearly. Cut and remove stomach and spleen. Draw and label. ***(20marks)***

5. You are provided with specimen K. dissect to display blood vessels that supply and those that drain structures anterior to the diaphragm on the left side of the body. With the heart displaced to the right, draw and label your dissection. (20 marks)
6. Dissect the specimen to display superficial structures on the left thigh, abdomen and left part of the thorax. Draw and label your dissection. (16 marks)
7. Dissect the thorax up to the base of the neck of specimen P to display:
   (i) Structures that channel materials and fluids in and out through the thorax.
   (ii) Main blood vessels in the thorax region. With the heart displaced to the right, draw and label your dissection. (19 marks)
8. You are provided with specimen X. dissect the abdomen, cut out the alimentary canal and associated structures. Continue with your dissection to display:
   (i) Blood vessels draining abdominal structures on the right of the specimen.
   (ii) Blood vessels supplying blood to the left half of the abdomen and those supplying the left hind limb. Draw and label your dissection. (25 marks)
9. You are provided with specimen B.
   (i) Open up the abdomen, cutout the alimentary canal. Dissect to display blood vessels draining the left half of the specimen.
   (ii) Open up the anterior part and display blood vessels supplying the right side of the head and thoracic regions. With the heart displaced to the right, draw and label what is displayed in (i) and (ii) on one drawing. (29 marks)
10. Dissect specimen G to display blood vessels:
   (i) Draining gut structures posterior to the stomach and those draining the left head region.
   (ii) Taking blood to right fore limb, right side of abdominal wall, right pelvic region and to abdominal structures involved in reproduction, secretion and excretion on the right side of the abdomen. With the heart undisplaced, draw and label your dissection in (i) and (ii) on one drawing. (35 marks)
11. Dissect specimen W to display:
   (i) Gut structures posterior to the stomach and blood vessels taking blood to them, blood vessels supplying blood to right side of the head region, right pelvic region and right abdominal wall muscles.
   (ii) Blood vessels draining the excretory organs and reproductive structures on the left side of the body and left hind limb.
   With the heart displaced to the right of the specimen, draw and label what is displayed in (i) and (ii) on one drawing. (36 marks)
12. You are provided with specimen A which is freshly killed.
   (i) Dissect the posterior part of the specimen to display structure anterior to caecum including their blood supply, and blood vessels taking blood to structures used for reproduction and those taking blood to the left hind limb.
   (ii) Continue with your dissection and dissect the anterior parts of the specimen to display blood vessel which carry blood to left head region and left thoracic region from the heart. Draw and label what is displayed in (i) and (ii) on one drawing. (31 marks)
13. Dissect the specimen to display blood vessels:
   (i) Draining the left side of the head, neck and fore limb.
   (ii) Taking blood to right side of the head, excretory and reproductive structures on the right side of the abdomen and right hind limb. With the heart displaced to the right, Draw and label your dissection. (30 marks)
14. Dissect to display blood vessels:

(i) Taking blood from the left hind limb and from structures responsible for excretion and reproduction on the left half of the abdomen back to the heart.

(ii) Taking blood to right forelimb and to alimentary canal structures responsible for chemical digestion from the heart. Draw and label blood vessels displayed in (i) and (ii) on one drawing. (32 marks)

15. Dissect the specimen to display blood vessels:

(i) Carrying blood from the left head region and digestive structures back to the heart.

(ii) Taking blood to anal canal, and to structures responsible for secretion and excretion on the right side of the abdomen of specimen and right hind limb from the heart. Draw and label. (30 marks)

16. You are provided with specimen Q.

(i) Dissect the specimen to display the structures underlying the left lung and blood vessels taking blood to the right head region.

(ii) Continue with your dissection to display the system used in the excretion and reproduction. Draw and label what is displayed in (i) and (ii) on one drawing. (24 marks)

17. You are provided with specimen T which is a freshly killed rat.

(i) Dissect the specimen to display superficial neck structures.

(ii) Continue with your dissection to open up the abdominal and thoracic cavities. Cut out the alimentary canal and associated structures and display blood vessels draining visceral organs on the right of the abdominal and those supplying the left fore and hind limbs. With the heart undisplaced, draw and label what is displayed in (i) and (ii) on one drawing. (23 marks)

18. You are provided with specimen B which is freshly killed rat

(i) Open up the abdominal cavity of the specimen. Dissect to display digestive structures anterior to the caecum and blood vessels that carry blood away from them and blood vessels draining structures in the right half of the abdomen and those that drain the hind limb.

(ii) Dissect the specimen further into the thorax and display blood vessels draining the right fore limb and right half of the thoracic cavity. Displace the heart to the left of the animal. Draw and label what is displayed in (i) and (ii) on one drawing.(37 marks)

19. You are provided with specimen N. Dissect the neck and thoracic region to display:

(i) Structures responsible for secretion, coordination and ventilation.

(ii) Blood vessels carrying oxygenated blood to structures on the left half of body anterior to the diaphragm and those carrying deoxygenated blood from the right half of the head region. Draw and label your dissection. (26 marks)

20. You are provided with specimen R which is freshly killed.

a) Open the mouth of the specimen widely. Examine the roof cleft and floor of the mouth.

i) State three observable differences between the roof/cleft and floor of the mouth. (3 mks)

| Roof/cleft | floor |
|---|---|
| | |

ii) Examine the teeth of the specimen. State the dental formula (1 mark)

iii) Open further the mouth of the specimen exposing the teeth. Examine the front and back of the incisors. State your observation (01 mark)

iv) What is the significance of your observation stated in (a) (iii) above (1 mark)

b) Place the specimen with its ventral side upper most. Examine it and identify its sex giving a reason (2 mks)

Sex:

Reason

c) i)measure the tail length (1 mk)

ii) Measure the body length

iii) State the ratio of tail length: body length (1 mark)
iv) What is the significance of the ratio stated in c (iii) above (3marks)
d) Draw and label the ventral side of the right fore foot of the specimen R (6 marks)
e) Dissect the specimen to display blood vessels draining the head, neck and thoracic regions with the heart displaced to its right. Draw and label. (20 marks)

21. Specimen T is a freshly killed animal.

(a) Classify the specimen basing on external features.

(i) Phylum

Reason

(ii) Order

Reason

(b) (i) Open up the skin on the dorsal surface of the thigh.

Describe the structure, arrangement of the structures after examining them.

(iii) Draw and label the structures.

(c) Dissect the specimen in the usual way. Draw and label structures located in thoracic and abdominal region responsible for blood circulation, gaseous exchange and food storage in their undisplaced state .

(d) Display the digestive system onto your right, trace for the blood vessels transporting blood to the left head region and structures for gaseous exchanges. Draw and label the blood vessels, organs with the displaced position.

22. You are provided with freshly killed specimen labeled Q.

(a) (i) Examine specimen Q. Identify and describe the structure of the two features that are formed by modifying the skin of specimen Q.

(ii) Relate the structure of the features in a (i) above to their function.

(b) Open the mouth slightly for the internal nares to remain obscured. With the head projecting towards you, draw and label the head features observed and the fore limbs.

(d) Dissect specimen Q, Cut out the intestine with its mesentery to display the vessels that:

(i) Supply blood to the excretory organs and the gut organs.

(ii) Drain blood from the left thigh Draw and label your dissection.

**DETERMINATION OF MAGNIFICATION OF A MICROSCOPIC DRAWING**

View the specimen using a given objective lens (magnification power) like medium power view and draw the specimen. Remove the specimen and place a transparent meter rule to measure the filed of view.

Record the size of the field of the view in millimeter (mm)

The size of the field is equivalent to the actual size of the specimen convert the size of the field of view into micrometer (um), (Imm=1000um).

Measure the size of the drawing in millimeter and convert it into micrometer.

The magnification of the drawing = $\frac{\text{size of the drawing (um)}}{\text{Actual size of the specimen (um)}}$

If apart of the drawing is drawn, calculate the actual size of the part drawn e.g one record it in micrometer then work out the magnification of the drawn part as for the whole specimen.

E.g

If 10cells are viewed in a field of 2mm. the actual size (length) of the one cell drawn is 2mm.

10cells =0.2mm.

This means that the actual size (length) of one cell is 0.2mm x1000=200um

Suppose the length of one cell drawn is 4mm, the length of the drawn cell in micrometer is

4 x 1000= 4000um.

This the magnification of the drawning=

$\frac{\text{=The length of the drawing (nm)}}{\text{Actual length of a cell (nm)}}$

$\frac{\text{=4000nm}}{\text{200nm}}$

=X20

Repeat the above procedure with varying magnification of objective lens to complete the table below

| Eye piece lens magnification | Objective lens magnification | Total magnification | Diameter of FOV (mm) | Diameter of FOV (µm) | Area (µm$^2$) |
|---|---|---|---|---|---|
| X10 | X4 | | | | |
| X10 | X10 | | | | |
| X15 | X10 | | | | |
| X10 | X60 | | | | |

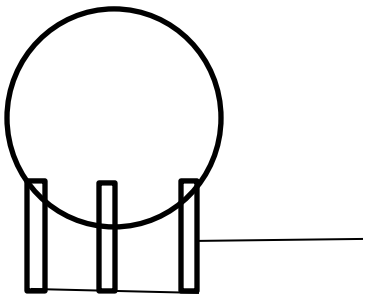
**Determining magnification of a specimen using field of view**

Actual length of one cell/specimen = $\frac{Diameter\ of\ field\ of\ view(\mu m)}{number\ of\ cells\ across\ field\ of\ view}$

Then, magnification = $\frac{length\ of\ drawing(\mu m)}{actual\ lengt\ of\ one\ cell(\mu m)}$

## Magnification of a microscope

Diameter of the field of view.




Field of view is 2mm

1mm = 1000$\mu$m

1 $\mu$m = 2000 $\mu$m

4 units occupy 2000 $\mu$m

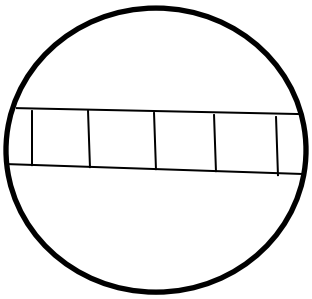
1 unit = $\frac{2000}{4}$ = 500 $\mu$m

m = $\frac{length\ of\ drawing}{length\ of\ tissue\ seen\ in\ microscope}$

4cm = $\frac{40000}{500}$

= X 80

Spirogyra look at cells across the slide



Onion epidermal cell

Diagram

- Count cells from L to R e.g. 20 – 30
- Count cells top to bottom 40 15
- Consider the least number of cells and record.
- Measure the diameter of the field of view, using a transparent ruler e.g. 2mm
- Convert the diameter to microscopic units e.g $\mu m = 2000\mu m$
- Calculate the length of one cell under the microscope

$$\frac{\text{Diameter of field of view } \mu m}{\text{The least number of cells}} = \frac{2000\mu m}{20} = 100\mu m$$

$\therefore$ The length of one cell under the microscope is $100\mu m$

- Measure and record the length of the drawn cell e.g. 4cm
- Convert the length to microscopic units e.g. $\mu m = 40{,}000\mu m$

$$M = \frac{\text{length of cell drawn } \mu m}{\text{length of one cell under the microscope } \mu m}$$

$$= \frac{40{,}000}{100}$$

= X 400

## GENETICS AND VARIATION

**Genetic** is the study of variations and heredity.

V**ariations** are differences that exist between individual of the same species.

**Continuous variation** is one in which individuals do not have clear cut differences; there is smooth gradation from lower to high extreme. E.g. Sizes and number of leaflets in cassia, mass of seeds, intelligence.

**Discontinuous variation**, is one in which individuals have clear cut differences, no gradations, can be plotted on bar graphs. Examples, Number of floral parts, sex of organism, leaf type.

**Heredity**. Is the process of passing of characteristics from parents to offspring.

The characteristics of organisms are determined by genes and the environment. Genes exist in alternative contrasting forms called alleles. E.g. a gene for height has allele for tallness and allele for shortness. Only one pair of alleles can occur on chromosomes in a nucleus. Chromosomes exist in homologous pairs (diploid, 2n) each carrying allele for a given gene in a specific location called locus. During **random fertilization** haploid (n) gametes containing chromosomes carrying alleles are fused to form a diploid (2n) zygote.

This concept is illustrated using representations like coloured beads or coloured seeds to represent a haploid set of chromosomes in gametes or to represent contrasting characteristics.

**Questions**

1. You are provided with 20 black beans and 20 white beans; and two large beakers. Put 10 black beans and 10 white beans in each beaker and shake the beakers to mix well. Mark 3 positions on your working table as BB, BW and WW respectively. Without looking into the beakers, use both

hands to pick one seed from each beaker simultaneously. If both seeds are black, place them at position BB; if both seeds are white place them at position WW and if one is white and the other is black, place them at position BW. Continue the procedure until the seeds are completed.

a) Count and record the number of pairs of beans at position
   i) BB……
   ii) BW…….
   iii) WW……..

b) (i) Determine the ratio of pairs at BB:BW:WW
   ……

c) Explain why the ratio in b(i) above is not 1:1:1?
   ……
   ……
   ……

d) What genetic features are represented by:
   i) The beans
   ……
   ii) The colour of beans
   ……
   iii) The beakers that contain the beans
   ……

e) What biological principle is illustrated by picking of a pair of beans at the same time?

f) Explain why it was necessary to:
   i) mix the beans thoroughly before picking
   ……
   ……
   ii) Pick the beans at random without looking
   ……
   ……

g) State the genetic term represented by the pairs of beans
   ……

2. You are provided with blue and red beads and five beakers labeled 1, 2, 3, 4 and 5 respectively. Put 50 blue beads in beaker 1. Put 25 blue and 25 red beads into beaker 2 and mix them thoroughly. Randomly pick one bead from beaker1 and 2 simultaneously. If the beads are both blue or both red, put them in beaker 3; while if one bead is blue and the other is red, put them in beaker 4. Repeat the procedures until all the beads from beakers 1 and 2 are transferred to beaker 3 and 4.

a) Count and record the pairs of beads
   i) in beaker3…….
   ii) in beaker4…….

b) what genetic term is used to describe the genetic makeup of offspring represented by pairs of beads in
   i) beaker3……
   ii) beaker 4……

c) What do the beads represent?
   ……

d) What conclusions can be concluded from the results obtained from the experiment?
   ……
   ……
   ……

e) Assume that the characteristic shown by the blue bead is dominant and is represented by B. fill in the spaces below. (1, 2, 3 and 4 are the beakers)
   Parents Genotype: 1…… X 2……
   Gametes: ……. …….
   Offspring Genotypes: 3 ……......4.....…….
   Ratio: ……..

