EXCRETION AND HOMEOSTASIS

- ✓ Excretion- It's the process by which living organisms get rid of metabolic waste products. In plants some waste products are removed while others are reused or stored as harmless substances.
- ✓ In animals, waste products resulting from the metabolic processes are generally removed from the body.
    - o **Homeostasis**- It's the control and maintenance of a constant internal environment around the cells in body despite the fluctuations in the external environment.
- ✓ **Egestion-** It's the removal of indigestible and undigested food substances from the body.
- ✓ **Secretion-** It's the release of substances from the cells into the body fluids such as blood and the tissue fluid or to the outside of the body. Examples of secretions; hormones, enzymes, mucus, sebum etc
- ✓ **Ecretion in Plants**
- ✓ Metabolic processes in plants occur at a slower rate than in animals. Some of the waste products prodused in one procces are used in another process eg CO_2 released during respiration is utilised in photosynthesis.
- ✓ Most of the substances that are broken down in plants are carbohydtrates in nature. Waste products from carbohydrates are not harmful to the plants.
- ✓ Some of the waste products eg resins, gums are stored in dead tissues of plants such as xylem.
- ✓ **Methods of Excretion**
- ✓ **Diffusion**- Eliminate waste products that are

in gaseous form eg CO_2, Oxygen and water vapour.

- ✓ **(ii) Transpiration**- water vapour.
- ✓ **Guttation**- water and dissolved mineral salts.
- ✓ **Exudation**- It's the release of a fluid from a plant at a slow rate eg gums, latex, mucilage, rubber, resins and Caicium pectate and oxalates.
- ✓ **Deposition**- Resins, tannins, caffeine, nicotine, quinine etc are deposited in the Xylem, bark, seeds, fruits, flowers and leaves of plants.
- ✓ **Storage of excretory substances in plant parts**
- ✓ Some plant waste substances that may be toxic to the plant are converted to less harmful substances which are then stored in different parts of the plant such as petals, leaves, fruits and seeds. Some of these plant parts are eventually shed by the plant.
- ✓ Some plant waste substances are stored in the vacuoles of plant cells. Some are stored in in dead permanent tissues such as the wood or barks or leaves which are shed seasonally. In this state they have no harmful effects on the activities of living tissues.
- ✓ Most perennial plants store excretory materials in dead tissues.
- ✓ Aquatic plants lose most of their waste substances by diffusion directly into the surrounding water.
- ✓ **Useful Excretory Products**
- ✓ **Anthocyanin**
- ✓ Gives colour to petals and leaves in plants. The dominant colours are red, purple and blue.
- ✓ These colours are of great aesthetic value and are extracted to make dyes.
- ✓ **Tannins**

- ✓ They are deposited in the dead tissues of trees such as wood and bark. They are common in conifers and mangroves.
- ✓ Tannins are used in the treatment of leather and manufacture of ink.
- ✓ They are also used in cosmetics eg henna which is a plant extract used to colour the nails, feet and hair.
- ✓ **Latex**
- ✓ It's a milky substance that is produced by some plants. Latex from the rubber tree is used to make rubber.
- ✓ **Gums**
- ✓ They are produced by different plants such as arabic, ghath and carob. These gums are edible and are used to thicken food and creams.
- ✓ Sapodilla gum is used in the manufacture of chewing gum.
- ✓ **Alkaloids**
- ✓ They are produced in many forms and are stored in different organs of plants eg
    - **Quinine**
- ✓ It's obtained from the bark of cinchona tree
- ✓ It's used in the treatment of malaria.
- ✓ Also its added in drinks as a stimulant.
    - **Cannabis**
- ✓ It's stored in flowers, fruits and also leaves of *Cannabis sativa.*
- ✓ It's normally extracted and used in the manufacture of drugs such as painkillers.
- ✓ *Cannabis sativa induces* hallucinations ie seeing or hearing unreal things.
    - **Cocaine**
- ✓ It's obtained from the leaves of a south American plant called coca plant.
- ✓ It's used as a local anaesthetic . when taken in large quatities it causes great physical or mental effects such as convulsions or hallucinations.
- ✓ It's addictive when taken in large amounts and can lead to ailments of the heart.
    - **Nicotine**

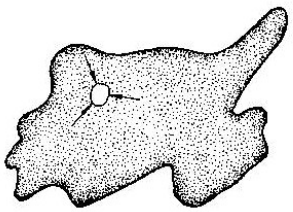
- ✓ Occurs in the leaves of the tobacco plant. Its used to manufacture insecticides and narcotic drugs.
    - **NB** Narcotic drugs are substances that cause one to sleep or become very relaxed and feel no pain.
- ✓ The tar from the tobacco is poisonous and cause lung cancer in human beings.
    - **Caffeine**
- ✓ It's stored in coffee beans and tea leaves.
- ✓ It's a mild stimulant which is refreshing. It increases mental activity and reduces fatigue.
- ✓ Excessive intake of caffeine can cause sleeplessness and so may cause mental illness.
- ✓ It can cause changes in cells of the foetus.
- ✓ It increases the activity of adrenaline.
    - **Morphine**
- ✓ It's extracted from the poppy plant and is used to make narcotic drugs.
- ✓ It's also a painkiller and muscle relaxant.
    - **Papain**
- ✓ Its extracted from pawpaw trees and used as a meat tenderiser.
    - **Colchicine**
- ✓ Its obtained from the roots of crocus plant. Its used to bring about mutation in genetic materials thus useful in plant breeding.
- ✓ Its carcinogenic ie it can cause cancer.
    - **Khat**
- ✓ Also reffered to as miraa (*Khat edulis*). Its extracted by chewing the leaves and the twigs of the tree.
- ✓ Its used as a stimulant.
    - **Pyrithrin**
- ✓ Its extracted from pyrethrum flowers. Its used to make insecticides.
    - **Alkaloids**
- ✓ Produced in irish potatoes when exposed to sunlight turn the tubers green. They are bitter and can be poisonous if ingested in large quantities.

Naturally, the alkaloids protect tubers exposed on the groundfrom being fed on.

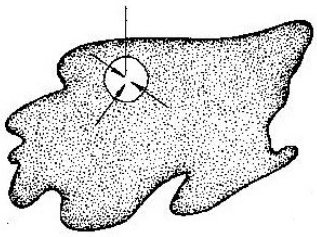
- ✓ **Excretion in animals**
- ✓ Unlike plants, animals have more problems of getting rid of waste substances for several reasons;
- ✓ -Animals are more active than the plants threfore their metabolic processes takesplace at a higher rate producing large quantities of waste products.
- ✓ -Animals do not put most of their waste products to other uses the way the plants do.
- ✓ -Animals take in certain substances in their food in excess of their needs. These extra substances eg proteins are broken down with the formation of toxic substances such as ammonia.
- ✓ **Excretion in unicellular organisms**
- ✓ Most simple organisms such as protozoa live in aquatic environments. Their waste products include CO_2 and nitrogenous wastes.
- ✓ Protozoa such as amoeba and paramecium depend on diffusion as a means of excretion.
- ✓ Their bodies have high surface Area to volume ratio that provide a large surface area for gaseous exchange and excretion to take place by simple diffusion. These waste products diffuse from the cytoplasm where they are at a higher concentration across the cell membrane into the surrounding water where their concentration is low.
- ✓ Another method of excretion is by use of contractile vacuole.
- ✓ Amoeba and paramecium live in an aquatic environment that is hypotonic to their body fluid hence there is excess inflow of water by osmosis. Excess water and dissolved chemicals accumlate in the contractile vacuole.

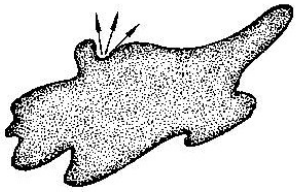
- ✓ On reaching the maximum size, contractile vacuole moves to the cell surface and bursts releasing the contents to the surrounding.
- ✓ Soon afterwards other contractile vacuoles form in the cytoplasm, accumlate more waste contents and the process continues eg

Contractile vacuole forming and wastes start to collect into it.

✓ 

Contractile vacuole enlarging to maximum size, pushes cytoplasm as it moves towards the membrane

✓ 



✓ Contractile vacuole burst and releases contents to the surrounding through the nearest part of the membrane.

