EXCRETION AND HOMEOSTASIS

Excretion is the removal of waste products of metabolism from the body of an organism.

Why Excretion is Necessary

Metabolic waste if left to accumulate in the body would become toxic to the body cells and may lead to death of the organism.

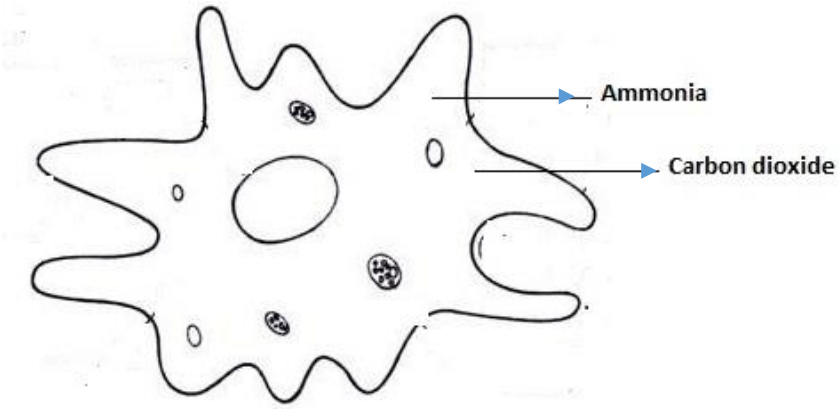
Concept of Osmoregulation

Osmoregulation is the process by which the osmotic pressure of blood and tissue fluid is kept fairly constant.

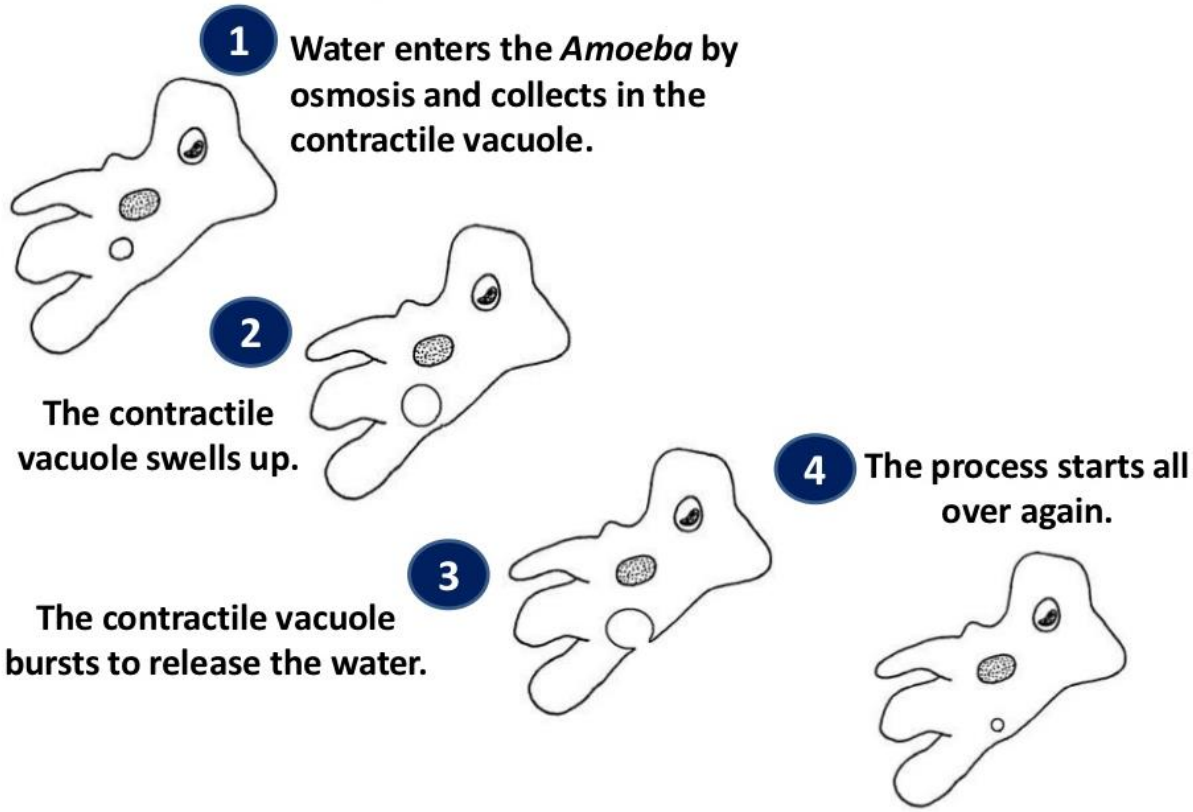
Involves controlling the water content and the salt concentration in the body fluid of an organism.

Excretion and osmoregulation in protozoa e.g amoeba

Protozoa e.g. amoeba and paramecium have large surface area to volume ratio; their waste products (carbon dioxide, and ammonia) diffuse out of all the cell across their cell membrane into surrounding water.



-In protozoa e.g. amoeba and paramecium osmoregulation of water is by a ***contractile vacuole*** .



During osmoregulation;

- contractile vacuole forms,
- water enters amoeba via its cell membranes by osmosis,
- excess water collects in the contractile vacuole making it to swell;
- Contractile vacuole with water moves towards cell surface, fusing with it and bursts open releasing its content into the surrounding water.

Revision questions one

1. *define the term excretion*
2. *Describe how excretion and Osmoregulation takes place in amoeba*
3. *Explain the concept of osmoregulation.*

EXCRETION IN PLANTS

Plants have simple excretory systems as compared to animals; ie depend on simple diffusion via lenticels, stomata and store wastes as less toxic products.