3. You are provided with blue and red beads and five beakers labeled 1-5 respectively. Pu 50 blue beads in beaker 1 and 50 red beads into beaker2. Close your eyes and then take a bead from each beaker. Put the beads together(to represent an offspring). If the offspring is homozygous dominant(both blue), put it in beaker3; if it is heterozygous, put it in beaker4 and if it is homozygous recessive(both red) then put it in beaker5. Repeat the procedure until all beads in beaker1 and 2 are transferred to beakers 3, 4 and 5.
   a) Count the number of:
      i) Homozygous dominant offspring…….
      ii) Heterozygous offspring…….
      iii) Homozygous recessive offspring…….
   b) What conclusions can you draw from the numbers counted?
      ……
      ……
      ……
   c) Assume that the characteristic shown by the blue bead is the dominant one and it is represented by B. complete the cross below. (figures 1, 2, 3, 4 and 5 represent the beakers)

| | | | |
|---|---|---|---|
| Parents Genotype | 1…… | X | 2…… |
| Gametes | …….. | | ……..……. |
| fertilisation | | | |
| Offspring Genotypes | 3……....4.....……5……. | | |
| Ratio | …….. | | |

**NB**

Adaptations must not be used with enabling or help. When writing adaptations

- ✓ State a structure.
- ✓ Describe a structure.
- ✓ Show the significance of the description, how does the description improve performance of the structure.
- ❖ When asked state habitat with reasons, you should be specific.
- ❖ When giving differences, avoid negative differences e.g. doesn't have

| Difference | |
|---|---|
| - Longer | - Shorter |
| - Thicker | - Thinner |
| - Spongy/soft | - Solid/compact/hard |

Tissue plan is a lay out of cells without the details of the cell. Put only layers of the cell.

**EXAMINATION QUESTIONS**

**1.** You are provided with specimen K which is freshly killed.
   (a) Examine the head of the specimen and state how it is adapted to its habit. ***(04marks)***
   ……
   ……
   ……
   ……
   (b) Open up the specimen and display the muscles of the thoracic region. Draw and label the muscles and other structures exposed in the thoracic region. ***(10 marks)***

(c) (i) Open up the abdominal cavity of specimen K and cut the alimentary canal. Dissect to display blood vessels taking away blood from the right hind leg and abdominal organs, back to the heart.

(ii) Dissect the specimen further into the thorax and display the blood vessels draining the left fore limb and the left half of the thoracic region.

Draw and label what is displayed in (c) (i) and (c) (ii) in one drawing. **(28 marks)**

**2.** You are provided with solutions **X** and **Y** and a filter paper.

(a) You are required to carry out tests on the solutions using the filter paper, following the procedure provided.

**Procedure:**

(i) Using a ruler measure out seven 1cmx 1 cm square grids on the filter paper provided, and then cut them out using apair of scissors or razorblade.

(ii) Pour $10cm^3$ of solution Y in a Petri dish and immerse the seven pieces of filter paper into it.

(iii) Label seven test tubes as $25^0C$, $35^0C$, $45^0C$, $55^0C$, $65^0C$, HCL and NaOH and add $10cm^3$ of solution X into each.

(iv) In a plastic beaker/ cup provided, create a water bath maintained at $25^0C$ by mixing the cold and hot water where necessary, while monitoring the temperature with a thermometer.

(v) Place the test tube containing solution X labeled $25^0C$ into the water bath and leaves it for 2 minutes.

(vi) Pick up one piece of the filter paper from the Petri dish with a pair of forceps and drop it into the test tube in the water bath.
Allow it to sink and immediately start a stop clock.

(vii) Stop the stop clock when the piece of paper floats at the surface and record the time taken for the paper to float, in Table 1.
Repeat steps (iv) to (vii) of the procedure using water baths maintained at $35^0C$, $45^0C$ and $65^0C$.

**Table 1**

| **Temperature($^0C$)** | **Time taken for floatation (s)** |
|---|---|
| 25 | |
| 35 | |
| 45 | |
| 55 | |
| 65 | |

**(05marks)**

(b) Add 2 drops of 2M hydrochloric acid to the test tube labeled HCL and 2 drops of 2M sodium hydroxide solution to the test tube labeled NaOH.

Create a water bath in a beaker or plastic cup maintained at $35^0$C and place both test tubes into it. Leave the test tubes in the water bath for 2 minutes. Drop a piece of paper from the Petri dish into each of the test tubes, one at a time and record the time taken for floatation to occur. **(02marks)**

(i) Hydrochloric acid.
……

(ii) Sodium hydroxide.
……

(c ) Draw a graph in the space provided, of time taken for floatation to occur against temperature. **(07marks)**

(d) Explain the time taken for floatation to occur at different temperatures. **(12 marks)**
……
……
……

(e) From your results,

(i) State the range of temperature with the fastest rate of floatation. Give a reason a reason for your answer. **(02marks)**
……

(ii) State the effect of hydrochloric acid and sodium hydroxide on the rate of floatation. Give a reason for your answer. **(02marks)**
……

**3.** You are provided with specimen **B** and **C** which are whole plants.

(a) (i) Examine specimen **B** and suggest its habitat. ……**(01 mark)**

(ii) Give **five** adaptations of the specimen to the habitat stated in**. (05marks)**
……
……
……

(b) Examine both specimens **B** and **C** and give **two** differences between their leaves, stem and roots. **(06marks)**

| | **B** | **C** |
|---|---|---|
| Leaves | | |
| Stem | | |
| Roots | | |

(i) Using a razor blade, cut a small piece of the leaf from each of specimen **B** and **C**, mount each separately on a microscope. Record your observations. **(02 marks)**

**B**
……
**C**
……

(ii) Peel off the epidermis on both sides of each specimen, mount and view them under low power of a microscope. Describe how each specimen is adapted for its habitat. **(08 marks)**

**B**
……
**C**
……

(c) Cut very thin transverse sections through the stems of specimens **B** and **C** and observe them under low power of a microscope. Draw the tissue plan of both sections. Do not label. **(08marks)**

**4**. You are provided with specimen H which is freshly killed.

(a) (i) Examine structures with the snout of the head. How are they adapted for the survival of the organism in its habitat? (3marks)

……
……
……

(ii) Describe the structure on the posterior dorsal body trunk region and related it to its functions. (3marks)

……
……
……

(b) Observe the dorsal foot region of the hind limb. Draw and label.

(c) Dissect to open abdomen and thoracic regions. Carefully cut out to remove the whole alimentary canal with associated vessels, diagram and thymus gland. Return the liver lobes to their original undisplaced state and turn the heart to the right. Continue to display structures anterior to heart, vessels draining blood from urinary structures back to the heart. Draw and label your dissection. (20marks)

(d) Cut out the stomach from the alimentary and open it. How is the pyloric region adapted to function digestion. (2marks)

……
……

**5.** You are provided with solutions P and Q which are extracts from different plant organs with same development stage and laboratory solution Rand T.

(a) Carry out tests indicated on table 1 to establish nutrient contents and their relative concentrations on each of the solutions P, Q and R. Record your tests, observations and deductions.

| Test | | Observations | Deductions |
|---|---|---|---|
| | P | | |
| | Q | | |
| | R | | |
| | P | | |

| | | | |
|---|---|---|---|
| | Q | | |
| | R | | |
| | p | | |
| | Q | | |
| | R | | |

(b) Obtain the whole pancrease organ and upper section of ileum from specimen H. Cut open ileum longitudinally and discard its internal contents and chop its wall into pieces using knife. Crush both pancrease and pieces of ileum wall using mortar and pestle into a fine paste. Add 12cm$^3$ of water stir and decant to get extract to be labeled S.
Label test tube P, Q and R. Add into each test tube 3cm$^3$ of corresponding solution followed by 3cm$^3$ of extract. Incubate the contents of test tubes for 1 hour at 35-40$^0$c (mean while do other work). After the time duration, carry out tests on the contents of test tubes as indicated on table II. Record only your observations and deductions.

Table II
(13marks)

| Test | Test tube | Observations | Deductions |
|---|---|---|---|
| Benedict's test | P | | |
| | Q | | |
| | R | | |
| | P | | |
| | Q | | |
| | R | | |
| | P | | |
| | Q | | |
| | R | | |

(c) Explain your results on table on the effect of extract S on the nutrients solutions P, Q, and R.

(d) (i) Further label test tubes P, Q, and R. Add into each $2cm^3$ of corresponding solution followed by $2cm^3$ of solution T at separate times. Observe any reaction taking place. Record your comparative observation in table III (3marks)

Table III

| Test tube | Observations |
|---|---|
| P | |
| Q | |
| R | |

(ii) Explain your results in tube III (3marks)

……
……..……
……..……

**6.** You are provided with specimens labeled V, W, X, Y and Z which are plant organs. Study them.

(a) Describe the floret arrangement on specimen V (2marks)

……
……..……..……
……..……..……

(i) Observe the inner floret from specimen X using ahand lens and open petals of specimen W to expose hidden structures. State four differences between parts of their floral Whorls.

| X | W |
|---|---|
| | |
| | |
| | |
| | |
| | |

(ii) Compare the gynoecuim parts of specimen Y and Z (4marks)

……
……..……
……..……

(b) State the likely type of pollination which can take place in specimen W with a reason. (2marks)

……..……
……..……

(c) Obtain the inner floret of specimen X and gynoecium of specimen Y. Place each on a slide, mount and observes each of them under low power of microscope. Draw and label.

(i) Inner floret of X (4 marks) (ii) Gynoecuim of Y (3marks)

(d) By examining inner floret of specimen X when its intact and with the rest of specimen floret/ flowers opened, use only primary reproductive descriptive structural features to construct a dichotomous key for the identification of specimen V,W,X,Y and Z. (4marks)

**7**. You are provided with specimen M which is freshly killed.

(a) (i) Name the class to which the specimen belongs.

……

(ii) Examine the specimen and give **three** characteristics of the class named in (a) (i) which can be observed on the specimen.

……

……

(b) Open up the specimen, clear the pectoral muscle of the thorax to expose the ribcage and structures in neck region. Draw and label the rib cage and structures located in the neck region of the specimen. **(12marks)**

(c) (i) Cut out the alimentary canal and dissect the posterior part of the specimen to expose blood vessels which drain blood from structures used for excretion and the left hind limb, back to the heart.

(ii) Continue to dissect the anterior pars of the specimen to expose blood from the left head region, left thoracic region and left fore limb back to the heart. Draw and label what is displayed in (c) (i) and (c) (ii) excluding the heart, in one drawing. **(22marks)**

**8.** You are provided with solutions **P, Q, R, S, T** and specimen **U**. You are required to carry tests on the solutions using specimen U, following the procedure provided.

**Procedure**

(i) Label five test tubes as **P, Q, R, S** and **T** and add 10 $cm^3$ of the corresponding solution to each test tube.

(ii) Using a cork borer cut out 10 pieces from specimen U, each measuring 4cm long.

(iii) Put two pieces of **U**, made in (a) (ii) into each liquid from test tube **P** into a measuring cylinder leaving behind the pieces of **U** in the test tube.

(iv) After one hour, carefully pour out all the liquid from test tube P into a measuring cylinder leaving behind the pieces of **U** in the test tube.

(v) Record the final volume of the liquid from test tube **P** in Table **1**.

(vi) Repeat steps (iv) and (v) for the remaining test tubes to obtain the final volume of the liquids from test tubes **Q,R,S** and **T**. Record each of them in table **1.** **(05marks)**

**Table 1**

| **Test tube** | **Final volume ($cm^3$)** | **Change in volume (Final volume-Initial volume($cm^3$)** |
|---|---|---|
| **P** | | |
| **Q** | | |
| **R** | | |
| **S** | | |
| **T** | | |

(b) Work out the change in volume in each test tube and complete Table **1** above.
……

(c) In the space provided draw a histogram of change in volume against solutions **P,Q,R,S** and **T**

(d) Using your histogram explain the changes in volume of each solution.

**P**
……
……

**Q**
……
……

**R**
……
……

(e) From your results, estimate the water potential of the cells sap of specimen **U.** Give a reason for your answer……***(02marks)***

**9.** You are provided with specimens **W, X, Y** and **Z.**

**(f)** Using a head lens, examine specimen **Z** and state how the features of its head are suited for its role in the community it lives. **(02 marks)**
……
……

**(g)** Examine the wings of specimens W and Y using hand lens and state three structural differences between them in **Table 1**. **(03marks)**

**Table 1**

| **Wings of specimen W** | **Wings of specimen Y** |
|---|---|
| | |
| | |
| | |

(h) (i) Observe the tibia and tarsus of each specimen using the low power of a microscope. State two descriptive features on the tibia and tarsus of each specimen in **Table 2.**

**(ii)** Observe the abdominal appendages on each of the specimens and state your observation in **Table 2.** **(12marks)**

Table 2

| **Specimen** | **Descriptive features on** | | |
|---|---|---|---|
| | **Tibia** | **Tarsus** | **Abdominal appendages** |
| W | | | |
| X | | | |
| Y | | | |
| Z | | | |

(i) Using the feature on the tibia alone, contract a dichotomous key to identify the specimens.

**(j)** In the space below, draw and label the last three segments of the tarsus of the hind limbs of specimens W and X, when viewed under low power of a microscope. **(08marks)**

**10**. You are provided with specimen K which is freshly killed.

(a) (i) Measure the length of the fore and hind limbs and record the results in Table 1. Express the results as a ratio of length of fore limb: length of hind limb.

| Length (mm) | Fore limb | Hind limb |
|---|---|---|
| | | |
| Ratio | | |

**(iii)** State the significance of the ratio.

……

……

(b). Examine the hind limb and state three ways it is adapted for the survival of the specimen in its habitat.

……

……

……..…

(a) Examine the head of the specimen and draw and label the dorsal view of the anterior part of the head to show the structures for sensitivity.

(d) Dissect the specimen to expose the heart. Turn the heart over to display the main blood vessels.

(i) Returning blood from the trunk region to the heart.

(ii) Supplying the structures for absorption of nutrients and excretory organs.

Draw and label.

**11**. You are provided with solutions D,E and X. you are to carry out tests on solutions D and E and investigate the action of X on the solutions.

