EXCRETION

Is the removal of the waste products of metabolism from the body of living organism. Most of these waste products would be toxic to the body if they were allowed to accumulate within its cell fluids. It also includes the elimination of unwanted substances from the body. e.g. Excess water and salt.

Egestion is the removal of indigested material from the body or cell e.g. in amoeba.

Secretion is the production of use full substance by living cells e.g. mucus, enzymes, hormones tears, nectar, wax, e.t.c.

Excretory products are divided into two categories.

Nitrogenous waste and non nitrogenous waste products are the two main categories of excretory products

Nitrogenous excretory products are those that contain nitrogen and arise from deamination of excess amino acids and include urea, ammonia, uric acid and trimethly amino oxide. The non nitrogenous waste products don't contain nitrogen and include, CO_2, excess salts and excess water.

A table showing nitrogenous excretory products and organs of animals in different habits.

Animal	Nitrogenous waste	Excretory organ	Habits.
Mammals	Urea	Kidneys	Terrestrial
Birds	Uric acid	Kidneys	Terrestrial
Reptiles	Uric acid	Kidneys	Terrestrial a few are aquatic.
Amphibians	Young –Ammonia Adult –Urea	Kidneys (Adult) Young (Gills).	Terrestrial Aquatic
Fish.	Ammonia	Kidneys	Fresh water.
Bony fish	Trimethyl amino oxide.	Kidneys	Marine water
Cartilaginous fish	Urea	Kidneys	Sea water
Insects	Uric acid	Malpighian tubes	Terrestrial
Amoeba	Ammonia	Cell membrane	Fresh water

EXCRETION IN MAN

Main waste products are CO_2, H_2O and urea. The main excretion organs are the skin, kidneys and the lungs. The skin excretes water, excess salt and urea inform of sweat. Kidney excretes excess water, excess salts, and urea as urine. Lungs excrete CO_2 and H_2O (g) in exhaled breath.

Carbon dioxide.

This is a waste products of respiration in the cells carried a way from respiring cells as hydrogen carbonate dissolved in the blood plasma. When it reaches in the lungs an enzyme converts the hydrogen carbonate to CO_2 which diffuses into the alveoli and passes from the lungs to air during exhalation. H_2O is produced in many metabolic processes especially respiration. However most of the water excreted usually comes from an access in our food and drink. The body loses excess water in three ways

1. From the lungs during exhalation.
2. From the skin as sweat.
3. From the bladder as urine.

Sweating is primarily a means of controlling temperature but also get rid of excess water.

UREA.

Nitrogenous waste products such as urea are from two main sources

1. An excess of amino acid is absorbed from food. Animals have to get rid of any excess amino acids before they become toxic.

The excess of amino acids are converted to urea by the liver is a process knows as deamination. Amino acids are broken down to carbohydrates and ammonia. Carbohydrates are stored in the liver as glycogen and the Ammonia being highly poisonous is immediately converted to urea in the liver.

2. Break down of protoplasm. Protoplasm has a limited useful life. It is continually being broken down and replaced. It breaks down mainly into amino acids which are also deaminated.

Urea is soluble and carried from the liver dissolved in the blood plasma.

When it reaches in the kidneys, it is filtered out of the blood to form part of urine.

The urine collects from the bladder and passed out in intervals.

The urinary system of a mammal.

Diagram of the urinary system of mammal pg 176

Cross section through the kidney (draw the diagram) INTRODUCTION TO BIOLOGY PG 106 AND 107 FIGS 21.1, 21.2, 21.3

Mammals have two beans shaped kidneys which lie inside the abdominal cavity attached to the dorsal wall. Kidneys are dark red and surrounded by fat which holds them in place. The cross section of a kidney consists of cortex, medulla and pelvis regions. The renal artery branches from the Aorta bringing oxygenated blood into the kidney while renal vein takes out deoxygenated blood to the posterior vena cava. Ureter leaves the kidney with the waste material to the bladder. Microscopically a kidney consists of kidney tubules /nephrones, blood capillaries and connective tissue.

Function of the kidney.

- Excretion of nitrogenous wastes e.g. urea from the body.
- Osmo-regulation with in the body.