QN **Explain why plants do not have an elaborate excretory system?**

- Plants are less active /do not locomote, and so have a low metabolic rate, hence very little accumulation of toxic waste in their bodies.

- Some plants waste products are utilized by plant e.g. carbon dioxide for photosynthesis, oxygen for aerobic respiration, and nitrogenous waste products are used to synthesize proteins
- Excess gaseous waste is removed from plants by simple diffusion via stomata and lenticels.
- Most waste substances formed are stored in the tissue in less harmful forms; e.g. Resins.
- Excess water and dissolved gases are removed through transpiration process via stomata and lenticels
- Plant convert toxic substances into harmless substances and store them in petals, Leaves, fruits and seeds that mature and fall off.
- Plants synthesize all their organic requirements according to demand hence no excess is always produced.
- Plant tissues are more tolerant to toxic wastes than animal tissues.

Apart from oxygen carbon dioxide and water, plants produce other waste products which man has put to use as shown in the table below.

Excretory products	**Plant source**	**Effects/Economics importance**
Caffeine	Coffee and tea plant	-Mild stimulant, increases mental activity and reduces fatigue. -increase activity of Adrenaline. -Addiction may cause heart and kidney damage.
Quinine	Cinchona tree	For treatment of ailment like malaria
Cocaine	Coca plant	-used as a local anaesthetic drugs -cause addiction -Leads to extreme agitation ,anxiety, hullucinations and even death
Rubber	Rubber plant	-Raw materials in leather shoes and tyre industry. -Manufacture of chewing gum
Cannabis	Cannabis sativa	-stimulant that leads to less concentration, intellectual and less manual abilities. -used to make drugs.
Tannins	Barks of trees	-Turn hides of cow into leather used in making shoes, bags belts etc -used in printing fabrics ,dyeing clothes and making mats
Latex	Barks of trees	-used in shoe industry, manufacture of tyres and making rubber

Nicotine	Tobacco plant	-Making insecticide, cigarettes. -cause lung cancer, respiratory disease, low birth weight in babies.
Papain	Pawpaw plant	Has papaw enzyme used in meat industry as tenderizer(softening tough meat)
Khat	Miraa plant (capha edulis)	-mild stimulant -used as medicine -used in Genetic research
Opiates	Opium poppy plant	-manufacture of pain killer drugs e.g. morphine -cause addiction -over dose can lead to coma and death
Gum Arabic	Arabic tree	-Food processing -printing industry -making perfumes and medicine.

How plants get rid of waste products.

- *Diffusion*

  Gaseous excretory products like carbon dioxide, water vapour and carbon dioxide diffuse out of the plant cells through the cuticle, stomata & lenticels.
- *Recycling*

  Oxygen from photosynthesis is used up during respiration at night.

  Carbon dioxide and water from respiration are used up during photosynthesis at day time.
- *Deposition*

  Some toxic waste substances are converted into harmless substances and stored in petals, leaves, fruits, Roots and seeds which then shed off.

- *Exudation*

  Resins , tannins, gums, latex, rubber, oils, mucilage, oxalate are exuded (released in fluid form) through the bark of the stem or pores of fruit.

- *Guttation*

  This is the process by which some plants lose excess water in form of liquid droplets by using special tissues called hydathodes.

- *Transpiration*

  Excess water in form of water vapour is excreted through transpiration.

- Aquatic plants release most of their waste products directly in the water.

Revision questions two

1. *Name plant waste products*
2. *Explain the role of stomata in getting rid of water vapour and carbon dioxide.*
3. *Explain how plants get rid of other waste products.*
4. *Explain how some waste products are useful to humans*

EXCRETION IN ANIMALS

Excretory products in animals are divided into **nitrogenous wastes** (e.g. ammonia, urea and uric acid) and **non-nitrogenous wastes**(e.g. carbon dioxide, water and excess salts).

The type of nitrogenous waste produced depends on the habitat of the animal ie:

Aquatic animals like fresh water fish and tadpoles excrete ammonia which is very toxic and so cannot be stored in the body yet it is very soluble in water. A lot of water is used to dilute the toxic ammonia.

Terrestrial animals that are exposed to moderate amount of water excrete urea which is less toxic and less soluble in water than ammonia hence can be stored in the body for some time.

Terrestrial animals that are exposed to very little water e.g. insects and birds excrete uric acid which has very low toxicity and is almost insoluble in water. Uric acid can be stored for long in the body and needs very little water to be excreted enabling the organism to conserve a lot of water in its body.

The major excretory organs in man include;

1. **Skin;**

Produces sweat which contains urea, excess water, excess salts and carries away heat.