(a) Carryout tests in Table 2 to determine the food nutrients in D and E. Record your tests, observations and deductions in the table.

| Tests | Solutions | Observations | Deductions |
|---|---|---|---|
| Benedict's test | D | | |
| | E | | |
| Iodine test | D | | |
| | E | | |

(b) Label four test tubes as 1,2,3 and 4 and add contents to each test tube as shown in table 3.

| | |
|---|---|
| Test tube 1 | $1cm^3$ of X + $3cm^3$ of D. |
| Test tube 2 | $1cm^3$ of X + $3cm^3$ of E. |

| | |
|---|---|
| Test tube 3 | $1cm^3$ of X + $5cm^3$ of D + $1cm^3$ of Y |
| Test tube 4 | $1cm^3$ of X + $3cm^3$ of E + $1cm^3$ of Y |

Incubate the test for 30 minutes in a water bath maintained at (37-40)oc.
After 30 minutes, divide the contents of each test tube into two and carryout the Iodine and Benedict's tests as shown in Table 4. Record your observations and deductions in the table.

| **Tests tube** | **Test** | **Observations** | **Deductions** |
|---|---|---|---|
| 1 | Iodine test | | |
| | Benedict's test | | |
| 2 | Iodine test | | |
| | Benedict's test | | |
| 3 | Iodine test | | |
| | Benedict's test | | |
| 4 | Iodine test | | |
| | Benedict's test | | |

(c) From your results, state the nature of solutions X and Y giving reasons for your answer.
(i) X……
(ii) Y……
3. You are provided with specimens **P, Q, R** and **S**.
(a) Examine them and state the phylum of each specimen giving a reason in each case.

| **Specimen** | **Phylum** | **Reason** |
|---|---|---|
| **P** | | |
| **Q** | | |
| **R** | | |
| **S** | | |

(b) Obtain a unit of P, mount it in water on a slide and observe under medium power of a microscope.
State how the specimen is adapted for nutrition.
……
……
(c)(i) Isolate one functional unit of specimen **Q** growing vertically. Put it on a slide and observe under medium power of a microscope. Draw and label.

(ii) Dust particles of Q from tips of vertically growing structures onto a slide. Observe under medium power of a microscope.
From the structures of Q explain how it is adapted for propagation.
……
……
(d) (i) Examine Specimen R and suggests its habitat.
……
……
……
……

(ii) Isolate one unit of R and examine it. State how the specimen is adapted for survival in the habitat stated in (d) (i).
……
……
(e) (i) Examine specimen S and state the class of plants it belongs to.
……
……

(ii) Give three descriptive features of specimen S which qualify it to be in the class stated in e (i).

……
……

(f) Cut a thin traverse section of the main root of specimen S. place it onto a slide and observe under low power of a microscope. Draw and label a plan to show the arrangement of tissues.

**12.** (a) You are provided with specimen O.Classify it into the following groups:
Kingdom……
Phylum…….
Class……

(b) Observe the head of the specimen and state how it is adapted to its habitat.
……
……

(c) (i) Open the mouth cavity widely to expose the tongue. Get hold of it with forceps and pull. Briefly describe its nature and its attachment and relate it to function.
……
……

(ii) Describe the position and structure of the.
Tympanic membrane……..
Hind limbs……

(d) Dissect the specimen to display,

(i) The blood vessels that drain blood from the left limb back to the heart.

(ii) The blood vessels that drain blood from the alimentary canal and its associated organs back to the heart, with the alimentary canal displaced to your right and the heart turned upwards and pinned through the ventricle.

(iii) The blood vessels that take blood from heart to the left thoracic region of the specimen.
Draw and label your dissection showing (i), (ii) and (iii) on one drawing.

**13**. You are provided with specimen T and sugar solutions of varying concentrations labeled F, H, I, J, K, L.

(a) Measure 7.0cm3 of each solution and transfer the solutions into test tubes labeled correspondingly. Using a cork borer, obtain six equal sized cylinders of at least 1cm diameter, from specimen T and trim the cylinders to a uniform length of 5.0cm. Immerse a cylinder into each of the solutions in the tests tubes and leave for 1 ½ hours.
(You may proceed with other work)

(i) After 1 ½ hours, transfer solution F into a measuring cylinder and record the final volume in table below. Measure also, the length of the cylinder and record the final length in the table. Repeat the procedure for the remaining solutions and cylinders.

Table:

| Solutions | F | H | I | J | K | L |
|---|---|---|---|---|---|---|
| Final volume | | | | | | |
| Initial volume to final volume ratio | | | | | | |
| Final length of the cylinder | | | | | | |

(ii) Calculate the initial volume to final ratio of the solutions, in the spaces provided in table above.

(iii). Arrange solutions F to L in order of decreasing osmotic potential.

……

……

(b) Explain the results obtained in tests tubes F, I and L

Test tube F

……

……..……

Test tube I

……

Test tube L……

(c) From the table, suggest the solution with the isotonic condition to that of specimen T. explain your answer.

……

……

(d) Examine closely the cylinder placed in solutions F and L.

Give the differences in the physical condition of the cylinders from the two solutions.

……

……

**14**. You are provided with specimen A, B and C which are reproductive structures of flowering plants.

(a) Describe the structure of each flower in respect to the parts:- Bracts, Sepals, Petals, Stamens and Carpels.

| Structure | A | B | C |
|---|---|---|---|
| Bracts | | | |
| Sepals | | | |
| Petals | | | |
| Stamens | | | |
| Carpels | | | |

(b) (i) Describe the features of B that promote the reproductive life of the plant.

……

……

(ii) Examine one inner flower from specimen B. Draw and label.

(c) (i) Open up one flower of specimen A and reveal the pistil and stamens. Draw and label the pistil of specimen A.

(ii) Obtain one pollen grain from specimens A and C. mount both pollen grains in a drop of water on one glass slide. View them under the medium power of a microscope.
Give the differences in structure between them.

……
……

**15**. You are provided with specimen Q which has been freshly killed.

(a) Open the mouth and identify one prominent structure on the flow of the mouth. Using a pair of forceps, pull it and release it.

(i) Describe its location

……
……

(ii) Relate the location to the role performed by the structure.

……
……

(iii) Draw the internal structures and label the structures on the roof.

(b) Dissect the specimen to display the internal structures. Cut off the alimentary canal. Draw and label fully.

(c) By further dissection display the blood vessels carrying blood with nutrients to the areas around the head, shoulders and the jaws. Draw and label fully.

**16.** You are provided with specimen P which is a plant organ together with solution X.

(a) Cut specimen P transversally. Observe the cut end of one half. State the descriptive features.

……
……

(b) Using a fresh specimen P peel the upper epidermis from the leaves of the specimen and obtain 6 pieces of the epidermis measuring about 1cm x 1cm.
Mount one piece of epidermis on the slide. Observe under low power of the microscope. Count and record the numbers of complete cells in the field of view.

Now transfer the remaining epidermal pieces into a petri dish; add solution X to fully cover the strips. Leave to stand for 5 minutes. After this time remove one strip and mount on the slide. Observe under low power and count the number of cells showing evidence of plasmolysis.

(a) Record your results in the table below.

| **Time / minutes** | **0** | **5** | **10** | **20** | **30** | **40** |
|---|---|---|---|---|---|---|
| Number of plasmolysed cells | | | | | | |
| Percentage plasmolysis | | | | | | |

Repeat the procedure for the remaining four pieces after 10,20,30 and 40 minutes. Enter your results in the table 1 above and compute the corresponding percentage plasmolysis.

(b) Plot a graph of percentage plasmolysis against time.

(b) Explain the shape of the graph.

……
……

(c) (i) Draw one cell after 40 minutes of the experiment. Don not label.

(ii) Describe the significance of appearance of the cell in c (i) above to plant life.

……

**17**. You are provided with specimen A, B, C, D and E which are plant organs. Cut specimens A, B, D and E and transversally and open specimen B.

(a) Fore each of the specimens, describe the arrangement of seeds.

A……
B…….
C……
D……..
E……

(b) Draw one half of specimen A.

(c) Describe the adaptations of specimens A and B for dispersal.

A……
B……

(d) Using features of the endocarp, construct a dichotomous key to identify the specimen A – E.

……
……
……

**18**. You are provided with specimen L a freshly killed mammal.

(a) Measure the length of the tail and that of the tail plus the whole body. Calculate the ratio of length of tail to length of tail + rest of body.

.....
.....

ii) Suggest the significance of this ratio in the life of the animal.

.....
.....

b) Dissect the specimen to display the heart, arteries at and veins of the thorax. No dissection of the neck is required to this stage. Do not remove or displace the right long. Make a labeled drawing of the dissection.

**19**. You are provided with a fresh bean seed labeled S. Remove the testa and spilt and split the seed into two. Cut a piece of stomach, two pieces of liver, a piece of the leg muscle and a piece of lung, from the dissection.
All pieces should be of the same size as one half of the split bean seed. Boil one half of the bean seed and one piece of the liver separately for 3 minutes and then cool.
Label six test tubes 1, 2, 3, 4, 5 and then add 2.0$cm^3$ of hydrogen peroxide to each test tube followed by the different cut pieces to each test tube as indicated in the table below.

| **PROCEDURE** | **OBSERVATION** | **DEDUCTION** |
|---|---|---|
| Test tube 1 add un boiled half of bean seed | | |
| Test tube 2 add boiled half bean seed | | |
| Test tube 3 add un boiled piece of liver | | |
| Test tube 4 add piece of leg muscle | | |
| Test tube 6 add piece of lung | | |

b) From your results above. State any three conclusions from the experiment in a.
.....
.....
c) Explain the significance of the observations in test tubes 3, 5 and 6 about body physiological process.
.....
.....

**20**. You are provided with specimens E, F, G, H, I, J and K.
a) Classify specimens G and H into the taxa below

| **Specimen** | **Class** | **Order** |
|---|---|---|
| G | | |
| H | | |

b) Name the order to which specimen I, J, and K belong.
.....
.....

c) Carefully examine the specimens with the help of a hand lens. Study their head and thoracic features.
i) Complete the table below.

| Specimen | Eyes | Type of Mouth | Antennae | Wings |
|---|---|---|---|---|
| E | | | | |
| F | | | | |
| I | | | | |
| J | | | | |
| K | | | | |

ii) Using the features in the table above construct a dichotomous key to identify the specimens in the order E, F, K, I and J.

**21**. You are provided with a freshly killed specimen 2.
a(i) Describe the position and structure of nostrils, eyes and ears.
.....
.....
(ii) What is the significance of the position of nostrils, eyes and ears.
.....
.....
b) From its external features, what inference can you make about its habitat? Give three (3) supportive features.
.....
.....
c) Pin the animal ventral side uppermost on a dissection dish/board. At the central paint of the mid-ventral line, lift the skin with a forceps and carefully cut through the skin along the median line using scissors. Make lateral cuts to enable the skin to be pinned back to reveal the underlying body wall. Observe the attachment of the skin to the underlying body wall.
(i) Describe briefly the attachment of the skin to the body wall.
.....
.....
(ii) Dissect further to display the blood vessels that supply nutrients and oxygen to the alimentary canal and the associated organs. Draw and label the heart, spleen and the blood.

**22**. You are provided with solutions A and B.
(a) Identify the food substances in the solution using iodine solution, Benedict's solution, NaOH & $CUSO_4$ only. Record your results in a suitable table.

(b) Cut a piece of stomach from the dissection in a question, measuring $1cm^3$. Wash and grind it in a mortar. Add $4cm^3$ of distilled water, leave to settle then decant. Label the extract, P. label four test tubes 1, 2, 3, and 4 and add contents to each test tube as follows.

| |
|---|
| Test tube 1 $1cm^3$ of A + $1cm^3$ of dil HCl solution |
| Test tube 2 $1cm^3$ of A + $1cm^3$ of dil NaOH solution |
| Test tube 3 $1cm^3$ of B + $1cm^3$ of dil HCl solution |
| Test tube 4 $1cm^3$ of B + $1cm^3$ of dil NaOH solution |

Divide extract P, into four equal portions and add to each of the test tubes 1, 2, 3, 4 above, incubate the test tubes at $40^oc$ for 25 minutes.

i) Observe test tubes 1 and 2 record your observations and deductions in the table below.

| | Observations | Deductions |
|---|---|---|
| Test tube 1 | | |
| Test tube 2 | | |

ii) Identify the food substances in test tubes 3 and 4 using the reagents provided. Record your observations and deductions in the table below.

| | Tests | Observations | Deductions |
|---|---|---|---|
| 3 | | | |
| 4 | | | |

c) Explain your results in table (i) and (ii)
.....
.....
.....

**23**. You are provided with specimen A, B, C, D, E and F. open B longitudinally and cut the rest transversely.

(a) Looking at the section, describe seed arrangement in each of the following specimens.

A.....
B.....
C.....
E.....

b(i) Give two internal features common to both specimens E and F.

.....
.....

(ii) State the differences in internal structure of specimen E and F.

| **E** | **F** |
|---|---|
| | |
| | |
| | |
| | |

c) Draw and label a transverse section of specimen D and one half of specimen B which contains the seeds.

d) Limiting yourself to the internal features of the specimens construct a dichotomous key to identify them.

**24**. You are provided with a freshly killed animal labeled A. Study the external features carefully and from your observations, answer the following questions.

(a) (i) Classify the animal under the following taxa

Phylum

Class

(ii) Give two observable features to support your classification in the phylum above.

.....
.....

(b) (i) identify the sex of the animal. Draw and label those external features which help you to determine the sex of the animal.

(ii) List those characteristic external features that would be formed on the animal of the opposite sex.

.....
.....

c) (i) Describe all the features of biological interest seen on its head anteriorly.

.....
.....
.....

(ii) State the number of joints on each of its legs and give its significance.

.....
.....

d) Remove the wings and legs of the specimen. Pin down the specimen on a dissecting board / dish with the dorsal surface uppermost. Now carefully dissect to display the internal organs. Add a little water to keep the internal organs moist.

i. List the organs visible after removing the terga.

.....
.....

ii. Draw and label the internal organs seen

iii. Carefully remove the gut, pin it down end to end, measure and record the length of the different parts as shown in the table below.

| Part | Crop | Gizzard | midgut | Rest of the gut |
|---|---|---|---|---|
| Length/ mm | | | | |

What is the significance of the results?

.....

.....

**25.** You are provided with solutions A and B together with suspension P. You are required to carry out the test on the solution A and B and then investigate the effect of suspension P and A and B.

