Explain what is meant by homeostasis. Homeostasis which is the maintenance of a constant internal environment around the cells despite fluctuations in the external environment. Excretion and regulation constitute homeostasis

Explain the meaning of metabolic, catabolic and anabolic processes. Metabolic reactions refer to the sum of anabolic reactions (which are involved in synthesis/ building up of materials e.g. photosynthesis) and catabolic reactions (involved in breakdown of materials e.g. respiration). Metabolic activities give rise to waste products collectively referred to as metabolic waste products. Most of these products are useless and harmful to the body and must therefore be eliminated.

Define excretion. Is the elimination of the waste products of metabolism from the body. It is the process by which organisms get rid of the metabolic waste products. The process takes place only in living cells.

Differentiate between excretion and egestion. Excretion is the elimination of the waste products of metabolism from the body while egestion is the removal of the indigestible and undigested food materials from the body. Such materials have not participated in the metabolic activities of the body cells. And

Differentiate between excretion and secretion. Excretion is the elimination of the waste products of metabolism from the body while Secretion is the release of useful substances such as mucus, nectar, hormones, enzymes, digestive juices, waxes etc. by the cells.

Why do we need excretion?
- To remove excess nutrients taken into the body.
- To remove the waste products produced after the useful materials have been used.

How do excretory products arise?
- From the absorption of unwanted substances along with food.
- From the absorption of excess of nutrients.
- From the break down of protoplasmic constituents.
- From the body metabolism.
- From osmoregulatory processes.

Give the categories of excretory products. Excretory products fall under two categories:

a. Nitrogenous waste products: Are those which contain nitrogen and they include urea, uric acid, trimethylamine oxide and urea.
b. Non- nitrogenous waste products: are those which do not contain nitrogen and they include excess water, excess salts and carbondioxide.

Give the metabolic processes of plants? The metabolic processes in plants are photosynthesis and respiration

Why don't plants have special excretory products? Plants do not have special excretory organs like animals because of the following reasons:

1. Some of the waste products like carbon dioxide, water and oxygen can be re- used by the plants to make other useful products e.g. the carbondioxide and water released in respiration can be used in photosynthesis. While the oxygen produced during photosynthesis can be used in the process of respiration.
2. Plants have a low metabolic rate and therefore produce waste products at a slow rate.
3. Some of the waste products in plants are less toxic and are stored within the plant tissues like the xylem. This is because plants do not carry out much protein metabolism like animals. Examples of such products are resins and gums.
4. Some plants convert the waste products into insoluble compounds which are stored in organs which drop off e.g. the leaves, petals, bark etc.

Apart from carbondioxide, water and oxygen give the other excretory products of plants.

1. **Tannins.** These are found in the bark of many trees including acacia, conifers and mangrove. Tannins are used in the treatment of leather and in the manufacture of ink. They are also used in cosmetics, to colour nails, feet and hair.
2. **Alkaloids**. These are very poisonous nitrogenous compounds e.g. quinine, cocaine, nicotine, caffeine, morphine, papain, colchicines, khat, pyrithrin etc. used in small quantities, most of them serve as medicine.
3. **Latex*.*** Is a milky substance that is produced by some plants. Latex from the rubber tree is used to make rubber.
4. **Gums.** Are produced by different plants, such as Arabica, Gnath and Carob. These gums are edible and are used to thicken foods and creams. Sapodilla is a gum used to manufacture chewing gum. Agar extracted from algae is used as a medium to culture micro- organisms.
5. **Anthocyanin.** Gives colour to petals and leaves in plants e.g. purple, red and blue. The colours are extracted to make dyes. They are also used to test the PH of chemical solutions.

Discuss the different methods of excretion in plants. Below is an outline of waste products and methods of excretion in plants:

1. **Diffusion.** Waste products that are in gaseous form like carbondioxide, and oxygen are excreted by diffusion.
2. **Transpiration.** Carbondioxide and oxygen dissolved in water are excreted by transpiration.
3. **Guttation.** Water and dissolved mineral salts are excreted through guttation.
4. **Exudation**. Exudation is the release of a fluid from a plant at a slow rate. Gums, mucilage, resins, latex, rubber, calcium pectate and oxalates are excreted through exudation.
5. **Deposition**. Resins, tannins, caffeine, nicotine, quinine, morphine, khat, pyrithrin and papain are deposited in the xylem, bark, seeds, fruits, flowers and leaves of plants. The plant is able to carry out metabolic activities without the influence of the deposited substances. When some of these structures such as the leaves, flowers fruits and bark age, they drop off from the plants thereby releasing the waste products.