2. **Kidneys**
   Produce urine which contains excess water, excess salts,heat and urea
3. **Lungs;**

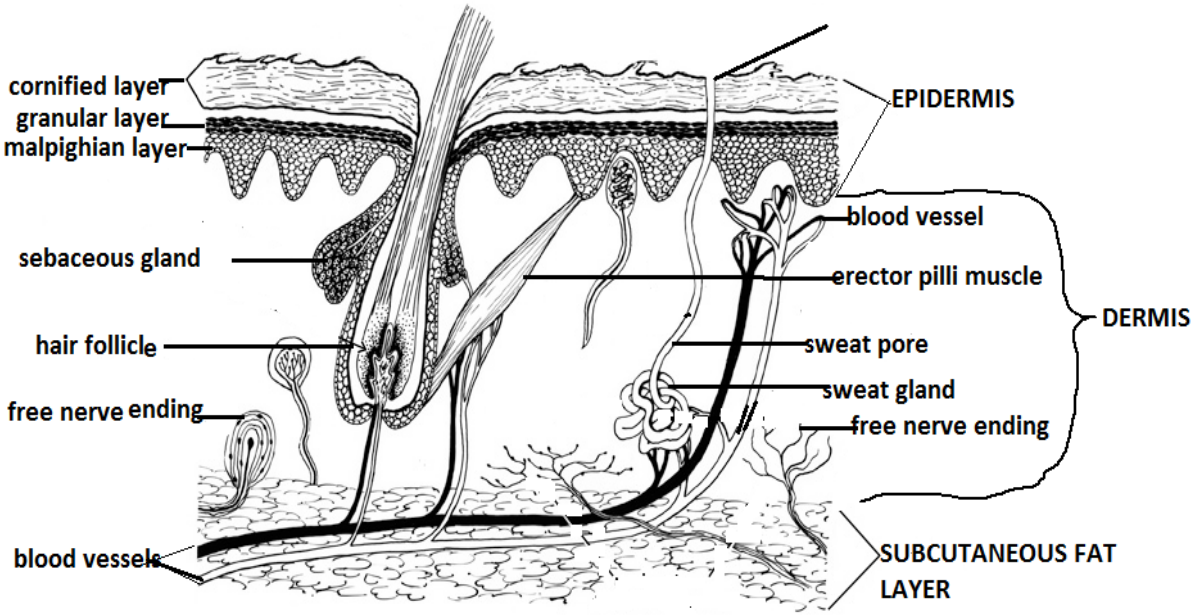
   Air removed from the lungs during expiration contains carbon dioxide, water vapour and heat.

4. **Liver;**
   produces urea from excess amino acids and bile from breakdown of haemoglobin

STRUCTURE AND FUNCTION OF MAMMALIAN SKIN

The skin is the organ that covers the bodies of human beings and animals.

Structure of the human skin



Detailed structure of mammalian skin.

Part	Structural features	Functions
(a) **Epidermis**		
(i) cornified Layer	-made up of dead cells filled with a protein keratin. -wears away and is continuously replaced by new cells produced by malpighian layer.	-protects against entry of microorganisms (pathogen) into the body. -reduces water loss -protect inner layers from mechanical damage.
(ii) granular layer	- made of living cells with granules.	-it gradually forms the cornified layer
(iii) malphighian layer.	- consists of actively dividing cells that renew epidermis. -it has melanin pigment.	Divides and replaces all cells of the epidermis as they wear off. Determines skin colour The melanin protects the skin from the harmful ultra violet rays of the sun.

(b) Dermis	- thick layer with blood vessels, nerve endings, sweat glands, hair and a subcutaneous layer of fat.	
	i) Blood capillaries	serve the skin with oxygen, nutrients and carry away carbon dioxide and other wastes.
	ii) nerve endings	- Detect different stimuli in form of heat, cold, pain, touch and pressure.
	iii) sweat glands	secrete and release sweat via pores on the surface of skin, & on evaporation , provides a cooling effect.
	iv)lymphatic vessels	They drain excess tissue fluid from the skin.
	v)Hair follicles; tiny pits in which hair grows.	Has a hair root from which hair grows. Provides a base for attachement of the erector pilli muscle
	vi) sebaceous glands (open into hair follicles)	produce an oily substance (sebum) which softens skin and kills bacteria on the skin surface.
	vii) Erector pilli muscle (attached at bottom part of hair follicle)	regulates the position of hair on the skin surface.
	viii)Subcutaneous fat	insulates against heat loss

General functions of the mammalian skin

- protect underlying tissue from mechanical injury, loss of water and entry of disease causing germs(pathogens) and ultra- violet rays
- Regulating body temperature.
- fat storage
- Excretion of excess salts, excess water, traces of urea and lactic acid via sweat.
- synthesis of vitamin D
- Receives stimuli inform of heat, cold, pain, touch and pressure since it has numerous sensory nerves.

Revision questions three

1. *List the parts of the mammalian skin.*
2. *Describe the functions of the skin*