(a) Carry out tests indicated in the table below on solutions A and B. record your test procedure, observations and conclusions in table 1 below.

| **Test** | **Observation** | **conclusions** |
|---|---|---|
| Benedict's test | A | |
| | B | |

(b) Now obtain two test tubes and label them 1 and 2. Treat the test tubes as shown in table 2 below.

| **Test tube** | **Contents** |
|---|---|
| 1 | 2 $cm^3$ of A + 1$cm^3$ of P |
| 2 | 2$cm^3$ of B + 1$cm^3$ of P |

(b) Incubate all the test tube in a water bath maintained at 35 – 400C (meanwhile continue with other tasks) shaking periodically. Pick an aliquot from each test tube after 30 minutes, carry out Benedict's test on the record your observations and conclusions in table 3 below.

| **Test tube** | **Observations** | **conclusion** |
|---|---|---|
| 1 | | |
| 2 | | |

(c) Continue with the incubation for another 30 minutes. After this time repeat Benedict's test record your observations and conclusion in table 4 below.

| **Test tube** | **Observations** | **conclusion** |
|---|---|---|
| 1 | | |
| 3 | | |

(d) Explain your results in;

(i) Table 3

……

……

(ii) Table4

……

……

**26.** You are provided with specimens X, Y and Z which are plant organs.

(a) (i) Examine specimen Y and describe the structure and arrangement of the florets.

……

……

(ii) How is the structure of the floret from the specimen Z adapted for successful propagation of the species.

……

……

(iv) Obtain the gynoecium and adroecium from one floret of specimen Z. observe under low power magnification of the microscope. Draw

Gynoecium

Androecium

(b) Describe the features of the following floral parts of specimen X.

(i) Petals……

(ii) Sepals……

(iii) Gynoecium…….

(iv) Androecium……

Make a thin transverse section through the ovary of specimen X. observe under low power. Draw and label.

**27.** Specimen X is a freshly killed animal.

(a) (i) Describe the structures on the head of the specimen.

……

……

(ii) How is the head of the specimen adapted for the specimen to live successfully in its habitat?

……

……

……

……

(iii).Observe the structures on the anterior view of the head of the specimen draw and label them.

(b). Dissect the specimen to display the blood vessels transporting oxygenated blood to the structures in the abdominal region.

**28.** You are provided with solutions P and Q.

(a) Carryout the following tests.

| **Test** | **Observation** | **deduction** |
|---|---|---|
| Benedicts<br>P<br><br>Q | | |
| Iodine<br>P<br><br>Q | | |
| Buiret<br>P<br><br>Q | | |

(b) Label four test tubes as $T_1$, $T_2$, $T_3$, $T_4$ carryout the following procedures.
In $T_1$ put 4 drops of dilute HCI add 1 $cm^3$ of solution P followed by 1$cm^3$ of solution Q.
In $T_2$ put 4 drops of dilute NaOH add 1$cm^3$ of solution P followed by 1$cm^3$ of solution Q.
In $T_3$ 1$cm^3$ of solution P.
In $T_4$ put 1$cm^3$ of P and 1$cm^3$ of solution Q boil for 2 minutes.
Put $T_1$, $T_2$, $T_3$ and T4 in a water bath maintained between $35^0$C to $40^0$C for 35 minutes. After the 35 minutes divide the contents in each test tube into two portions.

(i) Record your observations in the contents of the first portions.

$T_1$.....

$T_2$.....

$T_3$.....

$T_4$.....

(ii) Carryout iodine test on the contents of the second portions.

| Test | Observation | Deductions |
|---|---|---|
| $T_1$ | | |
| $T_2$ | | |
| $T_3$ | | |
| $T_4$ | | |

Comment on your results in (i) give an explanation in each test tube.

(c) (i) Name the factors being investigated in this experiment.
……
……
(ii) What is the effect of solution Q on solution P?
……
**29**. Specimens E, F, G, H, I and J belong to the same kingdom.
(a) (i) Giving reasons name the phylum of the specimens.
Phylum…….
Reasons……
(ii) Name the class of the specimens giving reasons.
Class for E and G …….
Reasons……..
Class for F,H,I,J …….
Reasons…….
(b) How is specimen G adaptated to its mode of life?
……
……
(c) Distinguish between specimens H and I.

| H | I |
|---|---|
| (i) | |
| (ii) | |
| (iii) | |
| (iv) | |

(a) Using features on the head and thorax only construct a dichotomous key for the specimens.
……
……
……

**30.** You are provided with specimen K which has been freshly killed. Study the animal carefully and answer the following questions.
(a) Examine the following mammalian features and describe how they are suited to the survival of the animal in its habitat.
(i) Ear lobes / pinnae……
(ii) Hairs / fur…….
(b) (i) Examine the tail using a hand lens. Draw fully but do not label.
(ii) Relate the features of the trail in b (i) above to the role performed.
……
……
(c) Dissect the specimen to display the blood vessels that supply organs that are used for;
(i) Excretion and reproduction on the left of the animal.
(ii) Food digestion and absorption.
With the alimentary canal deflected to the right of specimen, draw and label your dissection in c (i) and (ii) on the same drawing.

**31.** You are provided with extract $A_2$ which was obtained from a plant tissue. You are required to prepare on other extracts from specimen K.

Proceed as follows:

Cut and measure 1.5g of the lung from the animal and crush it into a mortar using a pestle to obtain a fine paste. Add $10cm^3$ of water. Mix well and transfer the contents into a clean boiling tube. Label it $A_1$

Obtain a $25cm^3$ measuring cylinder and transfer accurately $5cm^3$ of $A_1$.

Read and record the initial temperature in table 1 below. Add an equal volume of solution P and immediately start the stop clock. Read and record the temperature mixture at 30 seconds interval for 4 minutes.

Repeat the same procedure when using extract $A_2$. Enter your results in the table 1 below.

| Time / seconds | | 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 |
|---|---|---|---|---|---|---|---|---|---|---|
| Temp / $^0C$ | $A_1$ + P | | | | | | | | | |
| | $A_2$ + P | | | | | | | | | |

(b) Plot a suitable graph to represent the above data

(c) (i) Calculate the rate of temperature change for the first 60 seconds of the experiments for;

$A_1$ + P……..

$A_2$ + P…….

(ii) Explain your results in (c) (i).

……

……

(d) (i) Basing on your results, explain the different in the activity of plant and animal tissues.

……

……

(ii) State two biological significance of the results of the experiment.

……

……

**32.** You are provided with specimens X and Y which are plant organs.

(a) For both specimens;

(i) Describe the structure.

Specimen X……

Specimen Y……..

(ii) State three structures similarities.

……

……

……

(iii) State one functional similarity.

……

(b) Remove one spikelet from specimen Y and carefully cut off one sorus from specimen X. observe the spikelet using a hand and the sorus using the low power of the microscope.

(i) State the descriptive features of the vegetative structures of;

The spikelet:-……

The sorus:-……

(ii) Relate the descriptive features of the vegetative structures of the sorus to the role performed.

……

……

(iii) Draw and label the sorus

(e) Classify the plants from which the specimens were obtained according to the following taxa.

| **Specimen** | **X** | **Y** |
|---|---|---|
| Phylum | | |
| Class | | |

**33**. You are provided with a freshly killed specimen labeled P.

a) (i) Using a hand lens, examine the anterior view of the head and take note of the structures used for sensitivity on the left hand side of the head.

……
……

State how the above structures are adopted to their functions.

……
……

b) Place the specimen on the dissecting tray with dorsal surface uppermost. Cut along the left lateral side of the abdomen to open up the abdominal cavity. Also cut along the right lateral side of thorax to open up the thoracic cavity. Fix the crop with a pin in its original position.

Immerse the dissection in water. Displace the alimentary canal in the abdominal cavity to the left. Draw and label the secretory and absorptive structures displayed.

**34**. You are provided with solutions labeled R, S, T and V

(a) Carryout tests on the solutions as indicated in table 1. Record your test, observations and deductions.

| Test | Observation | | deductions |
|---|---|---|---|
| Iodine test | R | | |
| | S | | |
| | T | | |
| Benedict's test | R | | |
| | S | | |
| | T | | |
| Buirets test | R | | |
| | S | | |
| | T | | |

(b) Label test tubes as $R_1$, $R_2$, $S_1$, $S_2$ and T add $3cm^3$ of corresponding solution to each test tube. Further add into test tubes $R_1$, $S_1$ and T $3cm^3$ of solution V while into test tubes $R_2$ and $S_2$ add $3cm^3$ of solution T. incubate the test tubes in a water bath maintained at 370C – 400C for 60 minutes (meanwhile proceed with other work). After 60 minutes, carryout tests on the contents of test tubes in table II and record only the observation and deductions.

| Test | Test tube | Observation | Deductions |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Iodine test | $R_1$ | | |
| | $R_2$ | | |
| Benedicts test | $R_1$ | | |
| | $R_2$ | | |
| | T | | |
| Buirets test | $R_1$ | | |
| | $R_2$ | | |
| | $S_1$ | | |
| | $S_2$ | | |

(c) Explain your results in table I and II

……

……

**35.** You are provided with specimens labeled W, X, Y and Z.

(a) Obtain a small thin section of W using a razor blade and peel off a small piece of inner epidermis from X. place each a separate slide and stain with iodine solution. After two minutes blot off the iodine. Observe each under medium power of microscope.

(i) Give four differences between W and X

| W | X |
|---|---|
| | |
| | |
| | |
| | |

(ii) How is W adapted for successful survival of its parent plant.

……

……

(iii) Draw and label one half of Z.

**(iv)** How are Y and Z adapted for dispersal from the parent plant.

……

……..

**36.** You are provided with specimen K which has been freshly killed.

(a) Cut off the wings, limbs and antennae at their base. Turn the specimen such that the ventral side faces the wax of the dissecting dish. Draw fully (Don not label).

(b) Now turn the specimen such that the dorsal side faces the wax of the dissecting dish. Observe the posterior end of the abdomen.
Giving reasons, suggest the significance of the characteristic features.

……
……

(c) Pin the specimen and dissect to release the dorsal cuticle. Pin this cuticle to the left side of the specimen. Clear off any fat and any unnecessary tissue to display.

(i) All the parts of the alimentary canal and displaced to the side of your choice.

(ii) The structures associated with the inner surface of the abdominal cuticles. Draw and label the structures displayed in (i) and (ii) on the same drawing.

**37.** Solutions A and B are both mixtures of common carbohydrates.

(a) Using the chemicals and reagents provided carryout tests to determine the composition of solution A and B. Record your tests, observations and conclusions in the table 1 below;

| **TEST** | **OBSERVATION** | **CONCLUSION** |
|---|---|---|
| Reducing sugar | A | |
| | B | |
| Starch | A | |
| | B | |
| Non reducing sugar | A | |
| | B | |

(ii) Comment on the abundance of the common nutrient in solutions A and B

……
……

(ii) Explain the difference (if any) in observations for reducing sugar and non-reducing sugar where solution A was used.

……
……

(b) Set up tubes 1-4 below to determine the solution containing an enzyme between solutions C and D: Lucubate the contents of tubes 1-4 in water bath maintained at 35-40;C for 30 minutes.
After this time, carryout Benedict's test on contents of each tube.

**Summary of the contents**

| **Tube** | **Contents** |
|---|---|
| 1 | $2cm^3$ of A + $1cm^3$ of C |
| 2 | $2cm^3$ of A + $1cm^3$ of D |
| 3 | $2cm^3$ of B + $1cm^3$ of C |
| 4 | $2cm^3$ of B + $1cm^3$ of D |

Record your observations and conclusions in Table 2 below

| **TUBE** | **OBSERVATIONS** | **CONCLUSIONS** |
|---|---|---|
| 1 | | |

| | | |
|---|---|---|
| 2 | | |
| 3 | | |
| 4 | | |

(i) Compare and explain the results for test tube pairs:
1 and 3……
2 and 4……

(i) Giving evidence from your observations, name the active substance investigate in (b) above.
……
……
Name of active substance
Evidence……

**38** Using a hand lens/ low power magnification of the microscope, examine the external features of specimen R, S, T and U provided.

(a) (i) For each specimen, state two structural characteristics used to place the specimen into its class.
Specimen S:
1……

2……
Specimen T:
1……

2……

(ii) Name the order to which the specimens belong;
R……
S……
T……
U……

(ii) Mention three observable features used to classify the spciemns into the same major group.
……
……

(b) Using the low power magnification of a microscope, examine the antennae of specimens R and U.

(i) Give two structural differences and similiarities observed in the antennae of the specimen.
Differences

| R | U |
|---|---|
| 1 | |
| 2 | |

Similarities:
1……
2……

(iii) For specimen R, draw and label the left antenna and its attachment to the head.

(iv) State the view from which the antenna was drawn.

……
……

(c) What three structural characteristics show the specimen T survives on a parasitic mode of life?

……
……

(b) Excluding structures from the head region, construct a dichotomous key to identify the specimens in the order R, S, T and ending with U.

……
……
……
……

**39**. You are provided with specimen R which is a freshly killed animal.

(a) (i) Examine the head and describe its shape.

(ii) Measure the thickness, width and length of the head.
Length ……cm
Width ……..cm
Thickness……....cm

(iii) State the ratio of.
Thickness to length ……cm
Thickness to width……..cm

(iv) What is the significance of the shape and proportions of the head in relation to its mode of life.

(b) (i) Examine the limbs of the specimen and draw a forelimb and hind limb to the same magnification in the space below:
Fore limb.

Hind limb

(ii) Explain the significance of the differences between the fore limb and the hind limb to the mode of life of the animal.

……
……

(c) Dissect the specimen to display the blood vessels returning blood from the right side of the head and chest region of the animal to the heart.
(Do not throw away your dissection; you will need it for question 2).

**40.** (a) You are provided with solution P and Q using iodine solution, Benedict's solution and Biuret's reagent only.
Record your tests, observation and deductions in the table below.

| Tests | Observations | Deductions |
|---|---|---|
| | | |
| | | |
| | | |

| | | |
|---|---|---|
| | | |
| | | |

(b) Cut a piece of the stomach from the dissection in question 1, measuring $1cm^2$. Wash and grind it in a mortar. Add $4cm^3$ of distilled water, leave to settle then decant. Label the extract T. Label four test tubes 1, 2, 3 and 4 and add contents to each test tube as shown in the table below:

| | |
|---|---|
| Test tube 1 | $2cm^3$ of P and $1cm^3$ of dilute HCI solution |
| Test tube 2 | $2cm^3$ of P and $1cm^3$ of dilute NaOH solution |
| Test tube 3 | $2cm^3$ of Q and $1cm^3$ of dilute HCI solution |
| Test tube 4 | $2cm^3$ of Q and $1cm^3$ of dilute NaOH solution |

Divide extract T into four equal portions and add a portion to each of test tube 1, test tube 2, test tube 3, and test tube 4 above.
Incubate the test tube at $40^0C$ for 20 minutes after 20 minutes.

