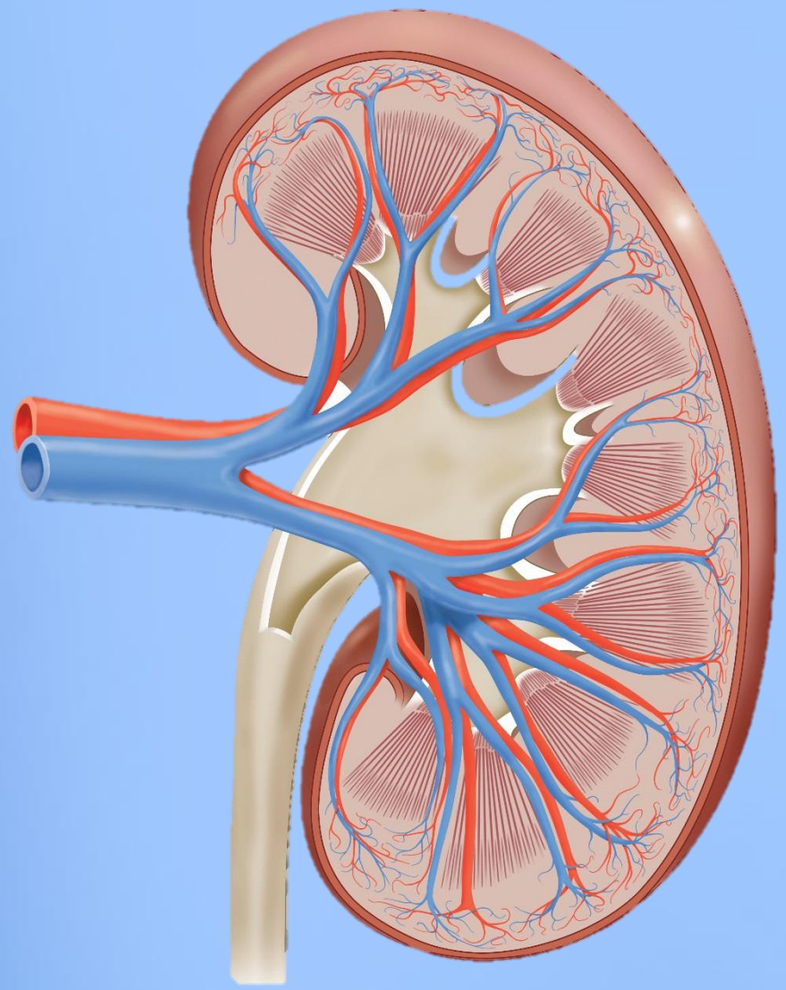
5&6

REABSORBATION AND SECRETION



Renal Block

@PhysiologyTeam

Pht433@gmail.com

Contact us: pht433@gmail.com

Objectives

Define tubular reabsorption, tubular secretion, transcellular and paracellular transport.

Identify and describe mechanism involved in Glucose reabsorption

Describe tubular secretion with PAH transport and K^+

Identify and describe mechanisms of tubular transport &
Describe tubular reabsorption of sodium and water

Study glucose titration curve in terms of renal threshold, tubular transport maximum, splay, excretion and filtration

Identify and describe the characteristic of loop of Henle, distal convoluted tubule and collecting ducts for reabsorption and secretion

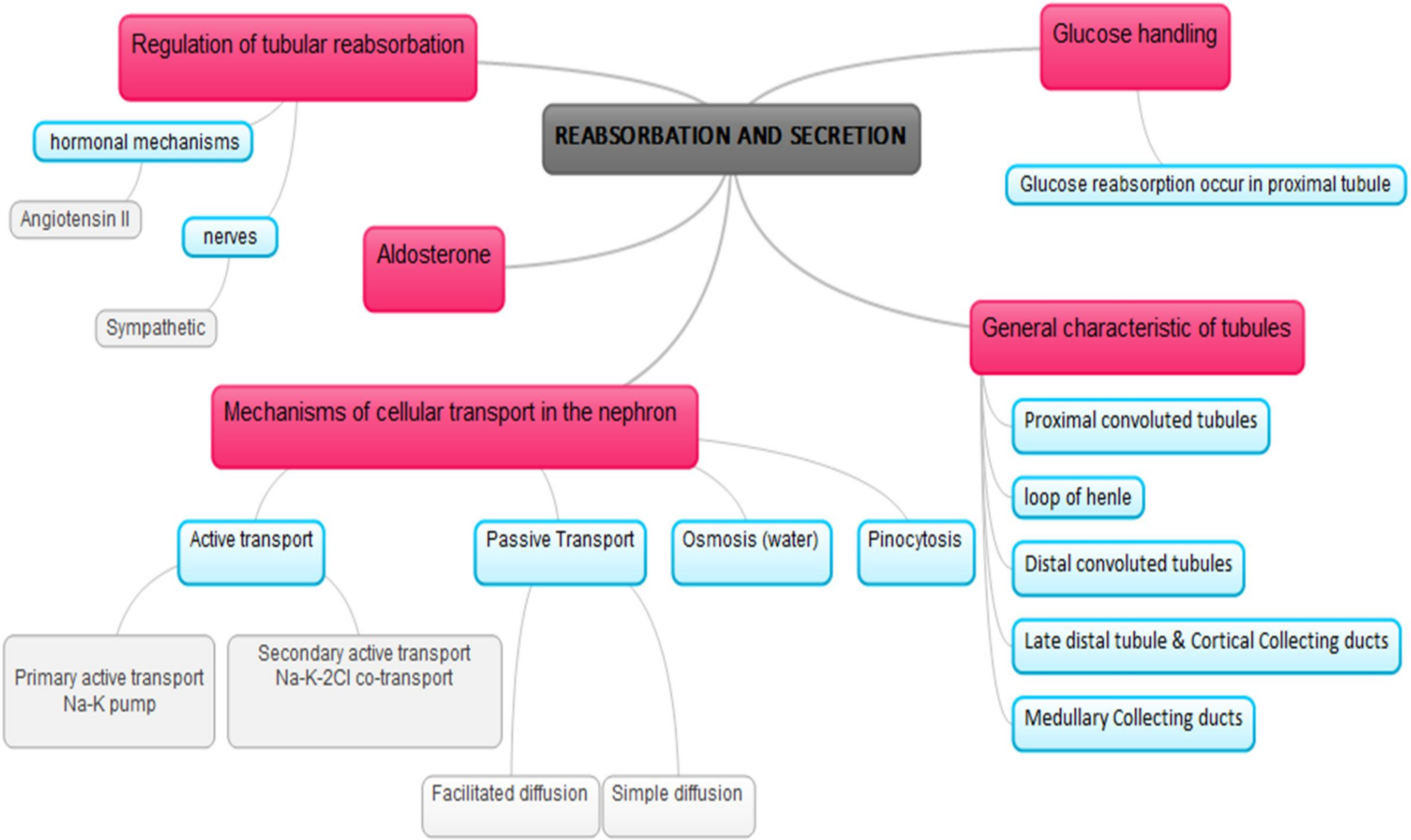
Revise tubule-glomerular feedback and describe its physiological importance

Identify the tubular site and describe how Amino Acids, HCO_3^-, Po_4^- and Urea are reabsorbed

Identify the site and describe the influence of aldosterone on reabsorption of Na^+ in the late distal tubules.