THE URINARY SYSTEM

Diagram showing parts of the urinary system

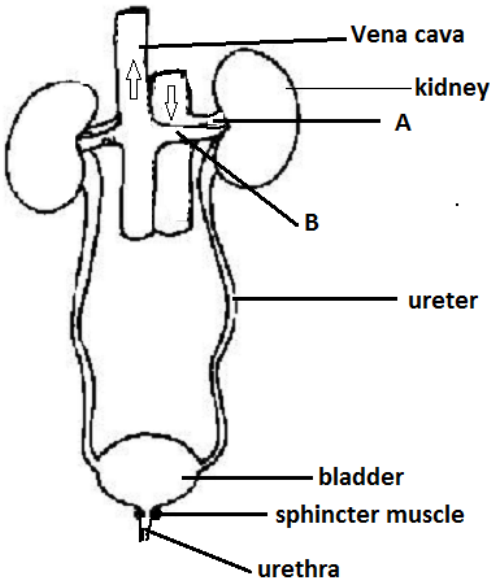


Diagram of the mammalian kidney through a vertical section showing its structure

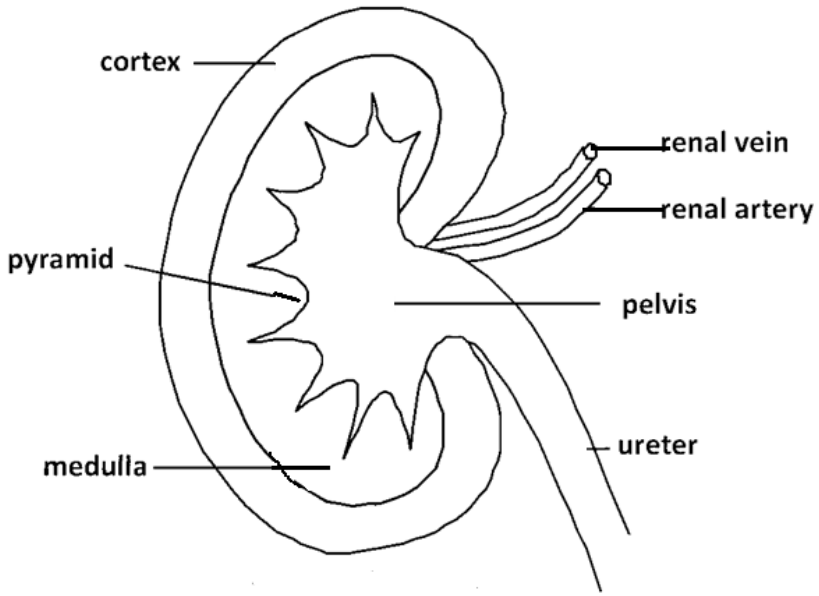


Table showing descriptions and functions of parts of the human kidney

Part	Description of part	Function of part
Cortex	A darker outer part of the kidney containing Bowmans capsules glomeruli and convoluted tubules	
Medulla	A lighter inner region of the kidney containing loops of Henle	
Nephron	A coiled tubule with a cup shaped end	Is the functional unit of the kidney
Pelvis	Space between the pyramids and ureter	Collects urine from the collecting ducts
Ureter	A fairly wide tube	Carries urine from the kidney to the bladder
Renal artery	A branch of the aorta	Brings oxygenated blood which also contains excretory waste to the kidney
Renal vein	A branch of the vena cava	Takes de oxygenated blood which has no wastes from the kidney to the vena cava

Revision questions four

1. *Draw and label the parts of the urinary system State the function of each part labelled.*
2. *Describe the structure of the mammalian kidneys(you can use a well annotated diagram)*

Functions of a kidney

- Excretion

- Osmoregulation
- Ionic balance of blood
- Regulate the blood pH

The functional unit of the kidney is the **nephron.** Each kidney has about one million nephrons .

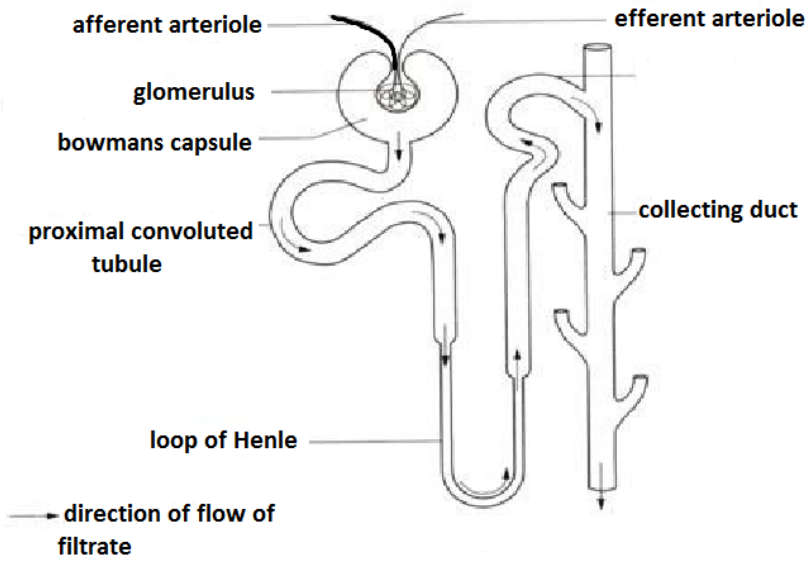
Role of the Nephron in Excretion

Structutre of a nephron

Table showing descriptions and functions of parts of the nephron.

Part	Description of part	Function of part
Glomerulus	A bunch of capillaries	Ultrafiltration occurs here.
Bowman's capsule	A cup shaped structure	Collects the filtrate from the glomerulus
Proximal convoluted tubule	first coiled tubule	Re-absorption of glucose,water,and amino acids takes place here
Loop of Henle	Tubule shaped like U-tube	Is where most water is re-absorbed
Distal convoluted tubule	Second coiled tubule	Controls pH
Collecting duct	tube	Reabsorption of water.

Diagram showing the structure of a Nephron



Process of urine formation

Involves two processes:- ultrafiltration and selective re-absorption

(i) **Ultra filtration;**

-occurs in the glomeruli which have small pores that act as a sieve of blood.

During ultra-filtration;

1. High blood pressure at the glomerulus is caused by:-
    i. the afferent arteriole entering the bowman's capsule is wider than the efferent arteriole leaving it. This creates higher pressure in the glomerulus. This forces the liquid part of blood with dissolved substances out through the pores in the glomerulus into the cavity of Bowman's capsule thus forming **glomerular filtrate**.
    ii. The pumping action of the heart.
    iii. The twists and turns of the capillaries of the glomerulus which offer resistance to blood flow and result in high pressure
2. Blood proteins and cells (RBC and WBC, platelets) are retained because of their large size. They cannot pass through the pores of the glomerular capillaries and as such are absent in urine. Thus glomerular filtrate has the same composition as tissue fluid.