Osmo- regulation is the balance of salts and water in the body fluid.

Structure of the nephron. (draw the diagram from introduction to biology (FIGs 21.4 AND 21.5))

The process of urine formation enables the kidney to purify blood of the toxic materials and balance the salt and water levels in it.

It occurs in two stages.

a. **Ultra filtration.**
b. **Selective Re-absorption**.

Ultra filtration.

It takes place in the glomerulus and requires two conditions

I. A very high pressure.
II. A filtering barrier.

The pressure is built up in two ways.

1) The usual high pressure of the blood in the arteries due to the pumping action of the heart and the renal artery takes blood from the dorsal aorta at a point close to the heart which has blood at a very high pressure.
2) Due to the fact that the afferent vessel that brings blood to the glomerulus is much wider than the efferent vessel that takes blood away from the glomerulus

The capillary walls of the glomerulus are permeable and act as the filtering barrier.

Because of the permeability of the capillary walls and very high pressure, smaller components of blood such as water, mineral salts, urea, glucose, vitamins, etc. are passed from blood into the the capsular space of the Bowman's capsule. The liquid which collects in the Bowman's capsule is known as glomerular filtrate. It is similar to tissue fluid in chemical composition. The process leading to the formation of the glomelular filtrate is known as pressure filtration or ultra filtration. The filtering barrier retains all blood components which are bigger than pores e.g the blood cells and the plasma protein like fibrinogen and globulin.

Selective reabsorption: this ensures that useful materials are not lost from the body.

As the glomerular filtrate passes from the Bowman's capsule along each tubule, substances in it which are still useful to the body are selectively reabsorbed. All the glucose, much of the water and small amounts of mineral salts are reabsorbed by active transport, osmosis and diffusion. In the proximal convoluted tubule all the glucose and some amino acids are re-absorbed into blood by active transport and some water is re-absorbed by osmosis. Also mineral salts are re-absorbed from here. In the loop of henle, more re-absorption of water takes place, large percentage of salts are re-absorbed here. The remaining glomerular filtrate passes to the distal convoluted tubules where salts and water are further re-absorbed. It moves to the collecting duct where more water is re-absorbed regulating the concentration of blood. The end product is urine which is carried by the collecting ducts to ureter then to the bladder.

All urea and small amounts of mineral salts remain in the tubules dissolved in water and are passed on to the bladder as urine.

substance	**%age cone in the following fluids**		**urine**	**Appr.increse in cone of urine / plasma**
	Plasma	**glomerular filtrate.**		
Plasma protein	7.5	0	0	-
Glucose	0.1	0.1	0	-
Sodium ion	0.32	0.32	0.35	X 1
Chloride ion	0.37	0.37	0.60	X 2
Urea	0.03	0.03	2.0	X 60
Water	91.9	91.9	95.0	X 1

Questions

1. **why is the protein concentration in urine zero**

Because protein are too large to go through the filtrate barrier.

2**. Glucose is filtered into the tubular. What explanation can you give its complete absorbance in urine?**

It is because all glucose is re-absorbed in the proximal convoluted tubule.

3. **How does the concentration of urea in the urine compare which that in the plasma?**

4. Suggest reasons for any differences in concentration?

HOMOESTASIS:

This is the maintenance of a constant internal body environment(the immediate surrounding of a cell) of living organisms: Examples of homoestatic activities of the body include;

1) OSMO – REGULATION

Is the process by which water and dissolved salts in the body are maintained at a relatively constant level, hence osmoregulation is a mechanism of keeping an organism's water content constant.

The hormone Anti-Diuretic Hormone (ADH) also called vasopressin hormone is produced by the pituitary gland and it regulates the re-absorption of blood from the glomerular filtrate in the kidney tubules. When blood passing over the hypothalamus is too concentrated (Blood osmotic pressure is high), the hypothalamus detects this fluctuation and stimulates the pituitary gland to produce ADH. This hormone makes the kidney tubules to become more permeable to water and therefore more water is re-absorbed from the urine making it more concentrated. When the blood passing the hypothalamus is less concentrated than normal/dilute (low blood osmotic pressure), ADH isn't produce so little re-absorption of water in the kidney tubules takes place resulting into large quantities of dilute urine. When an individual can't produce enough ADH, one complains of thirst and produces a lot of urine more frequently and the condition is known as **Diabetes insipidus / water diabetes.** Also the person is likely to become de-hydrated.