(i) Observe test tubes 1 and 2 and record your observations and deductions in the table below:

| | Observation | Deduction |
|---|---|---|
| Test tube 1 | | |
| Test tube 2 | | |

(ii) Identify the food substances in test tube 3 and 4 using the reagents provided. Record your tests observations and deductions in the table below.

| **Test tube** | **Tests** | **Observation** | **deduction** |
|---|---|---|---|
| 3 | | | |
| | | | |
| 4 | | | |
| | | | |

(iii) From your results, state two properties of the active substance in solution T.

……
……

(c) You have been provided with a fresh bean seed labeled D. Remove the testa and split the seed into two.

Cut another piece of the stomach, two pieces of the liver, a piece of the leg muscle and a piece of lung from the dissection in question1.
All the pieces should be the same size as one half of the split bean seed.
Boil one half of the bean seed and one piece of the liver, separately for 3 minutes then cool.
Label six test tube 1,2,3,4,5 and 6 then add 2cm3 of hydrogen peroxide to each test tube followed by different cut pieces to each tube as indicated in the table below.
Record your observations and deductions.

| | **Observations** | **Deductions** |
|---|---|---|
| Test tube 1 and un boiled half of bean seed | | |
| Test tube 2 add boiled half of bean seed | | |

| | | |
|---|---|---|
| Test tube 3 add un boiled piece of liver | | |
| Test tube 4 add boiled piece of water | | |
| Test tube 5 add piece of leg muscle | | |
| Test tube 6 add piece of lung | | |

(d) From your results state three conclusions from the experiment in (c).

……

**42.**

(a) Mount a little of specimen A and B on two separate microscope slides, mount and observe in each case. Also observe the other specimens critically.

State two characteristic features of each specimen.

A……

B…….

C……

D……..

E……

(b) Suggest on ecological advantage of each of the following specimens.

(i) B over A……..

(ii) C over D…….

(c) (i) Describe the structure of the leaves of specimen D and E

D…….

E……

(ii) Make an accurate drawing of the lamina of specimen D half its size.

Do not label.

(d) Using only the features state in (a) above, construct a dichotomous to identify the specimen starting with A, B, C, D and ending with E.

**43.** You are provided with a freshly killed animal labeled specimen M.

a) Examine the hind and fore feet of the animal.

(i) Draw and label one hind foot from the ventral side.

(ii) State three differences between the hind foot and the fore foot

| Fore foot | Hind foot |
|---|---|

| | |
|---|---|
| | |
| | |

(iii) State the significance of any one difference between the fore foot and the hind foot to the mode of life of the specimen

……

……

b) Identify three structures on the head of the specimen that are used for sensitivity and for each structure, describe its suitability to the role it performs.

| Structure | Suitability to the role performed |
|---|---|
| | |
| | |
| | |

A) Lay the animal ventral side upper most and dissect it in the usual manner.
Remove the alimentary canal and proceed as follows:Search for blood vessels that supply blood to the left hand side of the head, forelimb and lung. Trace for routes of blood flow, draining the arinogenital system and outer parts of the hind limb. Without displaying the heart, draw and label your dissection

**44**. You are provided with solutions W, X, Y and Z solutions X, Y and Z contain food nutrients. You are required to carry out tests to determine the food nutrients contained in the solutions and investigate the action of solution W on solutions X, Y, and Z following the instructions provided.

a) Carryout the iodine and Benedict's tests on solutions X, Y, and Z and record your tests, observations and deductions in table

| Test | Solution | Observations | Deductions |
|---|---|---|---|
| ) Iodine test | X | | |
| | Y | | |
| | Z | | |

| | | | |
|---|---|---|---|
| ) Benedict's test | X | | |
| | Y | | |
| | Z | | |

b) Label 3 tests tubes as X, Y, and Z and add into each of them $2cm^3$ of solution W incubator the mixtures at a temperature of $37^0C$-$40^0C$ for 1 hour ( you may proceed with other work in the meantime). After 1 hour, carryout the iodine and Benedicts' tests and record your observations and deductions in the table below.

| Test | Solutions | Observations | Deductions |
|---|---|---|---|
| Iodine test | X+W | | |
| | Y+W | | |
| | Z+W | | |
| Benedict's test | X+W | | |
| | Y+W | | |
| | Z+W | | |

(c) Suggest

(i)Explanations for your results in (b)

……

……

(ii) The nature of W.

……

**45.**

**46**. You are provided with specimen K which is freshly killed.

a) (i) Identify the sex of the specimen.

……

(i) Describe the structures you used to determine the sex of the specimen.

(ii) ……
……

c) Dissect the specimen to display the contents of the abdominal cavity. Cut out the specimen without breaking much of the mesentery.Describe the duodenum loop to the right of the specimen then turn the bulk of ileum to the left of the specimen. Displace the colon and the caecum downwords to the right of specimen to display the vessels that carry blood from the alimentary canal to the liver which is displaced anteriorty.
Draw and label structures visible in the abdominal region in the space provided

c) Cut out the alimentary canal then continue to dissect to display the vessel that drain blood from the upper parts of the hind limbs and abdominal region, back to the heart. Draw and label the vessels on the left hand side of the specimen excluding the heart

**47**. You are provided with solutions A and B. you are to investigate the action of saliva and dilute hydrochloric acid on these solutions (A – 1% starch solution, B – 5% sucrose solution)

Procedure

(i) Put $1cm^3$ of solution A and $1cm^3$ of benedict's solution in a test tube and boil. Allow it to cool. Record your observation and conclusions in table 1 below. Repeat the same procedure with solution B.

**Table 1**.

| **Test** | **Observation** | **Conclusion** |
|---|---|---|
| solution A + Benedicts solution boil and cool | | |
| Solution B + benedicts solution, boil and cool | | |

| | | |
|---|---|---|
| | | |

(ii) Put 1cm$^3$ of solution A into each of the two test tubes labeled 1 and 2. Put 1cm$^3$ of solution B into each of other two test tubes labeled 3 and 4. Put all the four test tubes in a water bath maintained at 35 – 40$^o$c.
Rinse your mouth with warm water to remove any food particles and then collect 2cm$^3$ of saliva in a test tube. Dilute the saliva with an equal volume of distilled water, mix well. Put 1cm$^3$ of the diluted saliva into each of the test tubes 1 and 3. Put 1cm$^3$ of dilute Hcl into each of the test tubes 2 and 4 and ensure thorough mixing. Leave the test tubes in the bath, shaking them well at regular intervals.

(iii) After 5 minutes take a sample from each of the test tubes (one) and add 5 drops of benedict's solution and boil. To each of the test tubes 2 and 4, add 1cm$^3$ of sodium hydroxide followed by 5 drops of Benedict's solution and boil. Record your observations in the table below. Repeat stage (iii) with the remaining contents in test tubes 1 -4 after 30 minutes.

| | Tests | | |
|---|---|---|---|
| | | After 5 minutes | After 30 minutes |
| 1 | Solution A + saliva | | |
| 2 | Solution A + dilute Hcl | | |
| 3 | Solution B + saliva | | |
| 4 | Solution B + dilute Hcl | | |

(a) from the results above, explain your observation for
(i) solution A
……
solution B
……

(b) What was the use of adding dilute sodium hydroxide solution to the test tubes 2 and 4 before carrying out Benedicts test?
……

(c) suggest with reason (s) what solution A and B are:
(i) Solution A
.....
.....
Reason
.....
(ii) Solution B
.....
Reason
……

**48.** You are provided with specimens P, Q, R, S and T which were obtained from the shoot system of different plants.

a) Observe specimen S, and T and describe their structures.
S……
T……

(i)Using the same pair of axes, plot a suitable graph to represent the above data (considering distance travelled by solution and surface area –volume ratio)

b) (i) Observe specimen P, Q, and R and describe the pattern of arrangement of their florets.
P……

Q……
R……

(ii) Remove a single floret from specimens P, Q and R. Examine the floret using a hand lens where necessary. Give two descriptive structural features on each of the following floral parts of each floret.

| Floral parts | Floret of specimen P | Floret of specimen Q | Floret of specimen R. |
|---|---|---|---|
| Pistil | | | |
| Stamens | | | |
| Petals | | | |
| Bracts | | | |

C) (i) Cut specimen T longitudinally into two halves, observe the internal structures using a hand lens. Draw one half of the flower showing only the essential reproductive floral structures.

(ii) Using the unique structural features, construct a dichotomous key to identify the specimen in the order given (Beginning with P, ending with T).

……
……
……
……

**49**. You are provided with specimen k.

a) Examine the specimen and name the external features which are characteristic of the class to which the specimen belongs

……
……

b) From your observation of the external features, state with reasons the sex of the specimen.

……

c) Place the specimen ventral side upper most .Draw and label the end to the abdomen.

d) Using a hand lens examine one antenna and draw .Do not label.

e) Place the specimen dorsal side upper most and dissect to expose the structure with in the abdominal cavity.

(i) Displace the structure to display the salivary gland on the left of the specimen.

(ii) Displace the alimentary to the right of the specimen. Remove all unnecessary tissue to display all the parts of the alimentary canal and the structures on the ventral cuticle. Draw and label.

**50**. You are provided solutions A, B and C. you are required to carry out the following tests to identify the nature of solution C, then find out the action of solution A and B on C
(2 – 2% pepsin, B – 2% trypsin, C – egg albumen)

(a) Carry out the tests, observation and deduction in table 1.

| Test | | Observation | Deduction |
|---|---|---|---|
| (i) | iodine test, To $1cm^3$ of C add 3 drops of iodine solution | | |
| (ii) | benedicts test to $1cm^3$ of C, add $1cm^2$ of benedicts solution and boil | | |
| (iii) | Burette test To $1cm^3$ of C, add 5drops of NaOH solution followed by 4 drops of $CuSO_4$. | | |

What is the nature of C?

Carry out tests described in table 2 and record your observations and conclusions in the table below

**51**. You are provided with specimen C, D, E and F which are inflorescences.

(a) Observe each specimen and describe the pattern of arrangement of florets.

C……

D……

E……

F……

b) Remove a single floret from specimens C,D and E. Examine the florets using a hand lens where necessary.

(i) Give two descriptive features on each of the following floral parts of each floret.

| Floral part | Floret of specimen C | Floret of specimen D | Floret of specimen E |
|---|---|---|---|
| Pistil | | | |
| Anthers | | | |
| Petals | | | |
| Bracts | | | |

(iii).With reference to the information in the table in b (i), state how the florets from specimen D and E are adapted to their modes of pollination

Florets from D

……

……

Florets from E

……

……

C). Remove one floret from specimen F. Cut it symmetrically into two halves. Observe the internal structures using a hand lens.

Draw one half of the floret and label only the essential reproductive floral structures.

**52**. You are provided with specimen C a freshly killed animal.

a) Examine the specimen and then answer the questions that follow

(i) Is the animal male or female? Give two reasons

.....

.....

.....

(ii) Describe the appearance and coloration of the body skin and state their significance to the animal.

.....
.....
.....
.....

b) (i) Using a piece of thread provided measure and record the length of one fore limb and one hind from the same side of the animal.
Length of fore limb.....
Length of hind .....

(iii) Calculate the ratio of the length of the hind limb to that of the fore limb.
.....
.....

(iv) What is the significance of the ratio to the locomotion of the animal?
.....
.....

c) Give three observable structural differences between the fore limbs and the hind limbs of the animal.
.....
.....
.....

d) Pin the amphibian with its ventral side uppermost on the dissecting board. Carefully proceed to dissect the animal to expose and display the spinal verves and the sympathetic nervous systems. Draw and label fully.

**53**. You are provided with two tissues labeled $X_1$ and $X_2$, and extract Y, made by crushing a fresh plant organ.

a) Carryout food tests on the extract Y using the reagents provided. Record your tests, observations and deductions in table 1 below.

| TEST | OBSERVATION | CONCLUSION |
|---|---|---|
| Starch | | |
| Proteins | | |
| Reducing sugars | | |

Tie one end of each tissue x1 and x2 tightly using a thread to ensure that it does not allow passage of material at this point.

Pour ten (10cm3) of extra Y each tissue and tightly tie so that it does not escape. Place the tissue x1 and x2 in water baths; x1 maintained at a temperature between 250c and 28oc. X2 maintained at a temperature between 400c and 480c.Ensure that the water baths contain just enough water to cover the tissue. Leave them to stand for 20 minutes. After this period, pour the extracts in separate test tubes and leave to cool for 5 minutes.

b) Carry out food tests on each of the extracts. Record your tests, observations and deductions in table 2 below;

| TESTS | OBSERVATIONS | DEDUCTIONS |
|---|---|---|
| Starch | | |
| Protein | | |
| Reducing sugar | | |

c) Using the solution from the water bath where x2 was placed, carry out tests and record your observations and deductions in table 3 below.

Table 3 (06 marks)

| TEST | OBSERVATION | DEDUCTION |
|---|---|---|
| Starch | | |
| Protein | | |
| Reducing sugars | | |

d) (i) Explain your results in table 2 and 3.

……

……

(ii) Suggest a specific plant organ from which extract Y was obtained

……

e) State two factors being investigated in (b) above.

……

**54.** You are provided with specimen L and M all of the species.

a) Peel off a small piece of the epidermis from the upper and lower surface of specimen L and M. Mount each piece of epidermis in a drop of water one at a time on a glass slide

(i) Observe under low power and count the number of stomata visible under two fields and calculate their average number.

| Specimen | Surface | Microscopic field | | Average number |
|---|---|---|---|---|
| L | Upper | | | |
| | Lower | | | |

| | | | | |
|---|---|---|---|---|
| M | Upper | | | |
| | Lower | | | |

(ii) Explain the observed stomata distribution in specimen M.

……

……

(iii) With reasons from the table above; suggest a suitable habitat from which each specimen was obtained.

L

Habitat……

Reason

……

M

Habitat……

Reason……

b) Peel off two small pieces of epidermis from the lower surface of specimen L. Irrigate one with a drop of 10% potassium chloride solution and the other with drop of distilled water on the same glass slide.

Observe both under medium power of a microscope.

(i) State two observable differences between the two pieces of epidermis

(i)……

(ii)……

(b)ii) Explain the observed difference in b (i) above.

……

b)(iii) Draw and label two cells from one piece that makes up a stoma.

(iv) State the adaptation of one of the cells in b (ii) above to its function.

……

……

**55**. You are provided with a freshly killed specimen, N.

a) Classify giving a reason according to the following,

(i)

Kingdom……

Reason……

Phylum……

Reason……

Class……

Reason……

b) How is the specimen adapted to its habitat?

**……**

**……**

C) (ii) Describe the structure of the hind limb

……
……

(ii) Draw and label the hind limb of the specimen.

c) Dissect specimen N to display the digestive system with its associated organs, draw and label.

**56**. In the presence of certain chemical substances, hydrogen peroxide decomposes easily, liberating water and oxygen by effervescence according to the equation.