Contact us: pht433@gmail.com

Mind Map


REABSORBATION AND SECRETION
Regulation of tubular reabsorbation
hormonal mechanisms
Angiotensin II
nerves
Sympathetic
Aldosterone
Glucose handling
Glucose reabsorption occur in proximal tubule
General characteristic of tubules
Proximal convoluted tubules
loop of henle
Distal convoluted tubules
Late distal tubule & Cortical Collecting ducts
Medullary Collecting ducts
Mechanisms of cellular transport in the nephron
Active transport
Primary active transport
Na-K pump
Secondary active transport
Na-K-2Cl co-transport
Passive Transport
Facilitated diffusion
Simple diffusion
Osmosis (water)
Pinocytosis

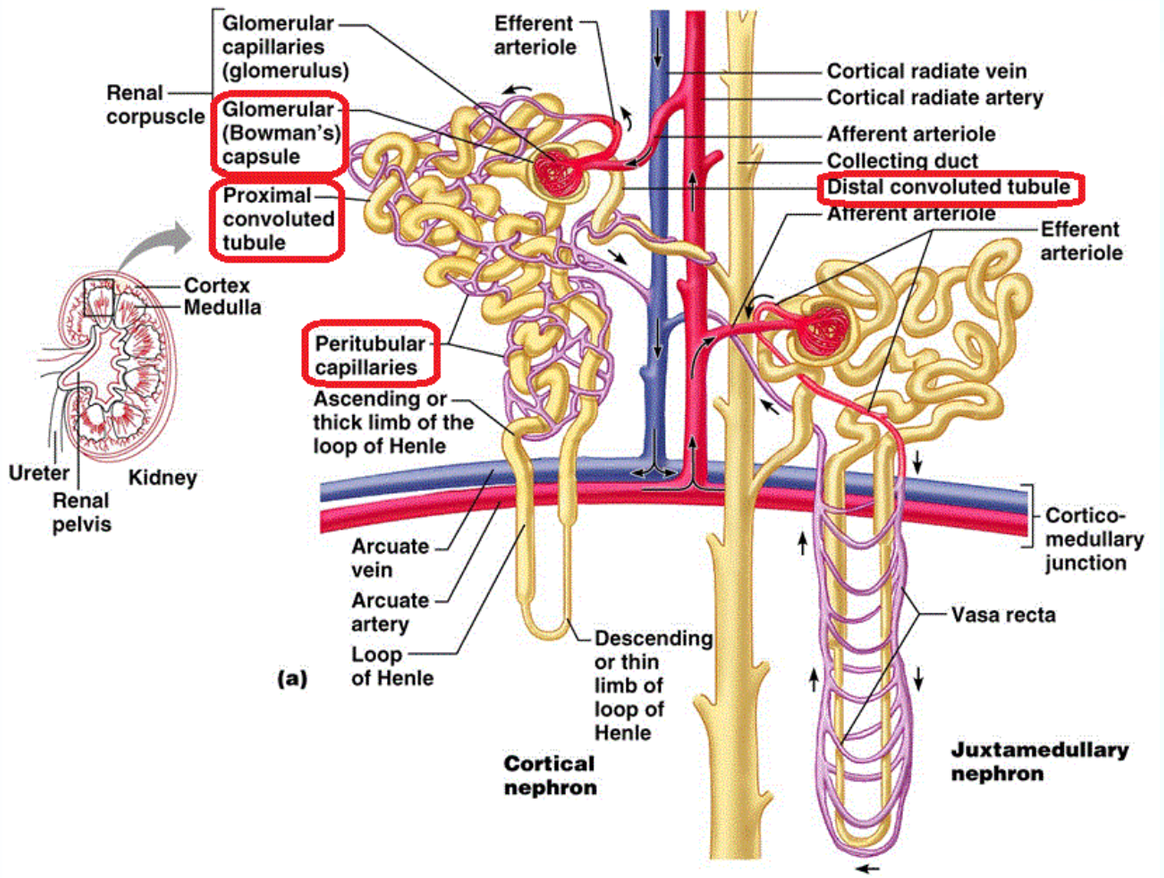
Reabsorbation and Secretion

As the glomerular filtrate enters the renal tubules, it flows sequentially through the successive parts of the tubule:
The proximal tubule → the loop of Henle(1) → the distal tubule(2) → the collecting tubule → finally ,the collecting duct, before it is excreted as urine.

A long this course, some substances are selectively reabsorbed from the tubules back into the blood, whereas others are secreted from the blood into the tubular lumen.

The urine represent the sum of three basic renal processes: glomerular filtration, tubular reabsorption, and tubular secretion:

Urinary excretion = Glomerular Filtration – Tubular reabsorption + Tubular secretion



Mechanisms of cellular transport in the nephron are:

Active transport

"Active transport can move a solute **against an electrochemical gradient** and **requires energy** derived from metabolism"

Primary active transport

Transport that is coupled directly to an energy source such as **ATP**

- **Sodium-potassium pump**

  (found in **basolateral membrane** along renal tubules)

- H+-pump

Secondary active transport

Transport that is coupled indirectly to an energy source due to **concentration gradient of ion**

- **Na-K-2Cl co-transport**
- **glucose-sodium co-transport (SGLT)**
- **amino acid-sodium co-transport**
- **H+/Na counter-transport**

Passive Transport

Simple diffusion

(without carrier protein)

Cl, HCO3-, urea , creatinine

Facilitated diffusion

(require carrier protein)

Glucose and amino acids at the basalateral border (GLUT)

Osmosis

Water is always reabsorbed by a passive (nonactive) physical mechanism called osmosis ,

which means water diffusion from a region of **low solute concentration (high water concentration)** to

one of **high solute concentration (low water concentration).**

Pinocytosis\ exocytosis

(Additional reading)

The proximal tubule, reabsorb **large molecules such as proteins** by pinocytosis. In this process, the protein attaches to the brush border of the luminal membrane, then invaginates to the interior of the cell until it is completely pinched off and a vesicle is formed containing the protein. Once inside the cell

the protein is digested into its constituent amino acids, which are reabsorbed through the **basolateral membrane** into the interstitial fluid. Because pinocytosis requires energy, it is considered a form of **active transport.**

(1) Co-transport : movement of two molecules in the same direction but they opposite in concentration gradient

(2) Counter-transport: movement of two molecules in opposite direction based on their concentration gradient

Tubular Reabsorbation

The ways of transport:

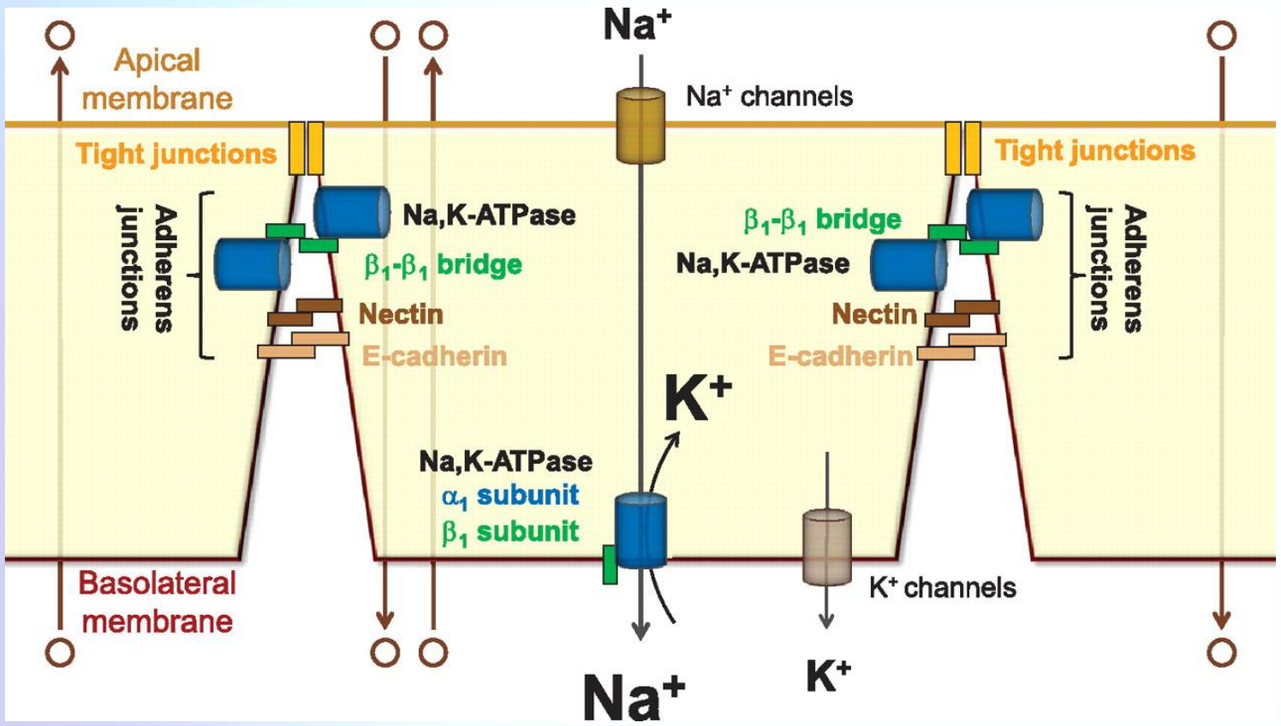
1- From lumen of tubules (Apical membrane"1") to epithelial cells then from epithelial cells to interstitium (Basolateral membrane):

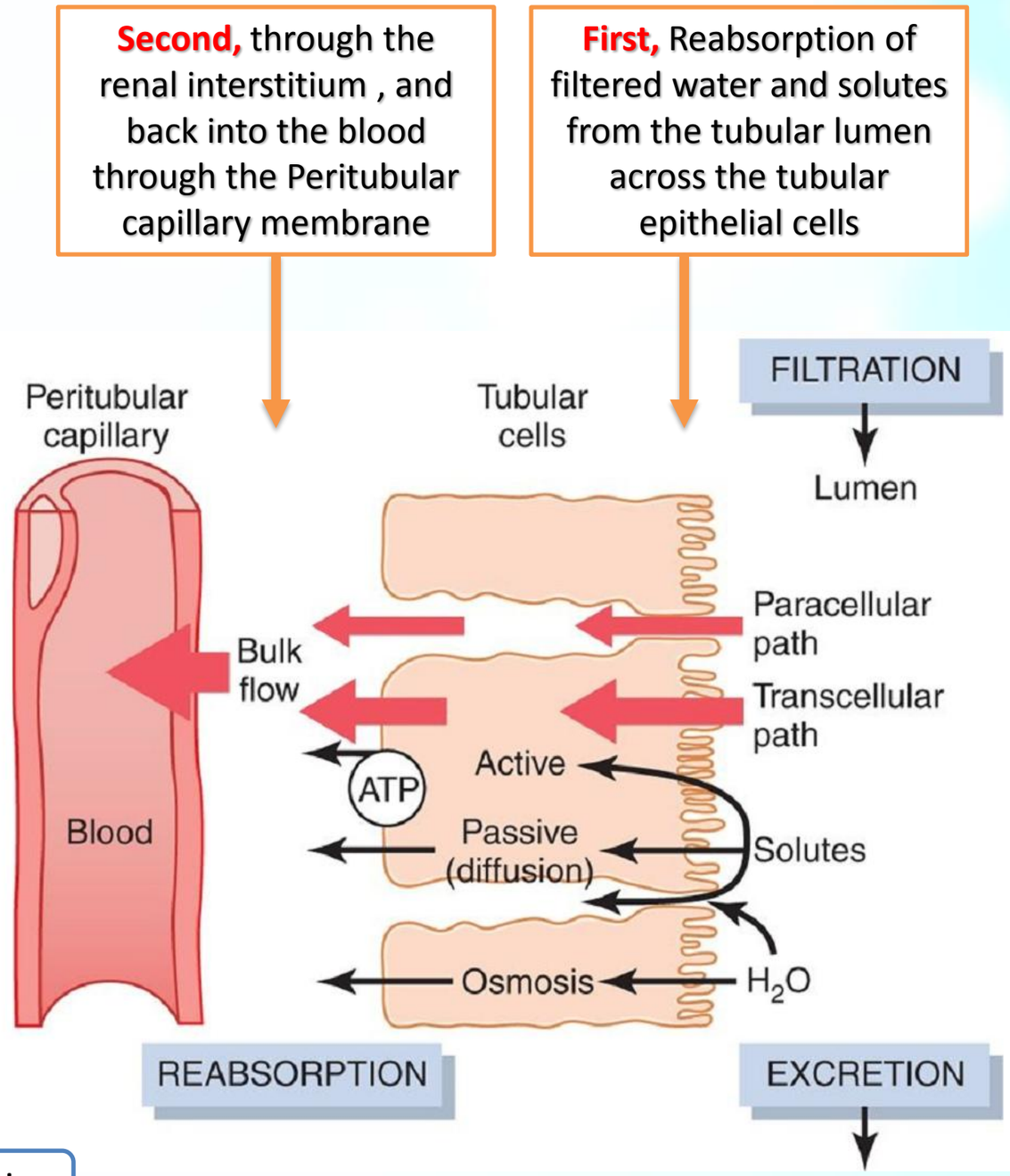
A-Transcellular route: (through the cell membrane)

B-Paracellular route: (between spaces of tight cell junction)

2- From interstitium (basolateral space) to the Peritubular capillaries: By **ultrafiltration (bulk flow)** that is mediated by:

hydrostatic and colloid osmotic forces





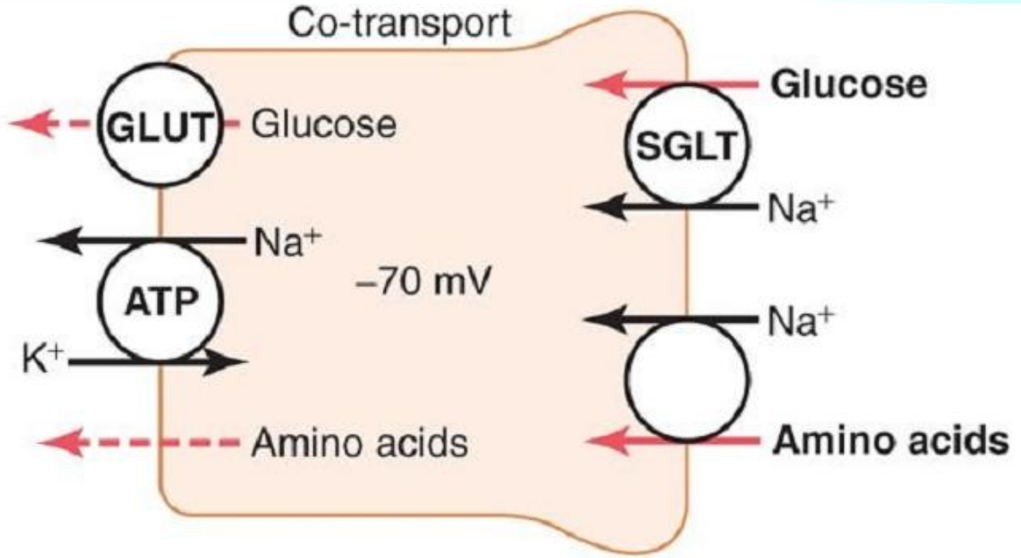
(1) Apical membrane = brush border which is numerous to help in reabsorbation

How is transportation take place from tubules to interstitium?

