EXCRETION AND OSMOREGULATION

Excretion is the removal of waste products of metabolism from the body. Most of the waste products are toxic when allowed to accumulate in the body.

Importance of excretion

- To remove toxic waste products whose accumulation in the body poisons/harms the organisms
- To remove excess materials in the body which when left to accumulate affects the body metabolism.

Excretory products are divided into two groups:

1. Nitrogenous excretory products.

These are excretory products, which contain nitrogen. They include ammonia, urea and uric acid.

Ammonia:

It is a highly toxic nitrogenous waste.
It requires a lot of water for its elimination.
It is very soluble in water and due to this it requires less energy to be excreted.
It is excreted by organisms which live in fresh water and therefore have a lot of water in their bodies. Such organisms include bony fish, protozoans, and amphibians when in water,

Urea:

It is a less toxic nitrogenous waste.
It requires less water for its excretion.
It requires a lot of energy for its excretion because of its low solubility in water compared to ammonia.
It is excreted by terrestrial organisms, which have easy access to water, and marine organisms. Such organisms include terrestrial mammals, amphibians when on land, cartilaginous fish, etc.

Uric acid:

It is less toxic than urea.
It requires no water for its elimination from the body.
It is insoluble in water.
It requires a lot of energy for its excretion.
It is excreted by animals on land with limited access to water eg birds, reptiles and insects.

2. Non nitrogenous excretory products.

These are excretory substances that do not contain the element nitrogen. Such products include Carbondioxide, excess salts and excess water.

A table showing examples of organisms, their excretory products, their excretory organs and their habitats

Example of organism	Excretory product	Excretory organ	Habitat
Bony fish	Ammonia	Kidney	Fresh water
Cartilaginous fish	Urea	Kidney	Marine water
Reptiles	Uric acid	Kidney	Terrestrial
Birds	Uric acid	Kidney	Terrestrial
Tadpoles	Ammonia	Gills	Fresh water
Adult amphibians	Ammonia	Kidney	Fresh water
	Urea		Terrestrial
Mammals	Urea	Kidney	Terrestrial
Insects	Uric acid	Malpighian tubules	Terrestrial

NB. Excretory organs are structures that release excretory products.

EXCRETION IN PLANTS

Plants excrete less poisonous waste products like CO_2 through the stomata and acids through dropping leaves and fruits. Plants do not require specialized excretory organs because;

i) They can store excess proteins unlike in mammals.
ii) They accumulate less metabolic wastes due to their low metabolic rate.
iii) They synthesize their organic food substances according to their requirements. This ensures that no excess is made.
iv) They do not produce nitrogenous waste products. They produce non-nitrogenous wastes, which are less toxic to their bodies.
v) Some wastes accumulate in particular parts of the plant and they are eliminated when this part of the plant falls off.
vi) Some of the wastes are useful in other processes within the plants body. For example Carbon dioxide produced from respiration can be used in photosynthesis.
vii) They do not locomote and they are less metabolically active than animals.

EXCRETION AND OSMOREGULATION IN AMOEBA

Amoeba excretes excess water by use of a contractile vacuole.

The cell membrane surrounding amoeba is semi-permeable and since the concentration of the cytoplasm is higher than that in the environment, water molecules move by osmosis from out into the cytoplasm of amoeba.

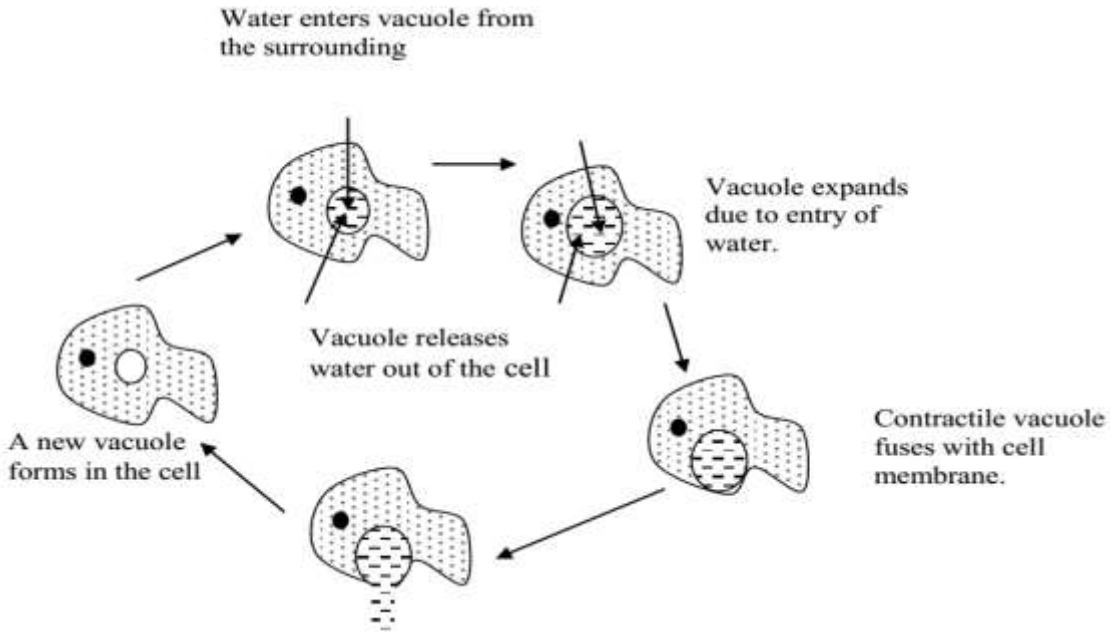
The organism uses some of the water and the excess is secreted in the contractile vacuole, which is formed in the process.

As the vacuole enlarges, it moves towards the cell membrane and finally fuses with it.

It then bursts to release the excess water out.

A new vacuole is formed for the organism to excrete more water.

Illustration

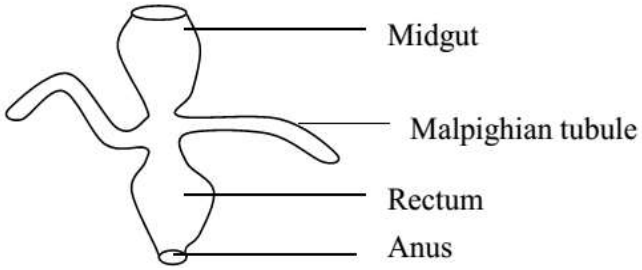


EXCRETION IN INSECTS

Excretion in insects is carried out by structures called Malpighian tubules, which are found between the mid gut and the rectum of the insect's alimentally canal.