$2H_2O_{2(u)} \longrightarrow 2H_2O_{(u)} + O_{2(g)}$

You are provided with soaked bean seeds and manganese dioxide. Carry out the following experiments to investigate the effect of soaked bean seeds and manganese dioxide on hydrogen peroxide.

**Procedure:**

i) Label four test tubes 1, 2, 3 and 4.
ii) To test tube 1 add a spatula end full of manganese dioxide
iii) To test tube 2 add a spatula endfull of manganese dioxide and heat for about 3 minutes. Leave to cool.
iv) Choose 2 – 3 soaked bean seeds for 5 minutes, crush and place in test tube 3.
v) Boil 2 -3 soaked bean seeds for 5 minutes, crush them and place in test tube 4.
vi) To test tube 1 add a few drops of hydrogen peroxide and record your observation in the table below.
vii) Repeat (v) for test tubes 2, 3 and 4. Record your results in the table below.

| **Test tube** | **Observation** |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

i) Suggest the name of the chemical substance that produced the changes in test tube 3.
.....
.....
.....

ii) Interprete your observations and comment on the biological principles underlying the experiment

.....
.....
.....

48. You are provided with specimens O and B

(a) (i) Identify the specimens using a hand lens where necessary.

Specimen O.....

Specimen B.....

(ii) To which phylum does each specimen belong?

Specimen O.....

Specimen B.....

(iii) State the habitat of each specimen.

O.....

B.....

b) Mount a filament of F in a drop of water. Put a cover slip observe high power. Draw and label fully the structure of one cell.

(c) Peel off a thin epidermal layer from the upper side of the specimen B. mount on the slide in a drop of water and cover with cover slip. Observe and count the number of stomata in a field of view. Peel the epidermal layer from the lower side and repeat the procedure before and count the number of stomata observed in one field on each side in the table below.

| Surface | High power | Medium power | Low power |
|---|---|---|---|
| Upper | | | |
| Lower | | | |

d) State the adaptations each specimen has to enable it survive in its habitat.

Specimen O

.....
.....

Specimen B

.....
.....

**57**. You are provided with specimen O which is freshly killed animal.

a (i) Examine the head and describe its shape

.....

(ii) Measure the thickness, width and length of the head.

Thickness.....

Width.....

Length.....

(iii) What is the significance of the shape and proportions of the head in relation to its mode of life?

.....
.....

b) (i) Examine the limbs of the specimen and draw a fore limb and hind limb to the same magnification in the space below.

Fore limb hind limb

(ii) Explain the significance of the difference between the fore limb and the hind limb to the mode of life of the animal.

.....

.....

c) Dissect the animal to display the heart and associated blood vessels that drain blood from the fore limbs, head region and skin in the thoracic region. Draw and label the heart and associated vessels on one side of your dissection. (Do not throw away your dissection. You will need it for question two)

**58**. Cut a piece of stomach from the dissection in question 34. Measuring $1cm^3$ wash and grind it in a mortar. Add $4cm^3$ of distilled water, leave to settle then decant. Label the extract S.
Label four test tubes 1, 2, 3, and 4 and add contents to each test tube as shown in the table below.

| | |
|---|---|
| Test tube 1 | $2cm^3$ of X + $1cm^3$ of dil Hcl solution |
| Test tube 2 | $2cm^3$ of X + $1cm^3$ of dil NaOH solution |
| Test tube 3 | $2cm^3$ of Y + $1cm^3$ of dil Hcl solution |
| Test tube 4 | $2cm^3$ of Y + $1cm^3$ of dil NaoH solution |

Divide extract S into four equal portions and add to each of the test tubes 1, 2, 3 and 4 above. Incubate the test tubes at 40ºC for 20 minutes.

i) Observe test tubes 1 and 2 and record your observations and deductions in the table below.

| | **Observations** | **Deductions** |
|---|---|---|
| Test tube 1 | | |
| Test tube 2 | | |

ii) Identify the food substances in test tubes 3 and 4 using the reagents provided.

| **Test tube** | **Tests** | **Observations** | **Deductions** |
|---|---|---|---|
| 3 | | | |
| 4 | | | |

From your results state two properties of the active substance in solution C.

.....

**59**. You are provided with the following specimens C, D, E, F and G.

a) Complete the table below.

| | **LAMINA** | **VEINS** | **MARGIN** | **PETIOLE** |
|---|---|---|---|---|
| | | | | |

| | | | | |
|---|---|---|---|---|
| **C** | | | | |
| **D** | | | | |
| **E** | | | | |
| **F** | | | | |
| **G** | | | | |

b) Using features in the table above, construct a dichotomous key for the specimens.

B) Draw and label specimen E.

**60**. You are provided with specimen B.

(a) Using a scalpel, peel the specimen then cut out two cubes from it. Cube B measuring, 2cmx2cmx2cm

(i)Calculate the surface area, the volume and the surface area to volume ratio of each cube in table 1. Show your working.

| | | | |
|---|---|---|---|
| B1 | | | |

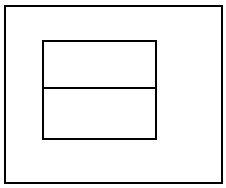
| | | | |
|---|---|---|---|
| B2 | | | |

b) Cut a very thin slice of specimen B using a sharp razor blade. Place the slice on a slice in a drop of water and irrigate with iodine solution. Observe the slice under the medium power of a microscope.
(i) Draw and label three adjacent cells observed.

(ii) Giving a reason, suggest the name of the tissue observed.

(iii) From your observation, state the function of the tissue observed.
(iv) Immerse each cube completely in a beaker containing potassium permanganate solution and leave for 15 minutes. After 15 minutes remove the cube from the solution and wipe them using a blotting paper.
Using a razor blade, cut each cube into two halves. Using one half of each cube, measure the distance in mm, a cross the un coloured portion as indicated in fig 1.

Fig 1



Record your results.
B1
B2.
(v) What physiological process is observed in (iv)?

(vi) How do the results in (iv) relate to the physiological process named in (v), in living organism?

C) Using a mortar and pestle, crush the remaining piece of specimen B.
Add $10cm^3$ of water to it, stir then decant the liquid part into a test tube.
(i) Carryout test for proteins, starch and reducing sugar on the solution using the reagents provided.
Record your tests, observations and conclusions in table 2.

| | Test | Observations | Conclusion. |
|---|---|---|---|
| Protein | | | |
| Starch | | | |

| | | | |
|---|---|---|---|
| Reducing sugar. | | | |

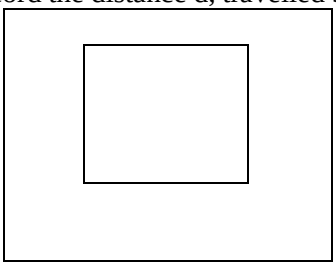
(ii) To 5cm$^3$of solution B, add 2cm$^3$of solution Y provided. Incubate in a water bath at 35-40$^0$c for 5 minutes. Repeat the tests in table 2 above using the incubated mixture. Record your observations and conclusions in table3.

| | | |
|---|---|---|
| Test for protein | | |
| Test for starch | | |
| Test for reducing sugar. | | |

(iii) From the results in (c) (ii) suggest the nature of solution.

(iv) State one property of solution Y shown by the results in C) (ii)

**61**. (a) You are provided with specimen N which is a plant organ and solution Y which is a common laboratory reagent. You are required to work out the values of;
Surface area for the cubes to be obtained from specimen N and the volume.
Distance, d, traveled by solution Yin the various size of cubes.
Procedure.
Obtain five cubes A, B, C, D and E of dimensions 10mm, 15mm, 20mm, 25mm and 30mm respectively from specimen N. Transfer them into a beaker containing solution Y. Ensure all are fully submerged. Leave the set up to stand for 120 minutes (meanwhile continue with other tasks). After this time, pour off solution Y and put all the cubes on a clean white sheet of paper provided. Cut through cube A and record the distance d, travelled by solution Y in the cubes as shown below.



Repeat the procedure for the remaining cubes B, C, D and E. Record your results in the table below including values of; surface area
Volume
Show your working clearly in the table where necessary.
**(i)**

| Cube | Volume of cube ($mm^3$) | Surface area / Volume. | Distance d travelled by solution y (mm) |
|---|---|---|---|
| | | | |

| | | | |
|---|---|---|---|
| A | | | |
| B | | | |
| C | | | |
| D | | | |
| E | | | |

(ii) What process is being investigated in this experiment?

b) (i) Comment on the trend of the graph plotted in (i) above.

(ii) Explain the biological significance of the results of the investigation.

(iii) Where in the human body is the process investigated involved in the movement of materials?

**62**. Crush the crop, midgut and hind gut separately from the dissection. Add about $5cm^3$ of water. Label the solutions crop solution, hindgut solution and mid gut solution.
Using the reagents provided, carry out tests to identify the food substances present in the crop solution, mid gut, hindgut solution. Record your tests, observations and deductions in the following table.

ii) In which region does digestion take place in cockroach? Give a reason for your answer.

.....

.....

d) Explain the results of each solution.

.....

.....

55. You are provided with specimens labeled W, X, Y and Z.
    (a) Make longitudinal cuts of each of the fruits W and X obtain equal parts
        (i) Draw and label all structures seen in one half of W and X.

        (ii) State three structural similarities between W and X
        .....
        .....

        (iii) State six structural differences between W and X
        .....
        .....
        .....
        .....

        b) Carry out the following experiment to determine the amount of the ascorbic acid, in fruits W, Y and Z.
        Mash W in a mortal and with the help of a glass rod and funnel, squeeze the juice through a muslin cloth into a test tube labeled W.

    c) Repeat the procedure above with a fruit Y and Z using fresh muslin each time.
    d) Label three small beakers W, X and Z into each measure exactly 2.0cm$^3$ of DCPIP. Measure exactly 5.0cm$^3$ of glacial acetic acid and then add it to each of the three beakers. The blue colour in each beaker will turn pink.
    e) Using a graduated pipette draw up the fruit juice W and note the amount drawn up. Slowly run it drop wise into beaker W with constant shaking until the pink colour in the beaker disappears, leaving the colour of the original fruit juice. Read and record the volume of juice used to neutralize 2.0cm$^3$ of DCPIP.
    f) Repeat procedure (iv) for fruit juice Y and Z using a clean pipette each time.
    g) Tabulate your results below.

| **Sample** | **Volume of juice used /cm$^3$.** |
|---|---|
| W | |
| Y | |
| Z | |

You are given that 2.0cm$^3$ of DCPIP is equivalent to 0.2mg of vitamin C.

i. How much vitamin C is present in each sample volume used to neutralize 2.0cm$^3$ of DCPIP? Give reason.
   .....
   .....

ii. Calculate the amount of vitamin C in 100cm$^3$ of each sample. Show your working clearly. Enter your results below

d) Which fruit has the highest concentration of vitamin C.
.....
ii) Give reasons why vitamins are important in nutrition.
.....
.....

e) Make a large labeled drawing of the lower surface of specimen of L.

**63**. You are provided with specimens F, G, H, I, J, K and L.
(a) Identify each specimen.
F.....
G.....
H.....
I.....
J.....
K.....

b) (i) What are the differences between the upper and lower surface of specimen I.
.....
.....
(ii) What is the cause of the difference?
.....
.....
c) What advantage do these differences offer the organisms from which the specimen was obtained?
.....
.....
d) Make a simple dichotomous key to identify the specimen in the order J, L, K, H, I, G, F.
.....
.....

**64**. You are provided specimens A, B, C, D, E
(a) State the observable differences between A and D.
Specimen A Specimen D
.....
.....
b) Using a hand lens examine the tarsus of the hind limb of each of specimen C & D.
(i) Draw the tarsus of each limb

(ii) Give the ecological significance of the structure of each tarsus.
.....
.....
.....

58. You are provided with a freshly killed animal S.

a. Classify the animal from phylum to order, giving the observable characteristics for your classification.
   Phylum
   Characteristics
   .....
   .....
   Class
   Characteristics
   .....
   .....
   Order
   Characteristics
   .....
   .....
   ii) Open the mouth of the animal and examine the teeth. What special adaptations do the teeth reveal?
   .....
   .....
b. Dissect the specimen to clearly display the structures lying posterior to the diaphragm without displacing any organs. Draw and label your dissection.

C) Dissect the specimen further to display the blood vessels that drain blood from the thigh of the left limb and kidney back to the heart.

**65**. You are provided with specimens C and D which are flowers.
(a) Using a hand lens, carefully examine specimen D and one flower of specimen C and state four observable differences between them.

| **Flower of specimen C** | **Specimen D** |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

b) State one functional difference between specimens C and D
.....
.....
.....
c) Give the functional advantages which specimen D has over specimen C.
.....
.....
.....
d)(i) What name is given to the whole of specimen C? Give a reason.
.....
.....
(ii) Using observable characteristics, further classify C
.....
.....
.....
60. You are provided with specimen P. Carry out the dissection of the specimen using the following procedure.
Pin the animal with the thoracic region including the neck. Lift the xiphoid cartilage and cut along the lower edge of the ribcage. Tie the xiphoid cartilage. Put it back and pin it down. Cut along the sidewall of the thorax on both sides to remove the ribcage. This should expose the main blood vessels, nerves, respiratory tract and glands in the region.

(a) draw the neck region and label fully

(b) Locate the trachea, examine it and describe its structure.

.....
.....
.....

(c) How is the structure of the trachea related to its function?

.....
.....
.....

**66**. You are provided with food extract E and you are required to make two extracts X and Y from your dissection above as, follows.

i. Obtain a whole stomach from the dissection, cut it open and wash out the contents.
ii. Chop the stomach into small pieces and grind it into a paste and add 10.0$cm^3$ of distilled water to obtain an extract.
iii. Allow to stand for five minutes and pour off the liquid, label it X.
iv. Obtain a whole pancreas and follow the steps above to obtain an extract and label it Y. Label 6 test-tube 1-6 put 1ml of food substance E in each test tube and add 1ml of X into each of the test tubes 1, 2 and 3 and 1ml of Y into each of the tubes 4, 5, 6. To each test tube 1 and 4 add 1ml of distilled water. To each test tube 2 and 5 add 1ml of dilute Hcl. To each of the test tubes 3 and 6 add 1ml of dilute NaOH. Place all the test tubes in a water bath of temperature (35 – 40$^o$c) and leave for 40minutes, shaking periodically. Observe and record your results in the table below.

b)(i) From your results comment on the nature of substance E.

.....
.....

(ii) What do the above results tell about the behavior of extracts X and Y?

.....
.....
.....
.....