✓ **Excretion in animals**

- ✓ Excretion in animals is carried out by elaborate systems made up of specialized tissues and organs. This is because their bodies are complex and have greater number of cells.
- ✓ The excretory tissues and organs include;
- ✓ -Flame cells-Platyhelminthes
- ✓ -Nephridia-Annelida
- ✓ -Malphigian tubules-Insects
    - -Gills, lungs, liver and kidney-Vertebrates
- ✓ These organs are specialized to function in different environments such as aquatic (marine and fresh) and terrestrial.
- ✓ **Excretion in mammals**
- ✓ The main excretory organs in mammals are;
- ✓ (a) Skin
- ✓ This is the largest body organ as it covers the whole body surface and even continues into many body openings like nostrils, mouth and ears.
- ✓ **Functions**

- Protection of the uderlying tissues from entry of micro-organisms, physical damage and ultra-vilet rays from the sun.

✓ -Since the outermost layer is waterproof, the skin preventsthe body from drying up.

- Regulation of body temperature.
- Excretion of salts, excess water and traces of urea.
- Reception of stimuli of heat, cold, pain, touch and pressure.
- Synthesis of vitamin D.
- Storage of fat.

✓ The skin consists of two main layers; outer epidermis and inner dermis.

✓ **The Epidermis**

✓ It's the upper layer of the skin and its made up of 3 layers of cells i.e.

✓ **The cornified layer**

✓ It's the outermost layer and it's made up of flattened dead cells that become filled with a tough flexible substance called keratin. This layer provides protection against mechanical damage and invasion of bacteria.

✓ It also reduces the loss of water by evaporation. Cells of this layer are continuously lost through friction and replaced from beneath by granular layer.

✓ Its thickness varies in the body e.g. its thickest in areas of high friction like palms of hands and soles of feet, but thinnest on lips and eyeballs.

✓ **Granular layer**

✓ It's the middle layer of epidermis and consists of living cells that have granules. It gives rise to the cornified layer.

✓ **Malphigian layer**

✓ It's the innermost layer of cells and is made up of actively dividing cells that give rise to new epidermis.

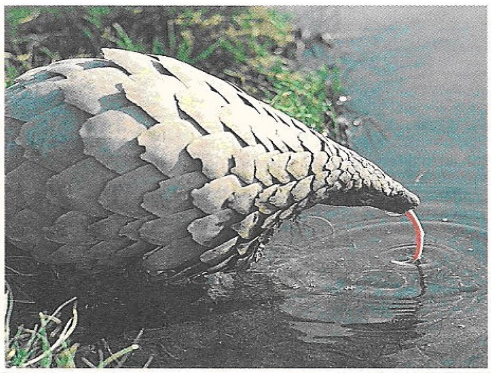
✓ The cells have pigment granules called melanin that gives colour to the

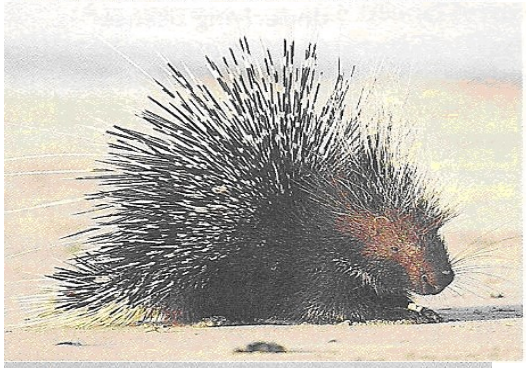
skin. The more it is, the darker the skin colour. It also gives protection against harmful ultra-violet rays from the sun.

- ✓ **Dermis**
- ✓ This is thicker than the epidermis and is located below it. It contains the following;
- ✓ **Sweat glands**
- ✓ These are tiny coiled tubes which secrete and release sweat through the pores on the surface of the skin.
- ✓ Sweat consists of water and mineral salts such as sodium chloride and traces of urea and lactic acid. The liquid that forms sweat is absorbed by the sweat glands from the blood capillaries supplied to each gland.
- ✓ It reaches the surface of the skin through the pore and water in it evaporates into the air. This cools the body.
- ✓ Sweat glands function when the body temperature rises above the normal by between 0.2 ºC-0.5 °C.
- ✓ **Blood vessels and Lymphatic vessels**
- ✓ Blood vessels contain blood that supplies nutrients and O_2 to the skin tissues and remove waste products and CO_2.
- ✓ Blood also helps in temperature regulation.
- ✓ Lymphatic vessels drain excess tissue fluid.
- ✓ **Nerve endings**
- ✓ The nerve cells that detect changes from the external environment thus creating awareness within the body of the changes in temperature (cold and heat), pressure and touch.
- ✓ **Hair**
- ✓ Originates from a deep infolding of the epidermis that forms the hair follicle. The hair follicle is lined with granular and malphigian layers of epidermis.
- ✓ At the base of the hair is a dermal or hair papilla from which the hair root develops.
- ✓ The hair follicle is supplied with sensory nerve to increase

sensitivity of the skin and blood vessels, for the supply of nutrients and removal of waste products.

- ✓ Each hair is made up of a base called hair root and hair shaft which protrudes outwards.
- ✓ 'Growth of hair' is due to continuous addition of new dead cells at the base of the hair.
- ✓ Erector pili muscles are attached to the follicle at one end and on the other end to the epidermis. These muscles undergo contraction and relaxation to alter the angle between the hair shaft and the skin and therefore vary the amount of air trapped between the hair and the skin.
- ✓ **NB** Certain hairs have become specially specialized adapted e.g.
- ✓ -Eye lashes and the hairs inside the human nose which help to keep out dust particles.
- ✓ -Cats, dogs, cats etc have long whiskers which help with the sense of touch.
- ✓ -The long stiff spines of porcupines, the horns of rhinoceros and the pangolin's scales are examples of modified hairs.

✓ 

✓ 

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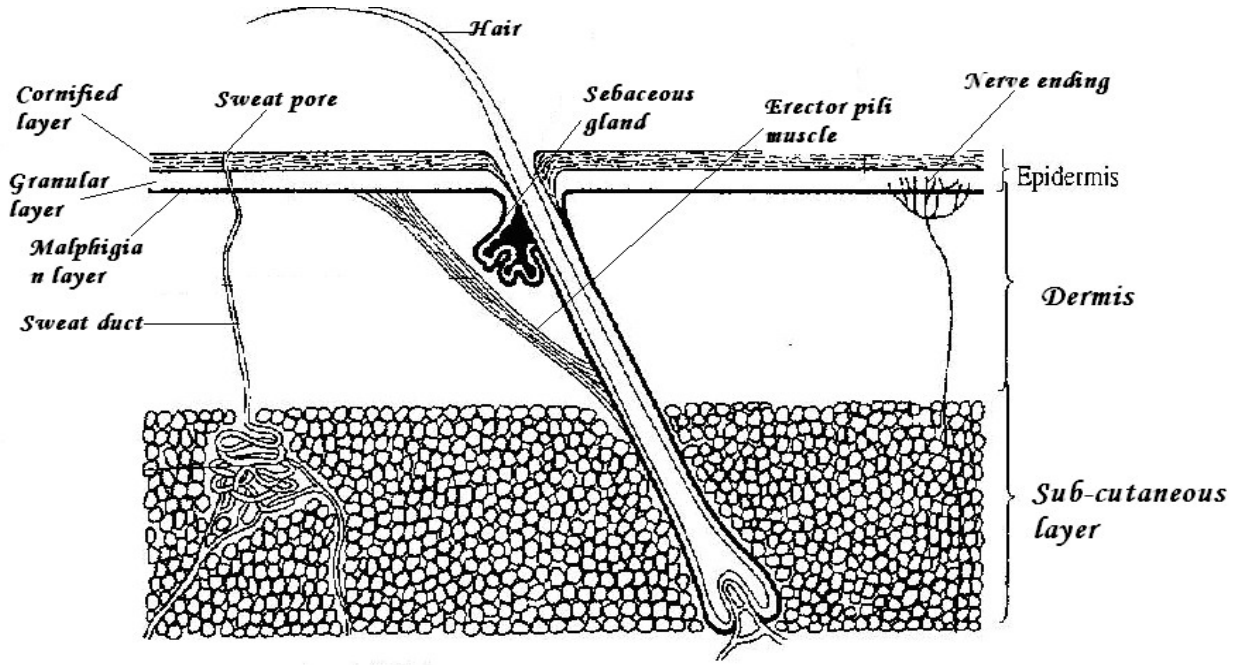
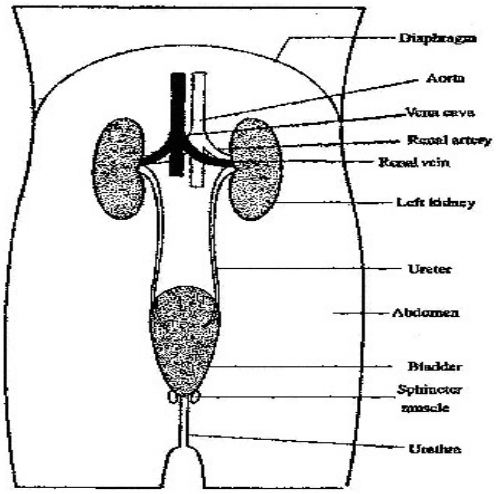
- ✓ **Sebaceous glands**
- ✓ They are attached to the follicle and the gland opens into the follicle. They secrete sebum which keeps the hair and epidermis flexible and waterproof (water repelling property).
- ✓ Also sebum contains antiseptic substances for protection against bacteria.
- ✓ Also keeps epidermis supple and reduces the tendency for it to become dry due to evaporation.
- ✓ **Subcutaneous layer**
- ✓ This is a layer of fat beneath the dermis and binds the skin to the muscles and other organs deep in the body.
- ✓ It acts as a storage region for fats and an insulation layer against heat loss.
- ✓ **NB** Skin lightening creams contain among other chemicals, mercury. They destroy;
- ✓ Malphigian layer- this leads to the destruction of melanin producing cells making skin appear lighter, but this exposes the skin to harmful U.V rays which cause cancer.
- ✓ Cornified layer- its destruction gives the impression of a softer skin but this exposes the skin to mechanical injury and microbial attack.