Insect tissues produce nitrogenous wastes in form of potassium urate, which is taken to the malpighian tubules. In the tubules, urate reacts with Carbondioxide and water to form uric acid, which is released out of the body along with faeces.

Diagram showing the position of the malpighian tubules



EXCRETION IN MAN

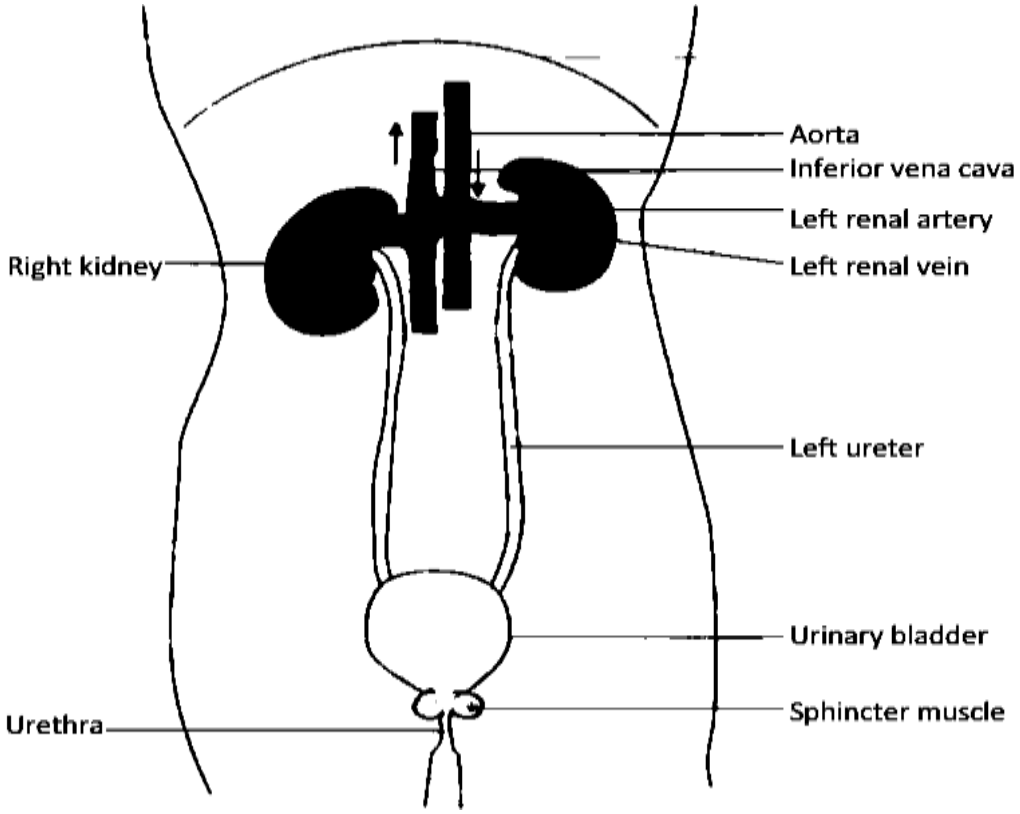
In man the excretory organs are the kidneys, skin and lungs. Their excretory waste products are as shown in the table below.

Excretory organ	Excretory product	Excretory substance
Skin	Sweat	Urea, excess salts and excess water
Lungs	Exhaled air	Carbondioxide and water

Kidney	Urine	Urea, excess salts and excess water.

THE KIDNEY AND THE EXCRETORY SYSTEM

Structure of urinary system



Parts and functions of the urinary system

1) Aorta

It carries oxygenated blood with all food nutrients to the kidney.

2) Renal artery:

It carries oxygenated blood containing excretory products to the kidney.

3) Renal vein:

It carries filtered blood from the kidney to the vena cava.

4) Ureter:

These are two narrow tubes that transport urine from the kidneys to the urinary bladder.

5) Urinary bladder:

It is a thick walled elastic sac-like structure which stores urine.

6) Sphincter muscles:

These contract and relax to control urine flow from the urinary bladder.

7) Urethra:

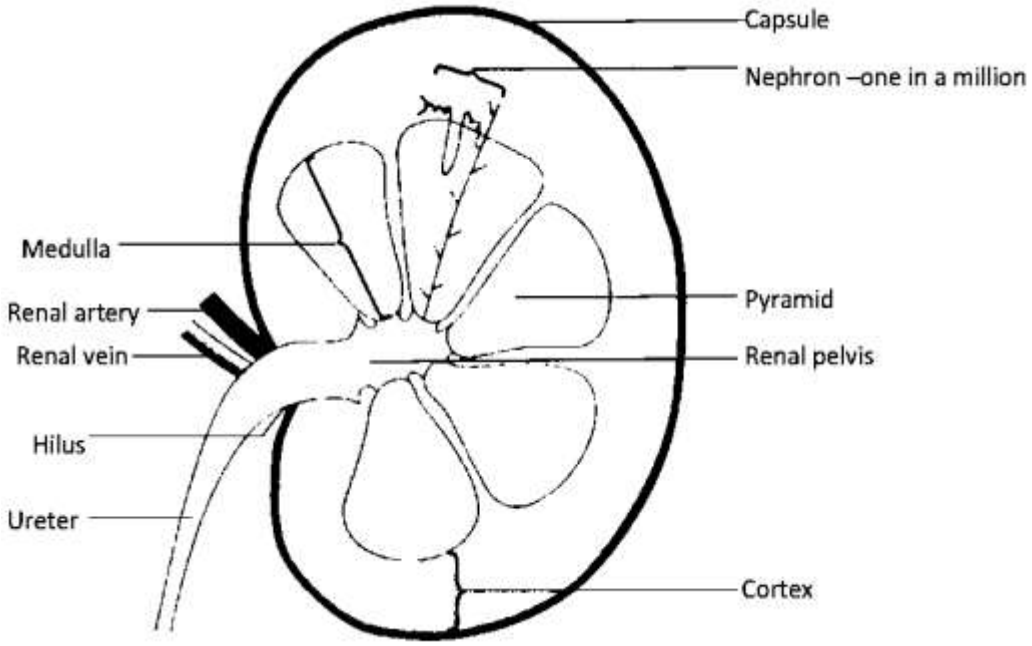
It is a passage for urine to the outside of the body.