(ii) selective rearbsorption;

-Is the process by which the useful substances in the glomerular filtrate are taken back into the blood in the capillaries surrounding the nephron so that they are not lost in urine.

-Selective reabsorption occurs in the proximal and distal convoluted tubules.

proximal convoluted tubule

- ✓ glomerular filtrate flows down into proximal convoluted tubule as useful substances are re-absorbed, into blood capillaries ,i.e., amino acids and glucose , water, some vitamins and some minerals which are actively re-absorbed in the Proximal convoluted tubule.

Loop of Henle

- ✓ More water is re-absorbed at loop of Henle .The longer the loop of Henle the more water reabsorbed and thus retained in blood. Desert animals have long loops of henle in order to conserve much water in the body. Aquatic animals have very short or no loop of henle to allow their bodies to lose a lot of water.

Distal convoluted tubule

- ✓ More salts and water are re-absorbed here
- ✓ From the distal convoluted tubule, glomerular filtrate then flows into collecting duct.

Collecting Duct

- ✓ Also more salts and water are selectively re-absorbed here. The re-absorption of water in the collecting duct is controlled by Anti Diuretic Hormone (ADH)
- ✓ Very little or no urea is reabsorbed making it more concentrated in urine than in blood and in the glomerular filtrate.
- ✓ Urine formed in several nephrons collects in the collecting duct and flows to pelvis, then to the ureter and finally urinary bladder where it is temporarily stored before it flows out through the urethra.

Percentage concentration of components in blood , Plasma, Renal fluid and urine

components	% in blood plasma	% in Renal fluid	% in Urine
Water	70-93	90-92	95
Protein	70	0.0	0.0
Glucose	1.1	0.1	0.0
Sodium ions	0.3	0.3	0.35
Chloride ions	0.4	0.4	0.6
Urea	0.033	0.33	2.0

Interpretation of the table

- composition of urine is water ,urea and salts(chlorides & sodium ions)
- Glucose is absent in urine because all the glucose is completely re-absorbed in the proximal convoluted tubule;

- Proteins are absent in urine because they are retained in the glomerulus since they are too large to filter through capillary walls.
- Amino acids are also absent in Urine because they are completely re-absorbed in the proximal convoluted tubule;

Role of the kidney in Osmo regulation

Kidney regulates osmotic pressure of blood.

High osmotic pressure may be due to:

i. Low intake of water
ii. Loss of water along with urine, feaces, sweat &breathe
iii. Excessive consumption of salt

A fall in water content in blood;

- ✓ is detected by the hypothalamus in the brain ,
- ✓ The hypothalamus then sends impulses to the pituitary gland, stimulating it to secrete Antidiuretic hormone(ADH) into blood :
- ✓ ADH is carried to kidney tubules making the walls of the collecting ducts more permeable to water
- ✓ This causes more water re-absorption from filtrate back into blood
- ✓ A small volume of concentrated urine is produced.
- ✓ The osmotic pressure of the blood is thus lowered.

Low osmotic pressure of blood may be due to:-

i. Low intake of salts
ii. High intake of water through food, drinks or metabolism
iii. loss of very little water through sweating, egestion urinating

Arise in water content in blood above normal;

- ✓ Is detected by the hypothalamus in the brain
- ✓ Hypothalamus responds by sending impulses to pituitary gland, stimulating it to secrete less or no ADH.
- ✓ This makes collecting duct walls less preamble to water ; decreasing its re-absorption back into blood stream

 Excess water in blood is lost as dilute urine and a large volume of urine is produced.

NB: Failure of the pituitary glands to produce ADH causes kidney condition described as **Diabetes inspidus /duiresis**..

It's characterized by producing large volumes of dilute urine frequently and hence frequent thirst and dehydration.

Treatment involves administration of natural or synthetic ADH

Revision questions five

1. *Explain how kidneys function in getting rid of waste products from the body*
2. *Explain the role of kidney in osmo- regulation in man*
3. *In an investigation , the approximate composition of plasma, glomerular filtrate and urine in a mammal was determined .The results are shown below in a table*

Components	*Plasma g/100cm ^{2}*	*Glomerular filtrate g/100cm ^{2}*	*Urine g/100cm ^{2}*
Urea	*0.04*	*0.04*	*2.10*
Uric Acid	*0.005*	*0.005*	*0.07*
Glucose	*0.20*	*0.20*	*0.00*
Amino acids	*0.07*	*0.07*	*0.00*
Plasma Proteins	*9.00*	*0.00*	*0.00*
Sodium ions(Na^+)	*0.0032*	*0.0032*	*0.0035*
Chloride ions(Cl)	*0.0037*	*0.0037*	*0.006*

(a) *Explain the absence of the following*

(i) *Plasma protein in glomerular filtrate*

(ii) *Glucose and amino acids in urine*

(b) *(i) From the above results, identify the two types of wastes eliminated from mammalian blood.*

(iii) *Other than excretion, give other functions of the mammalian kidney.*

(c) *(i) State the principle requirement of filtration that forms glomerular filtrate.*

(d) *Explain why urea concentration is greater in the urine than in plasma and glomerular filtrate.*

Solution

a) (i). Plasma protein are retained in the glomerulus; because they are large sized to filter through capillary walls;

(ii). Glucose and Amino acid are completely re-absorbed along the kidney tubules/proximal and distal convoluted tubules.

b) (i) Nitrogenous wastes, mineral salts /excess mineral salts, excess water

(ii). Osmoregulation , conservation of glucose and amino acids

c. (i).high pressure caused by lumen of afferent arteriole being wider than efferent arteriole, pumping action of the heart and narrow capillaries of glomerulus

d) Concentration of urea increases due to re-absorption of water in the tubules and No urea is reabsorbed.