1. :

A. Sodium diffuses across the luminal membrane (also called the apical membrane) into the cell down an electrochemical gradient (with other substances such as glucose, amino acids etc.) established by the sodium -potassium ATPase pump on the basolateral side of the membrane.

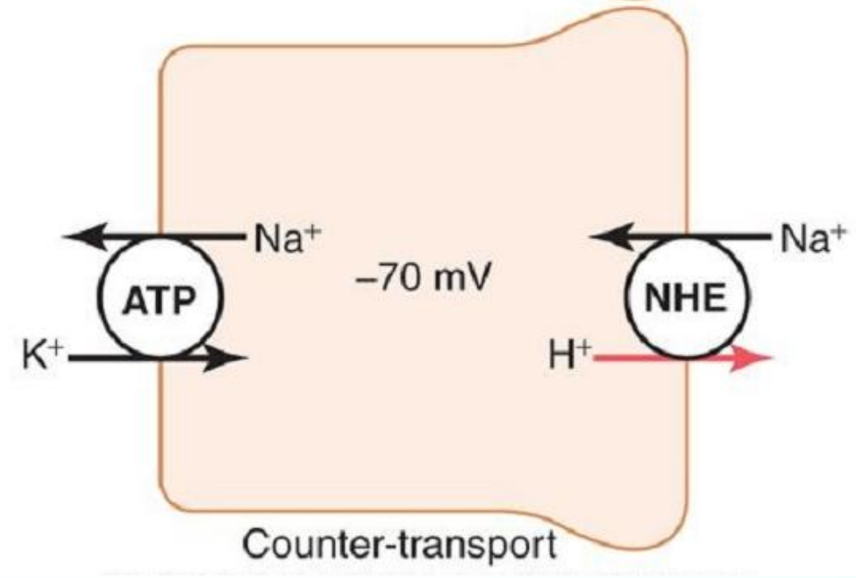
B. Other molecules like water and Cl , Ca etc. by osmosis and diffusion



2. :

A. Sodium is transported across the basolateral membrane against an electrochemical gradient by the sodium -potassium ATPase pump

B. other substances will across the basolateral membrane by passive diffusion



3. Sodium , water , and other substances are reabsorbed from the interstitial fluid into the Peritubular capillaries by ultrafiltration (bulk flow "1"), a passive process driven by the hydrostatic and colloid osmotic pressure gradients

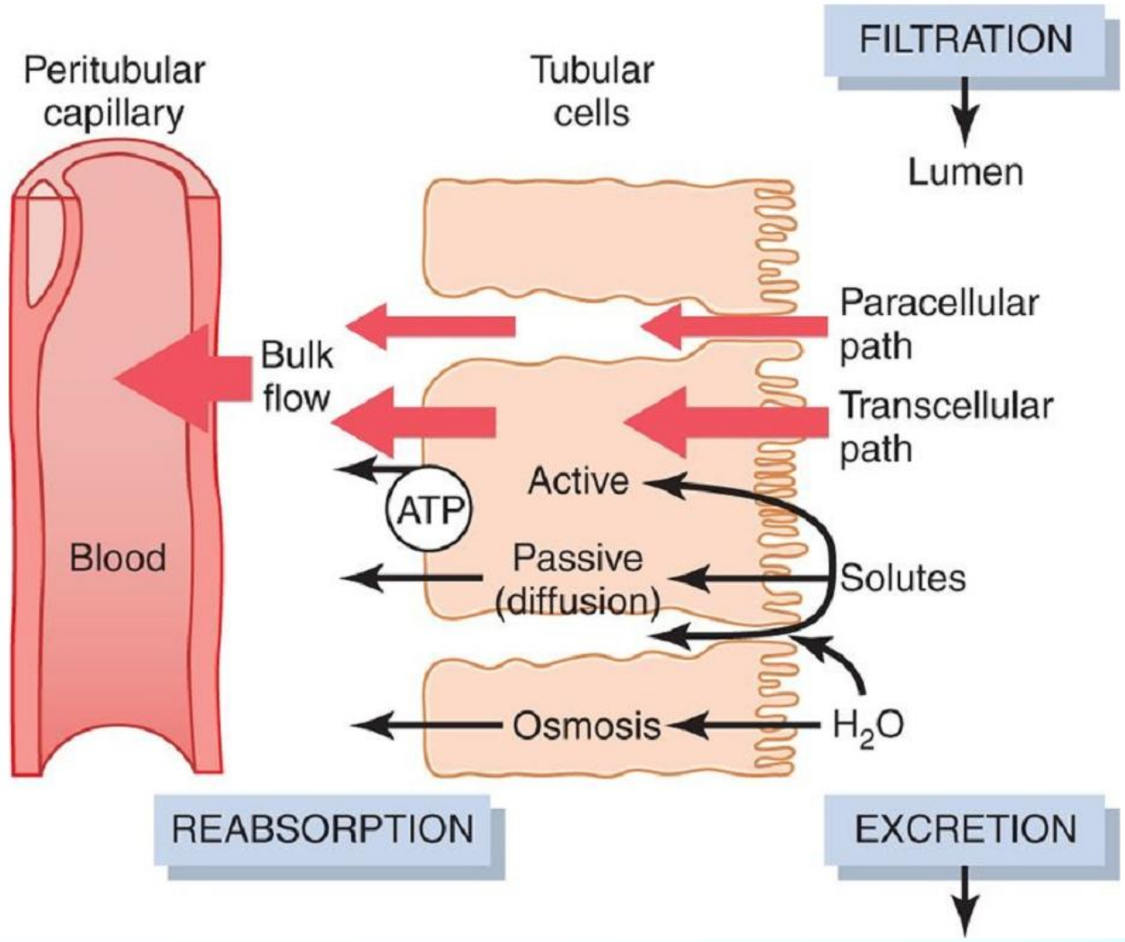
(1) **Bulk flow =** movement of water with other substances While **diffusion** = movement of substances without water.

How ultrafiltration take place?

