

9.0 HOMEOSTASIS



HOMEOSTASIS

*"..it is all about
a balancing act..."*

BY

Waseem ahmad

Sabar latif

Romana shams

THE UNIVERSITY OF LAHORE





HOMEOSTASIS

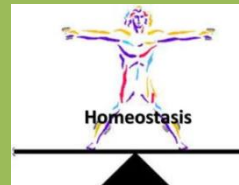
"..it is all about a balancing act.."

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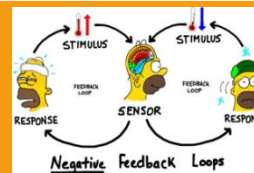
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Concept of homeostasis



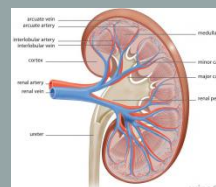
9.1

Negative feedback mechanism



9.2

Human Homeostatic organ: KIDNEY



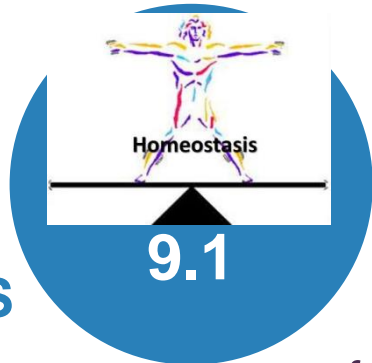
9.3



LEARNING OUTCOME:

At the end of the lecture, students should be able to:

CONCEPT OF HOMEOSTASIS

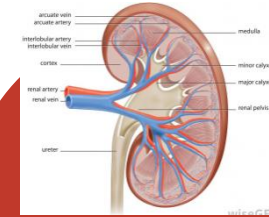
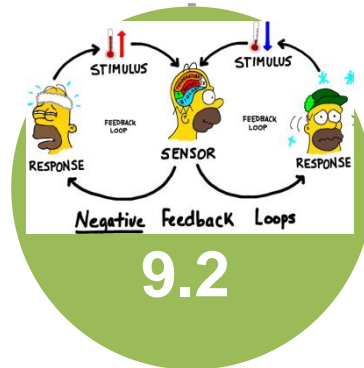


- a) Explain the concept of homeostasis and describe the homeostatic control system

NEGATIVE FEEDBACK MECHANISM

- a) Explain the negative feedback mechanism in controlling blood glucose level

HOMEOSTASIS



9.3

HUMAN HOMEOSTATIC ORGAN: STRUCTURE AND FUNCTION OF KIDNEY

- a) Describe the structure of nephron
- b) Analyse the processes in urine formation:
 - i. Ultrafiltration
 - ii. Reabsorption
 - iii. Secretion
- c) Describe the counter current multiplier mechanism in urine formation.
- d) Relate the regulation of blood water content with ADH

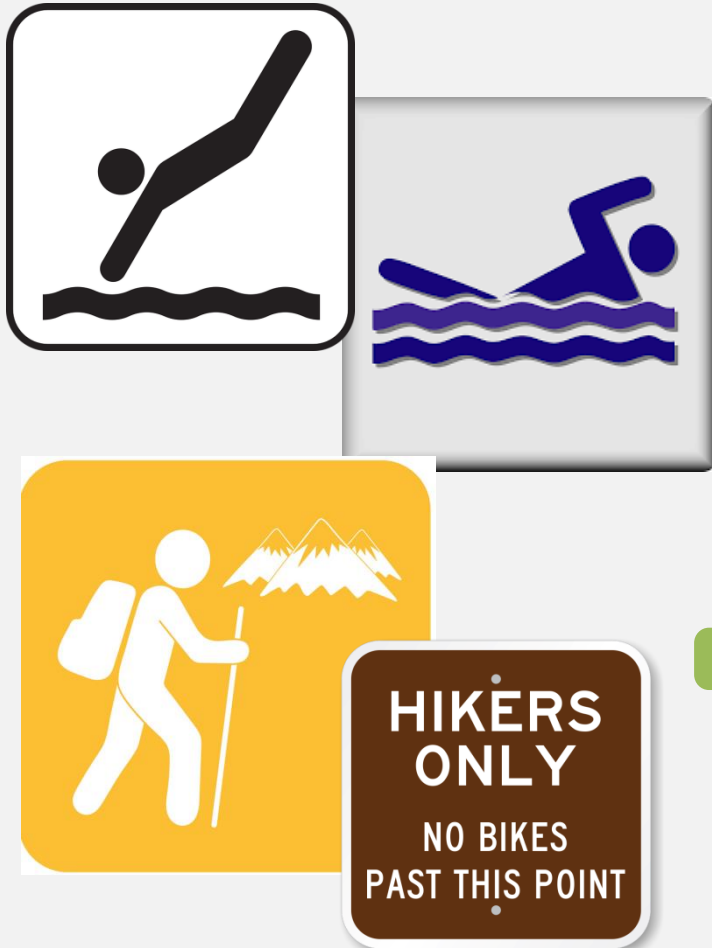
9.1 CONCEPT OF HOMEOSTASIS



When you are hot, you look red because your capillaries are bringing blood closer to the surface of your skin so more heat can be lost.



Homeostasis → maintenance of internal balance



The importance of homeostasis?

- Homeostasis provides cells within the body with a relatively constant environment
 - Helps cell to work efficiently, no matter what is going on outside of the body
- eg. whether you dive into a swimming pool, hike in the desert or swim in the ocean, your cells remain isolated from outside conditions



What is homeostasis?

A state in which the internal environment is being maintained within a range that cells can tolerate

(Biology: Starr Taggart, 11th edition, pg 484)

Dynamic consistency of the internal environment

(Biology: Raven 6th edition, pg 1174)



The existence of a stable internal environment

(Fundamentals of anatomy & physiology, 9th edition, pg 10)

The consistency of the body's internal environment

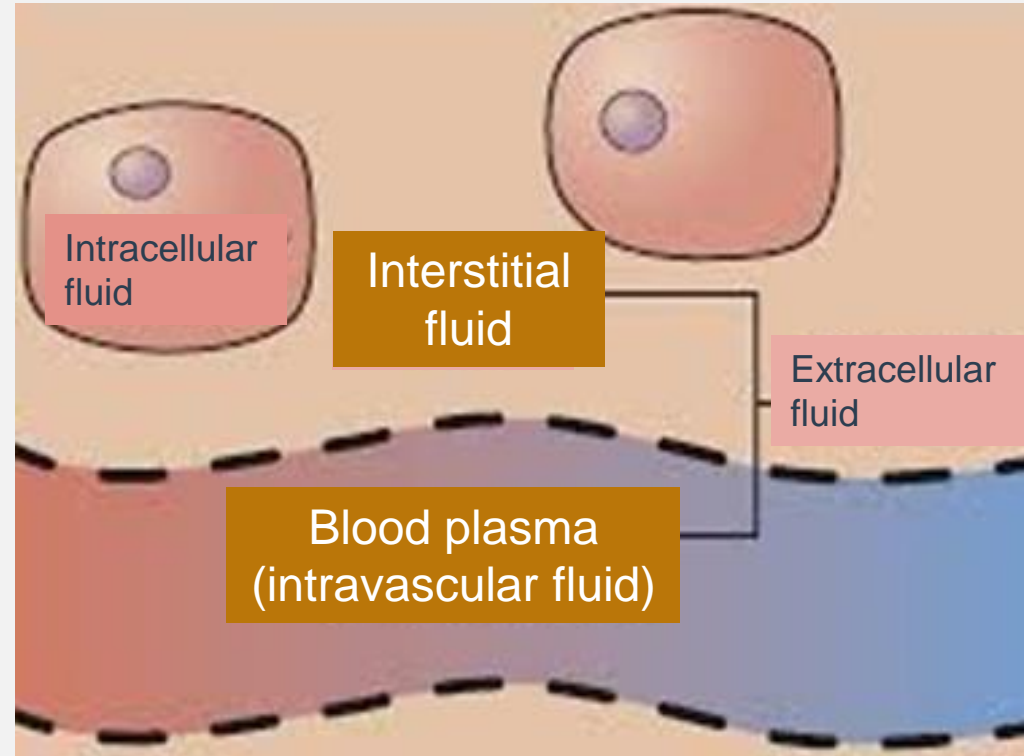
(Biology life on earth, 7th edition, pg 536)



Homeostasis → maintenance of internal balance

What is internal environment?

- Internal environment is all the fluid not inside the body's cells
- ◆ It consists of **interstitial fluid and blood plasma: extracellular fluid**



Body Fluids :

Intracellular compartment (inside cells)

- contains 67% of our water

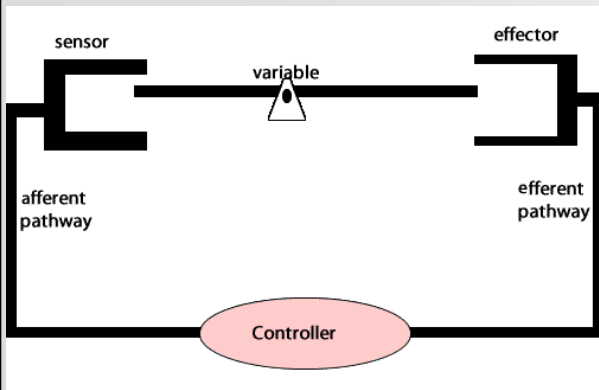
Extracellular compartment (outside cells)

- contains 33% of our water

- 20% is in blood plasma.

- 80% makes up interstitial fluid.



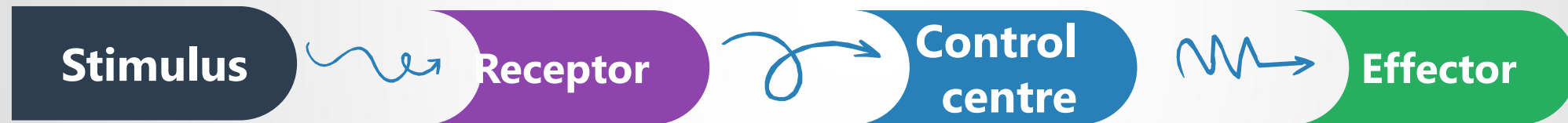


What is receptor?

- A body structure **that monitors changes** in a controlled condition
- Sends **INPUT** in the form of **nerve impulses or chemical signals** to a **control center**

What are the functions **effector**?

- A body structure **that receives output** from the control centre
- **produces a response or effect** that changes the controlled condition



What is stimulus?

- **Any disruption that changes a controlled condition**

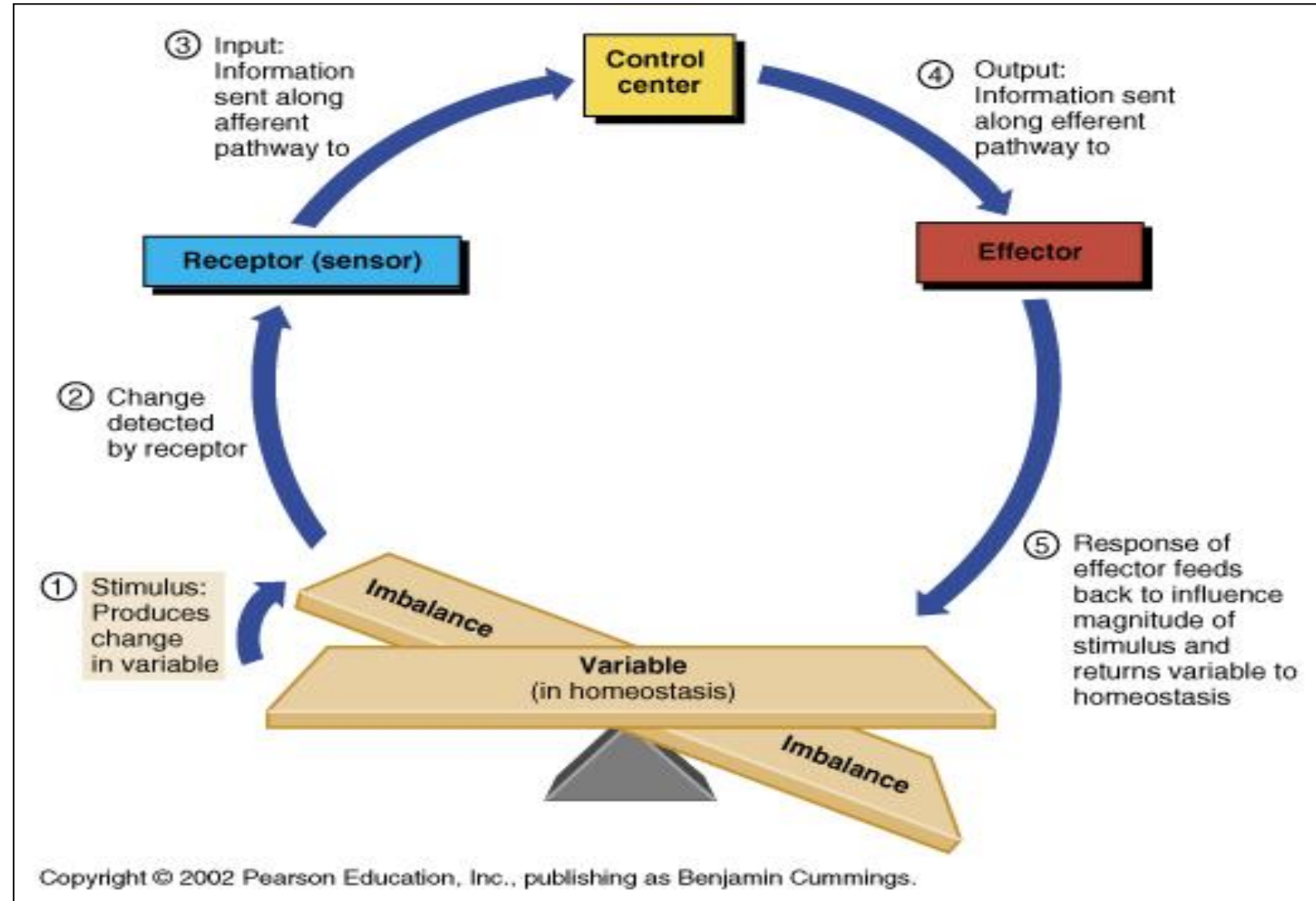
What are the functions of **control center**?

