Homeostasis

→ The control of an organism's internal conditions, such that it is always kept close to a constant.
(endrocrine system & nervous system are both involved)

Factors controlled by Homeostasis

* – Core body temperature
– Metabolic waste
– Blood pH
* – Blood glucose concentration
* – Water potential ~~of~~ of the blood

Receptor: detects stimulus or change in a physiological factor

Effector: Includes and glands that respond to stimuli

Stimulus: A change that initiates a response

Set point: The ideal value around which a physiological value fluctuates

Negative feedback loop: A system through which a change in a physiological factor is restored to its set point

• Negative feedback loop

** ~~receptor detects a stimulus associated with the physiological factor being regulated~~

→ The mechanism through which factors are kept within a set limit. It ensures the diff in actual value and ideal value is bare minimum.

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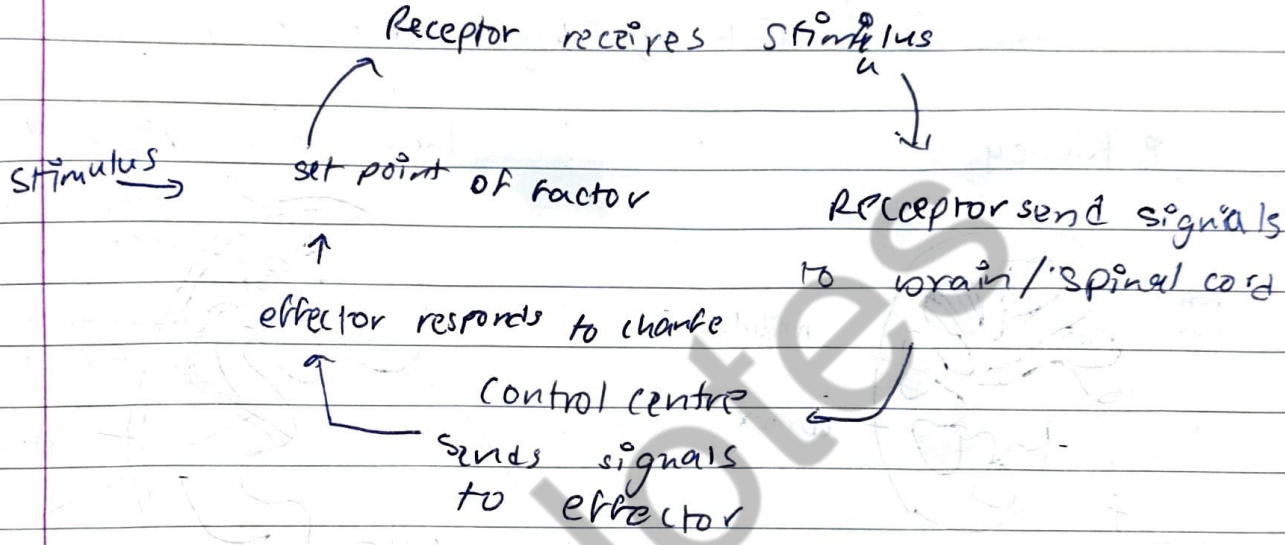
- Positive feedback

→ It reinforces the physiological factor changes. It continues the action (increases)

* Overall working of homeostasis



* Thermoregulation (Extra info not in portion)

- The hypothalamus is the central control for body temperature
- It is the region of the brain where inputs are delivered.
- Hypothalamus monitors the core temperature of the body by receiving info from the blood flowing through it

What happens when core temp of body of surrounding decrease (opposite for increasing) ↓

→ Vasoconstriction of arterioles so that less heat is lost from the blood

→ Muscles beneath the hairs of skin contract causing the hairs to rise and trap air which insulates the body as it cannot conduct heat

→ Shivering is an involuntary contraction of skeletal muscles which generates heat