- ✓
- ✓ **Lungs**
- ✓ In mammals , birds, reptiles and amphibians, CO2 formed during tissue respiration is removed from the body by the lungs.
- ✓ **The Kidney**
- ✓ The functions of kidney are;
- ✓ -Excretion
- ✓ -Osmoregulation
- ✓ -Ionic balance
- ✓ -Regulation of PH
- ✓ The kidney is an organ found in vertebrates and each organism has two kidneys.
- ✓ Kidneys are bean-shaped and are red in colour. They lie near the back of the abdominal cavity about the level of the waistline.
- ✓ Each kidney weighs approximately 142.5g, ie about the size of a clenched fist. The right kidney is generally slightly lower than the left. The kidney is surrounded by a layer of fat which helps to cushion it from mechanical or physical injury.
- ✓ The kidney is supplied with blood from the general circulatory system via the renal artery which branches off the aorta.

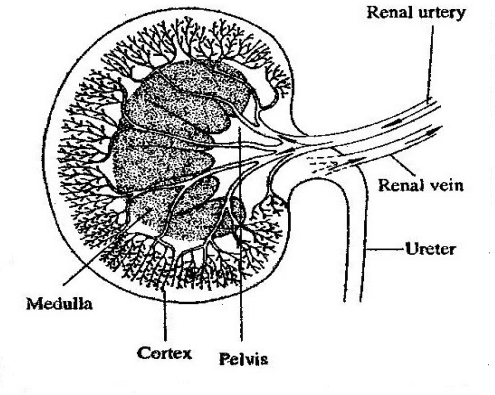
- ✓ Blood from the kidneys goes back to the general circulation through the renal vein which joins the vena cava.
- ✓ A tube called the ureter connects each kidney to the bladder located in the lower abdomen. From the bladder another tube called the urethra opens to the exterior of the organism.
- ✓ In males, the urethra is long and is joined to the reproductive system unlike in females hence refered to as urinogenital system.
- ✓ Two rings of sphincter muscles encircle the urethra and they control the emtying of the bladder. The two kidneys, two ureters, the bladder and the urethra make up the urinary system.



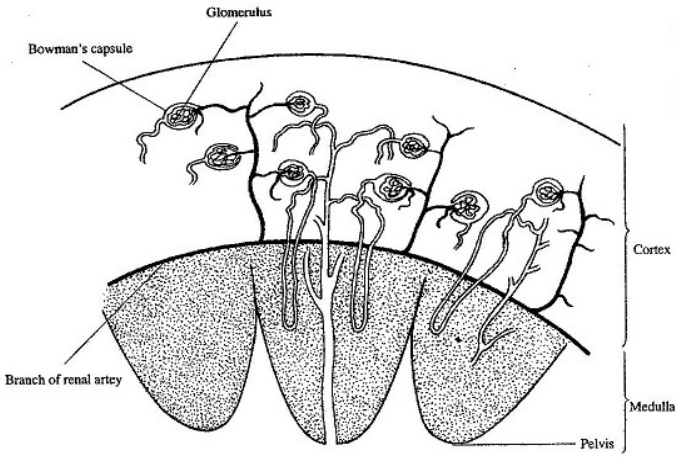
- ✓ **Structure ot the kidney**
- ✓ The kidney has two main functions;
- ✓ **Excretion**-They remove excess salts, water and nitrogenous wastes from the blood.
- ✓ **Osmoregulation**-They regulate the concentration of water and salts found in the body fluids.
- ✓ A longitudinal section of mammalian kidney shows 3 distinct regions i.e.
- ✓ **-Cortex**- Its dark red in colour and found to the outside.
- ✓ **-Medulla**- Its red in colour and lies to the center of the kidney and extends to form conical structures called pyramids. These

pyramids open into swollen cavity called pelvis.

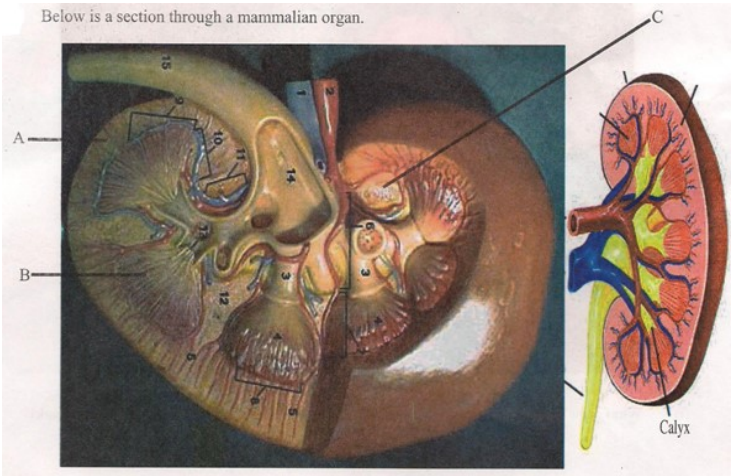
✓ **-Pelvis**- Its white in colour and narrows to form ureter.