Why do animals need excretory organs? Give the different animals, their excretory organs, their nitrogenous products and habitat.

Animals are more active than plants because they move about in search for food, mates and shelter. Their bodies have complex tissues and organs which carry out different metabolic activities and as a result, produce a variety of waste products in larger quantities than in plants. The table below shows excretory organs and nitrogenous excretory products of animals other than man.

ANIMAL	EXCRETORY ORGAN	NITROGENOUS WASTE PRODUCT	HABITAT
Insects	Malipighian tubules	Uric acid	Terrestrial
Bony fish	Kidney	Ammonia (fresh water dwellers) Trimethylamine oxide, TMO (sea dwellers)	Terrestrial
Cartilaginous fish	Kidney	Urea (sea dwellers)	Aquatic (marine)
Reptiles and birds	Kidney	Uric acid	Terrestrial
Amphibians a. Tadpole b. Adult	 Gills kidney	 Ammonia Urea, on land an ammonia in water	 Aquatic (fresh water) Aquatic and terrestrial
Mammals	kidney	Urea	Terrestrial

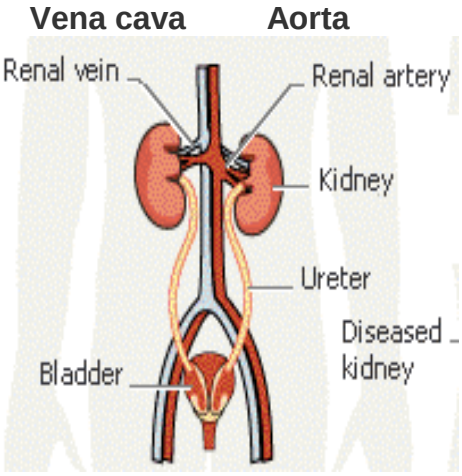
Differentiate between excretion in unicellular and multicellular organisms. Multicellular animals such as man have a large number of cells, tissues and organs. These animals cannot rely on simple diffusion for excretion. They therefore have specialized organs such as the kidneys, skin, liver and lungs for excretion.

Summarise the main excretory organs in man and their excretory products.

ORGAN	EXCRETORY PRODUCT
▪ Skin	excess salts, urea and excess water
▪ Lungs	carbondioxide and water
▪ Kidney	excess salts, urea and excess water
▪ Liver	bile, excess cholesterol and urea

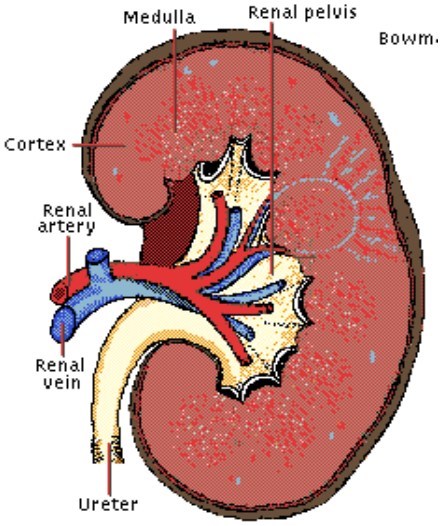
Discuss the external structure of the kidneys; The kidneys are two dark red bean shaped organs found on either side of the body in the abdominal cavity attached to the dorsal (hind) wall. They are supplied with blood by the renal arteries which are branches of the aorta and are drained by the renal veins which are branches of the vena cava. Each kidney is connected to the urinary bladder by the ureter.

Diagram showing the location of the kidneys in the body



Discuss the internal structure of the kidney: Each kidney consists of three regions; The **cortex, which** is a larger outer region which takes about 1/3 of the kidney tissue. The **medulla** which is the middle part with projections into the inner most region, the **pelvis** by projections called pyramids. Extending through all these regions are small tubules called nephrons.