- **Receives and processes the information (INPUT e.g nerve impulse, chemical signal) supplied from the receptor**
- **Triggers the action (OUTPUT e.g nerve impulse, hormone, chemical signal) that will correct the change**



9.1 CONCEPT OF HOMEOSTASIS

How does homeostatic control system operate?

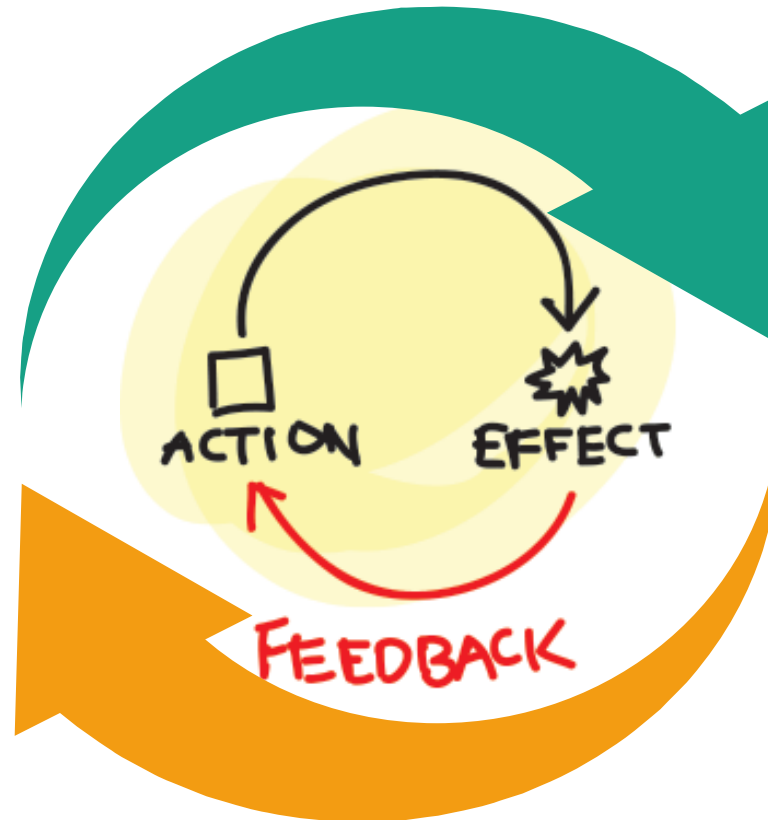


What is the **mechanism involved** in homeostasis?

• **NEGATIVE feedback mechanisms**

– **Correct deviations from a set point**

- Some **activity changes** a specific condition in the **internal environment**
- If the changes past a certain point, **a response reverses the change**



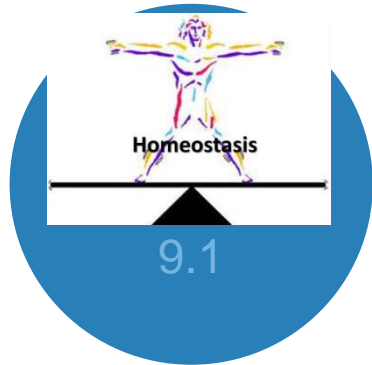
– Controls initiate a chain of events that **intensify change** from an original condition

- The **end result** is that change tends to proceed in **the same direction as the initial stimulus**
- After a limited time, the intensification reverses the change

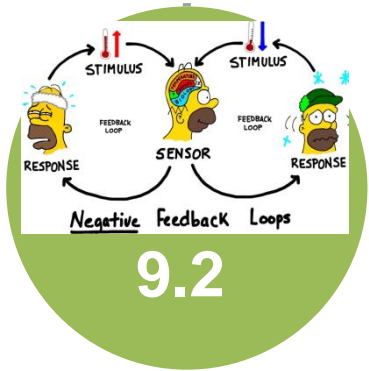
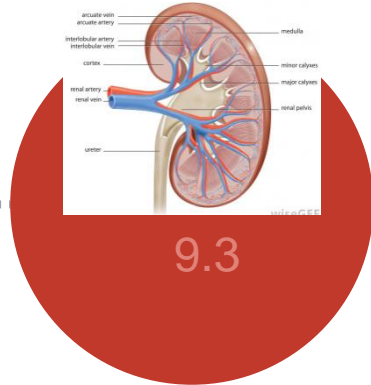
• **POSITIVE feedback mechanisms**

LEARNING OUTCOME:

At the end of the lecture, students should be able to:



HOMEOSTASIS

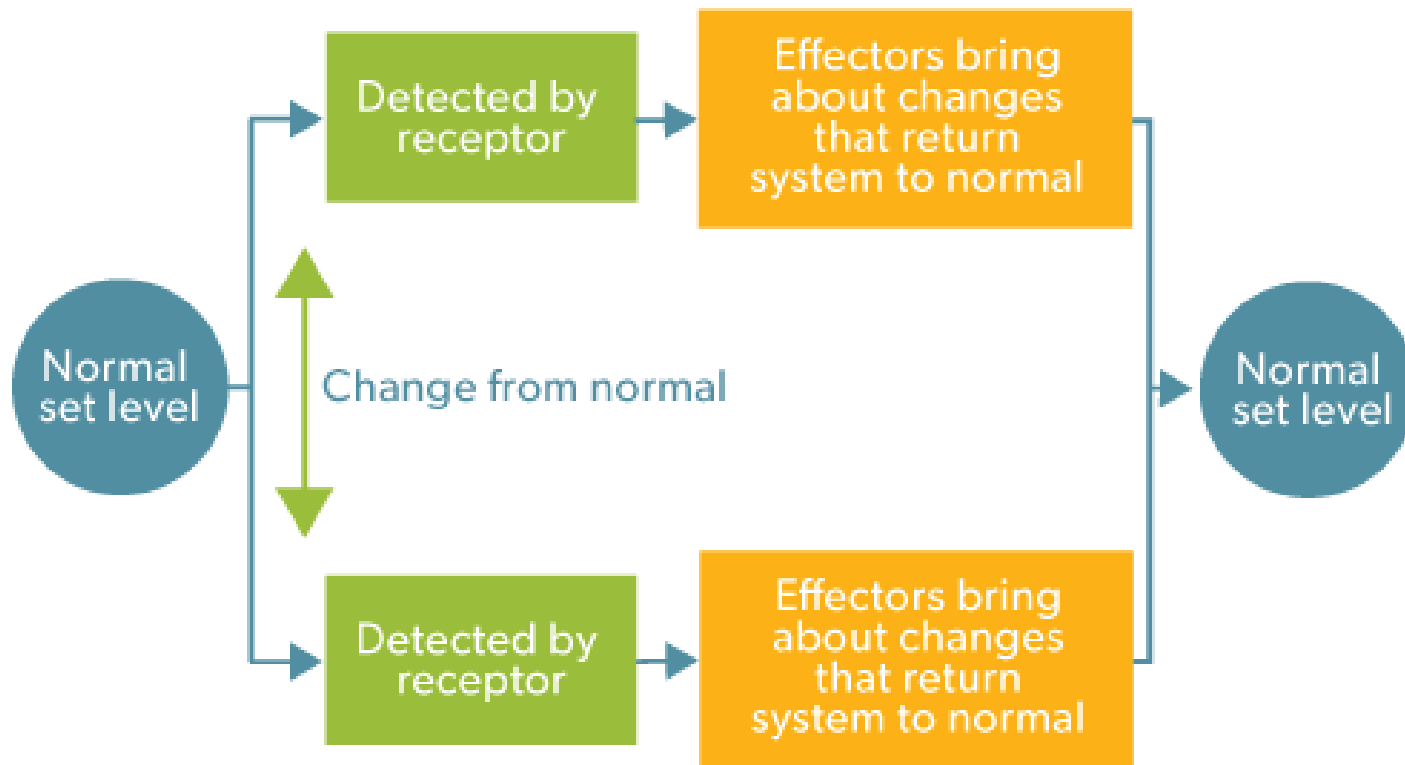


NEGATIVE FEEDBACK MECHANISM

a) Explain the negative feedback mechanism in controlling blood glucose level

9.2 NEGATIVE FEEDBACK MECHANISM

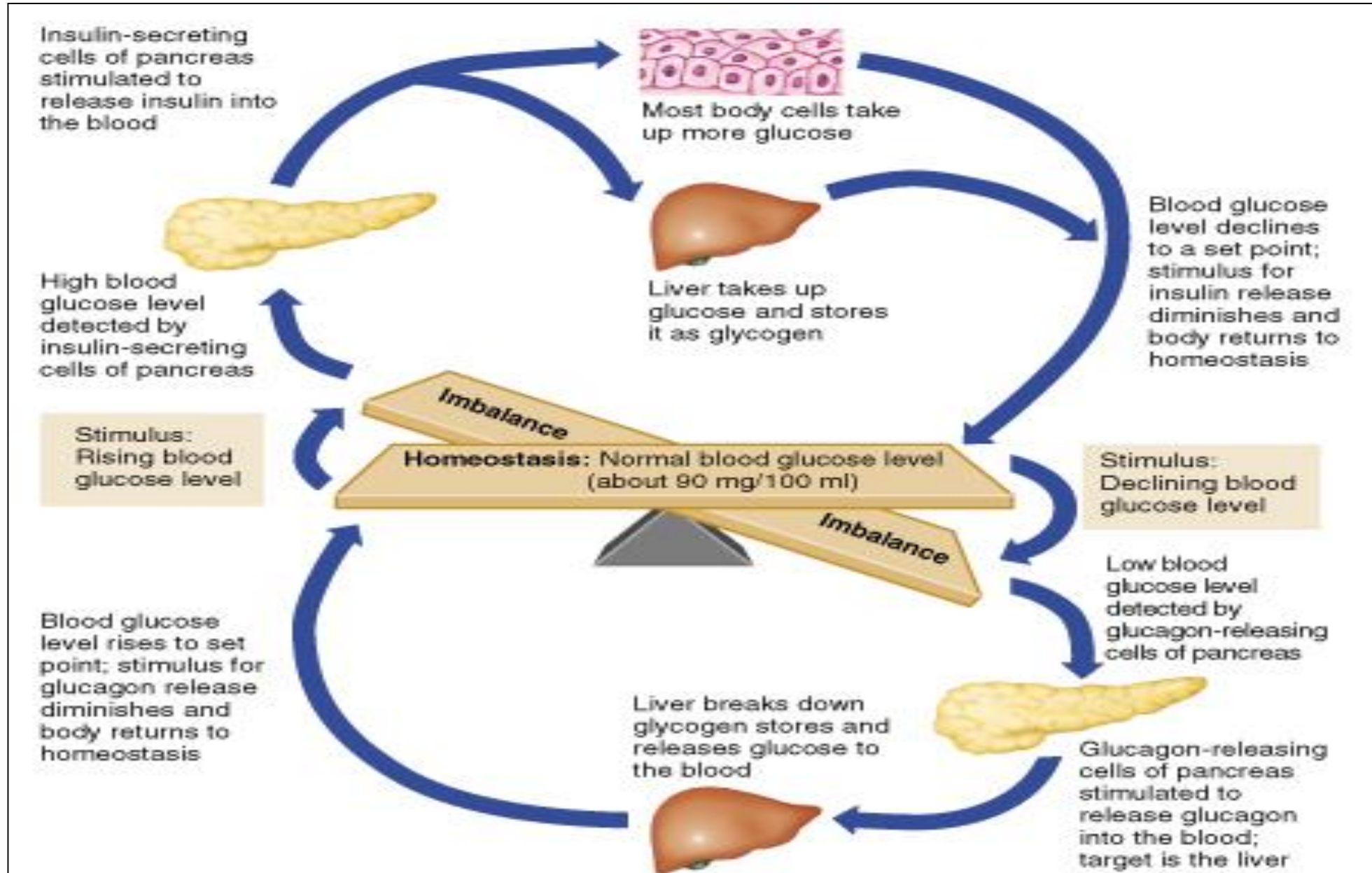
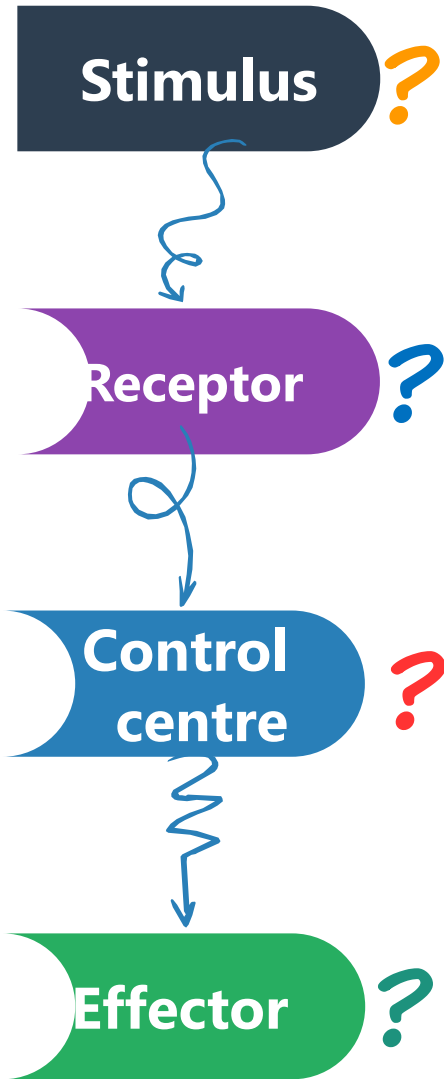
A summary of negative feedback