On the other hand, if an individual drinks large volumes of water and does not sweat much, blood become dilute and the hypothalamus does not stimulate the pituitary gland to produce ADH, more water is excreted, hence greater amount of urine is formed, blood concentration is maintained at normal level.

Effect of ADH in the body:

Increase in ADH	**Increased reabsorption of water in the kidney tubules**	**Less urine produced**	**Urine becomes concentrated**
Decrease in ADH	**Decreased reabsorption of water in the kidney tubules**	**More urine produced**	**Urine becomes dilute**

2) Regulation of blood sugar

The normal glucose level in the blood is about 90 mg of glucose for $100m^3$ of blood (90 mg / $100cm^3$). If the glucose level in the blood rises above the normal level.e.g. Immediately after a meal rich in carbohydrates the pancreases cells detect this rise and produce the hormone insulin. The insulin stimulated the liver to

A) Convert excess glucose to glycogen and stored in the liver or muscle cells.

B) Break down some of the excess glucose to energy which is stored in form of ATP.

If the glucose level in the blood falls below normal level the pancreases secretes another hormone called **glucagon** which stimulated the liver to:

- Convert glycogen to glucose
- Stop/reduce the oxidation of glucose

A person with a defective pancreas doesn't produce insulin, so the glucose is not re- absorbed in the tubules hence the urine contains glucose. This condition is known as diabetes mellitus.

Excretion and osmoregulation in other organisms

Marine fish (live in water which contain a lot of salts/sea water has a very high osmotic pressure than the body fluids of the sea fish, hence can easily lose water by osmosis) In order to conserve water, they excrete nitrogenous waste in form of a compound which is soluble and non toxic while fresh water fish excrete their nitrogenous waste as ammonia, a highly toxic substance which requires large volume of water for its dilution in the excretion process. This is not a challenge to fresh water fish because it has more water than it needs, hence no need for conserving water (fresh water fish body fluid has a higher osmotic pressure than the fresh water they live in hence they can absorb water the fresh water through the gills, lining of the buccal cavity and pharynx by osmosis) However marine water fish suffering a water shortage can not

afford such a loss. For this reason, ammonia is replaced by the non toxic **trimethyl amine** oxide which requires very little water for excretion.

Reptiles, insects and birds excrete nitrogenous waste as uric acid, which un like urea, is insoluble in water and as a result water is extensively removed from the uric acid as its being excreted. This ensures that a lot of water is retained in the body and there fore Uric acid is excreted in semi-solid form.

Contractile vacuole in Amoeba

It's a small sac like structure found in the cytoplasm of amoeba and other fresh water protozoans. Since it lives in fresh water, water enters by osmosis. If a lot of enters with out being eliminated, the cell burst. To counter this, water is secreted into the contractile vacuole as fast as it enters the body. As this happens, the contractile vacuole enlarges and then discharges its contents to the exterior via a small pore in the cell membrane, after which the whole process is repeated.
NB: earth worms use Nephridium for excretion.

Excretion and Osmoregulation in plants.

Compared with animals, plants produce waste products very slowly. Their main waste products are

1. Water vapour from the transpiration stream.
2. Oxygen from photosynthesis during day.
3. Carbon dioxide from respiration during night.

These pass out of a plant through the stomata lenticels by simple diffusion. A variety of substances present in a very small amount are found in plants. Some are thought to be waste products of metabolism and include:

1. Tannins are dark coloured substances found in the bark of many trees including Acacias, mangroves; Tannins are used for tanning leather.
2. Anthocyanins: The red purple and blue colours of petals and dying leaves are due to the presence of anthocyanins.
3. Alkalids are nitrogen containing compounds found in various plant organs many are poisonous to animal life including man. Some may be produced by the plants as a defense against diseases and pests. Most of the drugs used by drugs addicts are alkaline.

THE MAMMALIAN SKIN.