In Peritubular capillaries the high plasma oncotic pressure is due to fluid filtration in glomerulus

increase GFR → increase oncotic pressure & decrease hydrostatic pressure in efferent & Peritubular capillaries → increase bulk flow from lateral space to Peritubular capillaries → increse reabsorption

decrease GFR → decrease oncotic pressure & increase hydrostatic pressure → decrease bulk flow → fluid go back to lumen through tight junction → decrease reabsorption



General characteristic of tubules

Proximal convoluted tubule

1- **Proximal tubules is coarse adjustment (reabsorption a most of of water and solutes)**

3-100% of glucose and amino acids reabsorbed

2- Solute reabsorption in the proximal tubule is isosmotic (equal amount of solute and water are reabsorbed)

(1) Concentrate urine = remove water from fluid
(2) Dilute urine = remove solutes from urine

* The main function of tubules is concentrate urine and that has done in loop of henle of Juxtamedullary nephron

* Sodium-potassium pump that found in distal convoluted tubules is under control of aldosterone

Loop of henle

1- Responsible for producing a **concentrated urine** in the medulla.

2- When **ADH (antidiuretic hormone)** is present, **water is reabsorbed and urine is concentrated.**

Descending limb: (concentrate urine "1")
1- **water** permeable and allow **absorption of 25% of filtered H2O**.
2-It is **impermeable** to **Na-CL**.
3-fluid become **hyper-osmolar**

Thin ascending limb: (dilute urine "2")
1- impermeable to **H2O**
2- permeable to **NaCl (passive)**
3-By the end of ascending limb of loop, the tubular fluid becomes **hypo-osmolar**

Thick ascending limb: (dilute urine)
1- impermeable to **H2O**
2- **Na-K-2Cl co-transport** occur in this part. **(active)**
3-the tubular fluid becomes **hypo-osmolar** to plasma in this part

Distal convoluted tubules

1- **Distal tubule is fine adjustment (reabsorption a fine amount of water and solutes by hormonal control based on body needs)**

2- The first portion of DCT forms part of **Juxtaglomerular Apparatus**, that provides feedback control of GFR and RBF of the same nephron.

3-The next early portion has the same characteristics as **ascending limb of Henle** that is
1-impermeable to water
2-absorbs solutes.
So it is called the **diluting segment** & the osmotic pressure of the fluid ~ 100 mOsm/L.

Late distal convoluted tubules & cortical collecting ducts

1- Composed of two types of cells:
a. **Principal cells:** absorb Na+& H2O and secrete K+
b. **Intercalated cells:** absorb K+ & secrete H+

•Secretion of K+ and reabsorption of Na+ controlled by aldosterone.

2- water permeability under ADH control. (works under body needs)

3- Impermeable to Urea.

Medullary collecting ducts

1- Under ADH control. (works under body needs)
2- Highly permeable to urea.
3- Final site for processing urine.
4- Secretes H+ helps to:
a- maintain blood pH
b- reabsorb HCO3 and generate new HCO3

Continues in renal pelvis, ureters, urinary bladder and urethra

	Reabsorbation	Secretion
Proximal convoluted tubules	- Poorly reabsorbed of creatinine and urea - 60% - 75% of sodium and water - 90% of HCO3, K+, Ca and Cl- - 100% Glucose and amino acids	- H+ - Urea - ammonia
Descending loop of henle	-25% of water (H2O)	_____
Thin ascending loop of henle	- Sodium chloride (NaCl)	_____
Thick ascending loop of henle	- Sodium - Potassium - Chloride	_____
Distal convoluted tubules	- Sodium in response to **aldosterone** - Water in response of **ADH** - Calcium in response of **parathyroid hormone**	- Potassium in response of **aldosterone**
Late distal tubule & Cortical Collecting ducts	a. Principal cells: absorb Sodium Na+ & H2O b. Intercalated cells: absorb Potassium K+ & HCO3 -Water in response of **ADH** - Sodium in response to **aldosterone** - Calcium in response of **parathyroid hormone**	a. **Principal cells:** secert K+ b. **Intercalated cells**: secret H+ Potassium in response of **aldosterone**
Medullary Collecting ducts	-Water in response of **ADH** **- Highly permeable to urea (to maintain osmolarity of medulla)**	- H+

	Site	Between	Functions
Primary Active Transport			
Sodium-potassium pump	All renal tubules	Basolateral membrane	Reabsorbation of sodium and secrete potassium to maintain the intracellular and extracellular balance of Na and K
Secondary Active Transport			
H+/Na counter-transport	Proximal convoluted tubules, Distal convoluted tubules and collecting ducts	Apical membrane	Reabsorbation of sodium and secrete hydrogen ion and It is coupled with bicarbonate transport
HCO3/Na co-transport	Proximal convoluted tubules, Late distal convoluted tubules and collecting ducts	Basolateral membrane	Reabsorbation of sodium and bicarbonate
Na-K-2Cl co-transport	Thick ascending limb of henle's loop	Apical membrane	Reabsorbation of sodium, potassium and two chloride to dilute water
glucose-sodium co-transport (SGLT)	Proximal convoluted tubules	Apical membrane	Reabsorbation of sodium and glucose
Amino acid-sodium co-transport	Proximal convoluted tubules	Apical membrane	Reabsorbation of sodium and amino acid
Simple diffusion			
Passive NaCl transport	Thin ascending limb of henle's loop	Apical membrane	Reabsorbation of NaCl to dilute fluid in tubules
Passive channels of K+ , Cl , Ca etc.	All renal tubules	Apical membrane & Basolateral membrane	Reabsorbation and secretion
Facilitated diffusion			
Glucose transporter (GLUT)	Proximal convoluted tubules	Basolateral membrane	Reabsorbation of glucose to interstitial fluid
Osmosis			
Water	**All renal tubules except:** 1- thin and thick ascending limp and 2- early portion of distal convoluted tubules	Apical membrane & Basolateral membrane	Reabsorbation of water

Glucose handling

GLUCOSE REABSORPTION

- Glucose inter the tubular cells by secondary active transport "co-transport", It use **SGLT** "a specific transport protein "which needs Na" .
- Then it's cross the cell membrane into the interstitial spaces by facilitated transport "passive transport" which use **GLUT's** "do not need Na" .
- Glucose reabsorption occur in proximal tubule .

- Essentially all glucose is reabsorbed
- The renal **threshold** for glucose= 180 mg/dl
- the **tubular transport maximum** for glucose Tmg = 375 mg/min in men and 300 mg/min in women.

What cause the excretion of glucose in urine before reach to its maximum transport?