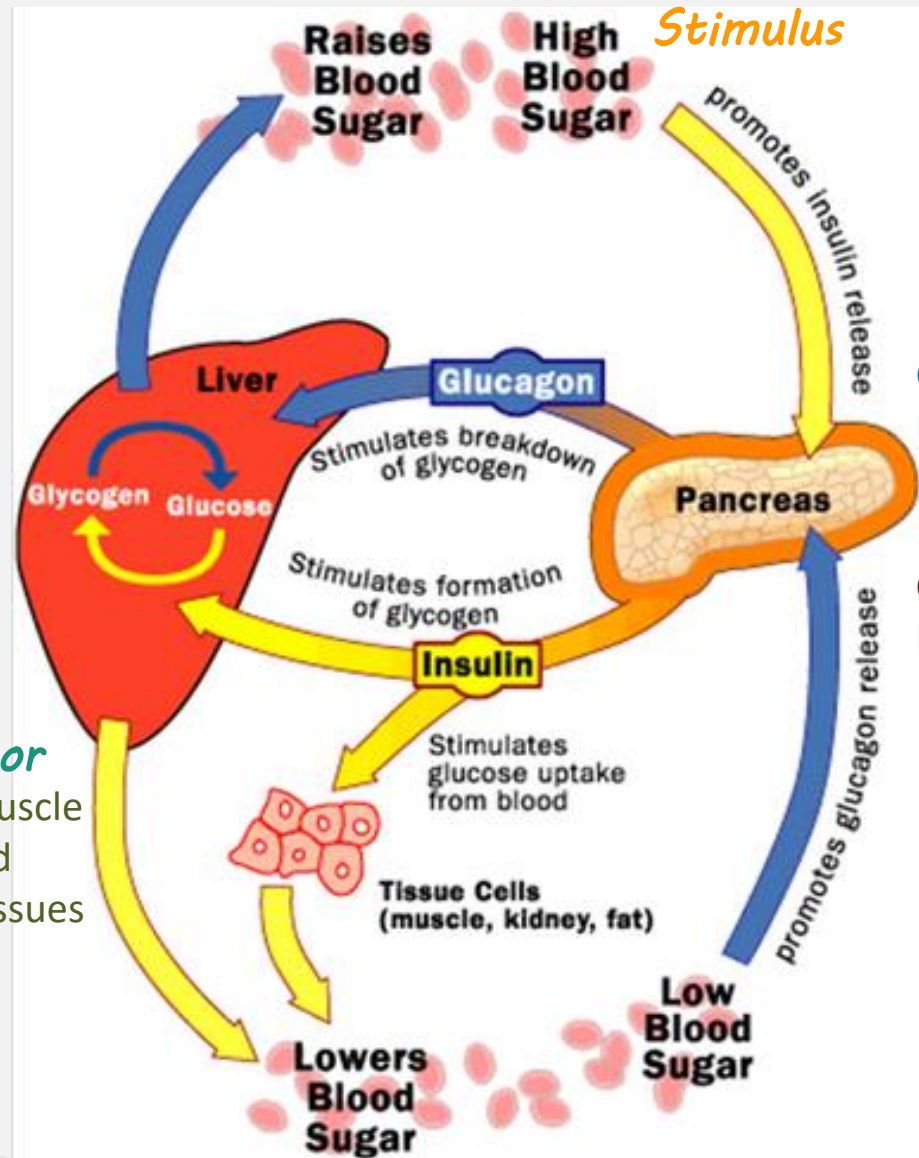


- A form of regulation in which **accumulation of an end product** of a process **slows the process**;
- In physiology, a primary mechanism of homeostasis, whereby **a change in a variable** triggers a **response that counteracts the initial change**.

(Campbell 11th edition)

9.2 a) Explain the negative feedback mechanism in controlling blood glucose level





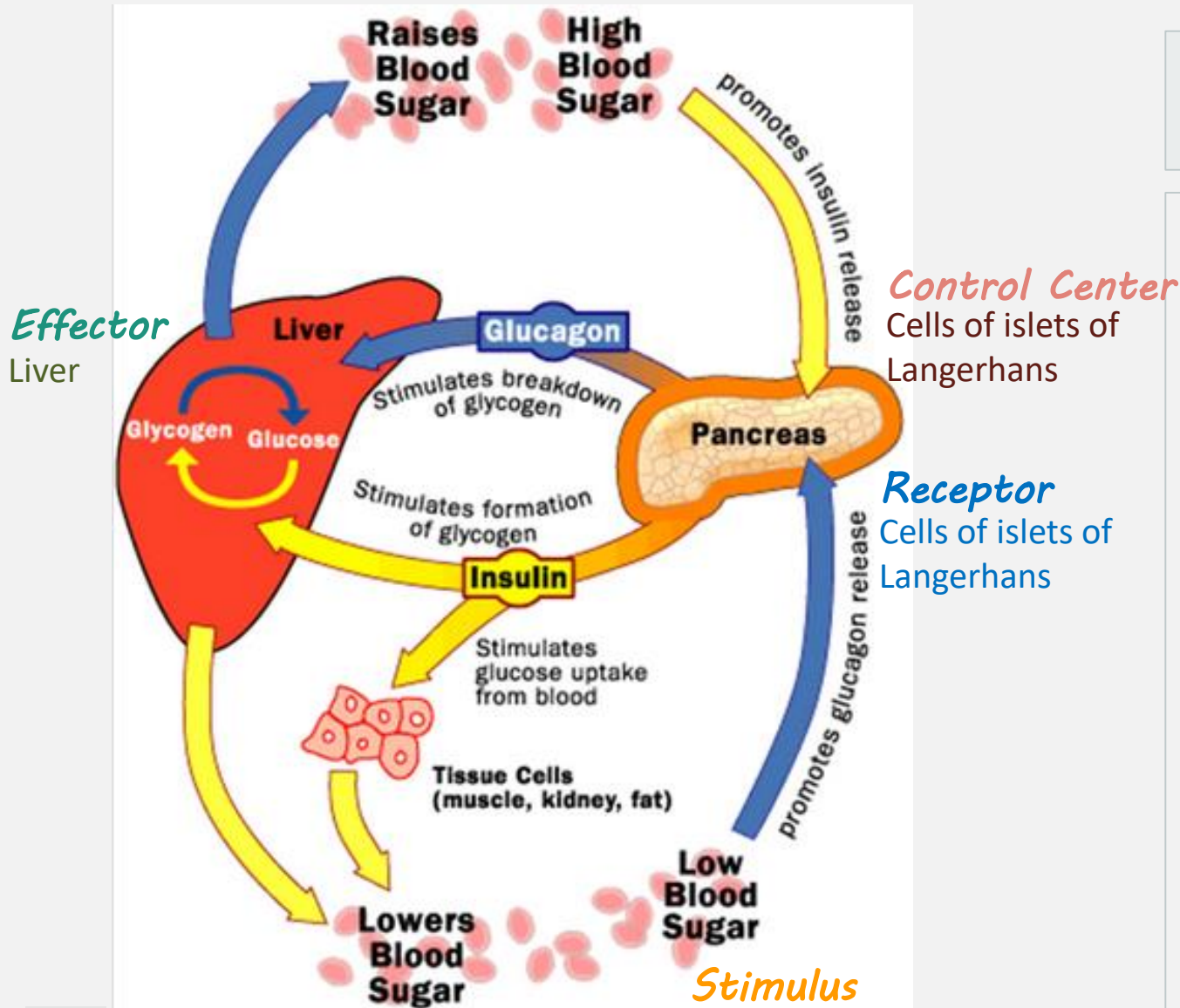
Involves negative feedback mechanism

➤ When blood glucose level **increase**,

✓ β - cells of islets of Langerhans in pancreas are stimulated

✓ Releasing **insulin**

- Triggers uptake of glucose from the blood
- Stimulates the **liver, muscle cells and other tissues** to store glucose as glycogen
- Blood glucose level return to normal
-Set point : desired level



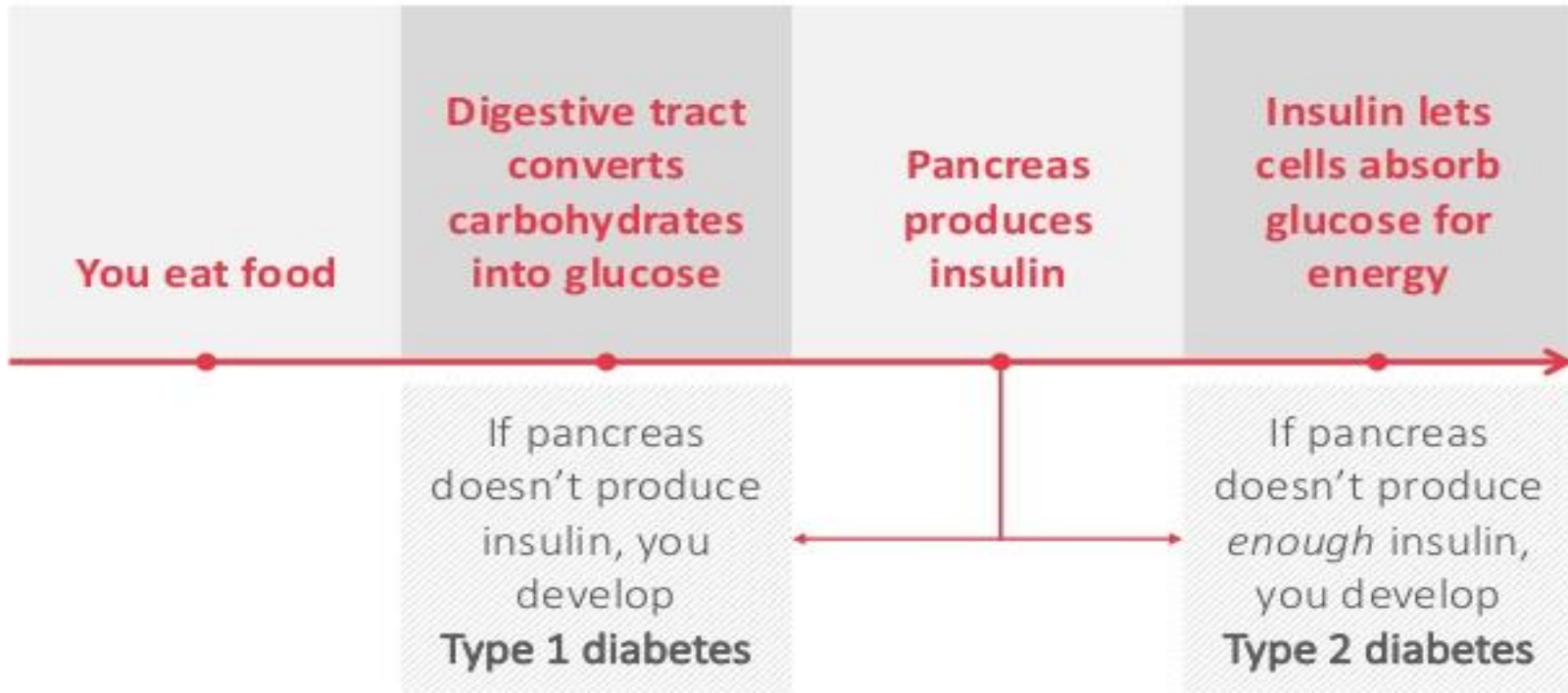
Involves negative feedback mechanism

➤ When blood glucose level **decrease**,

✓ α - cells of islets of Langerhans in the pancreas are stimulated

- ✓ Release **glucagon**
- Stimulates **the liver cells** to convert glycogen to glucose
 - Blood glucose level return to normal (set point)

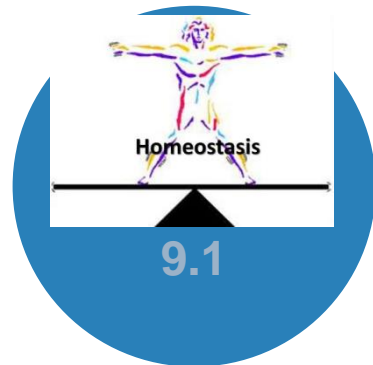
WHAT IS DIABETES?