THE KIDNEY

Major functions of the kidney in the body.

1. Excretion.
2. Osmoregulation.
3. It contains endocrine glands, which secrete hormones.

Structure of the kidney



The kidneys are solid bean-shaped structures and they occur in pairs in mammals. They are reddish-brown in colour enclosed in a transparent membrane and attached to the back of the abdominal cavity.

The kidney tissue consists of many capillaries and renal tubules connected together by connective tissue. The kidney has two major parts.

1. The **cortex** which is a dark outer part. It consists of the Bowman's capsule which is responsible for ultra-filtration of blood passing across it.
2. The **medulla**, which is a lighter inner part. It is made up of many portions called pyramids.

The pelvis is the area where the ureter leaves the kidney.

The kidney is made up of several microscopic structures called nephrons.

THE NEPHRON

This is the functional unit of the kidney. It carries out the function of excretion and osmoregulation in the kidney.

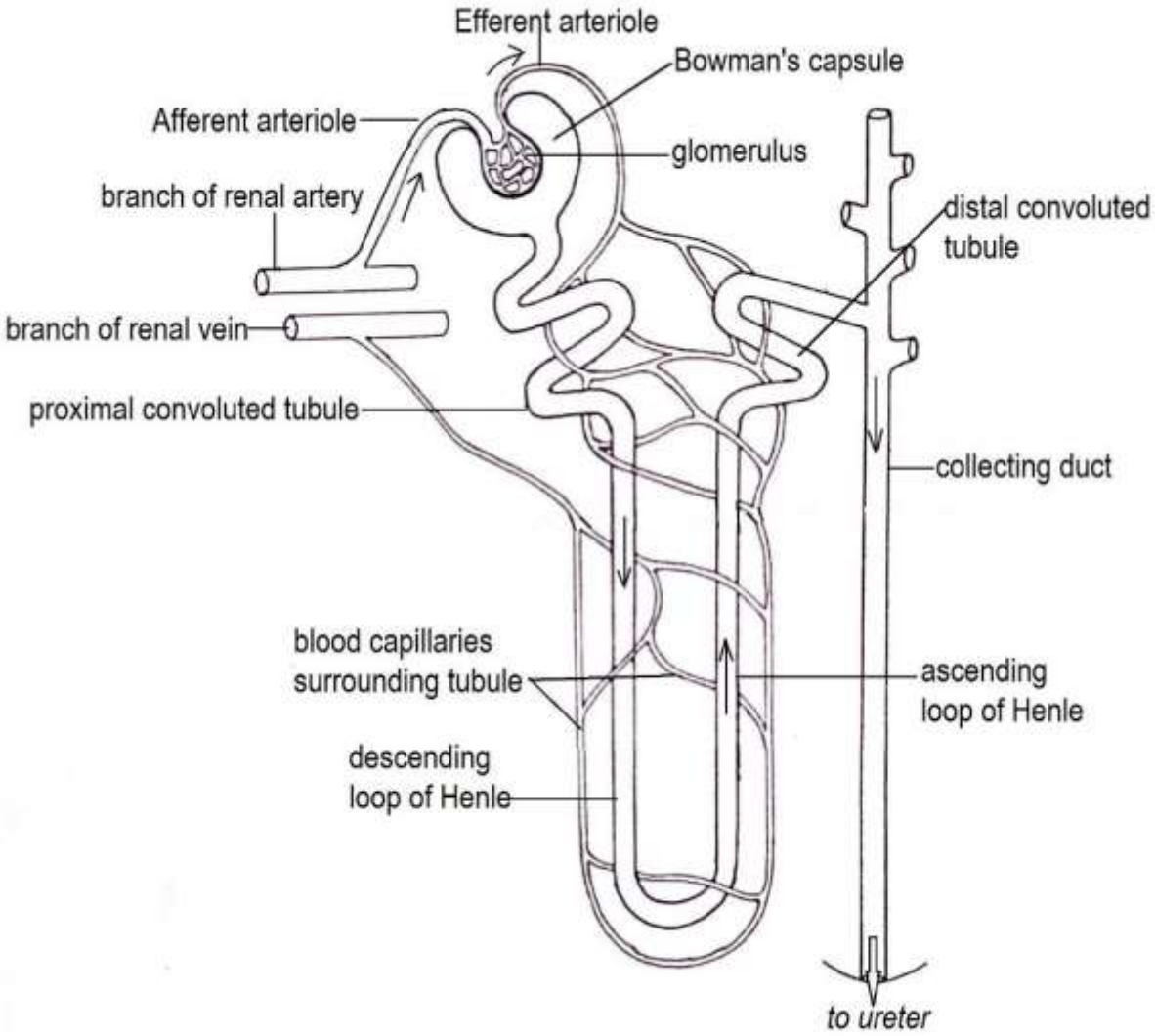
The nephron consists of a cup-shaped structure known as the ***bowmans' capsule***. Blood comes to the nephrone through the ***afferent arteriole***, which is a branch of the renal artery, and it leaves through the ***efferent arteriole***.

In the bowmans' capsule the afferent arteriole divides to form capillaries that are highly coiled forming a knot called ***glomerulus***.

Leading from the bowman's' capsule is a highly coiled tube known as ***proximal convoluted tubule***. It is continuous with a U shaped tubule called ***loop on Henle***, *having* the ***descending loop*** and ***ascending loop***.

From the loop of Henle, the tube becomes highly coiled to form the ***distal convoluted tubule*** which leads to the ***collecting ducts***.

Structure of the nephron



Parts of nephron

1. Bowman's capsule:

It contains a dense-network of capillaries called **glomerulus** and the **capsular space.** The glomerulus is formed from the wide afferent arteriole and ends in a narrow efferent arteriole.

The glomerulus filters small molecules in blood such as urea, glucose, water, salts, amino acids etc, a process called ultra-filtration.