4. The table below shows how the quantities of sweat and urine vary with external temperature;

External temperature in °C	*Urine cm^3/hour*	*Sweat cm^3/hour*
0	*100*	*5*
5	*90*	*6*
10	*80*	*10*

15	*70*	*20*
20	*60*	*30*
25	*50*	*60*
30	*40*	*120*
35	*30*	*200*

a) *Plot the quantities of urine produced and sweat produced against the external temperature on the same graph.*

b) *At what temperature are the amounts of sweat and urine produced equal*

c) *What happens to the amount of sweat produced as temperature rises .Explain the observation.*

d) *Explain the observation made on the amount of urine produced as the temperature increases*

e) *How is the skin adapted for temperature regulation.*

Solution

b) Sweat production increases with increase in temperature of blood; because high temperature increases the evaporation rate ; more sweat is converted to vapour ,using up latent heat of vapourization from the body and causing cooling.

d)An increase in the temperature decreases the amount of urine produced .This is due to increased sweating which raises the osmotic pressure of blood .A lot of water is the re-absorbed into the blood at the kidney tubules, resulting in the production of less and concentrated urine .

THE LUNGS

Lungs and their role in the temperature regulation

The body loses heat through breathing out .The air breathed in is cold , but gets warm as its carried along respiratory tubes .Cold air gains heat through conduction as it provides cooling effect.

Lungs and their Roles in excretion

- Lungs remove carbon dioxide, water inform of vapour and heat from the body.
- Carbon dioxide and water are end products of Aerobic respiration that diffuse out of the blood plasma into alveoli of lungs while in the lungs (water, carbon dioxide) are eliminated through exhalation.

MAMMALIAN LIVER

Largest organ in the body.

It is found beneath the diaphragm;

It is connected to blood vessels that include hepatic artery ,the hepatic portal vein and the hepatic veins.

Some functions of the liver are described below:

Formation of urea in the liver

Excess amino acids are deaminated in the liver

Involves removal of the amino group from each amino acid. This amino group is later converted into ammonia, meanwhile the remaining amino acid residue is converted to carbohydrate compound, and is oxidized during respiration.

Ammonia formed is very toxic so it is quickly combined with carbon dioxide thereby forming urea which is less toxic.

Urea is released into the blood stream and carried to the kidney where its excreted.

Detoxification

- Is the process of converting toxic substances like drugs, alcohol, and hydrogen peroxide to harmless ones

e.g. Hydrogen peroxide produced by respiring cells is broken down by enzyme catalase to form water and oxygen which are harmless.

Regulation of blood sugar level

-Glucose is vital for production of energy during respiration.

-The normal blood glucose level required in the body is regulated by the liver within 90-100 mg/100cm^3 of blood.

-After the digestion of a carbohydrate rich meal, glucose is formed that is absorbed at ileum, then transported to the liver through the hepatic portal vein.

Its absorption raises blood glucose level above normal,

- This is detected by the beta cells of the islets of Langerhans in the pancreas
- The beta cells of islets of Langerhans then secrete insulin hormone into bloodstream.

  Insulin lowers blood glucose levels
- On reaching the liver, insulin stimulates the liver to convert excess glucose into glycogen for storage in the liver and muscle cells.

- Insulin hormone also increases cellular respiration causing more breakdown of excess glucose into carbon dioxide and water,
- It also increases conversion of excess glucose into fats for storage.

All the above events cause blood glucose level to decrease to normal.

When the level of blood glucose decreases below normal due to starvation or during exercise,

- The deviation is detected by the alpha cells of islets of Langerhans.
- The alpha cells of islets of Langerhans secrete Glucagon hormone into blood stream.
  Glucagon raises blood glucose levels
- On reaching the liver glucagon stimulates the liver to convert stored glycogen to glucose and reduce cellular respiration thus restoring blood glucose level to normal.

Adrenaline hormone is secreted if glucose levels suddenly drop e.g. when one frightened or over excited. Adrenaline causes conversion of more glycogen stored in the liver to glucose. This leads to rising of the glucose level back to normal.

Diabetes mellitus (sweet urine)

Is a disease due to lack of enough insulin from the pancreas e.g. when the pancreas is damaged. So the glucose will not be converted to glycogen but excreted in urine and thus abnormally high level of glucose is excreted in blood.

Symptoms of Diabetes mellitus

- Presence of glucose (therefore reducing sugars) in urine/ glycosuria.
- Frequent passing of urine.
- Feeling thirsty due to excessive loss of water.
- Dehydration.
- Loss of weight because a lot of stored fat is used in respiration since the cells lack glucose.
- Sores that are slow to heal.
- Blurred vision.

Treatment and control

- Administration of insulin injection (insulin cannot be taken through the mouth because it is protein in nature and may be digested).
- Eat foods that do not contain much carbohydrate.
- Avoid alcohol and foods rich in sugar.

Other functions of the Liver

- ✓ Manufacture of Red blood cells during foetal stages
- ✓ Formation and elimination of excess cholesterol
- ✓ Storage of vitamins A,B,C,D,E and storage ions such as copper, Zinc and iron
- ✓ Storage of blood since its highly vascularized and holds a large volume of blood
- ✓ Formation of bile
- ✓ Destruction of old and worn out Red blood cells
- ✓ Breakdown of hormones especially during sex hormones
- ✓ Temperature regulation. The liver is very active with many metabolic activities that lead to production of heat.
- ✓ Synthesis and regulation of plasma proteins.