Diagram showing the internal structure of a kidney

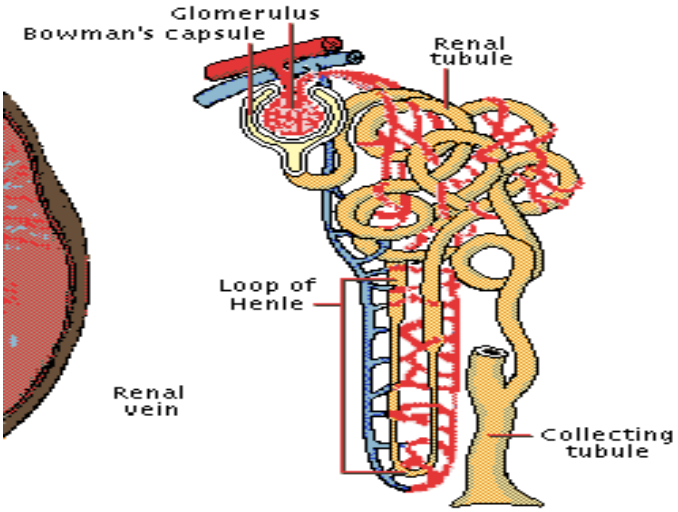


The nephrons help Kidneys to carry out excretion and osmoregulation.

They purify blood which flows through them by extracting and removing harmful substances from it which is an excretory function. They ensure the correct composition of blood and tissue fluid by regulating the relative concentration of water and salts which is and osmoregulatory function. Because of the above reasons, the kidneys receive more blood than any other organ in the body.

Discuss the structure of the kidney nephron. Each nephron consists of a cup shaped structure called a Bowman's capsule in which is a mass of blood capillaries called glomerulus. Blood reaches the glomerulus through the **afferent vessel** and leaves it through the **efferent vessel** both of which are branches of the renal artery and the efferent vessels combine to form the renal veins. A narrow tubule leads from the Bowman's capsule. The tubule is divided into three regions. The first coiled part called the **proximal convoluted tubule** which leads to a U shaped bend called the **loop of Henle**. The loop of Henle leads to another coiled region the **distal convoluted tubule** which is connected to the collecting duct which extends the pelvis. A number of nephrons may share the same collecting duct.

Structure of a nephron and the regions in which they are found



Explain the process of urine formation (urinification). The process of urine formation takes place in the nephrons. It occurs in two stages:
a. Ultrafilatration. Ultrafilatration means filtration of molecules through tiny pores at a high pressure. It takes place in the glomerulus and requires high pressure and a filtering barrier. The high pressure is brought about by the high pressure of the blood in the arteries and the fact that the afferent vessel which brings blood to the glomerulus is larger than the efferent vessel which carries blood away from the glomerulus. Therefore, more blood enters than leaves the glomerulus and this creates a high pressure in the glomerulus.

The filtering barrier is provided by
i. The capillary wall which retains red blood cells, and

ii. The basement membrane between the blood capillaries and the walls of the Bowman's capsule, which retains the plasma proteins. The red blood cells and plasma proteins are large and can not go through the pores in the capillary wall and the basement membrane.
The product of ultra filtration is the glomerular filtrate (also called the renal fluid). Its composition is similar to that of tissue fluid and lymph since they all lack red blood cells and plasma proteins. The glomerular filtrate flows from the capsule into the proximal convoluted tubule.

b. Selective reabsorption. As the glomerular filtrate flows along the tubules, useful substances in it are selectively reabsorbed. This takes place by active transport and diffusion and therefore requires energy. The main areas where reabsorption takes place are:

- The proximal convoluted tubule where glucose, amino acid, inorganic ions (salts) and water are reabsorbed.
- The distal convoluted tubule where inorganic ions (salts) and water are reabsorbed.
- The collecting duct where water is reabsorbed.

The reabsorption of water is assisted by the loop of Henle, which maintains a high concentration of salts in the medulla where the collecting duct passes. The resulting osmotic pressure of the medulla withdraws water from the collecting ducts by osmosis. The final composition of urine is therefore different from the glomerular filtrate.

Percentage composition of glomerular filtrate and urine

Substance	**Percentage in plasma**	**Percentage in glomerular filtrate**	**Percentage in urine**
Water	90- 93	90- 93	95
Protein	7.0	0	0
Sodium ions	0.3	0.3	0.35
Chloride ions	0.4	0.4	0.6
Glucose	0.1	0.1	0
Urea	0.03	0.03	2.0

From the above table it can be seen that the composition of urine is water, urea, sodium and chloride ions. There are no proteins and glucose (unless one is suffering from diabetes).