FUNCTIONS

- protection from ultra –violet sunrays
- Temperature regulation.
- Formation of vitamin D.
- Protection from bacterial invasion.
- It contains sense organs which are sensitive to temperature, touch and pain so make the organism aware of its environment.
- Excretion

DRAW THE STRUCTURE OF THE MAMMALIAN SKIN (INTRODUCTION TO BIOLOGY) pg 109 fig. 22.1

Parts of the skin

- Cornified layer - This consists of flattened cells which are continually shed off. On palm of hands and soles of feet it may become too thick. Its main functions are: to provide resistance to bacterial invasion reduces rate of loss of water from the body, it also provides mechanical protection.
- Granular layer - this contains living cells and lies next to the cornified layer. It cells are pushed up to form the cornified layer.
- Malphghian layer - it consists of actively growing cells which are continually under going cell division. It produces a pigment called melanin which determines the Skin colour. Melanin absorbs Ultra Violet light rays which might otherwise damage the body cells.
- Sebaceous gland - they open into hair follicles. They are responsible for production of oily substance called sebum that is thought to keep the skin supple.
- Hairs - Present in all mammals and in most, provide complete covering. A hair is a fine, solid rod of cells which grows out of a tube in the skin called a hair follicle. They provide protection to the body surface, and they also trap air thus providing an insulating layer of air against heat loss by the body.

- Nerve ending - receive stimuli and transmission of impulses to the nerves
- Erector muscle - this controls the falling and standing of the skin hair in response to fluctuation in body temperature
- Subcutaneous fatty layer - storage of fat that also acts as an insulating layer against heat loss.
- Sweat glands - they occur as slender, coiled tubes in the dermis. They continue as sweat ducts which open at the surface of the skin as sweat pores. The sweat glands are surrounded by a dense network of Blood capillaries which supply blood to the skin. They produce secrete sweat to the surface of the skin thus controlling body temperature. Also waste products such as urea, excess salts and water are excreted as sweat.

TEMPERATURE REGULATION

It's the process of keeping the body temperature at that which the body's enzymes can work best. In man, the body temperature needs to be maintained at about $37^{o}C$ for the optimum functioning of the enzyme.

Heat loss and heat gain.

In order to keep the body temperature constant, a balance must be kept between the processes by which heat is gained and lost from the body.

Heat loss from the body.

There are four ways in which is lost from the body.

a. Evaporation of water eg during sweating
b. Conduction from the body to ground or other objects
c. Convection from the body to air and water
d. Radiation from the body to air

Heat is gained in the following ways.

Metabolism of food

Absorption of solar energy

Radiation from hot objects

Convection from water

Conduction from hot object

Relationship of body temperature and environmental temperature

Animals fall into two broad categories with respect to their body temperatures namely;

a. POIKILOTHERMIC ANIMALS/ECTOTHERM (COLD BLOODED ANIMALS)

These are animals whose body temperature varies with environmental or their body temperature depends on the temperature of the environment. They are also called ectotherms (ecto-out side) because they depend on heat derived from the external environment. They include fish, reptiles and amphibians.

b. Homoiothermic animals/Endothermic animals(WARM BLOODED ANIMALS)

These are animals which maintain a fairly constant temperature regardless of the environmental temperature.

They are also called endotherms because they depend on internal heat sources. They have been described as warm blooded animals because of being warmer than their surroundings even in cold.

Graph showing relationship between the body temperature of (ectotherms and endotherms) and the environmental temperature.

Advantages of endothermy:

-it allows endothermic animals to live in a wide range of environment irrespective of the prevailing environmental temperature

--it promotes functioning of enzymes efficiently at optimum body temperature

--it enables animals to have higher rates of metabolism thus yielding more energy which is necessary for quick response to stimuli. This is important for survival of organisms, as they can easily escape from danger such as predators etc

Disadvantages of endothermy:

1. Its energetically expensive especially in cold environment because a lot of heat energy has to be produced to maintain a relatively constant body temperature
2. Much food has to be consumed so as to generate heat internally

Advantages of ectothermy:

Low food consumption since heat energy is derived mainly from external surroundings

Disadvantage of ectothermy

1. Slow response to stimuli due to low metabolic when the temperature is low
2. Restrictions in animal's activities in case of extremes of environmental temperature, and therefore, ectothermic animals can not live in a wide range of environment.