**67**. You are provided with specimens O and Q which are inflorescences. Pick one flower from each inflorescence and examine carefully using a hand lens.

a) Describe the structure of each flower in respect to the specified parts as indicated in the table.

| **Structure** | **Flower from O** | **Flower from Q** |
|---|---|---|
| Petals | | |
| Sepals | | |
| Bracts | | |
| Stamens and carpels | | |

b) Using the descriptive features in the table above. State how the structure of each flower is adapted to the reproductive life of the plant of each specimen.

Specimen O

.....
.....

Specimen Q

.....
.....

c) Draw and label a flower from specimen Q.

**68.** You are provided with specimen T which is freshly killed. Examine the secmen an answer the following questions.

(a) (i) Describe the structure and location of the nostrils. *(04 marks)*

Structure:

……

……

Location

……

(ii) Relate the structure of the nostrils to their functions. *(03 marks)*

……

……

……

……

(b) How is the mouth adapted for feeding? *(04 marks)*

……

……

……

……

(c) Place the specimen ventral side upper most on the dissecting board and observe. Draw and label the posterior half of the specimen showing the structures characteristic of the class to which specimen T.

(d) (i) Pin the specimen on the dissecting board the usual way. Dissect to open up the abdominal cavity. Remove all fat to clearly displa all abdominal structures without displacing any. Draw label the stomach and the structures in contact and those anterior to it. *(08 marks)*

(ii) Now lay the stomach and the intestine over to the right side of specimen T and then slightly deflect the stomach interiorly. Remove the lymph nodes and pluck away the fact close to the dorsal aorta to dislay the nerves and ganglia in this region and the vessels that supply the stomach and the anterior part of the intestines. Draw and liable. *(09 marks)*

(e) Further dissect the thoracic region to remove the ribcage and thymus gland to expose the heart and the blood vessels anterior to it as well as the glands around the neck region. Draw and dissection. *(17 marks)*

**69.** You are provided with coloured sucrose solutions each measuring $10cm^3$ and concentrations as shown. A (0.0), B(0.1m), C(0.25m), D(0.4m), E(0.75m) and F (1.0m).

(a) Using the clear sucrose solution (1.0m) and distilled water, prepare $10cm^3$ each of solution $A_1 - F_1$ with concentrations correspoinding to that of solution A – F above.

(i) Record the amount of the clear solution and distilled water used in the table below: *(06 marks)*

| Solutions | A1 | B1 | C1 | D1 | E1 | F1 |
|---|---|---|---|---|---|---|
| Volume of clear | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| solution used ($cm^3$) | | | | | | |
| Volume of distilled water used ($cm^3$) | | | | | | |

(b) Using a cork borer, cut six plant tissues of leng 6 cm each from specimen Q. Transfer one plant tissue into eah of the coloured solutions and leave the stand for one hour. After one hour:-

(1) Suck alittle of the coloured solution A into a dropper and insert the tip of the dropper halfway into the corresponding clear locution A1. Carefully release one drop of the coloured solution and withdraw the dropper.

(2) Observe the movement of the coloured drop and note the time taken for the drop to either rise to the top of the clear solution or sink to the bottom.

(3) Repeat procedures 1 and 2 using a drop from the remaining solution B – f.

(i) Record your results as following:-

- - ve values for time takne if drop sinks
- + ve values if drop rises.
- Zero if drop spreads out or remains stationary where it was released.

| Drop from solution | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Time taken (mins) | | | | | | |

(ii) Plot a graph to show the relationship between time taken and the original molariteis of solution A – F. *(11 marks)*

(c) Explain the observed behavior of a drop of coloured solution:

(i) Solution C *(01½marks)*

……
……
……
……

(ii) Solution E *(01½marks)*

……
……
……
……

(iii) Suggest how you would experimentally verify the explanations given in (c) (i) and (ii) above.

……
……
……
……

*(01½marks)*

(d) (i) Compare the physical condition of the plant tissues immersed in solution B and F.

| From section B | From secion F |
|---|---|
| 1. | |
| 2. | |
| 3. | |

(ii) Explain how the physical condition of the plant materials from the two solutions (B to F) may be used to establish their osmotic potentials. *(02 marks)*

……
……
……

(iii) Suggest **one** advantage of the observed physical condition of plant material from solution B has over than from solution F in non-woody plants. *(1 mark)*

……
……
……
……

**70.** You are provided with specimen U, V, W, X and Y which are reproductive organs obtained from different plants. Examine them carefully.

(a) Briefly described the structures of the main axis and floret arrangement of specimen U and V.

U: *(2½marks)*

……
……
……
……

V: *(2½marks)*

……
……
……
……

(b) Give **three** structural differences and **one** similarity between a floret of V and that of W. (from centre)

<u>Differences:</u> *(1½marks)*

……
……
……

<u>Similarity</u> *(1½marks)*

……
……
……

(c) (i) How is specimen X adapted to a named type of pollination. *(04 marks)*

……
……
……

(ii) Remove all the structures covering the ovary of X to expose it. Obtain a thin transverse section from it and mount under low power magnification of the microscope. Draw and label the observable features. *(6½marks)*

(d) Carefully remove all structures to expose the pistil of specimen Y. Observe using hand lens. Draw and label. *(4½marks)*

**71.** You are provided with freshly killed specimen T.

(a) Examine the ventral of the foot of the hind limbof specimen. Draw and label that region of the foot. *(5 marks)*

(b) Place the specimen dorsal side upper most. Open the mouth wide and stretch out the tongue towards ou and examine.

(i) Describe the structure and position of the tongue in the mouth. *(3marks)*

……
……

(ii) Suggest the significance of the structure and position of the tongue in the mouth. *(2marks)*

……

……

(c) (i) Following dissection instructions, open specimen T to expose body circulatory and excretory structures in –situ. Draw and label. *(14marks)*

(ii) Continue with your dissection. Carry out necessary displacements to expose blood vessels that supply blood to the right thoractric structures from heart and drain blood from secretory, digestive and excretory structures in the abdominal cavity back to the heart. Draw and label your dissection with ventral view of the heart. *(18 marks)*

**72.** You are provided with plant extracts K, L and N. L and N are from similar organs but at different stages of development.

(a) Carryout the following tests to determine the concentrations of nutrients in each extrat.

Record your tests, observations and deductions in the table 1 below

| Test | Observation | | Deduction |
|---|---|---|---|
| Iodine | K | | |
| | L | | |
| | N | | |
| Buiret's test | K | | |
| | L | | |

| | | | |
|---|---|---|---|
| | N | | |
| Benedict's test | K | | |
| | L | | |
| | N | | |

(b) With a reason from the table above, suggest.

(i) The significance of organ from which the extracts were obtained. *(2marks)*

……

……

(ii) Which of the organs L and N is younger than other? *(2marks)*

……

……

(c) (i) Prepare a water bath and maintain it between 30 and $40^0$C.

Label six test t ubes as $K_1$,$K_2$,$K_3$, $L_1$, $L_2$.and $L_3$.

To each test tube add $2cm^3$ of respective solutions. Further add add contents as directed below.

To $K_1$ and $L_1$ add $2cm^3$ of solution P followed by $2cm^3$ of N.

To $K_2$ and $L_2$ add $2cm^3$of solution Q followed $2cm^3$ of N.

To $K_3$ and $L_3$ add $2cm^3$ of N.

Incubate the mixtures in the water for 50 minutes and after this time, carryout the following tests on each of the mixtures and record your observatios and deductions in table II below.

Tabel II

| Test | Observation | | Deduction |
|---|---|---|---|
| Benedict's test | $K_1$ | | |
| | $K_2$ | | |
| | $K_3$ | | |
| Buiret's test | $L_1$ | | |
| | $L_2$ | | |
| | $L_3$ | | |

(ii) Explain your results in table II. *(5marks)*

……

……

……

……

……

……

**73.** You are provided with W, X, Y and Z.

(a) (i) classify specimens into the groups indicated on the table below. *(3 marks)*

| Specimen | Phylum | Class |
|---|---|---|
| W | | |
| X | | |
| Y | | |

(ii) Descrbe the structures you used to determine the class of W.
*(3marks)*

……
……

(b) (i) Using a razor blade, obtain a thin transverse section of the root close to the base of the specimen X and mount it on a glass slides, put a drop of acidified phloroglucinol stain . Observe under low power of microscope. Draw and label the tissue plan. (5marks)

(iii) Identify the following tissues relate their structure to significance in the life of organism.
Stained red tissue *(2marks)*
……
……
central most to stained red tissue *(2marks)*
……
……

(c) Carefully peel off a plece of epidermis from the the upper surface of leaf lamina of specimen place it in a petri dish dish with solution R and leave to stand for five minutes. After time duration, place it on a glass side and cover with slide. Observe under medium power of microscope.

(i) Describe the arrangement and structural modification of the majority cells observed. (5marks)
……
……
……..

(ii) How significant is your description in (i) above in the life of plants? (2marks)
……
……

(iii) Using high power microscope, identify two other unique adjacent cells. Draw but not label. *(3marks)*

(iv) Explain the significane of the state of the cells as observed to survival of the plant.
*(2marks)*

……
……
…….

(d) Observe a filament of specimen Y. Under high power of microscope. Draw and label one cell. (6marks)

**74.** (a) You are provided with specimen **T**. Classify it into the following:-
Order:
……
Family:
……
Genus:
……
Species:
……

(b) Carefully examine the specimen and state how it is adapted to defend itself in its habitat. *(4marks)*

……
……
……
……

(c) (i) Make a drawing of the out stretched left forelimb. Do not label. *(6marks)*

(ii) State **four** structural differences between the fore and limbs. *(4marks)*

| No | Fore limb | Hind limb |
|---|---|---|
| (i) | | |
| (ii) | | |
| (iii) | | |
| (iv) | | |

(d) Dissect the specimen to display;
(i) The orgns drained by the left portal system back to the heart.
(ii) The vessels suppying blood the left thoracic region from the heart. Without displacing the heart, draw and
label your dissectin. *(27 marks)*

**75.** You are provided with solution **U, V** and **W**, suspension **E** and food test reagents.
(a) (i) Cut and remove a piece of liver from specimen **T**, measuring approximately $1cm \times 1cm \times 1cm$. Crush it in a mortar using a pesle to form a fine paste. Add 6cm$^3$ of distilled water; decant to obtain a supernant, label it **F.**
Label three test tubes 1-3. To test tubes 1 and 2 add 2cm$^3$ of solution **U** and **V** respectively.
To test tube 3 add 2cm$^3$ of water. Add 2cm$^3$ of solution **W** to each of the test tubes 1-3 followed by 2cm$^3$ of **F** in each case. Record your observations in the table below.

| **No** | **Test tube** | **Observation** |
|---|---|---|
| **1** | | |
| **2** | | |
| **3** | | |

(ii) Explain the results in each test tube in (a) test tube 1. *(2marks)*
……
……
……
Test tube 2. *(2marks)*
……
……
Test tube 3. *(2marks)*
……
……
(c) Using only the reagents provided carryout tests to identify the nutrients in suspension **E**. Record your tests, observations and deductions in the space below. *(8½marks)*

(c) (i) Cut and remove the stomach of specimen **T**. Cut open the stomach and discard its contents. Wash the stomach with little water. Crush in a mortar using a pestle add $5cm^3$ of distilled water, decant to obtan a stomach extract, label this **G.** **C**ut and remove the whole pancreas. Crush it in a mortar using a pestle.

Repeat the above procedure to obtain a pancreas extrat, label it **H**. Label six test tubes 1-6 and to each add $2cm^3$ of suspension **E**. To test tubes 1-3, add $2cm^3$ of **G**. To test tubes 4-5, add $2cm^3$ of solution **H.** To test tube 1 and 4 add $2cm^3$ of solution **U**. To test tubes 2 and 5, add $2cm^3$ of solution **V**. To test tubes 3 and 6, add $2cm^3$ of distilled water. Incubate all the test tubes in a water bath maintained at about $35\text{-}40^0C$, shaking periodically for **one hour.** After the time of incubatin note the appearance of the contents of each test tube and then add 2 drops of iodine solution. Record your observations in each case in the table below.

**Table 2** *(6marks)*

| Test tube | Appearance of contents | Observation with iodine solution |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |

(ii) Explain the results in each of the following pairs of test tubes 1 and 4.

…….
……
……

Test tube 2 and 5 *(5marks)*

……
……
……

Test tube 3 and 5. *(4marks)*

……
……
……

**76.** You are provided with specimens **O, P, Q, R** and **S**. Examine the specimens carefully.

(a) (i) Mention **one** way in which each specimen is structurally unique from the others.

**O**

……
……

**p**

……
……

**Q**

……
……

**R**

……
……

**S**

……
……

(ii) Describe concisely the mode(s) of medication in specimens. *(4marks)*

**O**

……
……

**p**

……
……

(iii) Give **one** functional advantage specimen **O** has over **R.** ***(****4marks)*

……

(c) Construct a dichotomous key to identify the specimens in the order **O, P, Q, R** and **S.** *(7marks)*

……
……
……

**77.** You are provided with specimen **K** which is freshly killed.

(a) Describe the structure of whiskers and tail and relate each to significance of successful survivial in its habiat. *(6marks)*

……
……
……
……

(b) Discect the specimen to display the contents of the abdominal cavity and cut out the caecum and rectum together with the mesentries. Draw and label the vessels supplying blood to the remaining parts of the alimentary canal and those draining blood from left structures of the urinary system. *(18marks)*

(c) By further dissection expose structures of the thoracic region in the undisplaced state. Continue to clear away any tissues from around and anterior to the heart to expose vessels within the neck region that suppl blood to the head region, respiratory tract with nexk glands interct. Draw and label the visible vessels and structures mentione within the region of the dissection. *(17marks)*

**78.** You are provided with solutions **P, Q, R, S, T, X, Y** and **Z** and specimen **W.** Solutions **P** and **Q** are extracts from same plant organ but of different development stages. Solutions **R, S** and **T** are sucrose solutions of varying concentrations, solution **X, Y** and **Z** are laboratory reagents.

(a) Carry out procedures (i) - (iv) below.

(i) Label test tubes **R, S** and **T.** Add $8cm^3$ of corresponding solution to each of themas initial volume.

(ii) Cut out three equal sized cubes each measuring 2cmx2cmx2cm from specimen **W.** Continue to cut 1 cube into 8 equal sized cubes and insert all of them into test tube **R**and start timing.

(iii) Repeat procedure (ii) using remaining cube with solutions **S** and **T** respectively.

(iv) Leave the set up to stand for one hour (mean – while proceed with other work).

(v) After one hour, decant all the solution from test tube **R** into measuring cylinder and record the final volume.