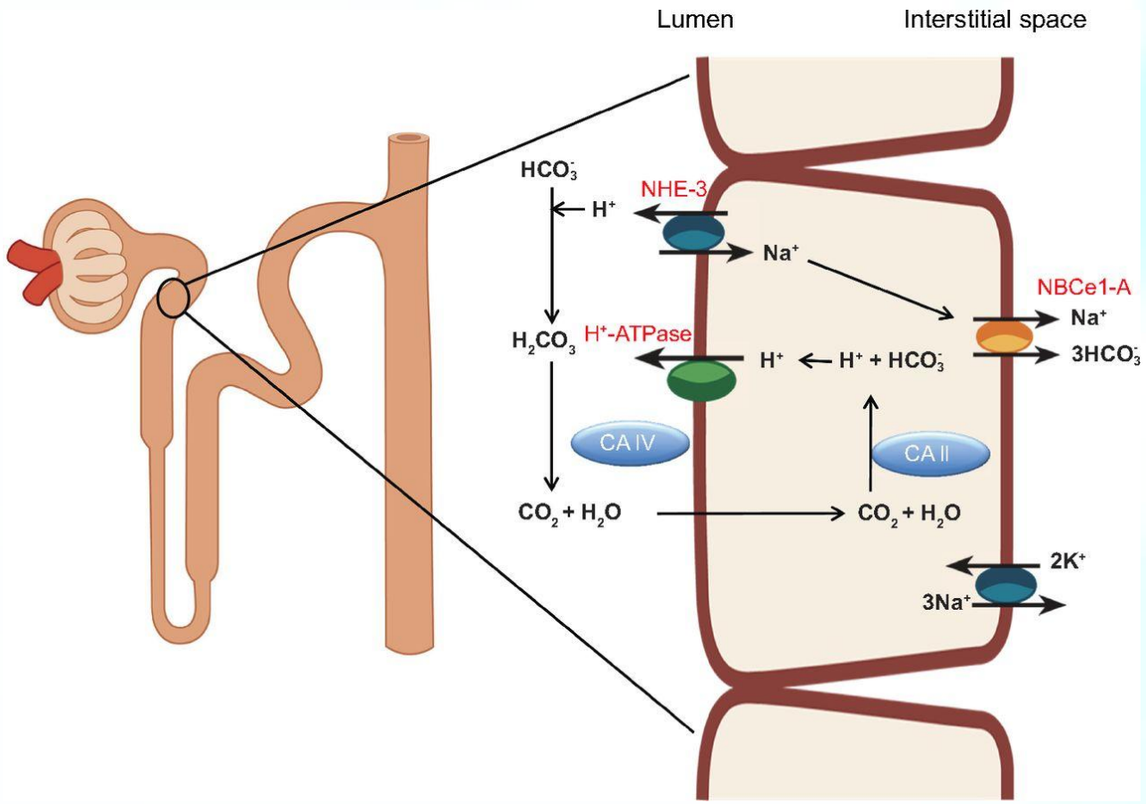
not all nephrons have the same transport maximum for glucose, and some of the nephrons therefore begin to excrete glucose before others have reached their transport maximum

What is the difference between renal threshold and tubular transport maximum ?

Renal threshold : it's the rate that glucose begins to appear in the urine .
transport maximum for glucose : all nephrons have reached their maximal capacity to reabsorb glucose "maximum saturation of transporters"

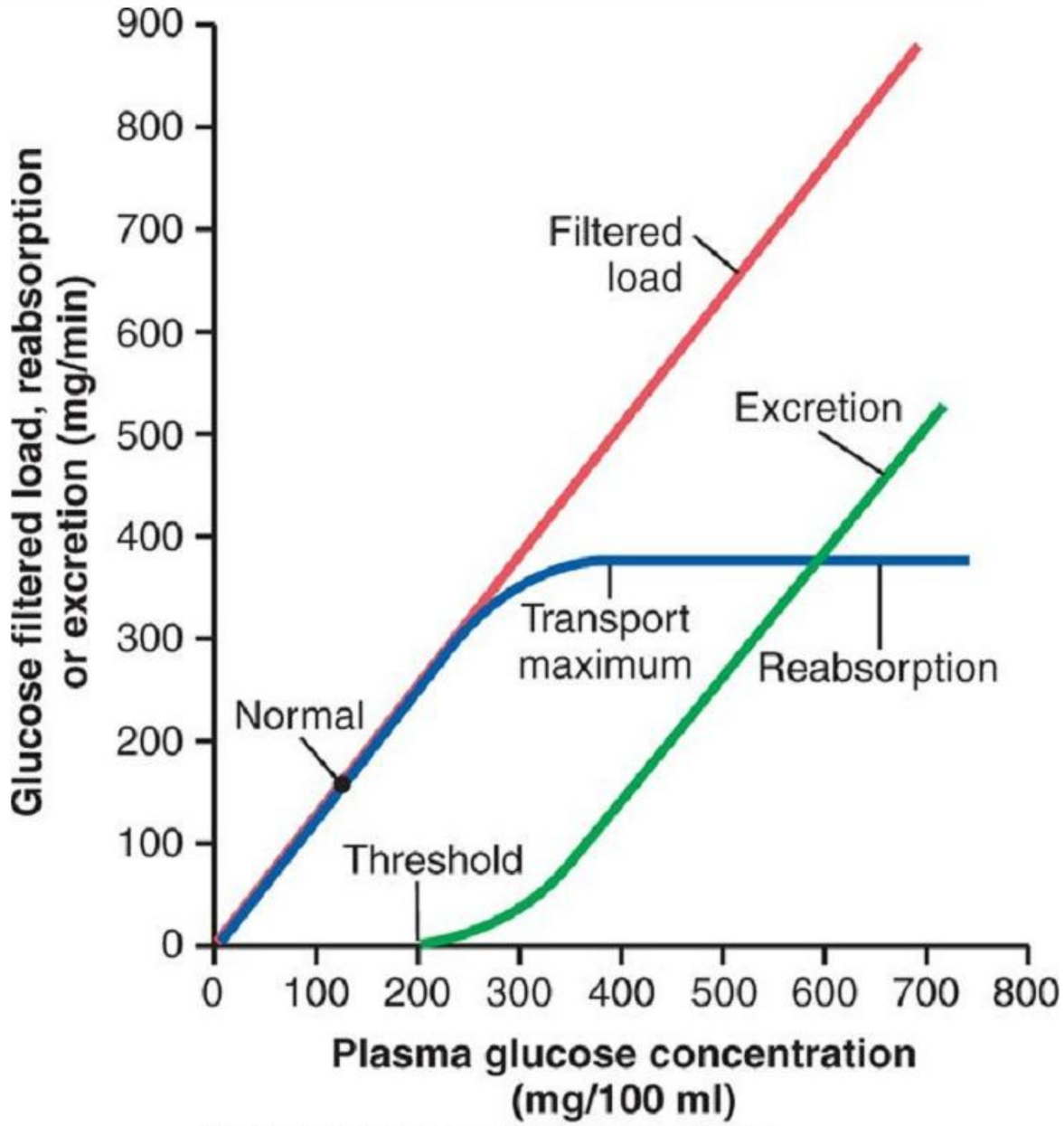
Reabsorption of bicarbonate

1. First of all, bicarbonate (HCO_3^-) attaches itself with hydrogen (H^+) then it becomes H_2CO_3 in the lumen
2. Carbonic Anhydrase will break H_2CO_3 down to water (H_2O) + carbonic dioxide (CO_2) which diffuses into the proximal tubule
3. Carbonic Anhydrase will convert the water (H_2O) + the carbon dioxide (CO_2) to HCO_3^- + H^+
4. Hydrogen will transport out and sodium (Na) will come in the proximal tubule
5. Lastly, the HCO_3^- will go into the blood



Contact us: pht433@gmail.com

Glucose titration curve



Relations among the filtered load of glucose, the rate of glucose reabsorption by the renal tubules, and the rate of glucose excretion in the urine

Contact us: pht433@gmail.com

Regulation of tubular reabsorbation

There must be a balance between tubular reabsorption and glomerular filtration.
This is controlled by local , nervous & hormonal mechanisms.

1.Glomerulotubular balance: prevents overloading of distal parts when GFR increases.