Adaptations of the glomerulus to ultra-filtration

i) Having a high blood pressure that forces small molecules out of the glomerulus. This is due to the afferent arteriole being wider than the efferent.

ii) Having many capillaries that give it a large surface area for ultra-filtration.
iii) Having a semi permeable membrane that can allow any small molecule to pass through.

Adaptations of the Bowman's capsule to collect the filtrate

i) Possession of cup-shaped structure which enables it to collect the filtrate.
ii) Having a porous upper membrane that easily allows filtration.
iii) Having a large volume that can accommodate more filtrate.

2. Proximal convoluted tubule:

It is highly coiled. Re-absorption of useful materials such as glucose, amino acids and water from glomerular filtrate back to blood takes place here.

3. Loop of Henle:

It has a descending and an ascending limb. Reabsorption of water and salts occurs here.

4. Distal convoluted tubule:

It is highly coiled. Reabsorption of salts occurs here, leaving a liquid called urine which passes down to collecting ducts.

5. Collecting duct:

There is reabsorbtion of water from the urine.

Adaptations of the nephron to re absorption of substances

i) Having a thin membrane (one cell thick) for easy diffusion of materials.
ii) Having micro villi to increase the surface area for re absorption.
iii) Having numerous mitochondria to provide energy for active reabsorption.

PROCESS OF URINE FORMATION

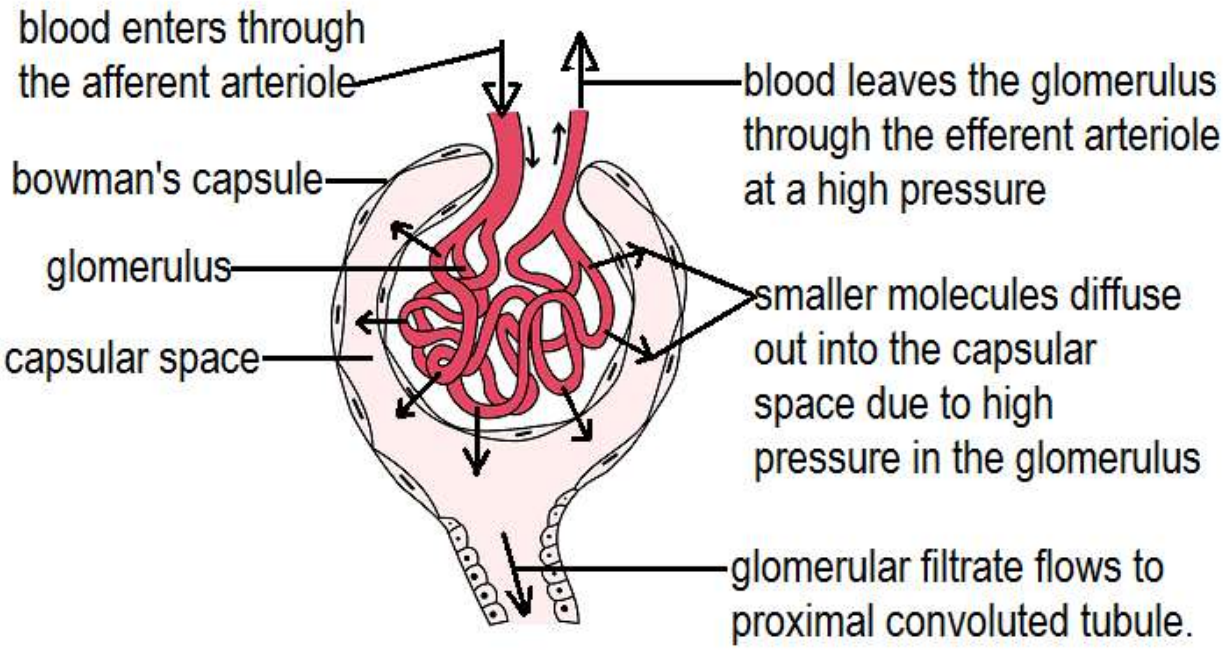
The process of urine formation takes place in the nephrone. It occurs in two phases.

1. Ultra-filtration.
2. Selective re-absorption.

Ultra filtration

- ✓ Much blood comes from the **afferent vessel** into the glomerulus than that which leaves through **efferent** because the afferent vessel is larger than the efferent vessel.
- ✓ This generates a high pressure in the glomerulus forcing small molecules like urea, water, salts, glucose, vitamins, to filter out of the blood capillaries of the glomerulus to form the glomerular filtrate in the capsular space of bowman's capsule.
- ✓ Proteins and blood cells do not filter out because they have bigger molecules, which cannot pass through the walls of the glomerulus.
- ✓ The filtrate formed moves from the Bowman's capsule to ***proximal convoluted tubule*** where selective reabsorption starts to occur.

Diagrammatic illustration of ultrafiltration



Selective reabsorption

In the proximal convoluted tubule:

- ✓ Glucose, vitamins, aminoacids and some salts are re absorbed into the blood capillaries by diffusion and active transport. Some water is re absorbed by osmosis.
- ✓ The glomerular filtrate then moves to the loop of Henle.

In the loop of Henle:

- ✓ As the filtrate flows down the descending limb, water is re absorbed back into the capillaries by osmosis leading to increased concentration of the filtrate.
- ✓ As the filtrate ascends the thick ascending limb of loop of Henle, salts like Na and K are reabsorbed by active transport. This leads to a decrease in concentration of the glomerular filtrate in the ascending limb.
- ✓ The filtrate then moves to the distal convoluted tubule.

In the distal convoluted tubule:

- ✓ Selective re absorption of salts by diffusion occurs.
- ✓ The filtrate then flows to the collecting ducts as urine.

In the collecting ducts:

- ✓ Water is reabsorbed by osmosis from the ***urine*** which goes via the ureter and temporarily stored in the urinary bladder.

Comparison of substances in blood and urine

Nitrogenous waste	In blood	In urine
Urea	0.03	2.0
Proteins	7-9	0
Glucose	0.1	0
Chloride ions	0.37	0.6
Sodium ions	0.32	0.35
Water	93	95

- ✓ There are proteins in blood and there is none in urine because proteins are not filtered out of the blood vessels into the glomerulus due to the large size of their molecules.
- ✓ Urea is more in urine than in blood because it is filtered out of blood and it is not reabsorbed back in the blood.
- ✓ Water is more in urine than in blood because it is used to dissolve urea.
  However the relative amounts of water in urine and in blood varies depending on the amount of water in the body, amount of solutes in the body, temperature and body activity.
- ✓ There is glucose in blood and no glucose in urine because all glucose is reabsorbed from the glomerular filtrate back into the blood.
- ✓ Salts like chlorides and sodium ions are more in urine than in blood. This is because they are in excess and they are not reabsorbed back into the blood. Because of this they tend to make urine concentrated.