(vi) Repeat this procedure for solutions from the test tubes **S** and **T** and tabulate your results in table 1 as follows.

Table 1 *(3marks)*

| Test tube | **R** | **S** | **T** |
|---|---|---|---|
| Final volume ($mm^3$) | | | |
| Change in volume (m | | | |

(b) Explain the results in test tube where the change in volume was.

(i) Lowest *(4marks)*

……
……
(ii) Almost zero *(3marks)*
……
……
(c) Examine the physical condition of the tissue removed from test tube **R.** Record your observationsin comparison with the original condition and suggest ecological significance of the changes in the cylinder significance of the changes in the cylinder on the plant from its natural environment. *(3marks)*
……
……
(d) (i) Label test tubes 1,2,3,4 and 5. In each add $2cm^3$ of solution **Z,** Further add contents to each as shown in table 2. Record your observations. *(5marks)*

**Table 2**

| **Test tube** | **Test** | **Observation** |
|---|---|---|
| 1 | $2cm^3$ of **P** | |
| 2 | $2cm^3$ of **Q** | |
| 3 | $2cm^3$ of **X** followed by $2cm^3$ of **P** | |
| 4 | $2cm^3$ of **Y** followed by $2cm^3$ of **P** | |
| 5 | $2cm^3$ of **P** that has been boiled and cooled | |

(ii) Explain your results in table 2. *(3marks)*
……
……
(e) (i) Carry out tests to establish the relative nutrient concentration of starch and reducing sugars in solutions **P** and **Q**. Record your tests, observations and deductions in table 3. *(16marks)*

Table 3

| **Tests** | | **Observations** | **Deductions** |
|---|---|---|---|
| Starch | **P** | | |
| | **Q** | | |
| Reducing sugars | **P** | | |
| | **Q** | | |
| Biuret test | **P** | | |
| | **Q** | | |

(ii) Explain any differences between the nutrient contents of **P** and **Q** in your results. *(3marks)*
……
……
**79.** You are provided with specimen **E**, **F, G** and **H**.
(a) (i) Describe the floret arrangement in specimen. *(2marks)*
**F**
……
……
(ii) **G**
……*(2marks)*
……
(b) Describe the structural features of bracts in florets of **E.** *(3marks)*
……
……

(c) How are the following features adapted for pollination?

(i) Stamen of floret of **E.** *(3marks)*

……

……

(ii) Observable gynoecium feature of **H**. *(2marks)*

……

……

(d) Carefully obtain one inner floret from specimen **F**. Observe using a hand lens draw and label. *(6marks)*

(e) Construct a dichotomous key for the identification of specimen **E, F, G** and **H** by using only essential reproductive structures. *(3marks)*

……

……

……

……

**80.** You are provided with specimen **R** which is freshly killed.

(a) Classify the specimen according to the following taxas.

(i) Kingdom

……

(ii) Phylum

……

(iii) Class

……

(iv) Order

……

(b) How are the structures on the trunk region useful in the survival of the specimen to its habitat? *(5 marks)*

81. You are provided with specimen Z.remove a fleshy scale leaf with a razor blade. Cut the inner epidermis into six (6) squares each 1cmx1cmx1cmx1cm.peel off each square of epidermal cells and place it in distilled water in a Petri dish for 5 minutes. Label six (6) test tubes and into each place 10 $cm^{-3}$ of sucrose solution of the following concentration 0.3, 0.4, 0.5, 0.6, 0.7 and 1.0$moldm^{-3}$

a) Put one piece of epidermis into each test tube and gently shake the contents. Leave the tissue in solution for 20 minutes. Remove the piece of epidermis from each test tube and amount it in a drop of solution in which it is immersed. Observe under low power and count all cells visible and record in table 1.then count all the plasmolysis cells and record them in table 1.

Table 1

| Morality of sucrose concentration in $moldm^{-3}$ | Total number of cells | Number of plasmolysed cells |
|---|---|---|
| 0.3 | | |
| 0.4 | | |

| | | |
|---|---|---|
| 0.5 | | |
| 0.6 | | |
| 0.7 | | |
| 1.0 | | |

b) i)calculate the percentage of plasmolysed cells (7 marks)

……
……
……
……
……
……
……
……
……

ii) Using the same axes. Plot a graph showing how percentage plasmolysis varies with morality of sucrose. (11marks)

c) i)state what is being investigated in the tests. (1 mark)

……
……

……
……
ii) Explain the results of your tests (3 marks)
……
……
……
……
……
……

82. You are provided with specimen c1, c2, c3, c4 and c5
a) Classify specimen c1 under the following taxa (2 marks)
i)Kingdom……
ii)Phylum……
iii)Class……
iv)order……
b) Carefully examine specimen c1.give three observable characteristics which make it to be classified in the class stated in (a) (iii) above (3 marks)
……
……
……
……
……
c)draw and label the anterior view of the head of specimen c1. ($10\frac{1}{2}$Marks)

d) Describe the features on the head of specimen's c1, c2, c3, c4 and c5. ($12\frac{1}{2}$ Marks)

| specimen | characteristics |
|---|---|
| C1 | ……<br>……<br>…… |
| C2 | ……<br>……<br>…… |
| C3 | ……<br>……<br>…… |
| C4 | ……<br>……<br>…… |
| C5 | ……<br>……<br>…… |

e) Construct a dichotomous key to identify the specimens (4 marks)
…….
…….
…….
…….

83. You are provided with solutions W, X, Y and two pieces of material K.

(a) Carry out tests on the solutions as indicated in Table 1. Record your tests, observations and deductions in the table.

Table 1

| Tests | Solutions | Observations | Deductions |
|---|---|---|---|
| Iodine test | W | | |
| | X | | |
| | Y | | |
| Benedict's test | W | | |
| | X | | |
| | Y | | |
| Burette test | W | | |
| | X | | |
| | Y | | |

- Label two boiling tubes W and X and two test tubes as W1 and X1.
  - Transfer 15cm$^3$ of warm water to be maintained at 35cm$^3$-40$^0$C into each boiling tube.
  - Tie each piece of material K at one end with a thread and open the other end with wet fingers.
  - Measure and pour separate 4cm$^3$ of solution W and X into test tubes W1 and X1 followed by 2cm$^3$ of solution Y.
  - Carefully pour the mixture in each test tube into separate piece of material K and the open ends with another thread.
  - Insert each mixture in material K to a corresponding boiling tube W and X respectively and leave the set up to stand for 30 minutes (mean while do other work)
  - After 30 minutes, remove material K from boiling tubes and pour content into test tube W1 and X1 respectively.

(ii) Carry out tests on contents of boiling tubes and test tubes as indicated on Table II. Record your observations and deductions.

Table II

| Tests | Solutions | Observations | Deductions |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Iodine test | W | | |
| | W1 | | |
| Benedict's test | W | | |
| | W1 | | |
| | X | | |
| | X1 | | |

(ii) Tissue of N

……
……
……
……
……
……
……
……
……
……
……...

b (i) Using high power of microscopes. Observe a single cell of L. Draw and label its observable features.

(ii) How is L structurally adapted for its survival in the environment?

……
……
……
……
……
……
……
……

(b) Label two Petri dishes P and Q. Add a piece an inner epidermal tissue of N into each and cover the tissue with corresponding solution and leave to stand for 10 minutes. After 10 minutes. Prepare slide of tissue from each solution and observe under high power of microscope.

(i) Draw observable features of one cell from tissue in solution P.

84. You are provided with solution L, M and N which are extracts from seedlings at different stages of germination and M are from the same type of seed.

a) (I) carry out the following tests in tables 1, 2 and 3 to determine the nutrient content of each solution. Record your tests. observations and deductions in tables

Table 1

| Iodine test | | observations | deductions |
|---|---|---|---|
| | L | | |
| | M | | |
| | N | | |

Table 2 (7 marks)

| Reducing sugar test | | observations | deductions |
|---|---|---|---|
| | L | | |
| | M | | |
| | N | | |
| Burette test | | observations | deductions |
| | L | | |
| | M | | |
| | N | | |

III) From your results, explain the pattern of nutrient distribution in extracts L and M.

……
……
……
……
…… (3marks)

b) I) to 4$cm^3$ of solution M, add 3$cm^3$ of solution N in a test tube. Incubate at 35-40$^0$c for 30 minutes. After the time duration, carry out the tests in the table 4 on the content of test tube to establish the effect of one extract onto the other. Record your observations and deductions

Table 4 (06 marks)

| test | observations | deductions |
|---|---|---|
| iodine | | |

| | | |
|---|---|---|
| Reducing sugars | | |
| burette | | |

ii) Relate your results of the experiment to the physiology of germination. (04 marks)

……
……
……
……

iii) Suggest why preliminary tests were carried out on the extract before mixing them

……
……
…… (1 mark)

85. You are provided with specimens P, Q, R, S, T and U.examine the external structures of specimens using a hand lense/low power magnification.

a) I)state three structural characteristics common to all the specimens, relating the structure to the function (6 marks)

i) Specimen p

……
……
……
……
……
……

ii) Specimen u

……
……
……
……
……
……

c) Observe the mouth parts of specimen R under R under low power. Draw and label fully (7 marks)

d) using a hand lenses give three structural differences and similarities in the features observed on the hind limbs of specimen R and S (6 marks)

Differences

| R | S |
|---|---|
| | |
| | |
| | |

Similarities

i)…….
ii)……
iii)……..

e) By limiting yourself to the structures used for locomotion and sensitivity, construct a dichotomuse key to identify the specimens in order p to u

86. You are provided with two sets of bean seedling labeled S and T of different period of germination and solution P which is a common laboratory reagent.

(a) Obtain two test tubes, label them CS (cotyledon of S) and GS (grown part of S). Select five large seedlings of S. Peel and separate seedling parts of S into cotyledon and grown parts.

Crush each part into a paste separately. Add 10 $cm^3$ of water. Decant clear extract into corresponding test tubes.

Repeat the procedure above for seedlings labeled T.

Write and carry out Iodine, Benedict's and Burette tests on extracts, record your observations in the tables below.

Table 1

| Iodine test | Extract of | Observations |
|---|---|---|
| | Cotyledon of S | |
| | Cotyledon of T | |
| | Cotyledon of S | |
| | Cotyledon of T | |

Table II

| Benedict's test | Extract of | Observation |
|---|---|---|
| | Cotyledon of S | |
| | Cotyledon of T | |
| | Grown part of S | |
| | Grown part of T | |

Table III

| Burette test | Extract of | Observation |
|---|---|---|
| | Cotyledon of S | |
| | Cotyledon of T | |
| | Grown part of S | |
| | Grown part of T | |

Table IV

| Test | Observation |
|---|---|
| To 2 $cm^3$ of grown parts extract of S add 1 $cm^3$ of solution P | |
| To 2 $cm^3$ of grown parts extract of T add 1$cm^3$ of solution P | |

(b) (i) Explain your observation in tables (I), (II),(III) and (IV) in a (i) above.

Explanation for table 1

……
……
……
……

Explanation for Table II

……
……
……

Explanation for table III

……
……
……
……

Explanation for table IV

……
……

……
……

(iii) With a reason, suggest the part of the bean seedling that is advised to use in the baby's diet.

……
……
……
……

1. i) You are provided with specimen N, G, B, M and D. State two of their descriptive features in the table below.

| Specimen | Parts of the florets | |
|---|---|---|
| | Stigma | Outer bract |
| N | | |
| G | | |
| B | | |
| M | | |
| D | | |

(ii) Basing on the description in the table above, construct dichotomous key to identify the specimen in the order of N, M, G, D, and B

……
……
……
……
……
……

(b)(i) Gently remove perianth from florets of specimen G. Draw and label its floral parts.

(ii) Examine the florets of specimen G after discarding its perianth with a reason. Suggest the type of pollination of specimen G.

……
……
……

87. (a) You are provided with solutions O,P,H,F,Z and W and food test reagents . Carry out test on solutions O, P and F. Record your observations, deductions and tests in the table 1 below.

| TESTS | OBSERVATION | DEDUCTION |
|---|---|---|
| Iodine | | |
| Benedict's | | |
| Buiret | | |

(b) Label 6 test tubes T1 $T_2$ T3 T4 T5 and T6. Carryout the following procedures

In $T_1$, put $1cm^3$ of solution O, add 2 drops of solution Z followed by $1cm^3$ of Solution H.

In $T_{2, put}$ 1 $cm^3$ of solution O, add 2 drops of solution W followed by 1 $cm^3$ solution H

In $T_3$, put $1cm^3$ of solution P, add 2 drops of solution Z followed by $1cm^3$ of solution

In $T_4$ ,put $1cm^3$ of solution P, add2 drops of solution W followed by $1cm^3$ of solution

In $T_5$ , put $1cm^3$ of solution H, boil for three minutes, then cool, add 2 drops of solution O followed by 1cm of solution Z.

In $T_6$, put $1cm^3$ of solution F , boil for three minutes ,then cool, add 2 drops of solution P followed by $1cm^3$ of solution Z.

Incubate all the test tubes in a water- bath maintained at $37^0C$ -$40^0C$ for one hour. Mean while continue with other numbers.

I) after one hour, carry out Benedict's test on $T_1$ T2 and T5. Record your observations and deductions only in the table below.

| TESTS | OBSERVATION | DEDUCTION |
|---|---|---|
| $T_1$ | | |
| $T_2$ | | |
| $T_5$ | | |

(II) Record the observations forT3 $T_4$ and T6 in table 3 below

| TESTS | OBSERVATION |
|---|---|

| | |
|---|---|
| $T_3$ | |
| $T_4$ | |
| $T_6$ | |

(C) Explain your observations in the different test tubes;

$T_1$

……
……
……

$T_4$

……
……
……

$T_5$

……
……
……

$T_6$

……
……
……

(d) Name the factors being investing ate in the experiment.

……
……
……

88. Specimens A, B, C, D and E belong to the same phylum.

(a) Classify the specimens according to the following taxa giving two reasons in each case.

(i) Phylum

……

Reasons

……
……
……

(ii) Class for A, B, and C

……

Reasons

……
……
……

(iii) Class for D and E

…….....

Reason

……
……
……

(b) How is specimen D adapted to its mode of life?

(i) ……
……
……

(ii) ……
……
……

(iii) ……
……
……

(c) Basing on features on the thorax differentiate between specimen A and C.

| No | Specimen A | Specimen C |
|---|---|---|
| (i) | | |
| (ii) | | |
| (iii) | | |

d) Cut off the head of specimen B draw and label it.

e)Using features on the thorax only construct a dichotomous key for the specimens in the order D,E,B,C,A.

……
……
……
……
……
……
……