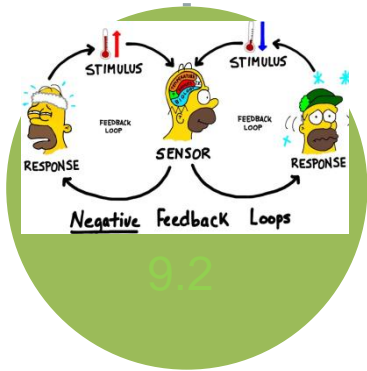
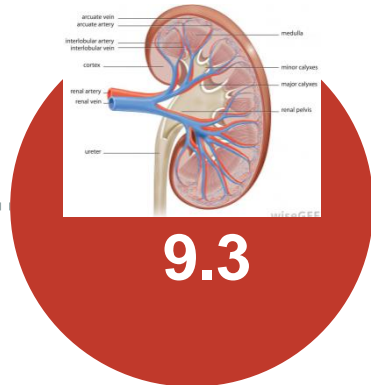
- As insulin is a protein, it cannot be administered orally as it will be broken down by digestive enzymes in the gut. Hence, it must be injected through the skin with a needle.

LEARNING OUTCOME:

At the end of the lecture, students should be able to:



HOMEOSTASIS



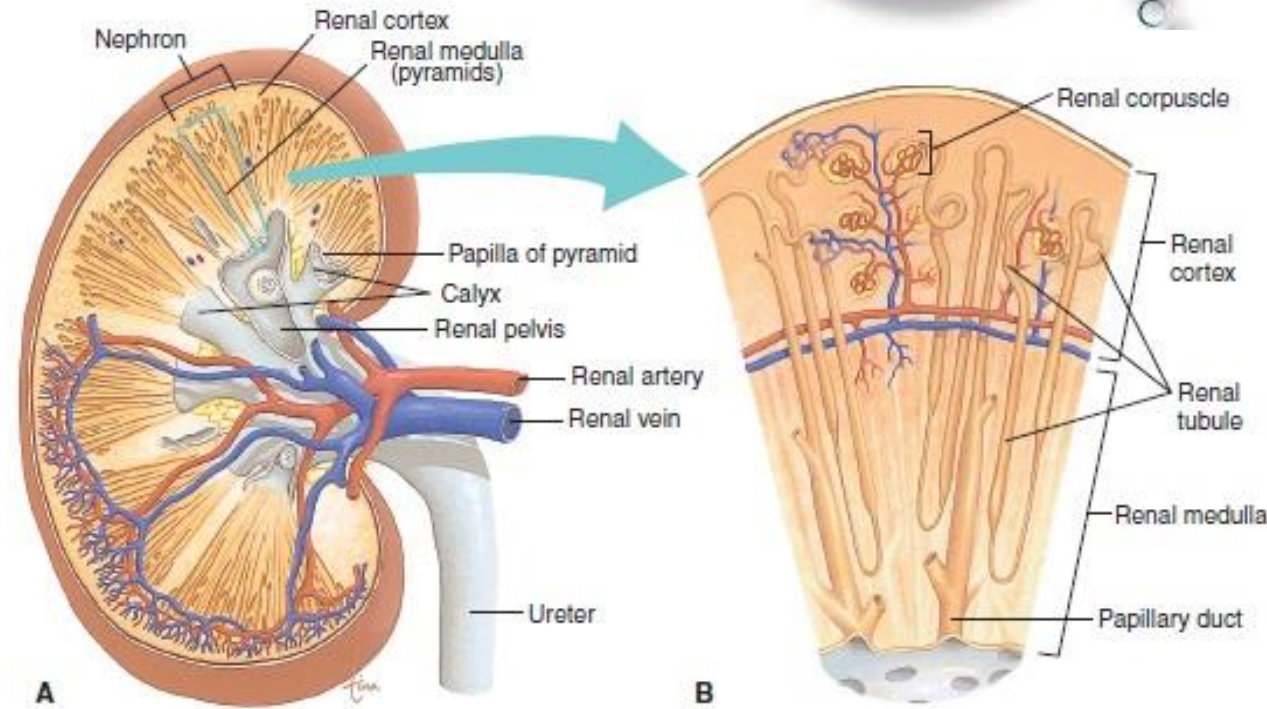
HUMAN HOMEOSTATIC ORGAN: STRUCTURE AND FUNCTION OF KIDNEY

- a) Describe the structure of nephron
- b) Analyse the processes in urine formation:
 - i. Ultrafiltration
 - ii. Reabsorption
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- c) Describe the counter current multiplier mechanism in urine formation.
- d) Relate the regulation of blood water content with ADH



Each individual kidney consists of at least 1 million and up to 2 million nephrons. Nephrons are nothing but very tiny filters that are capable of filtering blood and eliminating the waste materials.

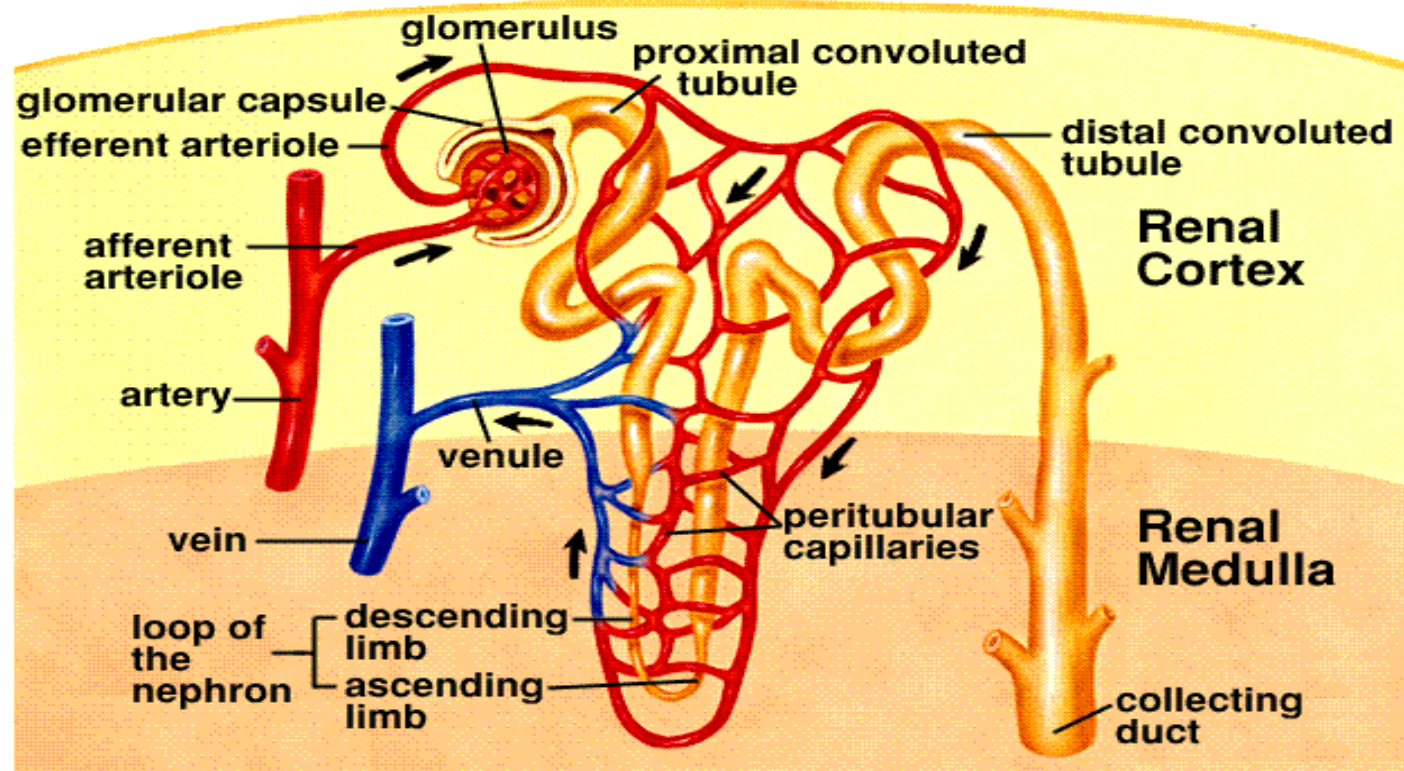
If one kidney is taken away and the functional capacity of the other kidney is reduced to just 75%, it can still sustain life. This happens because the nephrons are capable of enlarging and handling excess load. This is known as hypertrophy.



9.3 HUMAN HOMEOSTATIC ORGAN: STRUCTURE AND FUNCTION OF KIDNEY

Sylvia S. Mader, Inquiry into Life, 8th edition. Copyright © 1997 The McGraw-Hill Companies, Inc. All rights reserved.

Nephron Macroscopic Anatomy



Watch full video at <https://www.youtube.com/watch?app=desktop&v=owJZiPbrHRs>

a) Describe the structure of nephron

The **basic structural and functional unit** of the kidney

→ **nephron**

- Microscopic excretory tubules
- Packing the **cortex and medulla region**

Each kidney consists about a million **nephrons**

- Total tubule length: 80 km
- Enormous surface area for the exchange of materials



9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

a) DESCRIBE THE STRUCTURE OF NEPHRON

✓ Glomerulus

- A spherical cluster of blood capillaries

✓ Bowman's capsule

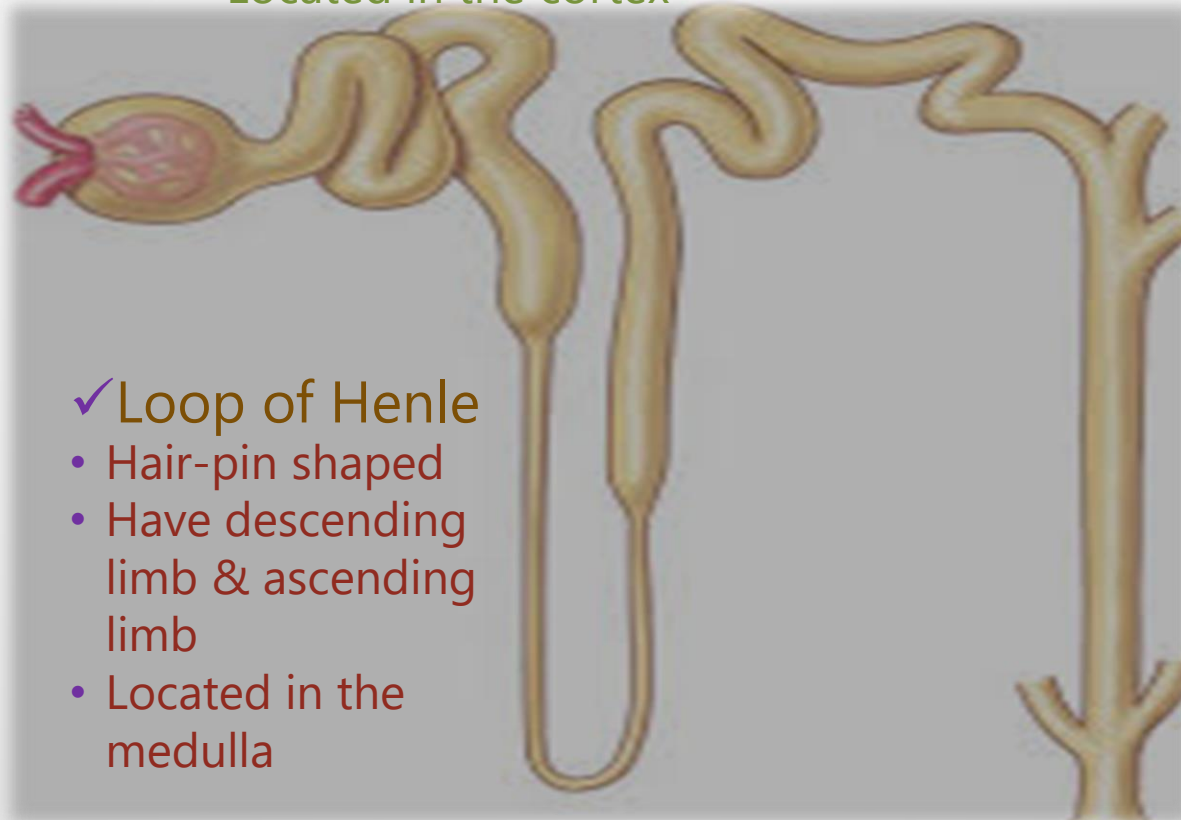
- A double-walled, cup-shaped swelling capsule
- Blind end of the tubule
- Located in the cortex

✓ Proximal convoluted tubule

- Lumen is continuous with the Bowman's capsule
- Highly coiled
- Located in the cortex

✓ Distal convoluted tubule

- Located in the cortex



✓ Loop of Henle

- Hair-pin shaped
- Have descending limb & ascending limb
- Located in the medulla