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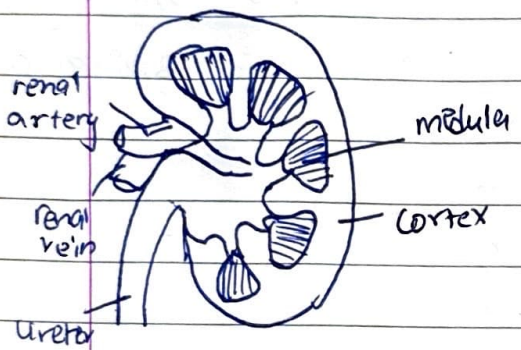
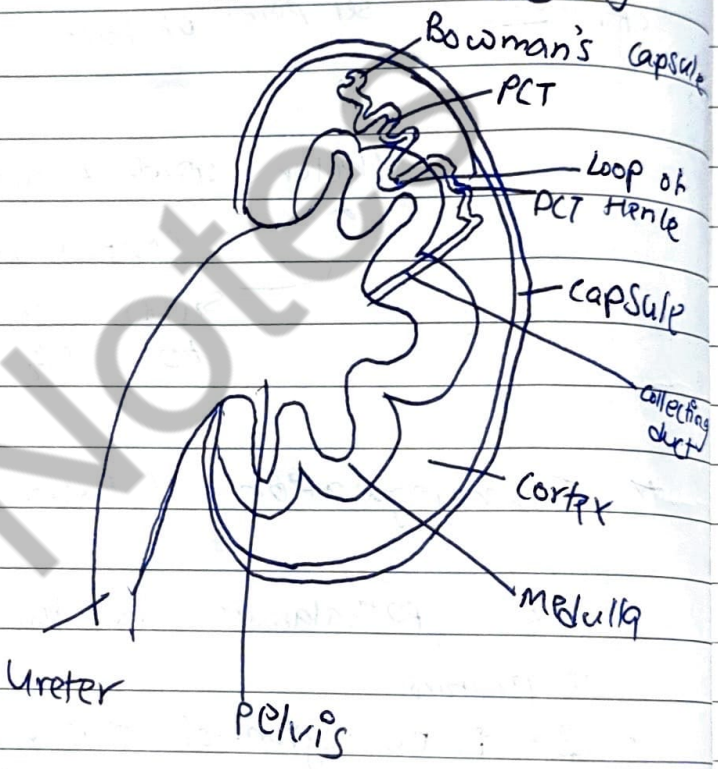
★ Excretion

Deamination: the breakdown of excess amino acids in the liver, eventually forming urea. Amine group is removed from amino acids forming ammonia which quickly converts to urea.