Longitudinal cross-section of a mammalian kidney

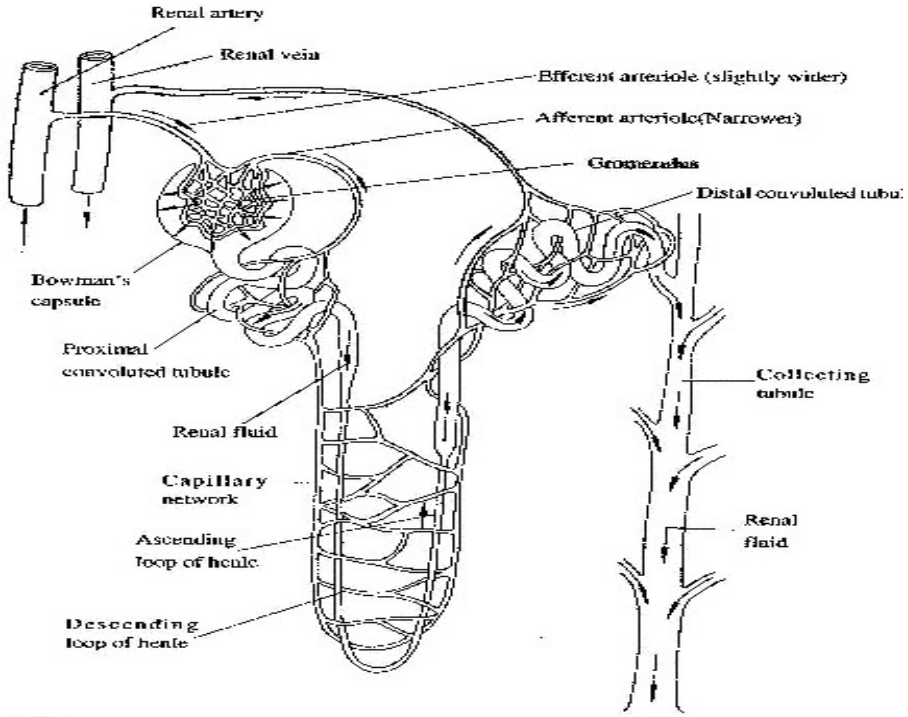


✓ *Section through cortex and medulla*



✓

- ✓ **Nephron**
- ✓ It's the basic functional unit of the kidney. Each kidney has about 1.25 million nephrons.
- ✓ Each nephron is made up of two main parts namely;
  - Renal tubule
- ✓ -Glomerulus
- ✓ **Renal tubule**
- ✓ It has 5 main parts i.e.
- ✓ **Bowmans capsule**-It's a thin double-walled and cup-shaped structure.



- ✓ **Proximal convoluted tubule-**Its coiled and extends into a U-shaped part.
- ✓ **Loop of henle**-It's the U-shaped part.
- ✓ **Distal convoluted tubule**- Its coiled and extends into a collecting tubule.
- ✓ **Collecting tubule**- Drains into a collecting duct into which Collecting tubules from several nephrons drain thus forming an outlet of urine through a pyramid into the pelvis.
- ✓ **Glomerulus**
- ✓ It's a fine network of blood capillaries

enclosed by the Bowman's capsule. Glomerulus is formed from the;

- ✓ **-Afferent arteriole**- It's a branch from renal artery.
- ✓ **-Efferent arteriole**- It collects blood from the glomerulus and extends to the renal tubule where it divides into capillaries that ramify the tubule.
- ✓ It channels blood away from the glomerulus.
- ✓ **Functions of the glomerulus**
- ✓ Excretion in the nephron is carried out in two stages i.e.
- ✓ -Ultra-filtration
- ✓ lumen-Reabsorption
- ✓ **Ultra-filtration**
- ✓ This is the process by which the useful substances enter the nephron.
- ✓ **Reabsorption**
- ✓ This is the process by which the useful substances are taken back into the blood so that they are not lost.
- ✓ Kidneys receive blood from the renal artery and branch off the dorsal aorta. This blood is rich in nitrogenous wastes e.g urea. It also contains dissolved food substances, plasma, proteins, mineral ions, hormones and oxygen.
- ✓ The Afferent arteriole entering the Glomerulus has a wider lumen than the Efferent arteriole leaving it.
- ✓ The narrowness of the Efferent arteriole produces both resistance to blood flow and back pressure which create extremely high pressure in the glomerulus.
- ✓ Also the renal artery branches directly from the dorsal aorta whose blood flow is at a high pressure.
- ✓ This pressure forces water, mineral ions and small molecules like glucose, amino acids and urea out of the the glomerulus. These pass through the tiny pores in the walls of the glomerular capillaries into the Bowman's

capsule. This process is known as ultra-filtration and the liquid collected in Bowman's capsule is called glomerular filtrate.

- ✓ The larger molecules in the blood eg blood proteins, white blood cells, red blood cells and platelets cannot pass through the capillary walls of the glomerulus hence the blood which remains is rich in plasma proteins and little water.
- ✓ The glomerular filtrate then flows from the capsular space into the Proximal convoluted tubule of the nephron. As the glomerular filtrate flows along, most of the filtered substances which are useful to the body are selectively reabsorbed back into the blood.
- ✓ In the Proximal convoluted tubule, all glucose , amino acids, some water (80%) and mineral salts are actively reabsorbed against the concentration gradient, a process that requires energy (active transport).
- ✓ **NB** The substances reabsorbed are those which are useful to the body hence refered to as selective Reabsorption
- ✓ **Adaptations of Proximal convoluted tubule for efficient Reabsorption**
- ✓ -Cells lining the tubules have numerous mitochondria which provides the necessary energy in the form of ATP.
    - -Cells of the tubules have micro-villiwhich increases the surface area.
- ✓ -The tube is long and highly coiled to provide a large surface area for Reabsorption.
    - -The coiling of the tubule reduces the speed of flow of the filtrate thereby giving more time for efficient Reabsorption.

- ✓ -The tubule is well supplied with blood capillaries.
- ✓ The glomerular filtrate flows into the loop of henle, which has a unique U –shape feature with a descending and an ascending limb.Salts especially sodium chloride are reabsorbed into the blood.
- ✓ The U-shape loop is generally longer and has a counter-current flow established between the flow of the filtrate and the blood supply in vessels.
- ✓ Active transport is involved in the reabsorption of sodium salts.To regulate the intake of sodium salt, a hormone called aldosterone is secreted by the adrenal glands.
- ✓ Low content of salt in the blood stimulates adrenal glands to secrete more aldosterone hormone and therefore more salt is reabsorbed from the filtrate and vice versa.
- ✓ The glomerular filtrate flows into the distal convoluted tubule where controlled amount of water is reasorbed into the blood by osmosis .This process is enhanced in 2 ways:
- ✓ (i) Due to the active intake of sodium salt into the blood at the loop of henle which increases the osmotic potential of the blood.
- ✓ (ii) A hormone known as antidiuretic hormone (ADH)/vasopressin. This hormone is secreted by the pituitary gland.
- ✓ ADH increases the permeability of the tubule and blood capillaries to water. When there is excess water in the body eg as a result of excessive intake of fluids, osmotic potential of the blood falls causing the pituitary gland to reduce its secretion of ADH into the blood. Water reabsorption in the tubule is thereby reduced and results in the

production of large amounts of dilute urine.

- ✓ If the body loses a lot of water through sweating, the blood pressure is raised hence the pituitary gland release more ADH which results in increased water reabsorption from the tubule into the blood. This results in the production of little amounts of concentrated urine.
- ✓ **NB** Adaptations of distal convoluted tubule are similar to those of proximal convoluted tubule.
- ✓ The glomerular filtrate flows into the collecting tubule from where more water is reabsorbed. The glomerular filtrate now becomes urine and trickles down into the collecting duct where it joins urine from the collecting tubules of other nephrons.
- ✓ The urine then flows into the pelvis via the pyramid and is finally emptied into the urinary bladder through the ureter.
- ✓ About 1-2 litres of urine trickles into the urinary bladder in a day. In the urinary bladder, about 250ml of urine will initiate the urge to urinate. The sphincter muscles relax and the urine is passed out.
- ✓ The resultant urine composition of a healthy person maybe as follows;
- ✓ Water---------- 95%
- ✓ Urea---------- 2%
- ✓ Uric acid---------- 0.03%
- ✓ Creatinine---------- 0.1%
- ✓ Salts (Na+, K+, cl-)— 1.4%
- ✓ Ammonia---------- 0.04%
- ✓ Proteins---------- 0.0%
- ✓ Glucose---------- 0.0%
- ✓ The quatinty and concentration of urine in animals is affected by terrestrial, aquatic, desert

conditions, the physiological and structural adaptations of the animals eg in a desert rat, water reabsorption is maximised by the development of a long loop of henle.