From the collecting duct urine flows to the pelvis and then to the urinary bladder for temporary storage through the ureter after which it is eliminated.

NB: selective reabsorption prevents the loss of useful substances from the blood serum (the liquid part of blood). As a consequence, blood leaving the kidneys through the renal veins contains less oxygen, glucose, and more carbondioxide, less water, salts and nitrogenous wastes like urea, uric acid and ammonium compounds.

Give the different ways of caring for the kidneys

1. Excess salt should be avoided since it damages the kidneys.
2. When alcohol is used regularly for a long time, it damages the kidneys.
3. A diet which is high in proteins should be avoided since it puts a lot of strain on the kidneys.
4. Enough water should be taken since little water causes parts of the kidneys to become clogged.
5. Eat well balance meals and drink a lot of water.

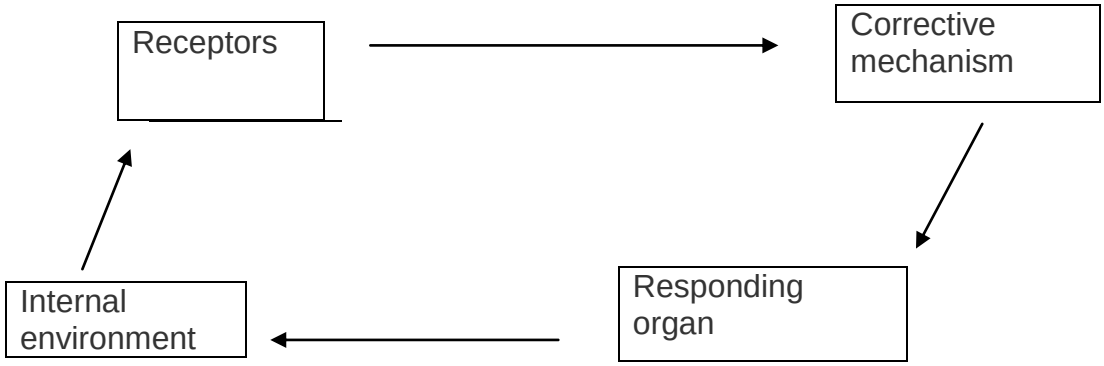
List the components of a homeostatic system. A homeostatic system consists of three functional parts which contribute to homeostatic balance. these parts are;

- Receptors,
- Control centres, and
- Responding organs.

Receptors detect changes in the internal environment and send messages to the control centres.

Control centres put into place (initiate) corrective responses.

Responding organs after receiving information from the control centres initiate processes that restore the balance, i.e. providing a feed back.