HOMEOSTASIS AND OSMOREGULATION

Homeostasis is the maintenance of a constant internal environment of the body. The internal environment is composed of tissue fluid and blood. Homeostasis involves controlling the blood sugar level, salt level, water level, temperature and Carbondioxide concentration.
Osmoregulation is the maintenance of a constant osmotic pressure of blood.

WATER BALANCE IN MAN

The level is maintained by loss of excess and gain if more is required.
Water is **lost** from the body through urine, sweat, expiration, and faeces during egestion.
It can be **gained** through; drinking, eating and water from metabolism.

When the amount of water in blood is low, the blood concentration increases.
- This is detected by the hypothalamus that stimulates the anterior lobe of the pituitary gland to secrete ***Antidiuretic hormone (ADH) / Vasopressin hormone*** into the blood stream.
- When the hormone reaches the kidneys, it causes the walls of the nephrons (Loop of henle and collecting ducts) to become more permeable to water thus it is reabsorbed from the glomerular filtrate back into the blood.

- The urine formed becomes more concentrated and yellowish in colour. This reduces the loss of water in urine.

When the amount of water in blood is high, the blood concentration lowers.

- This is detected by the hypothalamus that instructs the anterior lobe of the pituitary gland to stop the secretion ***Antidiuretic hormone (ADH) / Vasopressin hormone*** into the blood stream.
- This reduces the permeability of the nephrons to water, hence less water is reabsorbed from the glomerular filtrate back into the blood.
- The urine formed becomes dilute, colourless and in large volume.

NB.

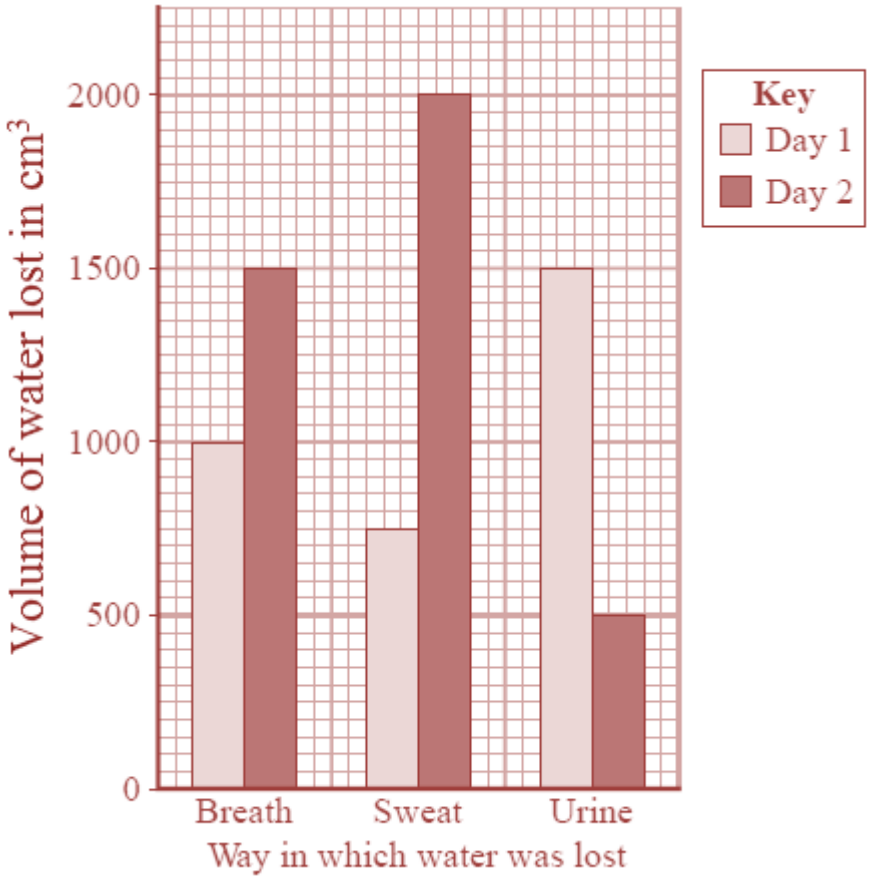
-On cold days, water loss through sweating is minimal. The person passes out large volumes of dilute urine.

-On hot days, sweating increases, lowering the water level in blood. This causes more re-absorption of water in the nephrones resulting in production of small volumes of concentrated pale yellow urine.

-Because of the high concentration, when urine is poured on grass or any plant, they get scotched because the cells lose water to the surrounding concentrated urine by osmosis and the plant cells become flaccid. This brings about wilting and drying of the plant.

-When the level of water in blood is too low, Antidiuretic hormone causes a feeling of thirst, which makes one to drink water in order to bring back the normal water level in blood.

-Failure of organisms to secrete ADH leads to constant urination of large amounts of dilute urine thus increases the blood concentration, a condition known as ***Diabetes inspidus.***



The bar chart shows the amount of water lost from the body of a student on two different days. The student ate the same amount of food and drank the same amount of liquid on the two days. The temperature of the surroundings was similar on the two days.

a) The total volume of water lost on day 1 was 3250 cm3. How much water was lost on day 2? Show your working.

*b) The student did much more exercise on one of the days than on the other. On which day did he do more exercise? Give **two** reasons for your answer.*

*c) State **one** chemical reaction that produces water in the body.*

d) Briefly explain how sweating is important to the body

e) If the body loses more water than it gains, it becomes dehydrated and the concentration of the solution surrounding the body cells increases.

f) Briefly explain how this affects body cells.

g) Describe the effect of ADH on the functioning of the kidney nephron.

CONTROL OF SALT LEVELS IN BLOOD

If the salt levels are low in blood, the blood concentration decreases.

-This is detected by the hypothalamus as blood flows through it.

- It then instructs the pituitary gland which then instructs the adrenal gland to secrete ***aldosterone hormone*** which causes reabsorption of more salts into the blood with in the nephrons.