- ✓ **Kidney Diseases and Disorders**
  - **Nephritis**
- ✓ This is a condition which affects the glomerulus. It is due to the poisons released during infection by certain bacteria called streptococci in various parts of the body.
- ✓ It can also be caused by small pox, measles, typhoid and sore throat.
- ✓ The glomeruli become so swollen that they are unable to carry out fitration of the blood.
- ✓ **Symptoms**
- ✓ Headaches, fever, vomiting and weakness.
- ✓ Swelling of the body called oedema.
- ✓ Urine is highly coloured and cloudy due to the presence of albumen.
- ✓ **Treatment and Control**
- ✓ Dietary restrictions especially salts and proteins.
- ✓ Administration of drugs.
  - **Kidney Stones**
- ✓ There are various causes;
- ✓ Improper balance of diet, lacking certain vitamin and inadequate intake of water.
- ✓ Chemical salts in urine eg oxalates, phosphates, urates and uric acid. These may undergo precipitation and form hard deposits or stones in pelvis, ureter hence causing blockage of urine.
- ✓ **Symptoms**
- ✓ Increased frequency in passing out urine.
- ✓ Pain and soreness in the upper back side.
- ✓ Pain, chills and fever.
- ✓ Difficulty in passing out urine.
- ✓ **Treatment and Control**
- ✓ Consult a physician.
- ✓ Take balanced diet with plenty of water.
- ✓ Take hot baths and massage the back with hot soft material.

- ✓ Dialysis or artificial washing out of wastes.
- ✓ Use of laser beams to disintegrate the stones.
- ✓ In severe cases, surgical treatment which may involve kidney transplant.
    - **Albuminuria (Protein in urine)**
- ✓ This disorder is also called proteinuria. It's a condition in which protein, mainly albumen, is found in urine.
- ✓ This is due to increased permeability of glomerular capillaries which may be caused by bacterial infections.
- ✓ **Symptoms**
- ✓ Fluid accumulation in tissues (oedema). Its fatal if not treated.
    - **Kidney failure/Renal failure**
- ✓ The failure of the kidneys to function may occur as a result of a drop in blood pressure due to heart failure, haemorrhage or shock. Haemorrhage means excessive bleeding.
- ✓ Due to the drop in blood pressure, the filtration rate in each glomerulus is reduced. In some cases the blood pressure is so low that no urine is formed and the kidneys stop working.
- ✓ If one kidney fails, a person can still lead a normal life using the other kidney. However, if both kidneys malfunction, the individual will still survive if treated promptly. Such treatment can be administered in two forms i.e.
- ✓ -Kidney dialysis
- ✓ -Kidney transplant
    - **Pyelonephritis**
- ✓ This is a bacterial infection of the renal pelvis. The infection may spread to the urethra and bladder.
- ✓ The kidney becomes swollen and filled with pus. It can be treated with antibiotics.
    - **Uremia (Uraemia)**

- ✓ It's a condition in which there is excess urea in the blood.
- ✓ It occurs when the kidneys are not working properly and the poisonous nitrogen-containing waste products accumulate in blood.
- ✓ **Symptoms**
- ✓ -Convulsions
- ✓ -Coma
- ✓ -Vomiting
- ✓ -Diarrhoea
- ✓ -Lethargy
- ✓ -Mental disorientation and confusion.
- ✓ -Difficulty in breathing
    - **Gout**
- ✓ This is a disorder caused by the absorption of uric acid salts into the blood.
- ✓ In high concentrations, uric acid salts form crystals in joints in the toes, fingers and even the kidney itself. Its very painful for the patient to make any movements including walking.
- ✓ Gout is caused by a diet that has too much organ meat eg kidneys or red - meat.
- ✓ **Treatment and Control**
- ✓ Patients are put on medications that break up uric acid into harmless compounds.
- ✓ They are advised to have a diet low in protein.
- ✓ Avoid red meat.
- ✓ Drink plenty of water.

- ✓ **The liver**
- ✓ It's the 2nd largest organ after the skin (Adult 2-3% of body weight-1.5kg) and it's a special organ of excretion because many excretory products are produced by it.
- ✓ It lies immediately beneath the diaphragm and is made up of several lobes.
- ✓ It receives blood from the blood vessels i.e hepatic portal vein and hepatic artery. Blood flows out of the liver through the hepatic vein.
- ✓ The liver consists of a large number of lobules. Each lobule is made up of many liver cells. The blood supply to each lobule is from two

sources i.e. hepatic portal vein and hepatic artery. These vessels branch between the liver lobules.

- ✓ Between the plates of liver cells are channels called canaliculi which receive blood. The bile moves outwards to the periphery of the lobules where it collects into bile salts.
- ✓ **Functions of the liver**
  - o **Deamination**

- ✓ **NB** Reptiles and birds need to conserve their water. Their ammonia is converted to **uric acid** that does not need water to eliminate. They are refered to as **uricotellic** organisns and they produce white droppings instead of urine.
- ✓ Animals that excrete mainly **ammonia** live in aquatic environments.

- ✓ It's the removal of the amino group from an amino acid. Proteins which are taken in by the body are digested producing amino acids. Excess amino acids are are not stored in the body but are deaminated.
- ✓ The amino group deaminated enters the ornithine cycle where it combines with CO_2 to form urea, which is excreted from the body through the kidney e.g

$$2NH_3 + CO_2 \xrightarrow{\text{ornithine cycle}} CO(NH_2)_{2\,(Urea)} + H_2O$$

CO_2 and the toxic ammonia can be diluted to harmless concentrations with plenty of water hence refered to as **ammonotelic** eg fresh water fish.

- ✓

- ✓ Enzyme orginase

- ✓ Terrestrial animals produce more **urea** since it does not need to much water for dilution hence

refered to as **ureotelic** eg mammals.

- **Detoxification**

✓ It's the process by which harmful compounds such as drugs or poisons are converted to less toxic compounds in the liver.

✓ The toxic substances are subjected to biochemical reactions. The toxins are rendered harmless through oxidation and reduction.

✓ Detoxification can also involve combining the toxin with another compound. The toxic substances are then excreted in the urine.

✓ Toxic compounds in the body may arise from medication, drugs and micro-organisms.

✓ **(c) Heat production**

✓ Many metabolic activities take place in the liver. These metabolic activities release heat energy which is distributed by the blood to the other parts of the body.

(d) Haemoglobin elimination

✓ Haemoglobin from the worn-out red blood cells is broken down in the liver and the residual pigments, urochrome which gives urine a yellow tinge, is eliminated by the kidney.

(e) Regulation of plasma proteins

✓ Plasma proteins are synthesised from amino acids in the liver eg prothrombin and fibrinogen which are involved in blood clotting.

✓ Other plasma proteins eg serum, albumen contribute to the maintenance of osmotic pressure in the body. Also non-essential amino acids are synthesised in the liver.

✓ Haemoglobin is broken down into haem and globin. Globin is digested into amino acids and enters the amino acid pool while the haem group is changed into **biliverdin** and **bilirubin** and taken

to the gall bladder. These are later released into the gut as bile and then passed out through the faeces. These two substances give faeces its characteristic brown colour.

(f) Storage of vitamins and mineral

- ✓ The liver stores vitamins A, B, D, E and K. The liver of cod fish is a rich source of vitamin A and D. When the RBC are broken down, iron is released and stored in the liver in the form of a compound called ferritin.

(g) Regulation of blood sugar level

- ✓ Excess glucose is converted into glycogen and fat under the influence of insulin. If the blood reaching the liver has less glucose, the stored glycogen is converted to glucose.

(h) Storage of blood

- ✓ The liver is highly vascularised and therefore able to hold a large volume of blood. This is achieved through the dilation of blood vessels to accommodate more blood.

(i) Formation of erythrocytes

- ✓ Erythrocytes are formed in the liver of the foetus. As the foetus develops, the role of the liver in the formation of erythrocytes declines. The liver breaks down old erythrocytes.
- ✓ **Diseases of the liver**
  - o **Liver cirrhosis**
- ✓ This disease is also called liver rot.
- ✓ Its caused by alcoholism i.e. taking too much alcohol over a long period causes the liver cells to die and they are replaced by fibrous scar tissue. The normal functions of the liver are greatly reduced.
  - o **Signs and Symptoms**
- ✓ Loss of appetite and indigestion.
- ✓ Abdominal pain around the location of the liver.
- ✓ Haemorrhage evident in the blood stained vomit.