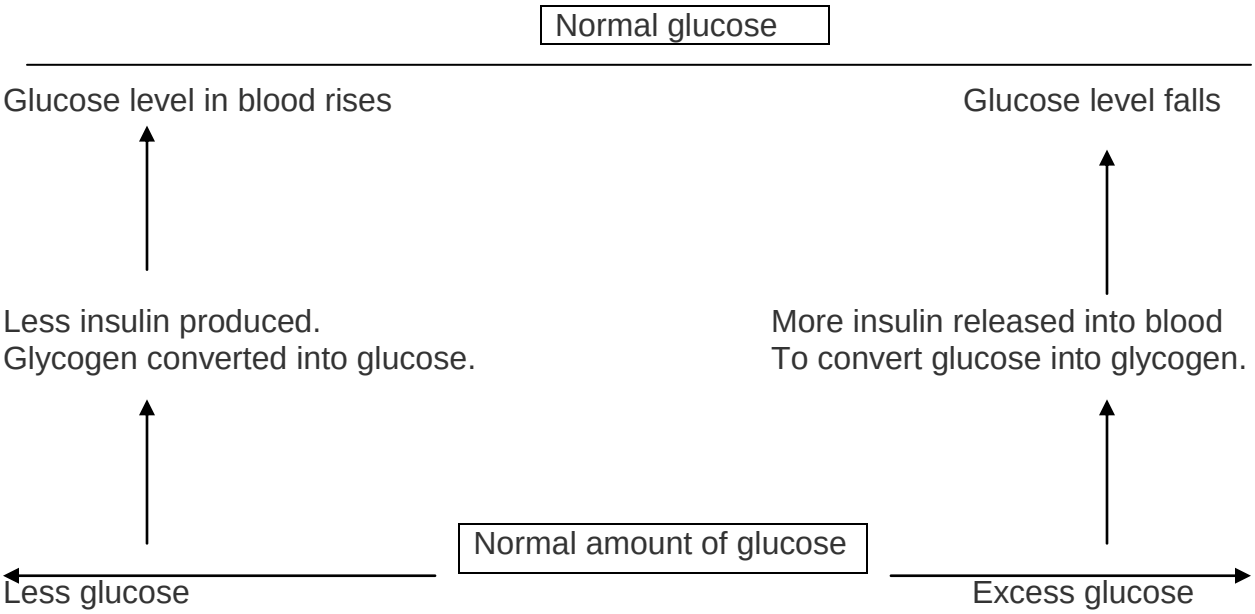


Discuss the liver and its role in the body. The liver is the largest organ in the body. It is reddish brown in colour. It produces many excretory products which are carried to excretory organs for elimination.

1. **Deamination.** Excess amino acids are deaminated. The amine group is removed to form ammonia which is combined with carbondioxide to form urea.
2. **Detoxification.** Toxins are made harmless by oxidation and reduction. The resulting products are excreted through the kidneys. Disease causing bacteria are removed by the kupffer cells of the liver. They also break down the harmful hydrogen peroxide to water and oxygen in the presence of catalase enzyme. (Practical using the liver, Irish and hydrogen peroxide).
3. **Heat production.** When the body temperature is low, the liver produces heat which is required for temperature regulation.
4. **Control of plasma proteins.** Plasma proteins are produced in the liver. They also act as pH buffers.
5. **Break down of red blood cells.** Worn out red blood cells are broken down into

bilirubin which is an important component of bile.

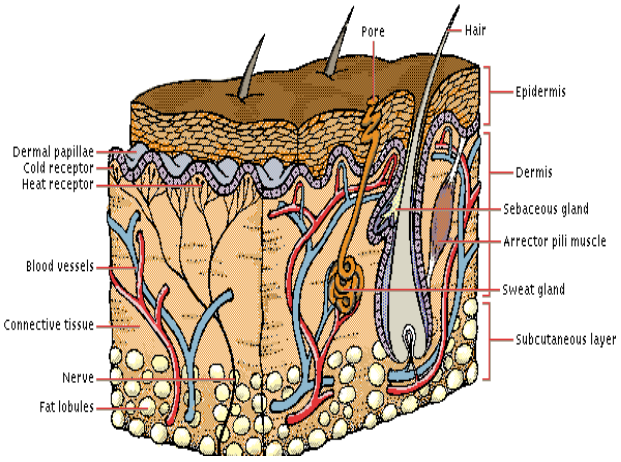
6. **Storage of vitamins.** It stores fat soluble vitamins; A, D, E, and K. small amount of molybdenum, zinc, calcium and cobalt are also stored by the liver cells.
7. **Control of sugar levels.** When there is excess glucose in blood, insulin converts glucose into glycogen (glycogenesis). Glucagon reverses the effect of insulin by converting glycogen into glucose when the level of glucose in blood falls/ decreases.



NB; the liver metabolises glucose by;

- Converting it into glycogen which is stored in the liver and muscle cells,
- Changing it into fats which are stored under the skin, and
- Breaking it into carbondioxide and water during the process of respiration.

Draw the structure of the skin in the space below. Explain the roles of the diferrent parts of the skin.



The skin is one of the toughest tissues in the body. It forms a continuous layer over the surface of the body and consists of two layers, the epidermis and the dermis.

a. **The epidermis or cuticle** is made of three layers;

1. The cornified layer (horny layer) made up of dead cells. The cells contain a tough substance called keratin which is a fibrous protein and is impermeable to water and gases. This layer protects the skin from mechanical damage, loss of water by evaporation, and invasion of the body by micro organisms. The cells of the cornified layer are continuously lost and replaced by cells from the granular layer.
2. The granular layer. Is a middle layer made of living cells that contain many granules. Its cells divide to give rise to the cornified layer.
3. The malipighian layer. Is an inner later of cell which contains a pigment melanin which is responsible for the differences in skin colour. Melanin blocks ultra violet (U.V) light from penetrating body tissues.