If the salt levels are high in blood, the blood concentration increases.

-This is detected by the hypothalamus as blood flows through it.
- It then instructs the pituitary gland which then instructs the adrenal gland to stop the secretion of ***aldosterone hormone*** thus little or no salts get reabsorbed back into the blood with in the nephrons.

CONTROL OF BLOOD SUGAR (GLUCOSE) LEVELS

When the blood glucose level increases above the normal concentration, it is detected by the pancreas, which secretes ***insulin hormone*** in to blood, and carried to the liver.

Insulin causes;

- Glucose to be converted to glycogen and stored in the liver.
- Glucose to be converted into fats and stored in adipose tissue.
- Glucose to be broken down to release energy in form of ATP at a higher rate.

This reduces blood glucose back to the normal concentration and insulin secretion stops.

When the blood glucose level decreases below the normal concentration, it is detected by the pancreas, which secretes ***glucagon hormone*** in to blood, and carried to the liver.

Glucagon causes;

- Glycogen in the liver to be converted into glucose.
- Fats in adipose tissue to be converted to glucose.
- The rate of breakdown of glucose slows down.

This raises the blood glucose back to the normal concentration and glucagon secretion stops.

NB:
Failure to secrete insulin hormone causes the presence of much glucose in urine, a condition called ***Diabetes mellitus.***

THE LIVER

The liver is the largest organ in the body of a mammal. It performs several functions, namely

1. **Regulation of blood sugar level.**
   Insulin hormone from the pancreas stimulates the liver cells to convert some of the glucose into glycogen and fats for storage in the body. This lowers the level of glucose in blood.
   Glucagon hormone from the pancreas stimulates the liver to convert glycogen and fats to glucose. This raises the level of glucose in the blood.
2. **Regulation of lipids.**
   The liver removes lipids from the blood stream by either breaking them down to release energy or storing them in fat deposits.
3. **Regulation of amino acids and proteins**
   The body cannot store excess proteins and amino acids therefore excess is sent to the liver where the amino group is removed from them and converted into ammonia or urea to be

excreted. This occurs in a process called deamination. The remaining part is broken down to release energy or it is converted into fats for storage.

4. **Detoxification.**
   This is the removal of toxic products from the body. All toxic products from any part of the body are taken to the liver where their toxicity is neutralized.
5. **Production of heat**
   When the body temperature falls, metabolic processes take place in the liver to produce heat, which restores the temperature back to normal.
6. **Production of bile.**
   Bile is manufactured in the liver and stored in the gall bladder.
7. **Formation of cholesterol.**
   Cholesterol is a lipid part used in formation of cell membranes.
8. **Elimination of sex hormones.**
   After their role is over, the sex hormones are modified and sent to the kidney or expelled into bile by the liver.
9. **Storage of blood.**
   The liver has a good network of blood capillaries and most of the blood is stored in these capillaries. It holds more blood than any other body organ.
10. **Storage of vitamins.**
    The liver stores most of the fat-soluble vitamins suck as vitamin E, vitamin D and vitamin K
11. **Formation of red blood cells.**
    In adults the red blood cells are produced from the red bone marrows but in the foetus they are made in the liver.
12. Elimination of heamoglobin from red blood cells.

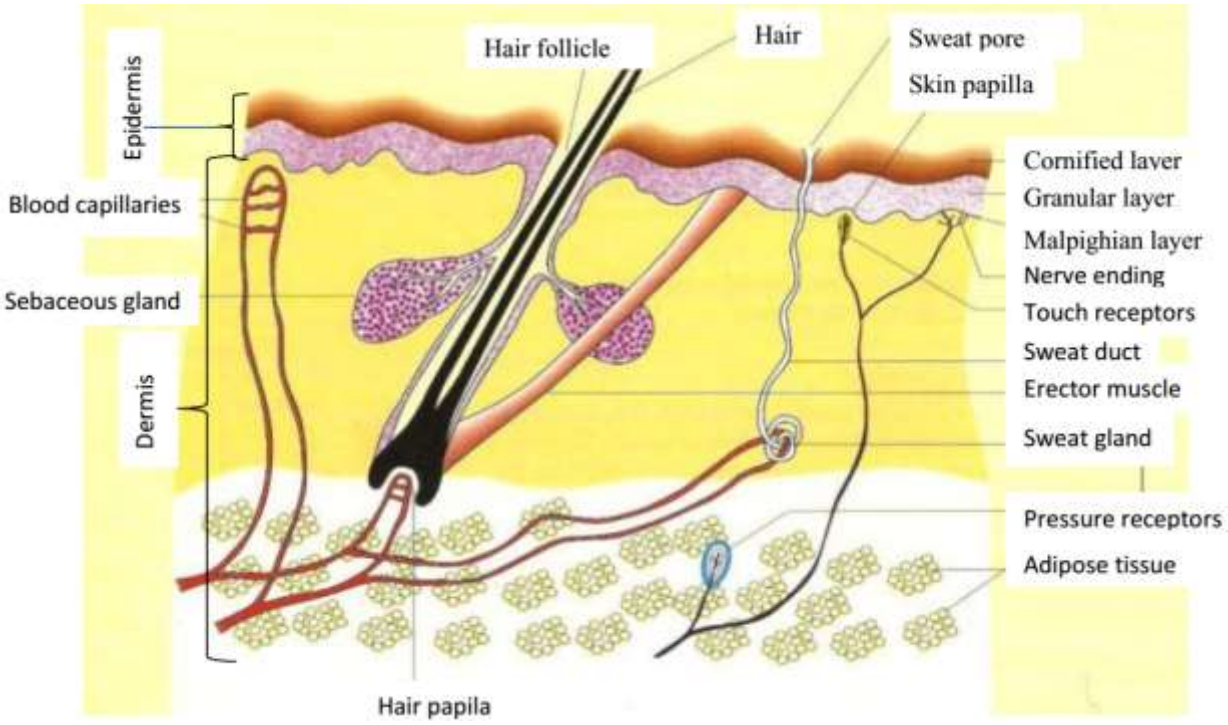
THE SKIN

It is a continuous protective layer over the body.