- **Treatment and Control**
- There are no drugs for curing cirrhosis. Most peopple with severe cirrhosis die from it.
- If the feet are swollen, the patient should stop taking salt in the food.
- Strict diet containing easily digestible foods.
  - **Hepatitis**
- It's caused by viruses. There are 3 types i.e.
- -Hepatitis A
- -Hepatitis B
- -Hepatitis C
- **Hepatitis A** is common among children and young adults.
- It's infectious and transmitted through contact, food and water contaminated with faeces of infected peopple.
- **Hepatitis B**
- It's common among adults and transmitted through body fluids eg saliva, blood and semen. Also transmitted through dry blood.
- **Hepatitis C**
- Transmitted in blood causing chronic liver disease.
- **Symptoms of Hepatitis B**
- Inflammation of the liver.
- Loss of appetite, nausea and fatigue.
- Abdominal discomfort.
- Jaundice of mucous membranes especially in the eyes.
- **Treatment and Control**
- Hygienic processing of food.
- Proper disposal of sewage.
- Treatment of water.
- Vaccination against the disease
- Proper handling of the blood products.
- Screening of all blood and blood products to be transfused .
- Use properly sterilised needles and syringes.
  - **Jaundice**
- Its caused by an increase in bile pigment called bilirubin in the blood. This may be due to;
- -Damage of the liver cells by toxic or

infectious materials. This blocks the bile canals in the liver and can not be transported to the gall bladder. As a result, bile pigments are reabsorbed into the blood.

- ✓ -Excessive destruction of red blood cells.
- ✓ -Obstruction of bile flow between the liver and duodenum. This occurs when gall stones block the bile duct. Gall stones are formed as a result of accumulation of excess insoluble cholesterol in the gall bladder.
- ✓ **Symptoms**
- ✓ Patient may have itching caused by retention of bile salt in the blood.
- ✓ The presence of bile pigment in the blood makes the eyes look yellow.
- ✓ **Activity; To investigate effect of catalase on Hydrogen peroxide**
- ✓ **Requirements**
- ✓ Test tubes
- ✓ Labels
- ✓ Measuring cylinder
- ✓ Hydrogen peroxide
- ✓ Liver
- ✓ Muscle tissue
- ✓ Potato
- ✓ Water bath
- ✓ Source of heat
- ✓ **Procedure**
  - o Label 4 test tubes A, B, C and D.
- ✓ Measure $2cm^3$ of Hydrogen peroxide and put in test tube A. Repeat the same procedure for test tube B and C.
- ✓ Cut a small piece of liver and place in test tube A. Immediately introduce a glowing splint into the mouth of the test tube.
- ✓ Repeat step III using muscle tissue (in test tube B) and a potato (in test tube C).
- ✓ Repeat step III using boiled liver (in test tube D) and make sure that the liver is thoroughly boiled for about 5 mins. Tabulate your results e.g.

Test tube	Observation	Conclusion
A-Hydrogen	-Relights glowing	A lot of catalase

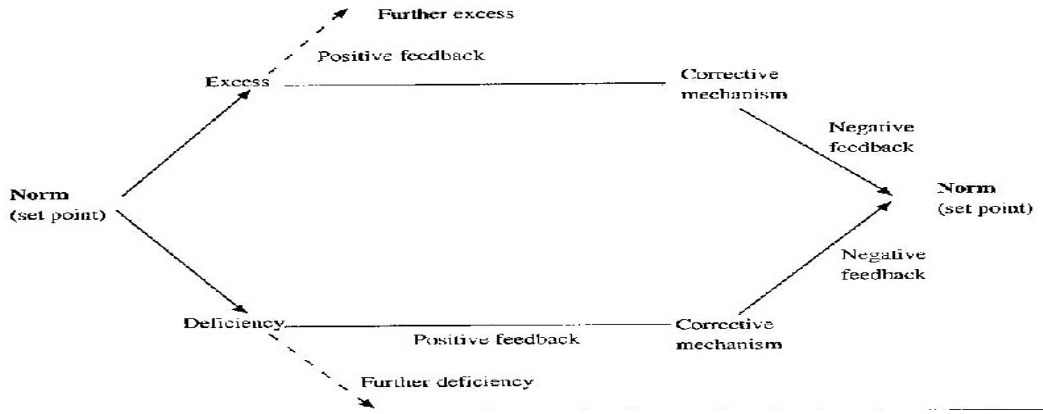
peroxide+ raw liver	splint -Vigorous production of bubbles	enzyme present
B-Hydrogen peroxide+ muscle tissue	-Relights glowing splint -A lot of bubbles produced	Medium amount of catalase enzyme present
C-Hydrogen peroxide+ potato	-Relights glowing splint - Production of bubbles	Little amount of catalase enzyme present
D- Hydrogen peroxide+ boiled liver	-No bubbles	Enzymes denatured

- ✓ **Discussion**
- ✓ Living things contain an enzyme called catalase which breaks down hydrogen peroxide to water and oxygen. The oxygen produced relights a glowing splint i.e.
- ✓ $2H_2O_2 \rightarrow 2H_2O + O_2$
- ✓ Hydrogen peroxide catalase water oxygen

- ✓ **Homeostasis**
- ✓ It's a process that adjusts changes in the body of an organism to optimum standards or levels and threfore brings about a steady state.
  - **External environment**-It's the immediate surrounding of the organism. It may be aquatic or terrestrial.
  - **Internal environment**- It's the immediate surrounding of the body cells.
- ✓ **Neuro-endocrine system and homeostasis**
- ✓ Neuro-endocrine system comprises of the nervous and endocrine system.
- ✓ Nervous system comprises of the receptors and nerve

fibres that make up the nervous tissue.

- ✓ Receptors detect the changes in the internal or external environment. An impulse passes through fibres to the Central Nervous System (CNS). The CNS in turn initiates the correct response. The CNS sends an impulse to the organ which responds appropriately.
- ✓ Receptors also send nerve impulses up the endocrine glands which comprises of the glands that secrete hormones. Endocrine system is also known as hormonal system. The hormones secreted are transported in the bloodstream to the target organs.
- ✓ **Principles of homeostasis**
- ✓ Inorder to maintain a state of balance in the internal environment, the various systems in the body work on a feedback mechanism eg
  - o **Negative feedback**
- ✓ When a factor in the body such as temperature drops below or shoots above the normal, it is detected and corrective action is taken. Such an action is either;
- ✓ -An increase in the level if it was dropping or
- ✓ -A decrease in the level if it was increasing. This feedback restores the condition to normal.
  - o **Positive feedback**
- ✓ In Positive feedback, a change below or above the normal is not corrected, instead, what is meant to be corrective action leads to further undesirable change from the normal e.g



✓

- **Role of hypothalamus in thermoregulation**

✓ Hypothalamus is a small region between the cerebrum and cerebellum part of the brain. It acts as a thermoregulatory centre.

✓ It has numerous temperature receptor cells which detect the slightest changes in the body temperature. The external temperature affecting the body is determined by the thermoreceptors in the skin.

✓ Thermoreceptors relay the impulse to the hypothalamus through the sensory nerves.

✓ The internal temperatures are detected by the hypothalamus as the blood flows in the brain.

- **Role of the liver in homeostasis**

- **Regulation of blood glucose**

✓ The normal amount of glucose in blood is about 90-100mg /100cm^3 of blood.

✓ The liver carries out the control of the blood sugar level through two hormones produced by the pancreas i.e **insulin** and **glucagon** which are produced by the interstitial cells of the pancreas in the islets of langerhans and released into the bloodstream. The functions of insulin are antagonistic to those of glucagon eg

✓ After a meal, carbohydrates are

digested forming glucose, thereby increasing glucose level in the liver. The high glucose level in the liver is detected by the brain which sends impulses to the pancreas to secrete insulin, which carries out corrective measures as follows;

- ✓ -Converts glucose into glycogen which is then stored in the liver and muscles.
- ✓ -Changes glucose into fats which is then stored under the skin.
  - -Breaks down glucose into CO_2 and water in a process of tissue respiration.
- ✓ When there is decreased glucose concentration in the blood eg during fasting, the pancreas is stimulated to release a hormone called glucagon which affects the liver ie
- ✓ -Converts glycogen to glucose.
- ✓ -Converts fats to glucose.
  - -Reduces respiration i.e. reduces rate at which glucose is being broken down to form water and CO_2.
- ✓ Also another hormone called **adrenaline** produced by the adrenal gland causes increased hydrolysis of glycogen and this results in increase in blood sugar. This hormone is produced during emergencies to increase available glucose for respiration and release of energy for the emergencies.
- ✓ **Diabetes mellitus (sugar disease)**
- ✓ From Greek –meaning sweet urine.
- ✓ This is a condition in which the pancreas fails to produce insulin or produces inadequate amounts. This may be due to hereditary reasons or disease affecting the islets of langerhans.
- ✓ A person with Diabetes mellitus has an abnormally high level of

glucose in the blood (**hyperglycaemia**). The kidney eliminates some glucose in the urine, a condition called **glycosuria** (sweet urine).