2. Peritubular capillary reabsorption is regulated by hydrostatic and colloidal pressures through the capillaries.

3. Arterial blood pressure: if increased it reduces tubular reabsorption. (increase in blood pressure will reduced GFR in response of myogenic mechanism and the decrease reabsorbation)

4. Nervous Sympathetic:
-Increases Na+ reabsorption.

5-Tubuloglomerular feedback: it will observe concentration of sodium chloride by macula dense in distal tubules and what will lead to:
1- constriction and dilatation of afferent arteriole which affect on GFR
2- release renin which increase reabsorabtion of sodium and play a role in production of angiotensin II

6-Hormonal:

- **Angiotensin II : release aldosterone**
- **ADH : H2O reabsorbation**
- **ANP : Sodium excretion and diuresis**
  Parathyroid hormone: Increases Ca reabsorption & decreases phosphate reabsorption

(1) ADH: Antidiuretic hormone
(2) ANP: atrial nitric peptide
(3) Diuresis: increase urine output

Aldosterone

Function

- 1-increases Sodium reabsorption
- 2-stimulates Potassium secretion

When does it secreted?

- (1) Increased extracellular potassium concentration.
- (2) Increased angiotensin II levels, which typically occur in conditions associated with **sodium and volume depletion or low blood pressure (so it will increase blood pressure)**

Site of secretion

- Aldosterone, secreted by the **zona glomerulosa cells** of the **adrenal cortex.**

Mechanism of action

- by stimulating the sodium-potassium ATPase pump on the **basolateral side of the cortical collecting tubule membrane.**
- Aldosterone also increases the sodium permeability of the luminal side of the membrane .

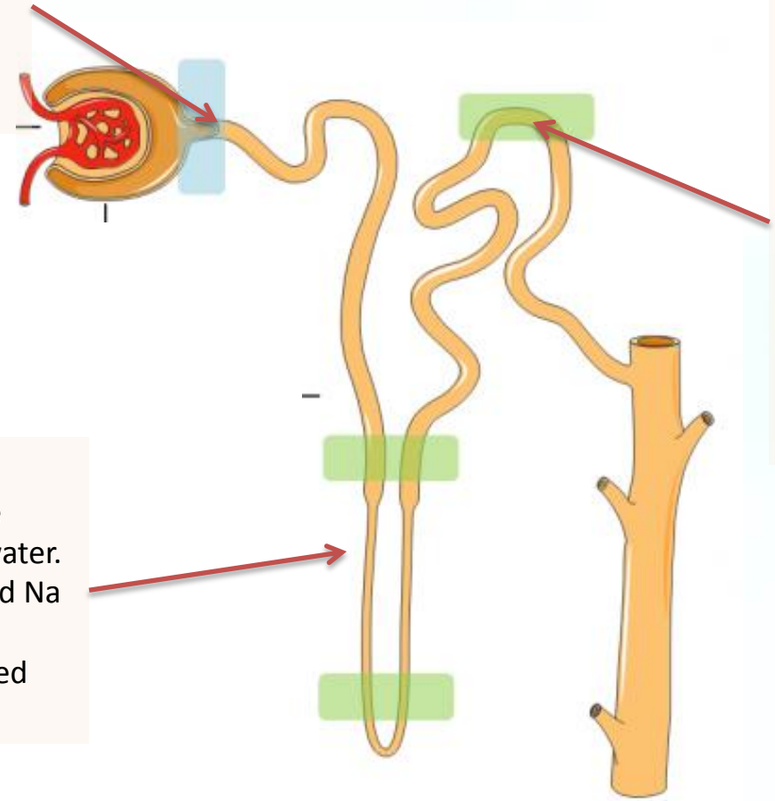
Diseases associated with aldosterone

- Absence of aldosterone, as occurs with adrenal destruction or malfunction **(Addison's disease)**
- Excess aldosterone, as occurs in patients with adrenal tumors **(Conn's syndrome)** is associated with:
  1- sodium retention 2- decreased plasma potassium concentration

Summary

- Absorption throw apical membrane is done **passively**.
- Movement of Na throw basal membrane is done **Na/K ATPase.**
- ↑ GFR → ↑ Absorption
- Sympathetic → ↑ Na absorption
- ADH → ↑ H2O absorption
- Aldosterone → ↑ Na absorption + K excretion
- ANP ↑ Na excretion

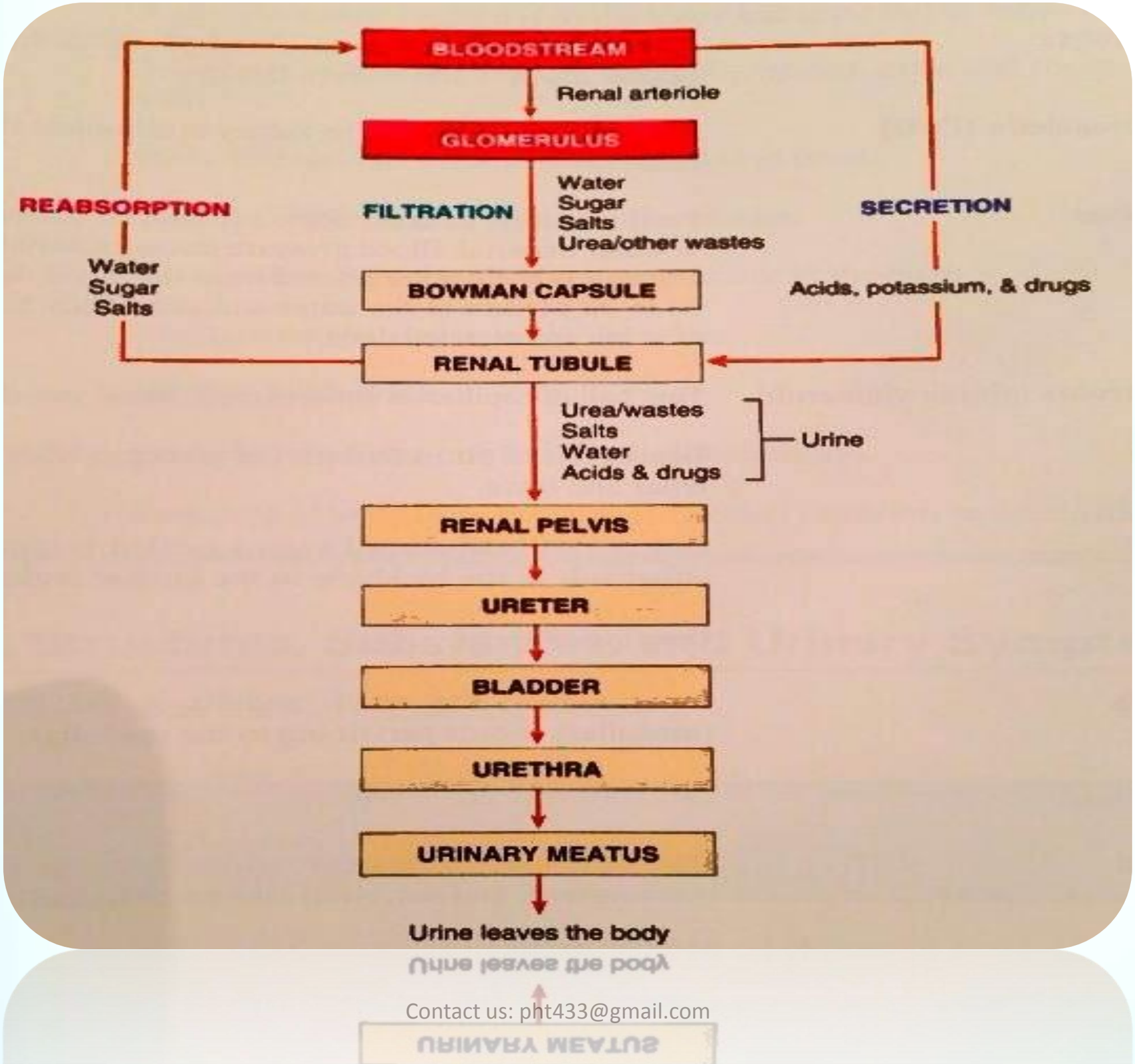
Proximal tubules:
1- has the greatest effect in all tubules.
2- the fluid inside it is isosmotic.