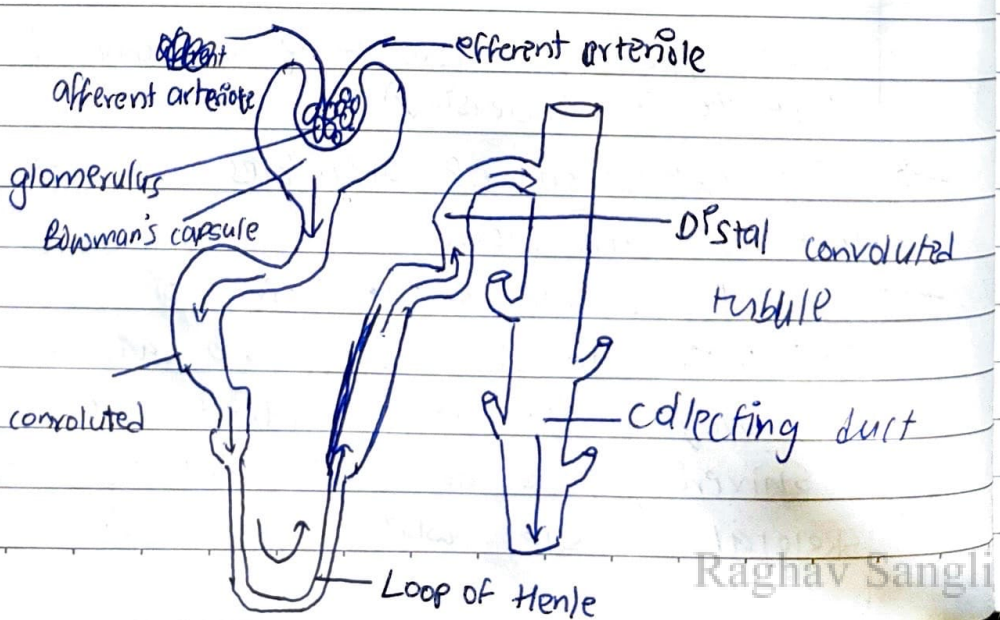
★ Kidney



Inside the Kidney



Different parts of nephron



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Ultrafiltration

→ Afferent arteriole feeds the blood into the glomerulus. It has a wider diameter than the efferent as to produce more pressure to push the blood out into the Bowman's capsule. It is hence filtered as any molecules small enough to get through the Bowman's capsule.

→ Ultrafiltration takes place in the epithelial cells that make up the lining of the Bowman's capsule.

→ These cells have tiny projections with gaps between them called podocytes. The gaps between these projections as well as holes in the endothelium allow substances in the blood plasma to get into the Bowman's capsule. The blood plasma is flowing through the glomerulus.

→ The basement membrane of the filter however acts as a filter and prevents protein molecules that are equal or greater than 69000 in mass from passing into the capsule. This also prevents red and white blood cells from passing through.

(whatever enters the Bowman's capsule is known as the glomerular filtrate).

→ The rate at which fluid filters from the blood in the glomerular capillaries into the Bowman's capsule is called the glomerular filtration rate. Avg rate is 125 ml/min

Factors affecting ultrafiltration

→ Water potential, Blood pressure and Solute concentration

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Selective Reabsorption in PCT

→ Some of the substances that go into the glomerular filtrate need to stay in the body, so they reabsorbed back. Most reabsorption in kidney takes place in PCT.

Characteristics of cells in PCT that enable selective reabs

- Microvilli to increase surface area.
- Tight junctions to hold the cells together so fluid does not flow between the cells.
- Lots of mitochondria to provide energy for the Sodium - potassium pumps.
- Co-transporter proteins in the membrane

The Process

- Sodium potassium pumps in the cells lining the proximal convoluted tubule move sodium ions out of the cells into the blood. This lowers the concentration of sodium in the cells

- As a result, sodium will diffuse out of the fluid in the tubule into the cells using co-transporter proteins in the membrane.

- As sodium is transported, the co-transporter also transports another molecule such as glucose or an amino acid.

- Glucose moves from the cell back into the blood. No glucose is left in urine. Other substances that are reabsorbed at PCT are amino acids, vitamins and Na^+ & Cl^- ions. (Uric acid & creatinine are not absorbed)