Temperature regulation in ectotherms

a. Response to cold or low temperature

- Basking in the sun to gain heat. This is common in lizards and crocodiles
- Hibernation; this is a state of long rest by burrowing. During hibernation, the body temperature falls close to environmental temperature hence reducing heat loss. Here the animal uses stored food reserves.
- Burrowing into cracks, crevices in the wall during cold

b. Response to high temperature

- Eastivation ie form of hibernation during hot temperature by sheltering under rocks or burrowing beneath the surface
- Thermal gaping in crocodiles (opening the mouth wide to allow evaporation of water which carries away excess heat)
- Moving into shades where the environmental temperature is too high
- Moving into water ponds, river etc

Temperature regulation in endotherms
Temperature regulation in endotherms can be achieved by;

1. **Structural means.**

They have hair and features on the skin and fat under the skin to insulate the body against heat.

2. **Behavioral means**

When external temperature is cold, one may take hot drinks, wear warm clothes and sit near a fire.

When external temperature is hot, one may take cold drinks, switch an air conditioner, move to the shades, swim etc.

3. **Physiological means.**

This includes all activities involving increase or decrease in the body's metabolism.

The hypothalamus acts as a thermo/temperature regulation centre in the brain. Therefore the hypothalamus is also informed of external changes out side the body by the temperature receptors in the skin. It then directs the appropriate changes that are discussed below.

During the cold;

The body tries to prevent heat loss because of the tendency to lose heat when the temperature is cold.

The hypothalamus therefore causes the body to make some adjustments.

1. **Decrease in sweat production**. Production of sweat decreases so that heat lost by evaporation is much less.

2. **Vasoconstriction**. Arterioles near the skin surface constrict (narrow) and less blood enters the capillary net work of the skin and there fore less heat is lost from the blood by radiation and convection.
3. Contraction of the hair erector muscles which results into raising the hairs on the skin surface hence trapping a thick layer of warm air which insulates the body against heat loss. The contracted hair muscles appear as goose pimples.
4. The metabolic rate increases which generates a lot of heat hence maintaining the body temperature
5. Shivering: this is the involuntary rhythmic contractions of the skeletal muscles of the body to increase temperature production.

During the hot weather, the body tries to prevent heat gain therefore the hypothalamus causes the body to carry out some adjustments.

1. **Vasodilatation**. This the expansion and increase in the diameter of the blood vessels that lead blood to the skin surface, thus allowing more blood to flow near the skin surface. The increase in the flow of blood to the skin carries more heat to the surface which is lost to the environment by either convention or radiation
2. **Production of sweat increases**. The water in the sweat evaporation drawing latent heat of vaporization from the body hence cooling the body.
3. The metabolic rate of the body decreases in order to reduce the heat generated with in the body.
4. Relaxation of the hair erector muscle (falling of the skin hairs)
   This results into the hairs lying horizontally to the skin reducing the insulation layer of warm trapped air thus allowing more heat to be readily lost.

OTHER BEHAVIORAL MEANS IN ENDOTHERMS

High temperature: panting (common in animals with a few sweat glands) this is the hanging out of the tongue eg in dogs, this causing evaporation of water from the mouth thus cooling the body, becoming nocturnal such as hippos, developing very large ears which act as fans (elephants flap them to develop an air current when its hot)

NB: animals living in very hot environment may have: thin layer of fur, fur which is usually light in colour to reflect the sun's radiation

b. thin layer of subcutaneous fat below the skin

Low temperature: **Hibernation** in some mammals like squirrels, becoming active during day ie **diurnal**, **man puts thick clothes eg sweaters.**

NB: animals which live in cold environments may possess:

a. thick layer of fur

b. thick layer of subcutaneous fat below the skin to act as an insulator

Relation ship between body size and heat loss

Small organisms have a large surface to volume ratio than large organisms. Hence small organisms lose heat more rapidly than large organisms. In order to maintain a constant body temperature, they must have a high metabolic rate to produce the necessary heat. Therefore they need to feed more frequently than large organisms.