Distal tubules:
1- Has mucla densa which is Na sensitive + excretes renin.
2- has principal cell: Na + H2o absorption & K secretion
3- has intercalated cell: absorbs K and secretes H+ (controls pH)

Loop of Hele:
* Descending: concentrate urine by reabsorption of water.
* Thin ascending: Absorbed Na Cl
* Thick ascending: Absorbed Na 2Cl K

Contact us: pht433@gmail.com



MCQS

Q1: One of these examples is control passively:
A/Transport maximum
B/Transcellular reabsorption
C/Paracellular reabsorption
D/co-transport

Q2: where is Sodium-potassium specific pumps?
A/Basement membrane
B/Basolateral membrane
C/Interstitial wall
D/Cytoplasmic membrane

Q3: Where can you found sodium-potassium pump? In between..
A/Tubular lumen & tubular cell.
B/Iinterstitial fluid & tubular lumen.
C/ interstitial fluid, tubular cell & tubular lumen.
D/interstitial fluid & tubular cell

Q4: When 3 Na / 2 K pumped in Basolateral membrane, the net result is:
A/High intracellular Na concentration
B/Low Extracellular Na concentration
C/↑ osmolarity in the basolateral space
D/↓osmolarity in the basolateral space.

Q5: Most of filtered water is reabsorbed in:
A/ Proximal convoluted tubule (PCT)
B/Distal convoluted tubule (DCT)
C/Ascending loop of henle
D/Descending loop of henle

Q6: Glucose reabsorption is the difference between:
A/the amount of glucose filtered and the amount Secreted
B/the amount of glucose filtered and the amount excreted.
C/the amount of glucose reabsorbed and the amount excreted.
D/the amount of glucose reabsorbed and the amount secreted

Q7: When plasma glucose reach which called "glucose renal threshold" , How much is glucose level in vein that will lead to appear in urine ?
A/250mg/dl
B/375 mg/dl
C/180mg/dl
D/200mg/dl

Q8: How much is maximum absorptive capacity for glucose in men?
A/375mg/min
B/200mg/dl
C/250mg/min
D/300mg/min

Ans: 1-C, 2-B, 3-D, 4-C, 5-A, 6-B, 7-C. 8-A,

MCQS

Q9: Amino acid is reabsorbed in Basolateral membrane by :
A/ATP
B/ Diffusion
C/ Co-transport with Na
D/Na+/K+ ATPase

Q10: What is the main important mechanism for Na exchange on Bicarbonate reabsorption ?
A/Reabsorpetion of HCO_3
B/Secreted H^+
C/Diffuses CO_2
D/Filtered HCO_3

Q11: At the end of descending loop of henle the osmolarity will be :
A/Decrease
B/No change
C/Minimal change
D/Increase

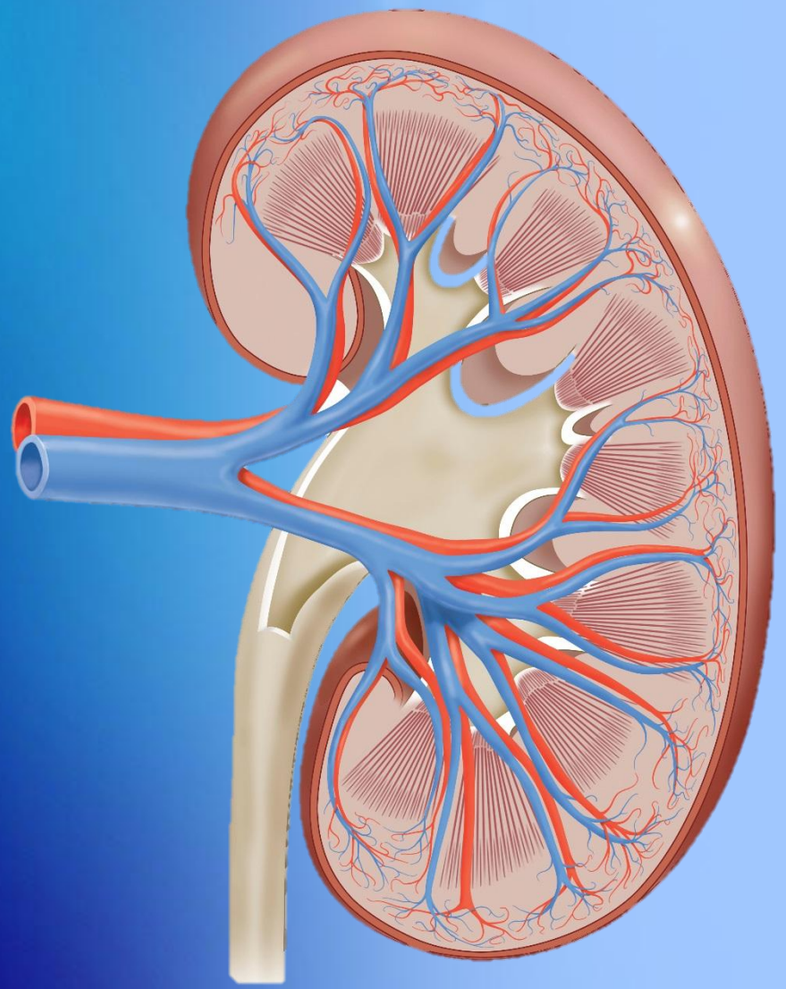
Q12: Which site has a high permeability of water:
A/Thick ascending loop of henle
B/Thin ascending loop of henle
C/Early portion of Distal convoluted tubule
D/Thin descending loop of henle

Q13: Which of the following is an site of NaCl diffuses passively ?
A/Proximal convoluted tubule (PCT).
B/ thin ascending loop.
C/ Distal convoluted tubule (DCT).
D/ thick ascending limb .

Q14: the amount of water, solute reabsorption and secretion depends on :
A/Age
B/Wight
C/ body's needs
D/secrete H^+

Q15: During Reabsorption/secretion of H2O in Late Distal Tubules and Collecting Tubules, the H2O is more dependent on :
A/Angiotensin II
B/principal cells
C/Aldosterone
D/Anti-Diuretic hormone

Ans: 9-B, 10-B, 11-D, 12-D, 13-B, 14-C, 15-D.



Renal Block

Done by :

Mojahed Otayf
Abdulmalek Al Qhtani
Mohaned Al Wabel
Ahmed Al Zoman
Hamad Al Dossari

Revised By:

Rahma Alshehri
Areej Alalwan
Nada Bin Dawood

@PhysiologyTeam

Pht433@gmail.com