✓ Collecting duct

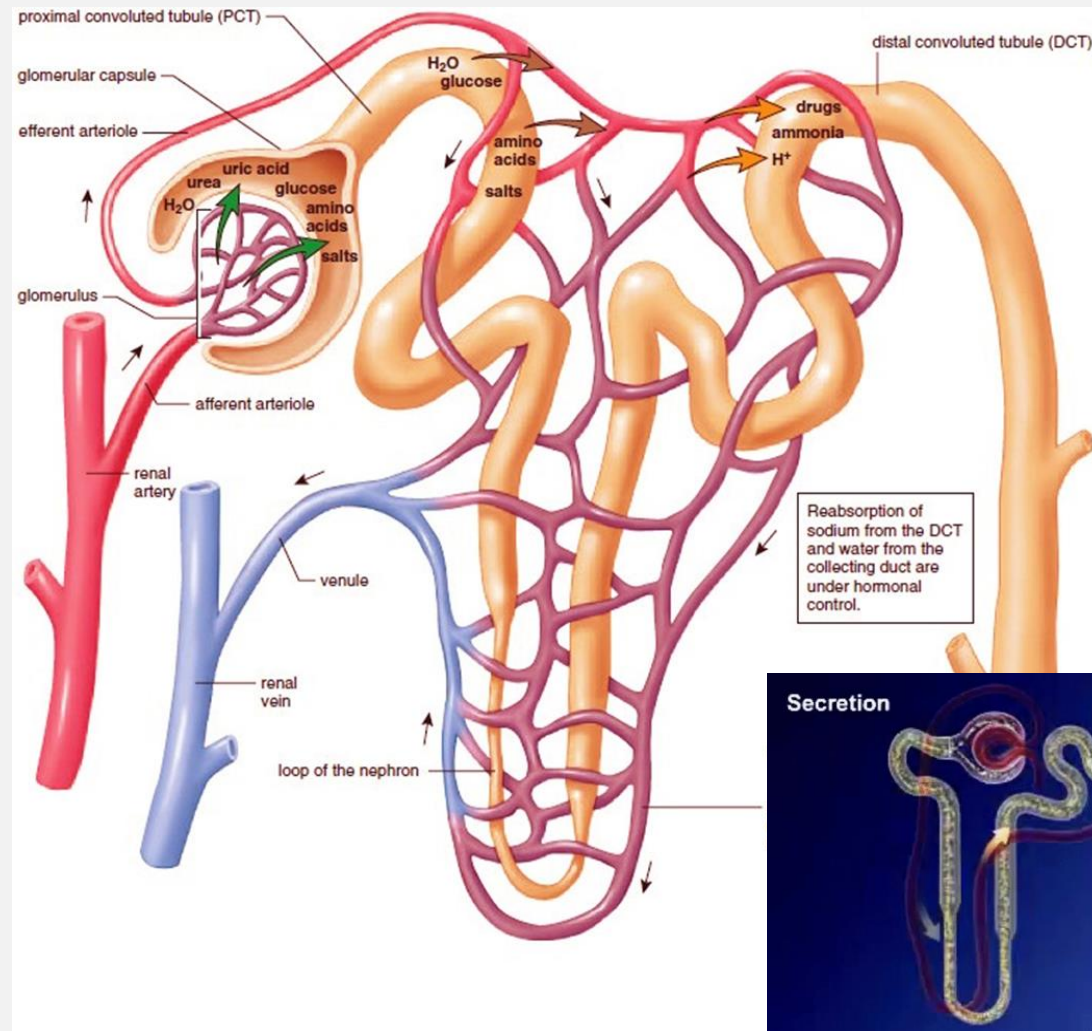
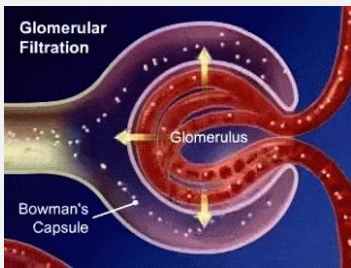
- End of kidney
- Eventually drain into the pelvis of the kidney
- from where the urine flows into the ureter
- Located in the medulla

9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

b) Analyse the processes in urine formation: i. Ultrafiltration, ii. Reabsorption, iii. Secretion

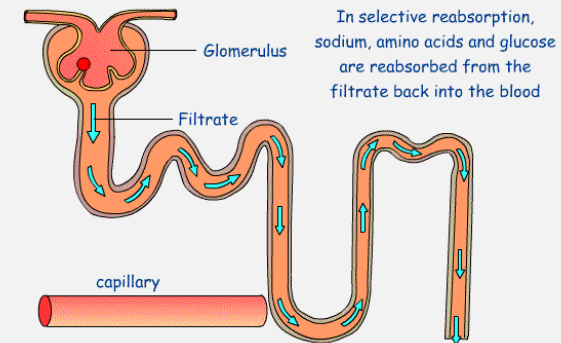
ULTRAFILTRATION

- ✓ Takes place in the **glomerulus** and the **Bowman's capsule**
- ✓ Occurs due to the **hydrostatic pressure** caused by the blood pressure



REABSORPTION

- ✓ The process of **absorbing useful substances into capillaries** which wrapped around tubule
- Glucose, amino acids, vitamins, most of the water, sodium and chloride ions

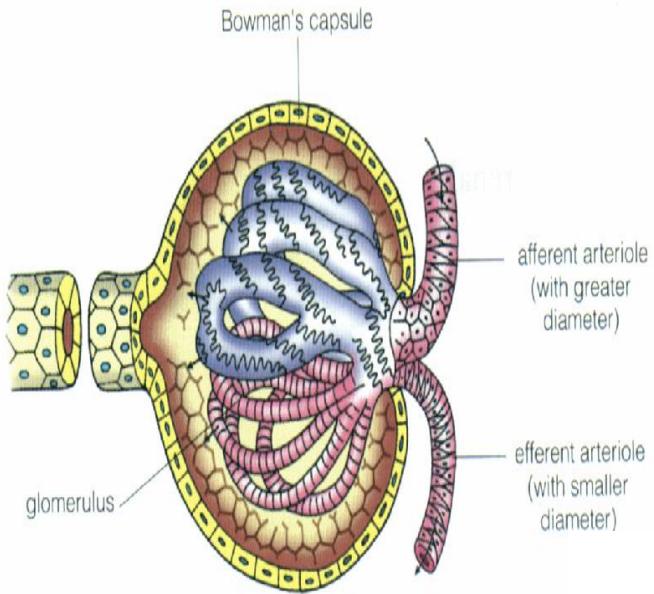


SECRETION

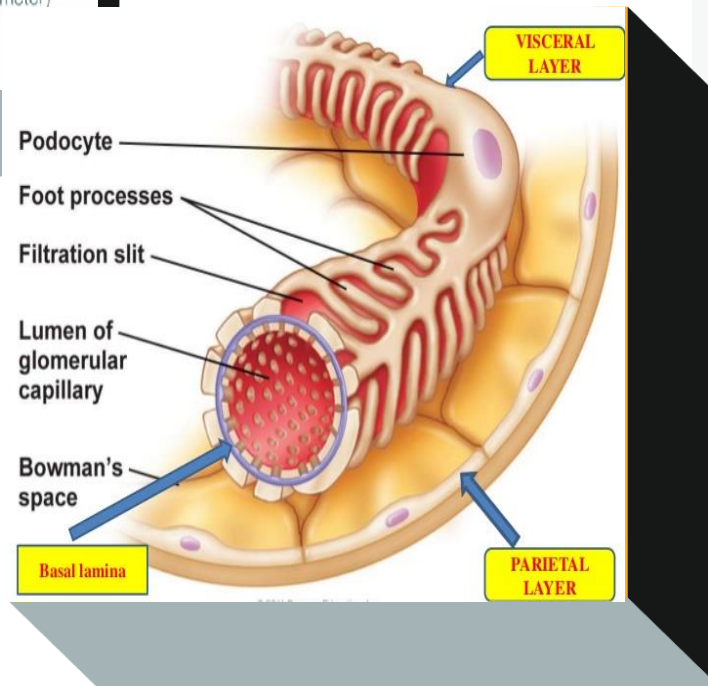
- ✓ Occurs in the **distal convoluted tubule** and the **proximal convoluted tubule**
- Mainly in distal tubule



. ULTRAFILTRATION



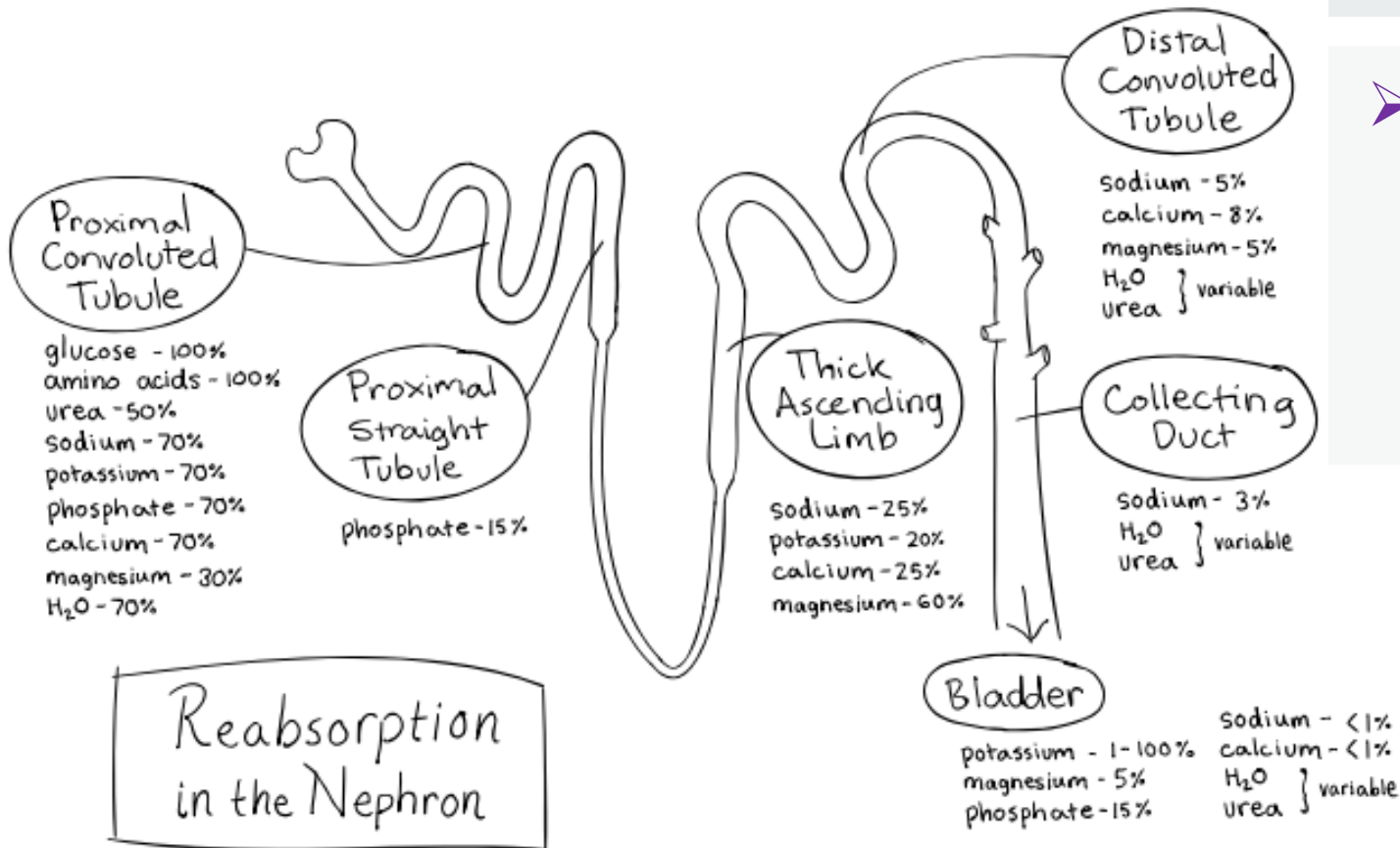
- ✓ Blood enters the glomerulus via **afferent arteriole (larger diameter)** and leaves via **efferent arteriole (smaller diameter)**
→ Produce **high hydrostatic pressure**



- ✓ Forces **small molecules** through the walls of capillaries and Bowman's capsule into the capsular space
 - **Except RBC, plasma proteins and platelets**
- ✓ The perforated walls of the capillaries and the podocytes form a **filtration membrane**
 - Permits fluid and small solutes to pass

. REABSORPTION

- Occurs in:
- ✓ Proximal convoluted tubule
 - ✓ Loop of Henle
 - ✓ Distal convoluted tubule
 - ✓ Collecting duct