Functions of the skin

i) It protects the tissue below it from mechanical damage, bacterial and viral infections.
ii) It prevents excess loss of water from the body.
iii) It is a sense organ sensitive to pain, touch and heat. This helps the organism to be aware of its environment.
iv) It keeps the body temperature of endothermic organisms constant.
v) It synthesizes vitamin D in presence of sunlight.
vi) It is an excretory organ. It excretes sweat, which contains urea, water and excess salts.

Structure of the skin



The skin consists of two main layers.

1. The epidermis (outer layer)
2. The dermis (inner layer)

THE EPIDERMIS:

This is made up of three sub layers.

a) The Malpighian layer.
b) The granular layer.
c) The cornified layer.

1) The Malpighian layer

This is the inner most layer in the epidermis. It consists of dividing cells which give rise to cells of the granular layer. It secretes a pigment called melanin, which gives the skin its colour and protects the skin from ultraviolet rays. Albinos do not produce melanin in their skins.

2) The granular layer

This contains living cells arising from the malphigian layer. It is the biggest layer of the epidermis. It gives rise to cells of the cornified layer.

3) The cornified layer.

This is the outermost layer of the skin. It is made up of dead cells, which are keratinized. Cells of this layer continuously ware away and are replaced by cells from the granular layer. Its function

is to protect the inner parts of the body from mechanical injury and entry of bacteria and other germs. It also offers water proofing to the skin.

THE DERMIS:

This is the inner layer of the skin. It is below the Malpighian layer. It is thicker than the epidermis. It contains the sweat glands, nerve fibers, fat cells and blood capillaries.

Other parts of the skin

1) Hairs.

The hairs extend from the dermis through the epidermis. They arise from hair follicles in the dermis. They protect the body and trap a layer of air on the skin, which insulates the body against heat loss.

2) Sebaceous gland

This secretes an oily substance called sebum. This oil softens the cornified layer and prevents it from cracking. The oil also provides water proofing to the skin.

3) Nerve endings.

These perceive external stimuli and transport impulses to the central nervous system.

4) Sweat glands.

These are coiled tubular glands located in the dermis. They excrete sweat, which is released out of the skin through the sweat duct.

CONTROL OF BODY TEMPERATURE (TEMPERATURE REGULATION).

This is the process of maintaining the temperature of the organism within narrow ranges, which favour body activity, and ensures optimum activity of body enzymes.

To maintain the body temperature constant, there must be a balance between heat loss and gain.

The body loses heat by;

a) Radiation: Heat diffuses from the warm body to the cold environment.
b) Conduction: The body loses heat to the cold object in contact with it.
c) Convection: Where cold air or wind carries heat from the warm body.
d) Evaporation**:** e.g. sweating leading to loss of heat

The body gains heat by;

a) Radiation: e.g. from the sun's heat and reflection from the ground.
b) Conduction: e.g. from the ground via the feet.
c) Convection: e.g. from the wind bringing hot air to the body.
d) Metabolism**:** e.g. since many of the body's chemical reactions release heat e.g. in respiration.

The rate of heat loss and gain depends on;

a) Surface area to volume ratio i.e.
   Small organisms having a large surface area to volume ratio tend to lose more heat than the large ones with small surface area to volume ratio.
b) Temperature of surrounding environment:
   Organisms tend to lose more heat in cold environment and gain more in hot environment.
c) Rate of respiration
   The higher the rate of respiration, the more heat energy gained by the body.
d) Humidity of the environment
   Heat loss increases in humid conditions because high humidity makes the environment colder.

Endothermic / Homoiothermic animals:

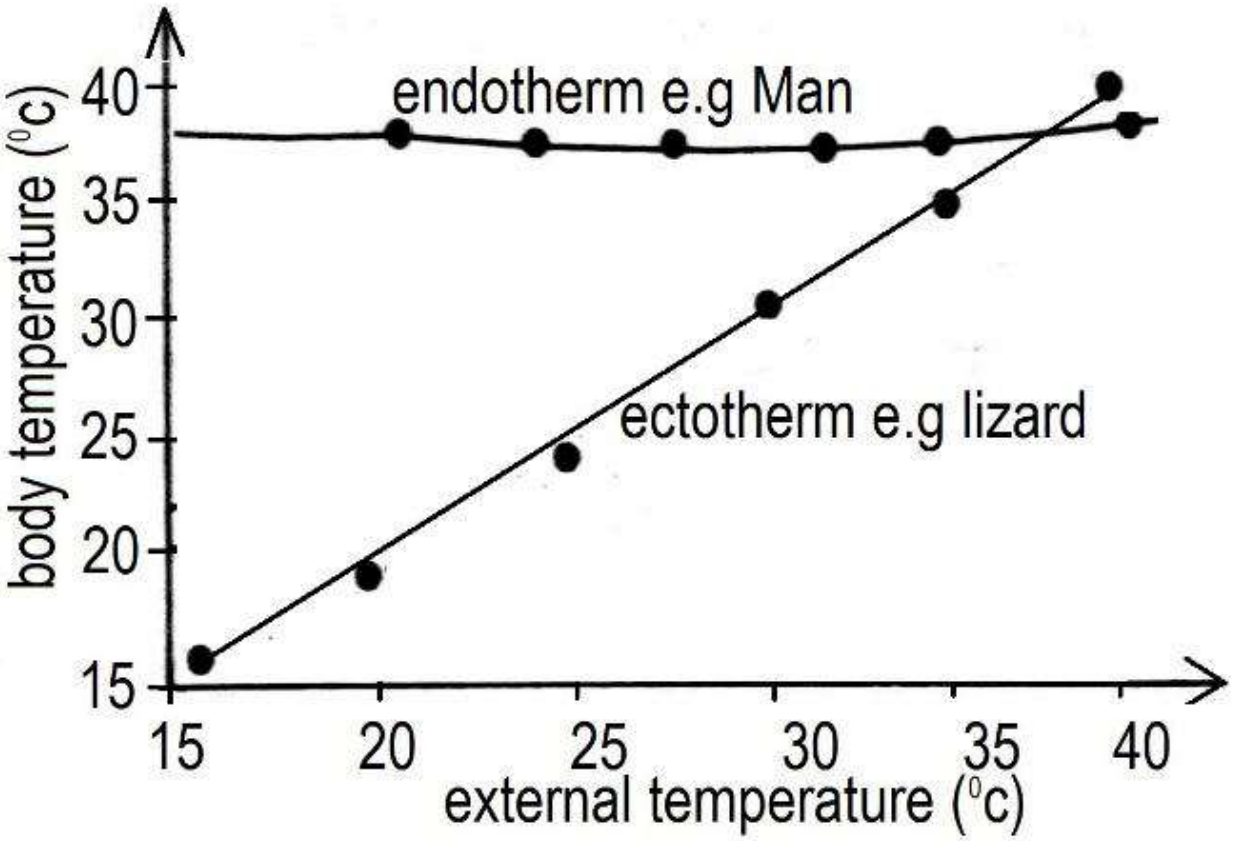
Endothermic organisms are those that are able to maintain a constant body temperature irrespective of the surrounding environmental temperature.