Revision questions six

In an investigation, two persons A and B drunk the same amount of glucose solution. Their blood sugar levels where determined immediately and thereafter at intervals of one hour for the next six hours. The results where as shown in the table.

Time(hours)	*Blood glucose levels*	
	Person A	*Person B*
0	*90*	*120*
1	*220*	*360*
2	*160*	*370*
3	*100*	*380*
4	*90*	*240*
5	*90*	*200*
6	*90*	*160*

a) *Draw a graph of blood sugar levels of persons A and B against time on the same axes*
b) *Explain each of the following observations*
i) blood sugar level increased in person A

between 0 and 1 hour ii) The blood sugar levels

dropped between 1 and 4 hours

c) *From the graph, what is the normal blood sugar level for human beings*
d) *Suggest a reason for high sugar level in person B*
e) *How can the high blood sugar level in person B controlled*
f) *What is the biological significance of maintaining a relatively constant sugar level in a human body?*
g) *Account for the decrease in the blood sugar level of person B after 4hours*

Homeostasis;

Is the process of maintaining a constant internal environment in living organisms**.**

Internal environment is the immediate surroundings of the body cells. It is the tissue fluid. Factors to be kept constant include;

Temperature, pH of blood, osmotic pressure of blood and, glucose concentration, etc.

Importance of Homeostasis

- Enable the body of organism to maintain optimum conditions for efficient functioning of enzymes.

How homeostatic systems work

The homeostatic processes in the body work on a feedback mechanism. When a factor in the body such as body temperature drops or rises above normal, it is detected. The corrective action is to bring it back to normal. Such a response is called negative feedback.

Temperature Regulation in Animals

Animals have the ability to regulate body temperature within an optimum range.

Temperature regulation is important to enhance proper functioning of enzymes within their optimum range i.e., low temperature below optimum inactivates and high temperature above optimum denature enzymes.

Processes by which organisms gain or lose heat:

Internally the body gains heat from:

i) Metabolism e.g. respiration ii) Contraction of muscles

The body gains heat from the external environment or loses heat to it through:

i) Conduction ii) convection iii) radiation

iv) Evaporation e.g. sweating v) urination and defecation

Factors that affect the amount of heat gained or lost by a body:

1. Environmental conditions e.g. Humidity, air currents, temperature difference between the body and the environment.
    - High humidity reduces evaporation from the body hence reduces heat loss so the body is warmer on a hot humid day than on a hot dry day.

- The closer the temperature of the body is to that of the environment, the less heat lost. The bigger the temperature difference the more heat lost.
- Air currents increase evaporation from a body and thus increase heat loss.

2. Rate of metabolism; the higher the metabolism the more heat generated within the body.
3. Size of the organism; the smaller the organism the larger the surface area to volume ratio hence the more heat lost. Large organisms have a problem of getting overheated to reduced heat loss. Elephants have large ears that flap and cool the body. Older ones flap faster due to slower heat loss than young ones.
4. Nature of the insulator on the skin e.g. the thicker the fur or feathers, the less heat lost. The thicker the subcutaneous fat (adipose) layer, the less heat lost.
5. Size and length of the body extremities e.g. ears. Cold dwellers like the arctic fox have small short ears which decrease surface area for heat loss while foxes in deserts have long large ears to increase surface area for heat loss.

Revision questions seven

1 Attempt Question 31 UNEB:UCE 2012

Categories of organisms according to temperature regulation

a)Endotherms/Homoiotherms (b) Ectotherms/poikilotherms

(a**) Endotherms/Homoiotherms**

Animals which are able to maintain constant body temperature irrespective of the changes in environmental temperature;
E.g. Mammals and Birds

Advantages of Endothermy

- ✓ allows organisms to live in a wide range of environment conditions since they are able to regulate their body temperature.
- ✓ allows enzyme controlled reactions to go on without interference since body temperatures do not reach extreme.
- ✓ Permits organism to be active always

 Endotherms usually have quick response to stimuli

Disadvantages of Endothermy

- ✓ require more food to provide heat energy
- ✓ Require efficient methods to raise or lower body temperature in very cold or hot seasons respectively
- ✓ Require advanced structures for excretion due to high metabolic rate.

(b**) Ectotherms /poikilotherms**

are animals whose body temperatures depend entirely on those of the environment; thus unable to maintain a fairly constant temperature.

e.g Amphibians, Reptiles and Fish, insects.

Their body temperature changes periodically with that of the surroundings.

Advantages of ectothermy

- ✓ require less food /food consumption is low because of low metabolism
- ✓ Require simple activities to regulate their body temperature e.g basking in the sun

Disadvantages

- ✓ They have low metabolic rates and therefore respond slowly to stimulus.
- ✓ They are less active at low environmental temperatures
- ✓ They are unable to survive in some habitats with extreme temperature

Temperature regulation in Endotherms

a) In cold conditions, /When body temperature drops below normal,

- ✓ Increase the rate of metabolism to ensure production of more heat
- ✓ Vaso constriction;- Arterioles constrict so that less blood enters the capillary network towards the skin surface, this reduces heat loss by radiation and convection.
- ✓ There is decreased sweat production which reduces heat loss by evaporation.
- ✓ Shivering may occur. It leads to increase in muscular contractions that generate heat.
- ✓ Contraction of erector pilli muscles causing the hair to stand erect thus trapping a lot of air close to the skin which. The air is an insulator and prevents heat loss.
- ✓ Increase in metabolism to generate more heat.