It made up of living cells what divide actively to give rise to the upper layers of the skin.

The epidermis contains no blood vessels or nerves.

b. **The dermis**. This is thicker than the epidermis. It contains sweat glands, receptor cells, blood vessels, lymphatic vessels, adipose tissue, sebaceous glands and hair follicles. Receptor cells. Are found in the dermis and detect different stimuli like heat, pressure cold, touch and pain,

Give the roles of the skin. It is responsible for the following;

1. Protection of the body from entry of microorganisms (bacterial infection) and physical damage (It protects the tissues under it from mechanical injury)
2. Excretion of salts, excess water and urea,
3. Reception of external stimuli. It contains many sense organs which are sensitive to temperature, touch and pain and so, makes the organism aware of changes in its surroundings.
4. Production of vitamin D on exposure to sunlight,
5. Regulation of body temperature. To keep the body temperature constant.
6. Prevents loss of water from the body. Protects the body from desiccation (drying up).
7. Melanin blocks ultra violet light from penetrating the body tissues.

Explain what is meant by body temperature regulation. Give the different ways in which heat is lost or gained by the body and the different ways ectotherms and endotherms maintain their body temperature. Body temperature regulation is the process of keeping the body temperature at that temperature at which the enzymes can work best. In man the body temperature has to be maintained at about 36.9^0 C for the optimum functioning of the enzymes which control the body metabolic processes.

Heat gain and loss; For the body temperature to be kept constant, there should be a balance between the processes that lead to heat loss and those that lead to heat gain.

Heat is gained by the body in the following ways:

1. By radiation. For example from the sun's heating and reflection from the ground.
2. From metabolism. Since many of the body's chemical reactions release heat e.g. in the process of respiration.
3. By convection. For example from the wind bringing hot air to the body.

4. By conduction. For example from the ground through the feet.

Heat is lost from the body in the following ways:

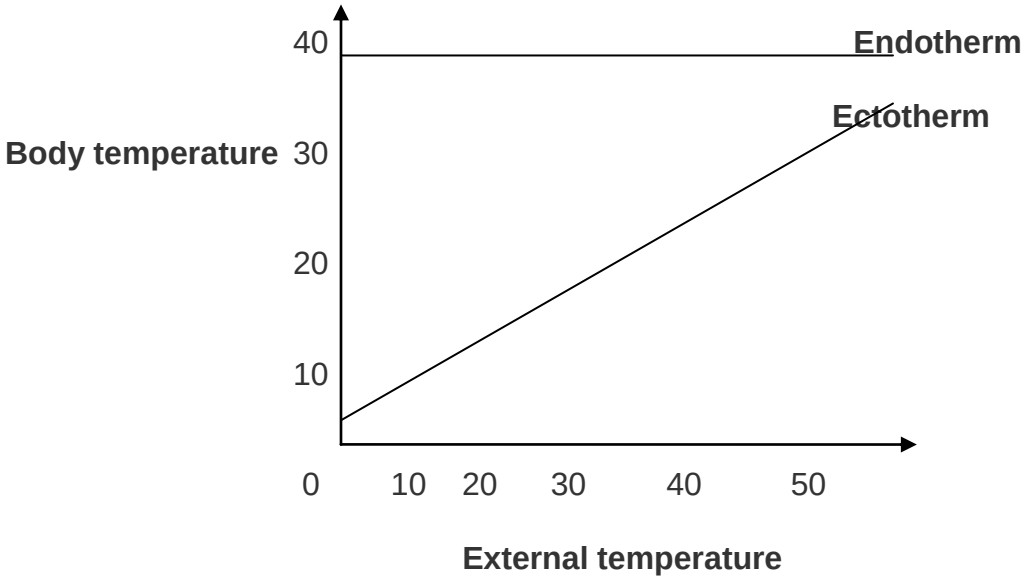
1. By radiation. This is the diffusion of heat from a warm body to relatively colder objects through air e.g. loss of heat from a warm body to the surrounding air when the air is cold.
2. By evaporation. This depends on either the temperature or the humidity of the environment and the presence of air currents. It results into cooling of the evaporating surface. In man heat is lost by evaporation from the mouth and nose during breathing and through the skin during sweating.
3. By convection. The movement of air resulting from warm air being replaced by cooler air in currents e.g. from the body surface to air in the currents.
4. By conduction. This is the transfer of heat from a hotter to a cooler object in contact with each other for example to the ground through the feet.