- ✓ **Symptoms**
- ✓ Passing large amounts of urine**.**
- ✓ Excessive excretion of glucose in the urine.
- ✓ Loss of body weight due to the breakdown of proteins and fats.
- ✓ Chronic starvation.
- ✓ Feeling of thirst.
- ✓ **Treatment and Control**
- ✓ Eating foods with less carbohydrate.
- ✓ Taking tablets that activate islets of langerhans in the pancreas to produce sufficient insulin.
- ✓ Administering injections of insulin everyday.
- ✓ **NB** insulin cannot be taken by mouth because it is a protein and hence will be digested in the alimentary canal before reaching the liver.
- ✓ Avoid excessive intake of alcohol.
- ✓ **NB** when a higher than normal amount of insulin is introduced in the blood, the patient;
- ✓ -Feels hungry
- ✓ -Sweats
- ✓ -Becomes irritable
- ✓ -Has double vision

- o **Deamination;**

- ✓ The liver breaks down excess amino acids; The amino group is removed as ammonia; and the remaining carbon skeleton oxidized to carbon IV oxide and water; This process leads to release of energy. The carbon skeleton may be converted to glucose to be used during respiration;

- o **Detoxification;**

- ✓ Ammonia from the process of deamination is converted in the liver into urea; which is less toxic. Bacterial toxins are converted to less toxic substances by liver cells;

- **Regulation of plasma proteins;**

✓ The liver produces most of the proteins found in blood; fibrinogen and prothrombin which play a role in blood clotting. Albumin and globulins are also produced by the liver. Globulins act as antibodies;. Albumin contributes to the maintenance of osmotic pressure in the body; Non essential amino acids are synthesized by the liver;

- **Heat production;**

✓ The various metabolic activities of the liver lead to release of heat energy; This energy is distributed by the blood to other parts of the body hence contributing to maintenance of constant body temperature;

- **Regulation of fat metabolism;**

✓ When carbohydrates are in short supply in the body, fats in different parts of the body are mobilized and taken to the liver; The fats are oxidized to carbon (IV) oxide and water with the production of energy or modified and sent to tissues for oxidation;

✓ **Role of kidney in homeostasis**

- **Osmoregulation**

✓ It's the mechanism of regulating water in the body. It attempts to maintain an optimum osmotic pressure in the body tissues and fluids that is favourable to normal functioning of cells.

✓ When the osmotic pressure of the body rises as a result of dehydration, the hypothalamus is stimulated and sends impulses to the pituitary gland which releases a hormone called Antidiuretic hormone (ADH)/vasopressin into the blood.on reaching the kidney, the diastal convoluted tubule and the collecting tubules

become more permeable to water which is then reabsorbed into the bloodstream thus lowering the osmotic pressure of the blood. This leads to the production of concentrated urine.

- ✓ When the osmotic pressure of the blood falls due to large intake of water, pituitary gland is less stimulated. This leads to reduced release of ADH into the bloodstream. The kidney tubules become less permeable to water and less reabsorption of water into the bloodstream takes place. The osmotic pressure of the blood rises and dilute urine is produced.
- ✓ **Diabetes Insipidus**
- ✓ When pituitary glandreleases very little ADH or fails to release it completely, the kidney nephrons are unable to reabsorb the required amounts of water. This leads to the production of excessively large volumes of dilute urine. This is known as diuresis. Patients may excrete upto 20 litres of urine per day.
- ✓ The urine can also be described as 'tasteless' or insipid thus the name Diabetes Insipidus**.**
- ✓ **Symptoms**
- ✓ Frequent urination .
- ✓ Secretion of a lot of urine.
- ✓ Production of dilute urine.
- ✓ Frequent thirst sensation.
- ✓ **Treatment**
- ✓ Administration of synthetic or natural ADH.
- ✓ **Regulation of ionic content**
- ✓ A hormone called **aldosterone** which is produced by the adrenal glands regulates the level of sodium ions.
- ✓ When the level of the sodium ions is low in the blood, adrenal glands are stimulated to release aldosterone into the blood which then stimulates loop of henle

of the kidney and the gut to reabsorb Na+ into the blood.

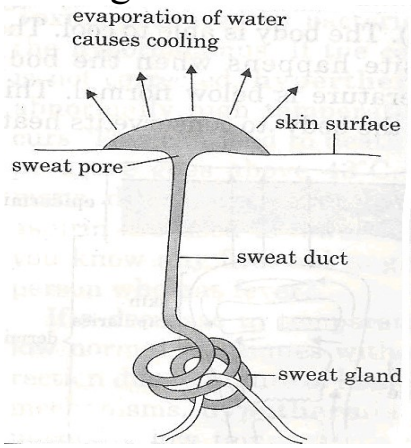
- ✓ If the sodium concentration in the blood rises above the optimum level, adrenal glands produce less aldosterone into the blood and less amount of Na+ are reabsorbed.
- ✓ **Role of the skin in homeostasis**
  - o **Salt and water balance**
- ✓ Skin has sweat glands which secrete waste products of metabolism such as water, mineral salts especially sodium chloride. These waste products are lost in the form of sweat through the pores in the skin.
- ✓ About 99% of the sweat is water while the remaining 1% is mainly mineral salts. The water and mineral salts lost in the sweat contribute to osmotic changes of the body cells and fluids.
- ✓ On a hot day, the body loses a lot of water and mineral salts resulting in a sensation of thirst being felt due to tissue dehydration. The osmotic balance is however restored by drinking large volumes of water and intake of mineral salts in the diet.
  - o **Temperature regulation**
  - o **Homeotherms/Endotherms**- They are organisms whose body temperature is maintained at a constant despite the wide fluctuations in the temperature of the external environment.
- ✓ Poikilotherms/Ectotherms- Their body temperatures fluctuates with that of the external environment.
- ✓ **Thermoregulation in humans**
- ✓ **Heat loss**
- ✓ The body loses heat to the environment when it's in a cold environment. The heat is lost by;

- ✓ -Radiation
- ✓ -Conduction
- ✓ -Convection
- ✓ -Evaporation
- ✓ **Radiation**- It's the transfer of heat by diffusion through the air between a warmer body and a colder one.
- ✓ **Conduction**- It's the transfer of heat from a hot body to a colder one when the two are in contact.
- ✓ **Evaporation**- It's the change of liquid to vapour.
- ✓ **Convection**- It's the movement of air in which warm air in one place rises and cooler air replaces it.
- ✓ Heat loss occurs through;
- ✓ -Sweating and breathing
- ✓ -Passing out of urine and faeces.
    - -Mammals such as cats lose heat by licking fur on their limbs and bellies.
- ✓ **Heat gain**
- ✓ The body gains heat from metabolic activities such as respiration and by muscle contraction.
- ✓ The body uses physiological and behavioural means to regulate the temperature.
- ✓ **When cold**
    - **Physiological mechanisms**
- ✓ **Decrease in sweat production**-This leads to less heat lost through the latent heat of vapourisation.
- ✓ **Shivering-** It involves the rapid contraction of skeletal muscles to generate heat.
- ✓ **Increased metabolism** yields heat to raise the body temperature. Increase in secretion of the hormone Thyroxine raises metabolism and heat production.
- ✓ Arterioles beneath the skin constricts which decreases the blood flow to the skin hence less heat is brought close to the skin surface and this reduces heat loss. This is called **vasoconstriction**. White people appear pale/white