. REABSORPTION

- Occurs in:
 - ✓ Proximal convoluted tubule

Active transport

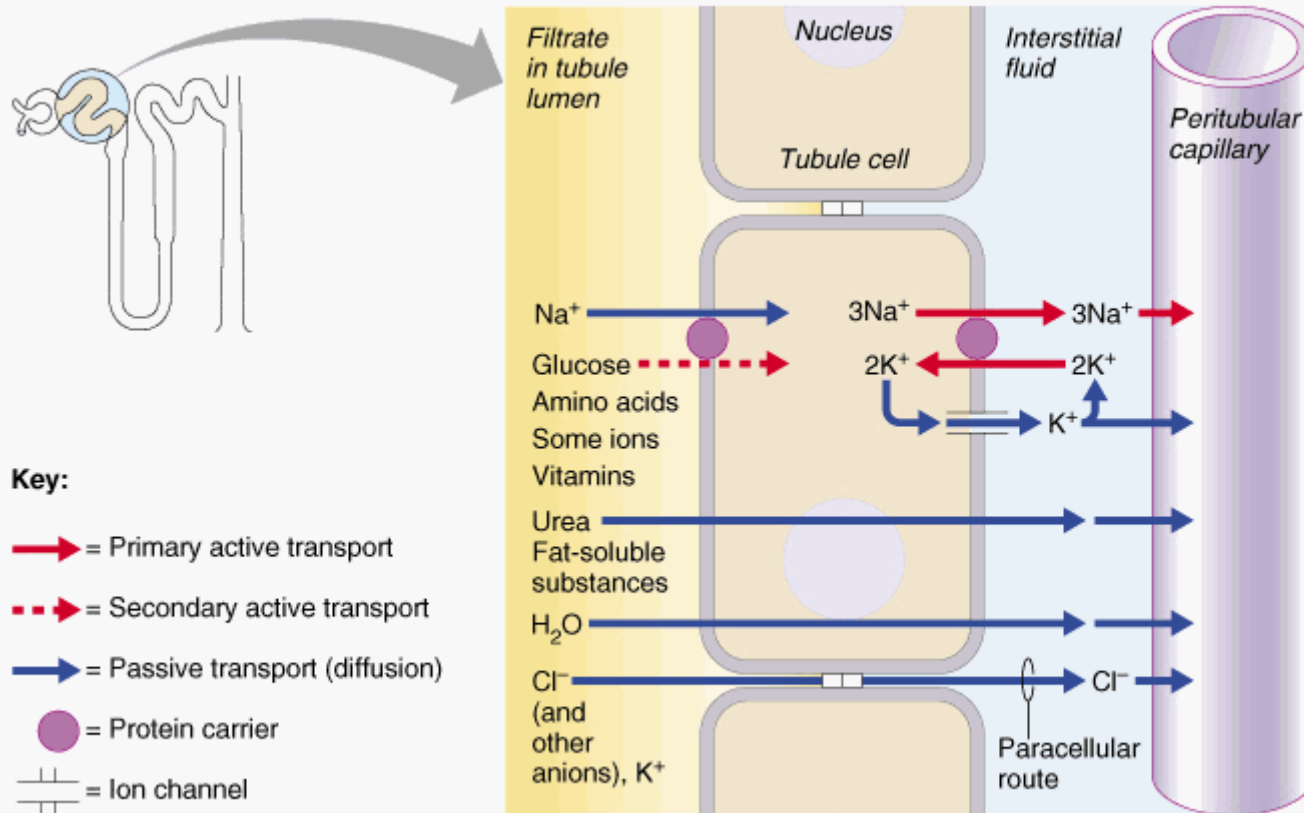
- ✓ Most reabsorption occurs : over 80%
 - All glucose, amino acids, vitamins and hormones
 - 85% of NaCl and other ions

Diffusion

- ✓ 40-50% of urea

Osmosis

- ✓ 85% of water



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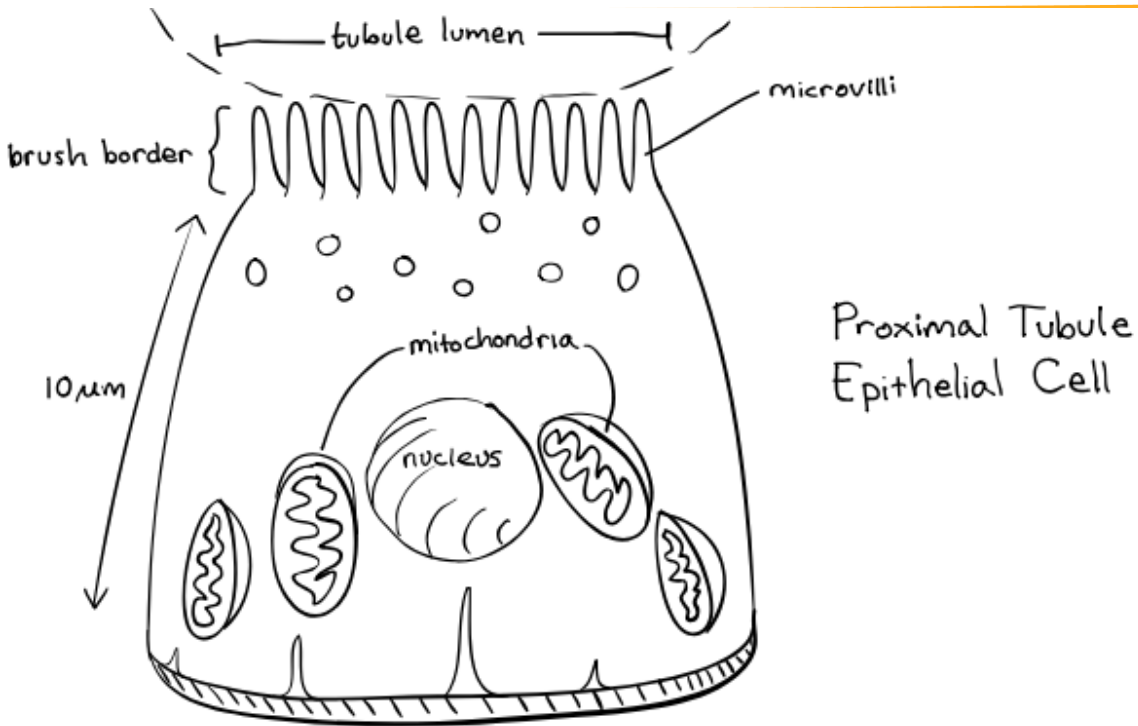
. REABSORPTION

➤ Occurs in:

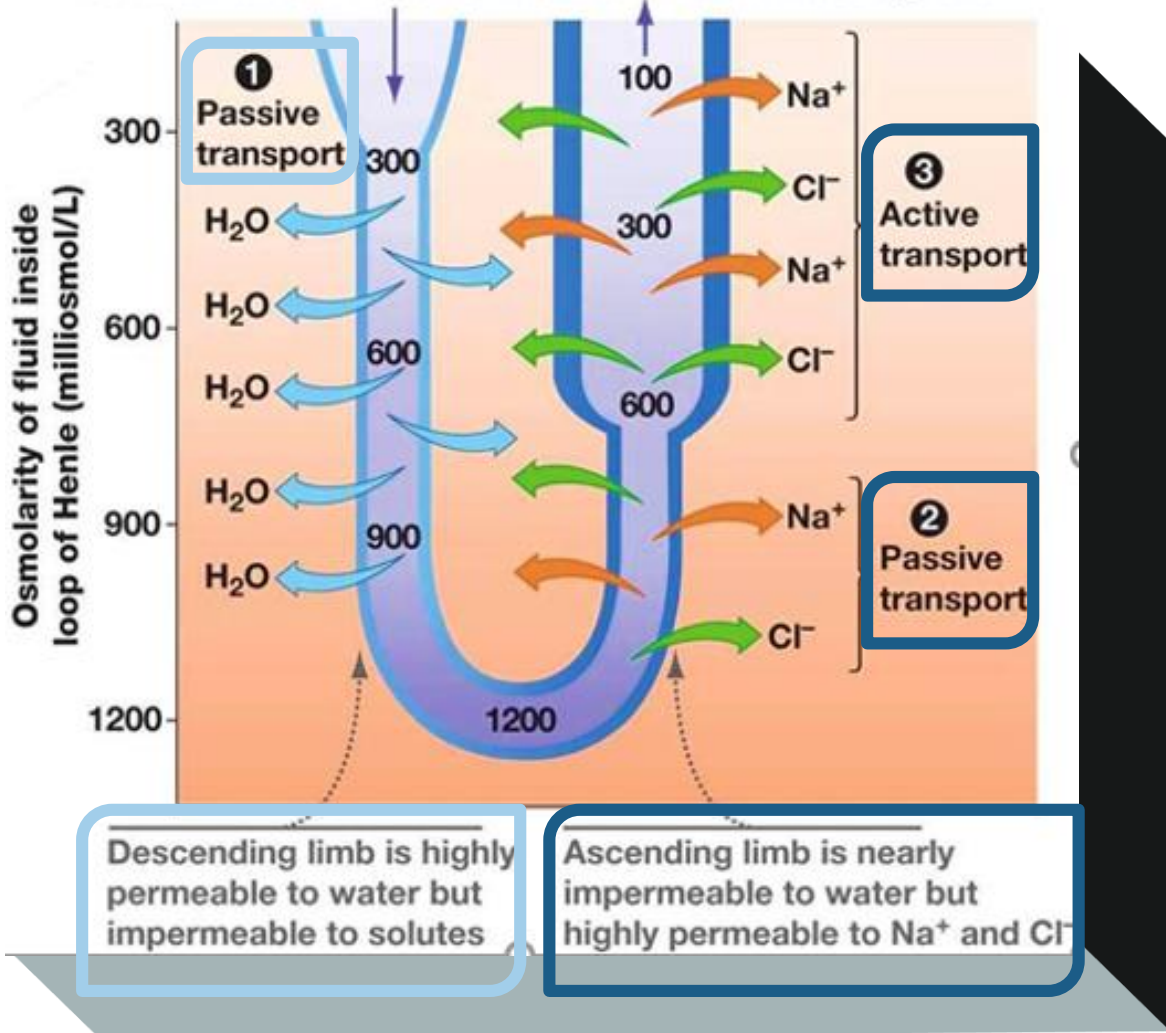
✓ Proximal convoluted tubule

- ✓ **Luminal surface** of the epithelial is covered with **densely packed microvilli**
 - greatly **increase the luminal surface area** of the cells
 - facilitating their reabsorptive function.

- ✓ The **cytoplasm** of the cells is **densely packed with mitochondria**
 - **supply the energy** for the active transport of sodium ions out of the proximal tubule.
 - water passively follows the sodium out of the cell along its concentration gradient.



Water and ion movement differ in the three regions.



. REABSORPTION

- Occurs in:
 - ✓ Loop of Henle

Function:

- To **create a water potential gradient**
 - Between the filtrate and the interstitial fluid in the medulla

Longer : urine produced is more concentrated

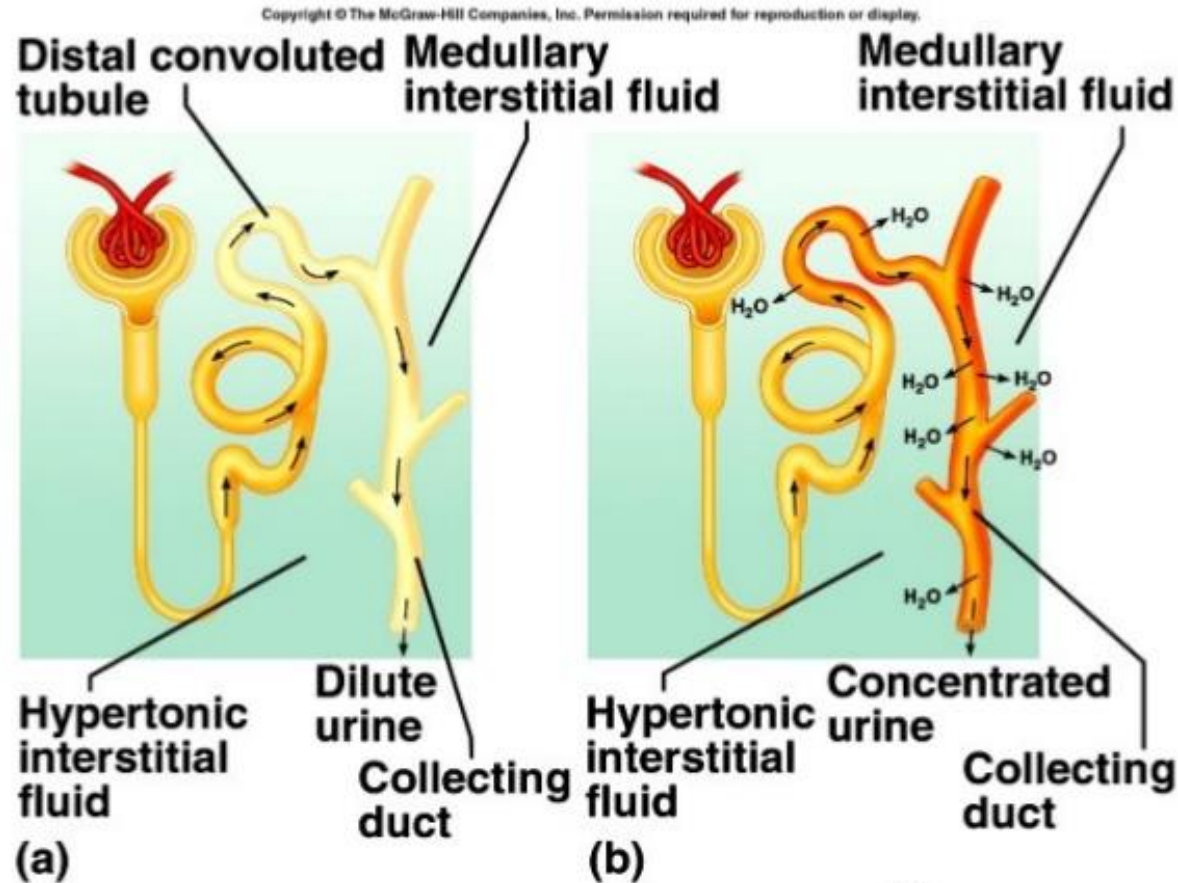
9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