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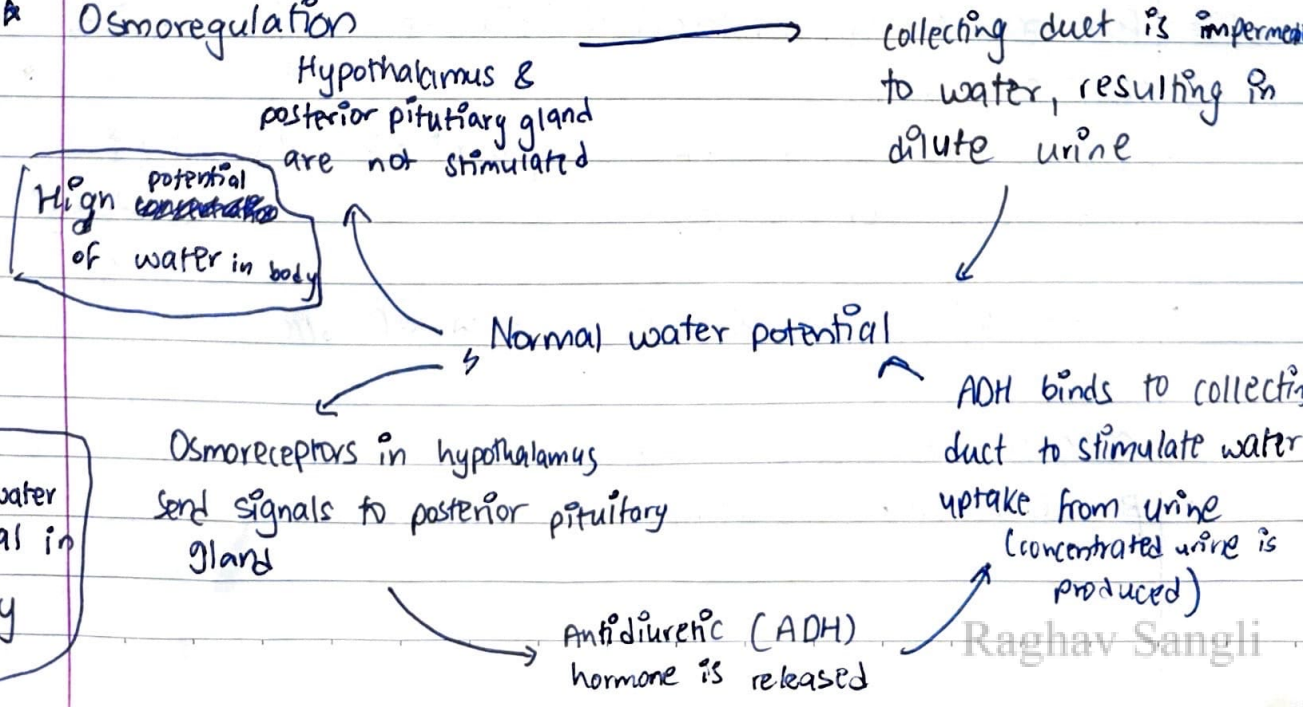
Selective Reabsorption in the Loop of Henle (in medulla)

- By the time the urine reaches the loop of Henle, the water potential is high
- The loop of Henle is made up of a descending and ascending limb, descending limb is permeable to water.
- Since descending limb is permeable to water and Na^+ & Cl^- ions, water moves out of the side of the loop into the tissue fluid while Na^+ & Cl^- diffuse into the loop.
- Fluid is more concentrated with Na^+ & Cl^- ions at the bottom, fluid moves up the ascending limb, sodium and chloride ions move out of the loop into tissue fluid causing it to have a lower solute concentration.

→ Selective Reabsorbtion in DCT

- Sodium-Potassium pumps determine the concentration of sodium and potassium in the urine.

Osmoregulation



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* How ADH acts on collecting duct (For Low water potential)

- Hypothalamus detects loco water potential in blood using osmoreceptors
- Hypothalamus stimulates the posterior pituitary gland
- Posterior pituitary gland releases ADH
- ADH binds to the walls of the collecting duct
- Stimulates the production of vesicles containing aquaporins
- They bind to the walls of the collecting duct and enable the movement of water out of the collecting duct.
- Resulting in concentrated urine with lower volume.

* Control of Blood glucose

→ In healthy humans, blood glucose concentration is b/w 80 to 120 mg per 100 ml of blood. If it decreases, cells cannot respire well or carry out their function. If it increases, it can result in diabetes.

- Hoco blood glucose is controlled.

→ Pancreas is an endocrine tissue located behind the stomach

→ It is made up of a group of cells called the islets of Langerhans

→ The islets contain two types of cells

- α cells for secretion of glucagon.
- β cells for secretion of insulin

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Role of insulin & glucagon

- Insulin (when glucose concentration is high)

→ Insulin is a protein molecule and is unable to pass through the cell membrane. Instead, it binds to the receptors on the cell surface membrane to stimulate cells to absorb glucose at an increased rate, convert it to glycogen and use it in respiration.