The process of heat gain and loss depends on;

1 The temperature of the surrounding.
2 The surface area to volume ration of the organism. Small organisms have a higher surface area to volume ratio and lose more heat than larger organisms which have a small surface area to volume ratio.
3 The rate of body metabolism since it responsible for generating heat within the body.
4 Other environmental factors such as air currents and humidity.

Differentiate between endothermic and exothermic animals. Endothermic organisms are those which maintain a constant body temperature regardless of the temperature of the surroundings. They are also called homotherms. They mainly depend on heat generated within their bodies in the process of metabolism to maintain a constant body temperature.

A graph showing the relationship between the body temperature of an endotherm and an ectotherm with that of the surrounding



Give the advantages and disadvantages of ectotherms and endotherms

Advantages of being ectotherms

- It allows animals to live in a wide range of environments irrespective of the temperature of the surrounding.
- They can maintain a high metabolic rate this enables them to respond to stimuli faster and move faster both of which are important for their survival.
- It enables enzyme controlled reactions to proceed efficiently at the optimum body temperature.

Disadvantages of being endotherms

- When the environmental temperatures are low, the homotherms need efficient means of preventing heat loss.
- When the environmental temperature is high, homotherms need efficient means to prevent overheating.
- They require a lot of food since most of the heat used for temperature regulation is generated from within by metabolism.

Advantages of ectotherms

- The organisms are able to modify their behaviour patterns so as to regulate their body temperature.
- They don't need a lot of food since they do not depend on internally generated heat.

Disadvantages of being ectotherms

- Their response is slow since they have low metabolic rates hence releasing little energy.
- During times of temperature extremes like when it hot or cold they are limited in their activities.

Discuss temperature regulation in endotherms. The methods of temperature control are categorized as shown below;

Structural methods of temperature control include the following;

- Vasoconstriction (blood vessels deep in the skin) of the blood vessels to conserve heat. And vasodilatation (blood vessels near the surface of the skin) when it is hot.
- Hairs standing when it is cold to reduce on heat loss from the body by trapping air which acts as an insulator. Flattening when it is hot to allow loss of excess heat.
- Fats insulating the body against heat loss.
- Shivering when the temperatures are low.

Behavioural means of temperature control include the following;

- Roosting in birds
- Taking hot drinks
- Sitting near a fire
- Wearing thick clothes
- Exercising in human beings
- When it is hot,
- Moving to shade
- Using a fan
- Taking cold drinks
- Wearing light clothes

Physiological means of temperature control include the following;

- An increase in the rate of metabolism when it is cold and a decrease in the rate of metabolism when it is hot.
- A decrease in sweat production when the temperatures are low. And an increase in the rate of sweating when the temperatures are high.

Discuss temperature regulation in ectotherms

- Basking in the sun to gain heat for example in the lizards.
- Moving to a shade to cool their bodies when it is hot.
- Burrowing in cracks when it is cold.
- Hibernation. A state of rest when it is cold until warm conditions return.
- Salivation like in the tortoises when it is hot.
- Thermal gaping in large reptiles like the crocodiles by opening their mouths to allow evaporation of water and as a result loss of heat when it is hot.

Discuss water balance and osmoregulation.

Water is lost from the body in urine, faeces, sweat and in exhaled air.

It is gained by drinking and eating.

The losses and gains produce corresponding changes in the blood.

Changes in the concentration of blood are detected by the hypothalamus in the brain. If the blood is too concentrated, the hypothalamus stimulates the pituitary gland beneath it to secrete into blood a hormone called ant diuretic hormone (ADH) which is also called vasopressin. When this hormone reaches the kidneys, it causes the kidney tubules to absorb more water from the glomerular filtrate back into blood. Urine becomes more concentrated and further loss of water is reduced. If blood passing through the hypothalamus is too dilute, production of ADH from the pituitary is suppressed and less water is absorbed from the glomerular filtrate.

How do the kidneys maintain a constant internal environment?

- By eliminating harmful products such as urea from blood,
- By removing excess water from blood, and
- Expelling excess salts.

Which functions are excretory and osmo- regulatory?