. REABSORPTION

- Occurs in:
 - ✓ Distal convoluted tubule

- Receives a **hypotonic filtrate** from the ascending limb
- **Not permeable to water** but depends on hormonal control
- Becomes **permeable under hormonal control**
 - Anti-diuretic hormone (ADH)

- Active reabsorption of Na^+ under hormonal control
 - Aldosterone



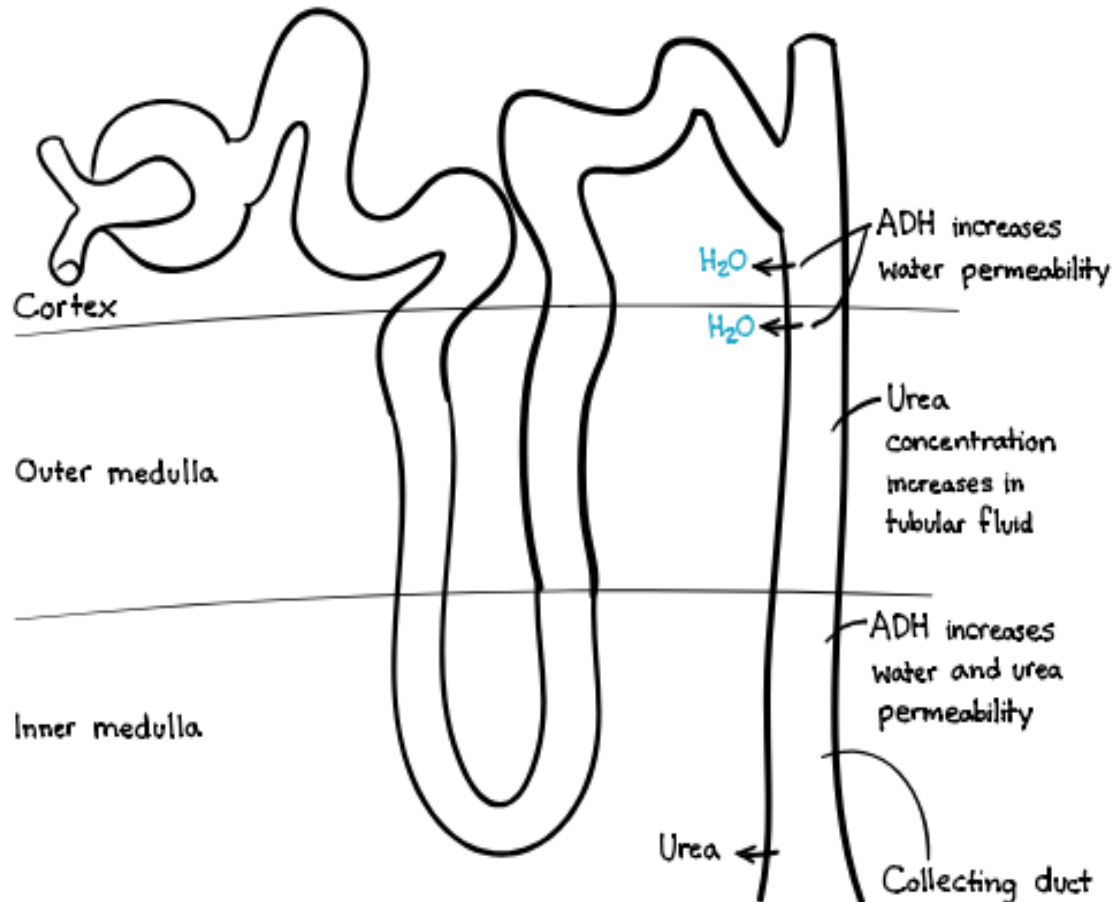
. REABSORPTION

- Occurs in:
 - ✓ Collecting duct

- Carries the filtrate from cortex to medulla to the renal pelvis
- **Permeability to water and urea** is under hormonal control

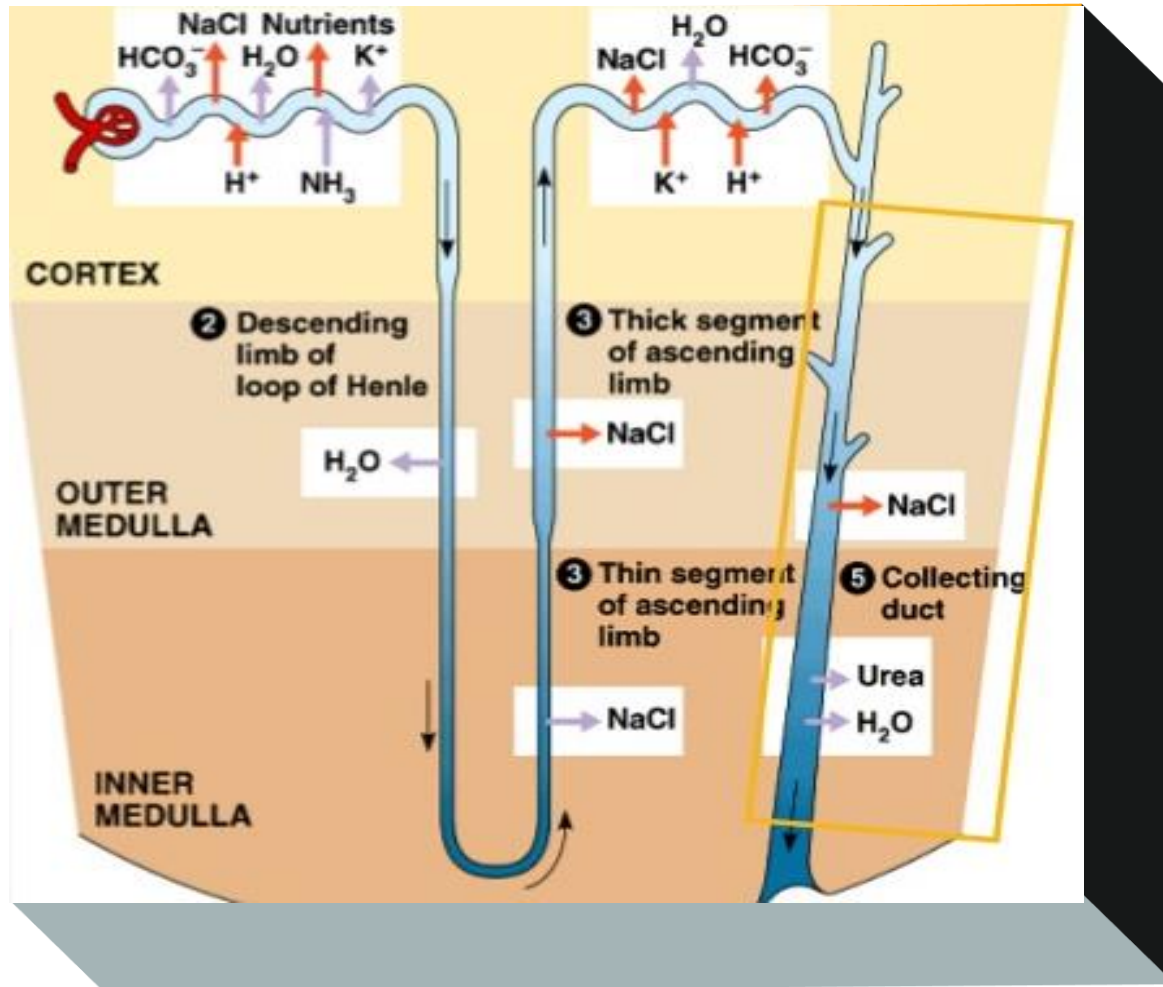
→ **Anti-diuretic hormone (ADH)**

- When the filtrate pass along the collecting duct
 - Water moves out **by osmosis to the interstitial fluid**



9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

. REABSORPTION



- Occurs in:
 - ✓ Collecting duct

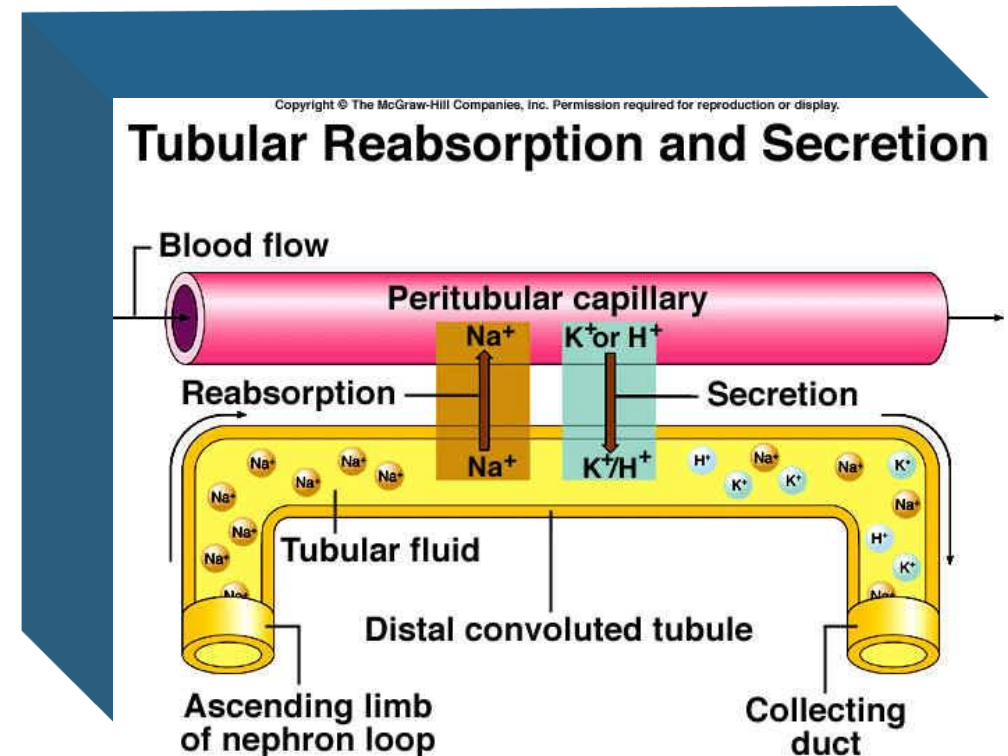
- Some **urea** will also **diffuse out**
 - **along with NaCl**, contributes to the high concentration of solute (lower water potential) in the interstitial fluid
- This urea is recycled by **diffusion into** the **ascending limb** of loop of Henle

9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

. SECRETION

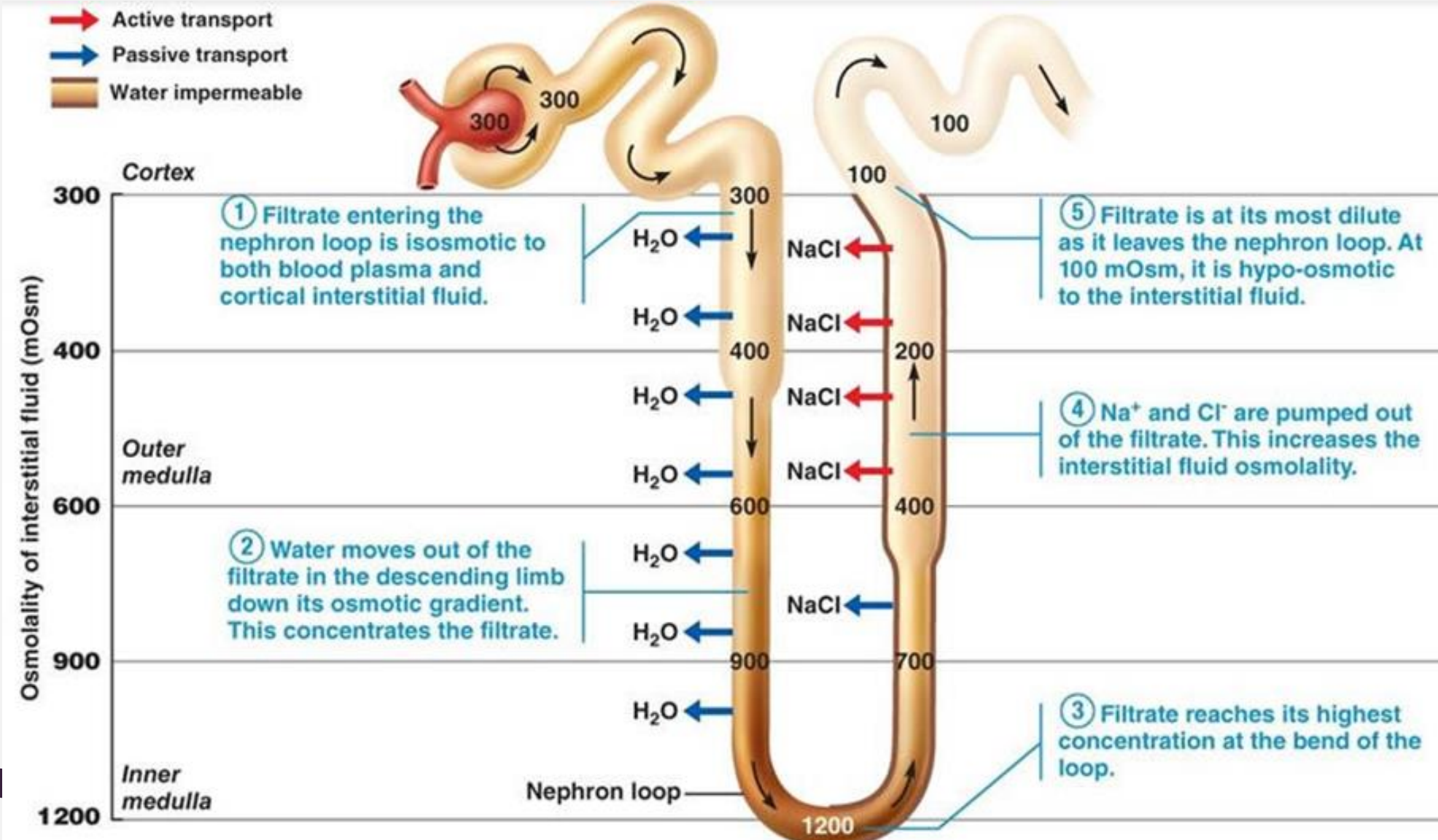
- ✓ Distal tubule **secretes** H^+ and NH_3 from the blood into the filtrate
 - Helps to maintain blood pH
- ✓ **Secretion of K^+** occurs under hormonal control: **aldosterone**
- ✓ **Proximal & distal tubule** also actively **secretes harmful or toxic** substances into the filtrate
- ✓ Removed by urine
e.g: drugs such as penicillin and caffeine

- Occurs in:
 - ✓ Distal convoluted tubule



9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

c) Describe the counter current multiplier mechanism in urine formation.