→ Insulin also stimulates the activation of the glucokinase. Glucokinase phosphorylates glucose, thereby preventing it from passing through the transporters in the cell surface membrane.

→ Insulin also stimulates the activation of phosphofructokinase and glycogen synthase – enzymes that help with the conversion of glucose to glycogen

- Glucagon (when blood concentration is low

→ β cells stop secreting insulin and α cells start secreting glucagon.

→ The decrease in insulin concentration means uptake of glucose by liver and muscle cells are greatly reduced.

→ Glucagon binds to cell receptors and activates a cell-signaling process

- Schematic (Enzyme cascade reaction)

→ Glucagon binds to membrane receptor of liver cell

→ Activation of G-protein and enzyme

→ Active enzyme produces cyclic AMP from ATP

→ Cyclic AMP activates protein kinase to activate an enzyme cascade.

→ Enzyme cascade leads to activation of many molecules of glycogen phosphorylase that break down glucose

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Note:

→ Glucose can also be made from amino acids and lipids in a process called gluconeogenesis

→ Adrenaline can also increase the concentration of blood glucose.

Urine test

→ Can be used for the presence of glucose and ketones in urine.

→ When glucose concentration is higher than a certain renal threshold, not all the glucose is reabsorbed in the PCT of the kidney.

→ When ketones and proteins are present in urine, it shows that the kidneys have a problem. This is because proteins are too large to filter through kidneys.

Measuring glucose in urine (Dip sticks)

→ Dipsticks are used to test the presence of glucose, ketones & protein and urine pH.

→ Dipsticks contain two enzymes: glucose oxidase and peroxidase

→ Glucose peroxidase reacts with glucose to form a compound and hydrogen peroxide

→ The peroxidase enzyme catalyzes a reaction between hydrogen peroxide to produce different colours to show how high or low blood glucose concentration is.

Disadvantages

→ Exact concentration of blood is not known

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Measuring glucose in blood

- Biosensor

→ They contain a pad that contains glucose oxidase
→ Blood is collected on the pad and glucose oxidase catalyses glucose to produce a compound.
→ Simultaneously, an electric current is generated. The current is detected by an electrode, amplified and read by the meter producing a blood glucose reading
→ The higher the concentration of blood glucose, the greater the current detected, ∴ the greater the reading.

* Homeostasis in Plants

- Plants regulate the amount of CO_2 that enter &
- The stomata control the entry & exit of CO_2. It is a small hole between two guard cells.
- Stomata open and close to control the amount of CO_2. They open in response to increasing light intensity or low CO_2 concentration in the air spaces in the leaf.
- Stomata close in response to darkness, high CO_2 concentration, low humidity, high temp and water stress due to high rates of transpiration.

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Opening & Closing of Stomata

- Each stoma is surrounded by two guard cells. The guard cells gain or lose water by osmosis. They are turgid when they gain water (stoma opens) and flaccid when they lose water (stoma closes).

- Hydrogen ions (protons) are pumped out of the guard cells using proton pumps powered by ATP

- This decreases the concentration of protons inside the cell making the cell negatively charged.

- In order to balance the charges, channel proteins on the surface open up so that potassium ions can flow into the cell.

- The presence of potassium ions in the cell lowers the water potential inside the cell causing the water to move into the cell through aquaporins in the cell membrane. This increases the turgidity of guard cells and opens the stomata

- When the proton pumps stops pumping out of the cell and potassium ions move out, water leaves the guard cells and they become flaccid, therefore closing the stomata.

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Abscisic acid (Hormone)

- When a plant is water stressed, the hormone abscisic acid (ABA) is produced to stimulate stomata closure
- ABA is a stress hormone and its concentration increases when plants are exposed to stressful conditions. High concentrations of ABA stimulate closure of the stomata in order to save water or reduce the rate of transpiration.

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