- ✓ The **liver** and **spleen** store some of the blood which should be in the general body circulation. Thus heat is retained in the body.
- ✓ **Erector pili muscle contract** and pull the hair follicles. This way, the hair is raised to trap a layer of air which is a good insulator against heat loss.
    - **Behavioural mechanisms**
- ✓ Dressing in warm heavy clothing enables the body to conserve heat.
- ✓ Basking in the sun or warming of the body using a source of heat.
- ✓ Increased muscular activity such as rubbing hands and stamping feet
    - **NB** Some animals hibernate i.e. go into deep sleep due to cold conditions.
    - **When hot**
    - **Physiological mechanisms**
- ✓ **Increase in sweat production**- It leads to heat loss through latent heat of vapourisation.
- ✓ Arterioles beneath the skin dilate and this increases the blood flow to the skin hence more heat is brought close to the skin surface. This increases heat loss to the atmosphere. This is called **vasodilation.** White people appear pink.
- ✓ **Erector pili muscles relax** and this makes the hair to lie flat on the skin. This way, air is not trapped beneath the hair and a lot of heat is lost to the environment
    - **Behavioural mechanisms**
- ✓ Dressing in light clothes which do not retain much heat.
- ✓ Moving to a shade to avoid exposure to direct sunshine.
- ✓ Some homeotherms such as elephants have large ears which are flapped vigorously to create air currents which take heat away from the body of the animal.
- ✓ Some animals aestivate i.e. a state of inactivity

by some animals that occur during prolonged period of heat e.g. Bats and lungfish. Some animals are only active around sunrise, sunset and at night.

- ✓ Decreased muscular activity.
- ✓ **Parts of the skin concerned with thermoregulation**
- ✓ **Sweat glands**
- ✓ They are coiled tubular glands in the dermis. When the body temperature increases, the sweat glands increase the rate of sweat production. Water in the sweat evaporates by absorbing heat (latent heat of vapourisation) from the body and a cooling effect results.



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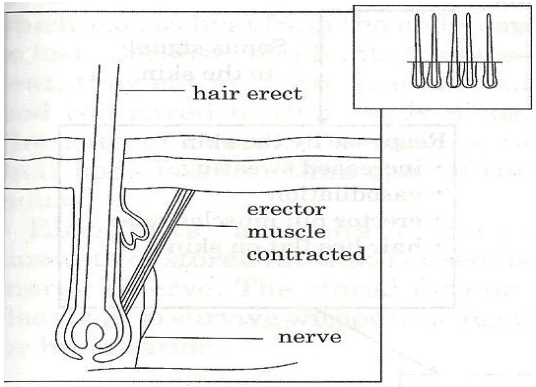
  - **NB** (i) Birds do not have sweat glands.

- ✓ Dogs only have them on the pads of the feet.
- ✓ **Hair and Erector pili muscles**
- ✓ When the body temperature lowers, Erector pili muscle contract and pull the hair follicles. This way, the hair is raised to trap a layer of air which is a good insulator against heat loss.



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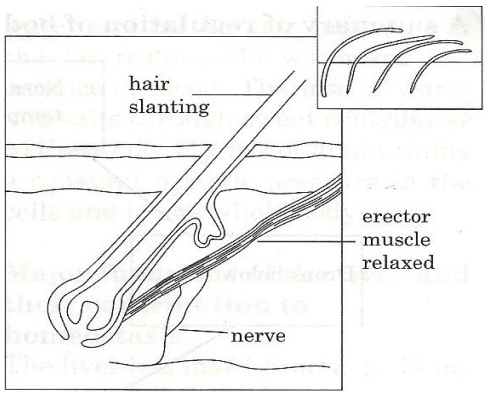
- ✓ When its hot, the Erector pili muscles relax thus trapping little air hence heat can be lost from the body surface.



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- ✓ **Blood vessels**
- ✓ When the body temperature lowers, the blood vessels in the skin constrict (vasoconstriction) and blood is diverted to a shunt system. This reduces the blood flow to the skin and more blood is stored in the spleen as an adaptation to lose less heat.
- ✓ Dilation of blood vessels (vasodilation) increases blood flow to the skin encouraging heat loss when the body temperature is too high.
- ✓ **Subcutaneous fat**
- ✓ It's a good insulator against heat loss. Animals in cold areas have thick cutaneous fatty layer for this purpose.
- ✓ Organisms in warm areas have thin fatty layer to encourage more heat loss to the environment.
- ✓ Once the temperature changes have been detected by the hypothalamus, the hypothalamus sends impulses to the appropriate responding tissues of the skin.
- ✓ When the hypothalamus fails to register an increase in the body temperature above normal level, a further rise in body temperature occurs. This causes **fever** in humans.
- ✓ If this condition is not corrected, abnormally high body temperature occurs (**Hyperthermia**). This leads to death if body temperature goes **above 43ºC**.
- ✓ If a decrease in body temperature below normal continues, without correction due to the failure of homeostatic mechanisms, abnormally

low body temperature occurs (**Hypothermia**). Death occurs if body temperature falls **below 26°C.**

- ✓ Temperature regulation in other animals
  - **Camels**
- ✓ The camel is able to withstand high environmental temperatures without sweating and will only start to sweat when its body temperature goes beyond 40ºC.
- ✓ Its hump stores fat which can be metabolized to provide water in times of shortage.
- ✓ The camel goes for a long time without drinking water and survives as much as 30% reduction in body weight due to dehydration. Under such conditions, a man would die in 2 days.
- ✓ When a dehydrated camel finds water, it drinks very fast and can drink water equivalent of 30% of its body weight in about 10 minutes.
- ✓ A camel has a long loop of henle and collecting ducts. These enable it to secrete scanty but highly concentrated urine.
  - **Kangaroo rat**
- ✓ It has fewer and smaller glomeruli and Long loops of henle. This reduces ultra filtration while increasing the reabsorption of water
- ✓ It releases insoluble uric acid thus conserving water in the body.
- ✓ It metabolizes fats and retains the water resulting from the oxidation of fats.
  - **Birds**
- ✓ They are homeotherms and use physiological and behavioural mechanisms to regulate body temperature
  - **Reptiles**
- ✓ They are ectotherms and its body is cooled when water evaporates from its skin surface.
- ✓ .when the temperature is high; the reptiles open their mouths and pant. Panting leads to heat loss

through evaporation of water from its mouth.

- **Amphibians**

✓ They have moist skin and lose heat through evaporation of water. They lose heat rapidly to the dry atmosphere.

- **Fish**

✓ They are aquatic ectotherms. The body temperature is in equilibrium with the temperature of the water.

✓ **Size of animal and body size**

✓ Small animals such as rats have a large surface area to volume ratio hence they tend to lose heat at faster rate than the large animals.

✓ Large animals e.g. elephants have a small surface area to volume ratio hence they tend to retain most of their body heat. Hence small animals eat a lot of food to increase their metabolism. This produces heat which replaces the lost heat.

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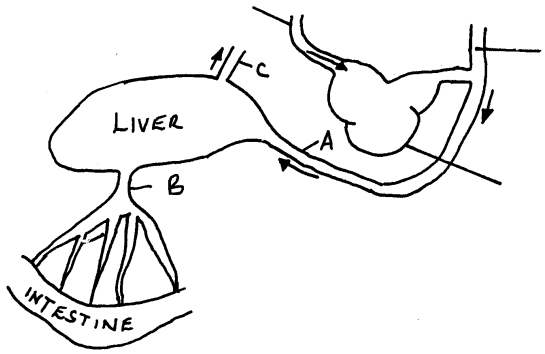
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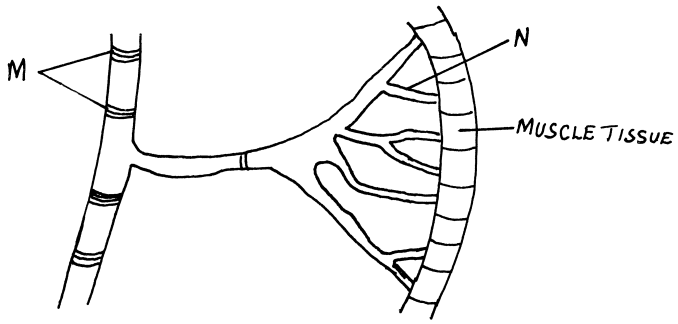
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