They depend mainly on heat generated within their bodies. They are also called warm blooded animals e.g. mammals.

Ectothermic/poikilothermic animals:

These are animals that cannot maintain a constant body temperature but their temperature changes with that of the environment. They are also called cold blooded animals e.g. reptiles and amphibians.

A graph showing how body temperature varies with environmental temperature



The body temperature of endotherms remains constant despite the increase in surrounding temperature.

The body temperature of ectotherms increases with increase in environmental temperature.

Control of body temperature in endotherms

When temperature is high, organisms respond in a way that lowers the temperature and when the temperature is low, organisms respond in a way that raises their body temperature. These responses are categorized into two types.

1. **Physiological responses**. These are involuntary actions and they occur in body in response to temperature changes.
2. **Behavioral responses**. These are voluntary responses from the organism. The organism consciously decides what to do when external temperature changes.

Response to cold weather in endothermic animals

Physiological means.

1. The erector pill muscles of the hair contract to make the hairs stand upright on the skin. The hairs trap a layer of air, which insulates the skin.
2. The rate of sweating reduces in order to reduce on the amount of heat lost through it.
3. The metabolic activity of the liver increases to produce energy in form of heat.

4. Blood vessels near the skin constrict, a process called vasoconstriction to reduce on the blood reaching the skin. This reduces heat loss through radiation.
5. Shivering. This is the rhythmic contraction of the skeletal muscles resulting into production of heat energy.
6. Small animals like the mouse undergo hibernation where they dig holes and live deep in them to reduce heat loss

Behavioral means.

1. Sitting near hot bodies to raise their body temperature by conduction or radiation.
2. Humans take hot drinks.
3. They do physical exercises to raise the metabolic activity of the body.
4. They can take a hot bath
5. They put on thick clothes, which insulate their bodies.

Response to hot weather in endothermic animals

Physiological means.

1. The erecter pilli muscles of the skin relax making the hairs to fall on the skin. This allows heat loss by radiation.
2. The metabolic rate of the body reduces to reduce on the amount of heat produced.
3. Sweating increases. In this process excessive heat is lost as latent heat of vaporization to evaporate the sweat from the body hence losing heat.
4. Vasodilatation. Vessels dilate and allow more blood to reach the skin surface in order to lose heat to the surroundings by radiation.
5. Animals living in hot environments have a thin fat layer to reduce on the insulation.

Behavioral means.

1. Some rest on cold bodies like rocks to lose heat by conduction.
2. Humans sit near fans.
3. Some take cold drinks.
4. They put on light clothes
5. Panting. This involves hanging out of the tongue for example in dogs. This results into evaporation from the mouth, which eventually cools the animal.
6. Swimming.

Adaptations of mammals to cold conditions

1. They have a lot of hairs / fur over their bodies to trap a layer of air that insulates the body.
2. They have a thick fat layer which insulates the body.
3. Some are very big and thus have a small surface area to volume ratio. This reduces the rate of heat loss.
4. They have few sweat glands to reduce of the heat lost during sweating

5. They have fewer blood vessels on the skin surface to avoid heat loss through radiation.

Behavioral:

1. Putting on thick clothes like in humans
2. Doing physical exercises
3. Hibernation. This is a state of long rest by burrowing into crevices and holes during extreme coldness.
4. Sun bathing

Adaptations of mammals to hot conditions

1. Having little hairs on the body to allow easy loss of heat.
2. Having less fat to reduce on the insulation effect of fats.
3. Having a large surface area to volume ratio to allow a faster rate of heat loss.
4. Having many sweat glands to increase heat loss.
5. Having many blood vessels near the skin for easy loss of heat by radiation.

Behavioral:

1. Resting under shade.
2. Bathing cold water.
3. Aestivation. This is a state of long rest by burrowing in crevices and holes during extreme hotness.
4. Putting on lighter clothes.
5. Sitting near cold things.

TEMPERATURE CONTROL IN ECTOTHERMIC ANIMALS

Ectothermic animals are animals whose body temperature changes with that of the environment. Examples of ectotherms are fish, reptiles and amphibians. Their body temperature is controlled by only behavioral means.

During hot conditions, they lose heat by.

1. They rest on cold rocks to lose heat by conduction.
2. They rest on cold stones and in shades to lose heat.
3. They burrow in cracks and lose heat by radiation.
4. Aestivation. This is a state of long rest by burrowing underground or under rocks during high temperatures.
5. Thermal gaping. This is the opening of the mouth to lose water by evaporation. This results into cooling. Thermal gaping occurs in crocodiles and a few other reptiles.

During cold conditions, they gain heat by;

1. Resting on hot rocks to gain heat by conduction.

2. They rest under the sun to gain heat by radiation.
3. They rest near hot bodies to gain heat by radiation.
4. They burrow in hot sand to gain heat by conduction.
5. Basking in the sun to gain heat.
6. Hibernation. This is a state of long rest by burrowing into crevices and holes during extreme coldness.

Advantages of being endothermic

1. They are always active because their temperature is maintained at an optimum temperature for enzyme activity.
2. They can live in a wide range of environments i.e. both hot and cold.
3. Their metabolic rate is maintained at a high rate due to the ability to maintain a constant body temperature.

Disadvantages of being endothermic

1. Having a high rate of food consumption due to high rate of metabolism.
2. Maintaining the body temperature constant requires much energy.

Advantages of being ectothermic

1. Low food consumption due to low metabolic rate.
2. Easy to control body temperature by only behavioral means.

Disadvantages of being ectothermic

1. They have limited body activity in cold environments.
2. Show response to stimuli due to low metabolic rate.