Counter-current multiplier

The interaction between the flow of filtrate through the ascending and descending limbs of loop of Henle and the flow of blood in the vasa recta

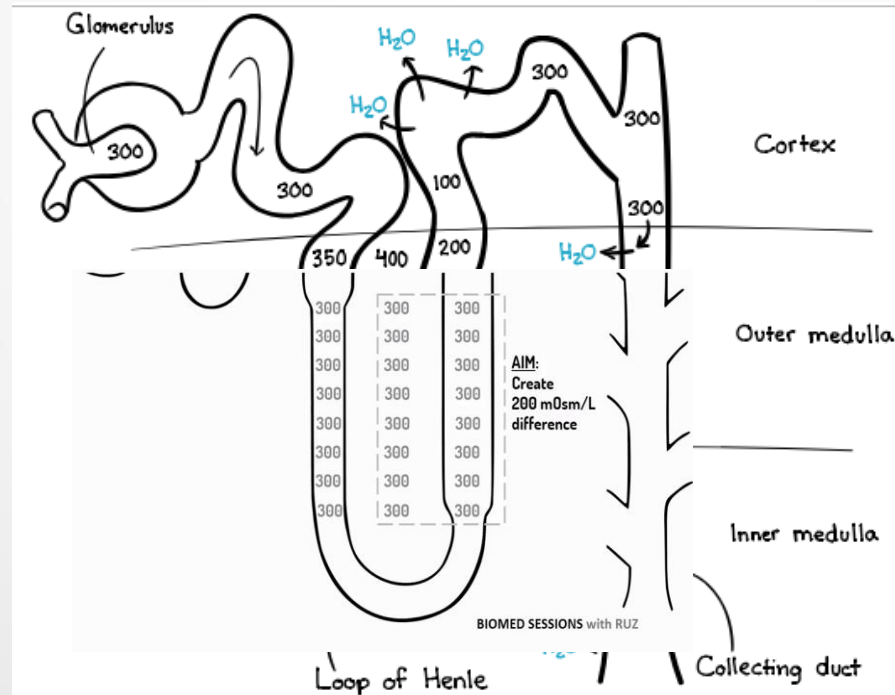
Function:

To establish and maintain a high salt concentration in the loop of Henle extending from the cortex through the medulla

✓ Enable water to be reabsorb into the vasa recta >> Water conservation

✓ Counter-current mechanism

- Filtrate past each other in opposite directions
- The descending and ascending limb



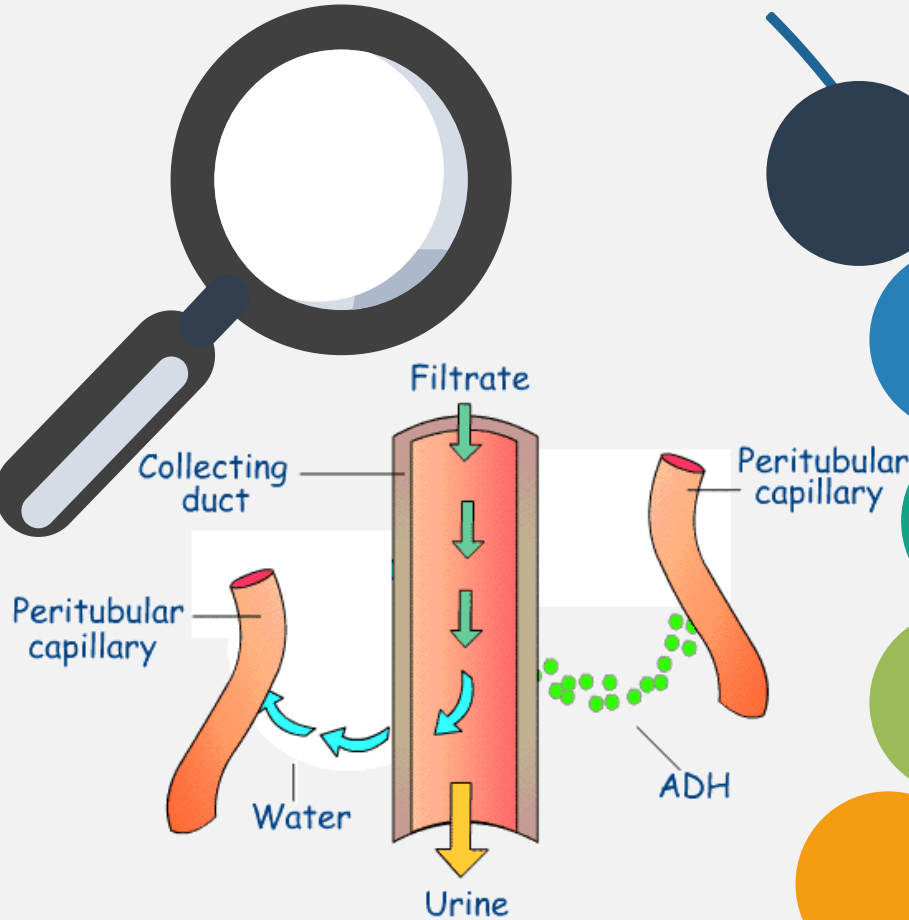
Numbers indicate osmolarity in (mosm/L)

Multiplier

- Filtrate flow down the descending limb
 - High concentration of NaCl
 - Most hypertonic round the hairpin
- Filtrate flow up the ascending limb
 - Less concentration of NaCl
 - More hypotonic

**9.3 Human homeostatic organ:
STRUCTURE AND FUNCTION OF KIDNEY**

d) Relate the regulation of blood water content with ADH



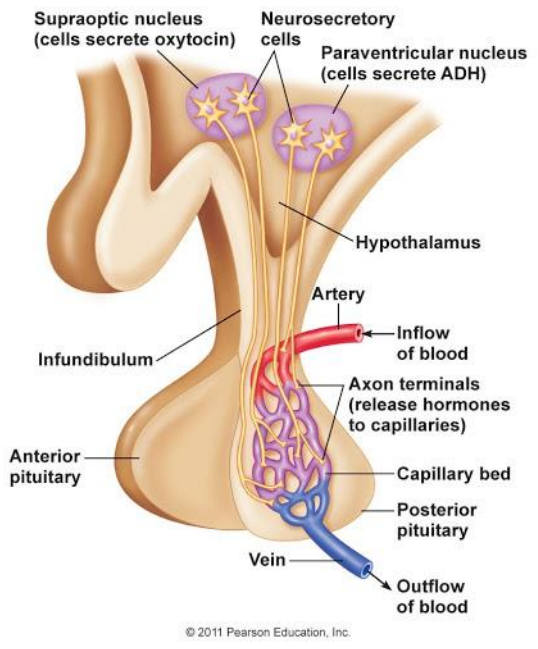
Controlled by Antidiuretic hormone (ADH)

Produced in hypothalamus

Released by posterior pituitary gland

Target tissue : Distal convoluted tubule and collecting ducts

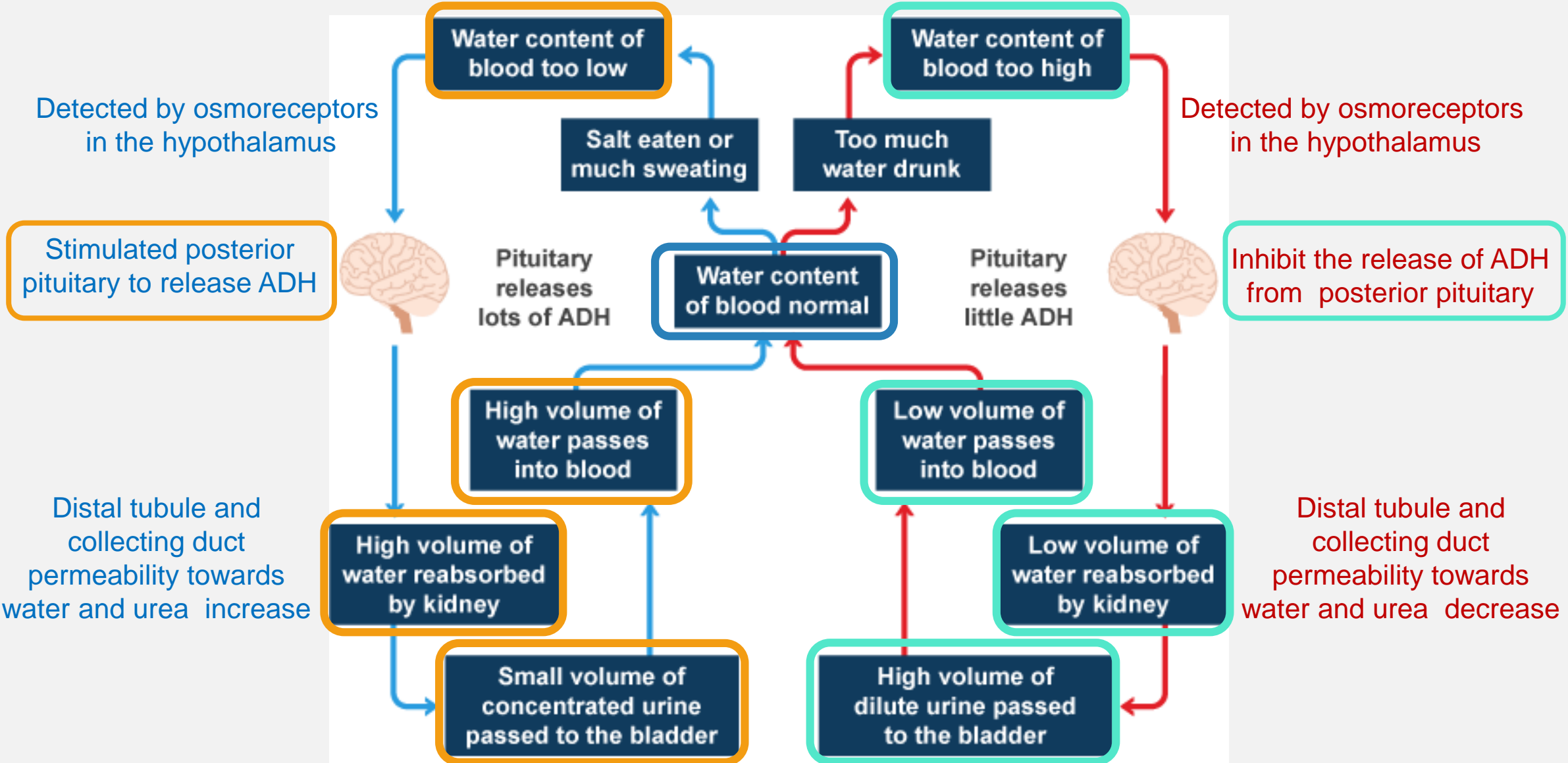
Actions : Increases permeability to water and urea



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9.3 Human homeostatic organ: STRUCTURE AND FUNCTION OF KIDNEY

d) Relate the regulation of blood water content with ADH



Revision

- HOMEOSTASIS -

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CONCEPT OF HOMEOSTASIS
NEGATIVE FEEDBACK MECHANISM

<http://gg.gg/quizletHomeostasis1>



HUMAN HOMEOSTATIC ORGAN:
STRUCTURE AND FUNCTION OF KIDNEY

http://gg.gg/quizletHomeostasis_Kidney



NEXT LECTURE : COORDINATION