Behavioral means may include

- through taking hot /warm drinks e.g man/human beings,

- Wearing many clothes,
- Engaged in vigorous exercise
- sleeping under heavy blankets,
- sit near heat source,
- some animals come close together(rooting) to gain heat from one another.

b) In hot conditions,

- ✓ Increased sweat production to ensure heat loss through evaporation of sweat.
- ✓ Hair Erector pilli muscles relax making hair to lie flat on the body .This encourages heat loss through radiation and convection.
- ✓ Rate of metabolism decreases so that less heat is generated
- ✓ Vasodilation ;-Arterioles relax and more blood enters the capillaries network near skin surface to encourage more heat loss via Radiation and convection.
- ✓ No shivering to prevent heat production.
- ✓ Panting in dogs occurs so that water in saliva evaporates as the animal exhales
- ✓ Behaviorally through ;
    - Moving away from direct heat source
    - Moving under shade
    - Putting on light clothes
    - Taking cold drink to allow cooling effect
    - Regular bathing/swimming as in some animals
    - Turn on fun and air conditioners e.g. human beings

Exam tip: When asked to describe the endotherms's response to hot or cold conditions only mention how the body adjusts its temperature using physiological processes only. Do not include behavioral means

Temperature regulation in Ecotherms

They only use behavioral means

Behavioral means in response to the cold

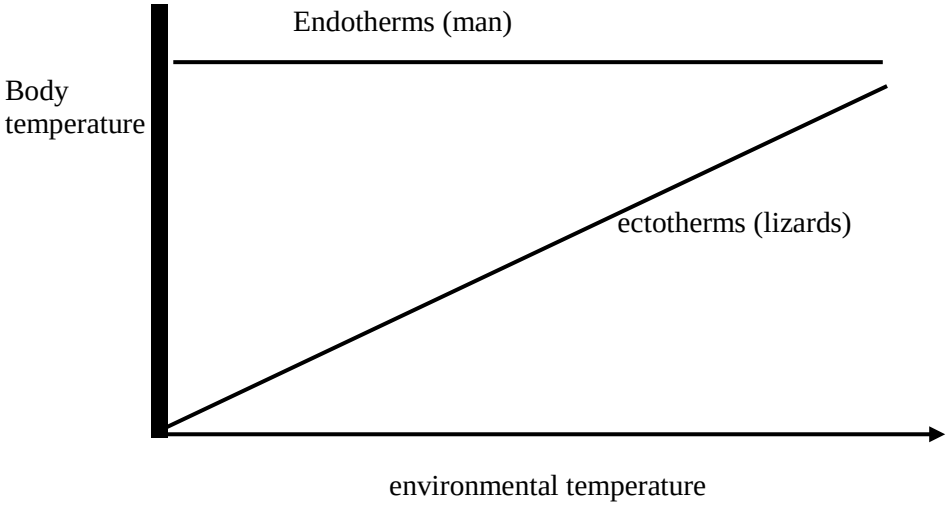
- ✓ Basking in the sun to gain heat
- ✓ Burrowing into cracks in walls on cold days
- ✓ Hibernation :Where animals become dormant during extreme cold

Behavioral means in response to the hot

- ✓ Swimming
- ✓ Thermal gapping, opening their mouth widely so as to lose heat through evaporation
- ✓ Aestivation: Dormancy of animals that occurs during very hot conditions that are prolonged.
- ✓ Salivation over the neck and legs to increase heat loss by evaporation.

- ✓ Moving to the shade to cool their body temperature

Graphical relationship between environmental temperature and body temperatures of Ectotherms and Endotherms



Interpretation

- For endotherms, as the environmental temperature increases, body temperature remains constant. This is because their body is able to maintain a constant internal temperature.
- For ectotherms as environmental temperature increases, body temperature increases. This is because they lack means for maintaining a constant internal body temperature.

Adaptations of animals to cold conditions:

- Animals are usually large (so they have a small surface area to volume ratio to reduce heat loss)
- They have thick fur to trap a lot of air that insulates the body against heat loss.
- They have thick epidermis to reduce heat loss by evaporation
- They have a thick subcutaneous fat layer which insulates the body against excessive heat loss.
- They have high metabolic rates to generate a lot of heat energy.
- They are active during the day.

Adaptations of animals to hot conditions:

- Animals are usually small (so they have a large surface area to volume ratio and this increases heat loss)
- They have little fur hence trap little air reducing insulation and so faster heat loss.
- They have thin epidermis to increase heat loss.
- They have a thin subcutaneous fat layer of the skin to reduce on insulation the body and increase heat loss.
- They have low metabolic rates to generate little heat energy.
- Many are nocturnal to avoid the high temperatures of the day.

- Some eat food with a lot of fat to produce much metabolic water when oxidized during respiration
- The camel has fat concentrated at the hump, leaving little fat at other parts which reduces insulation and increases heat loss.
- Birds, reptiles and insects excrete uric acid which requires little water for its excretion hence conserving much water within the body.
- Some animals have long loops of henle to increase amount of water reabsorbed by the kidney.
- The camel has tissues which are tolerant to dehydration.
- They have water proof covering that prevents water loss eg the waxy cuticle of insects and scales in reptiles.

Revision questions eight

Describe adaptations of desert animals to:

i. High temperatures

ii. Scarcity of water