



SNS COLLEGE OF ALLIED HEALTH SCIENCES
SNS Kalvi Nagar, Coimbatore - 35
Affiliated to Dr MGR Medical University, Chennai



DEPARTMENT: ALLIED HEALTH SCIENCES
COURSE NAME: PHYSIOLOGY

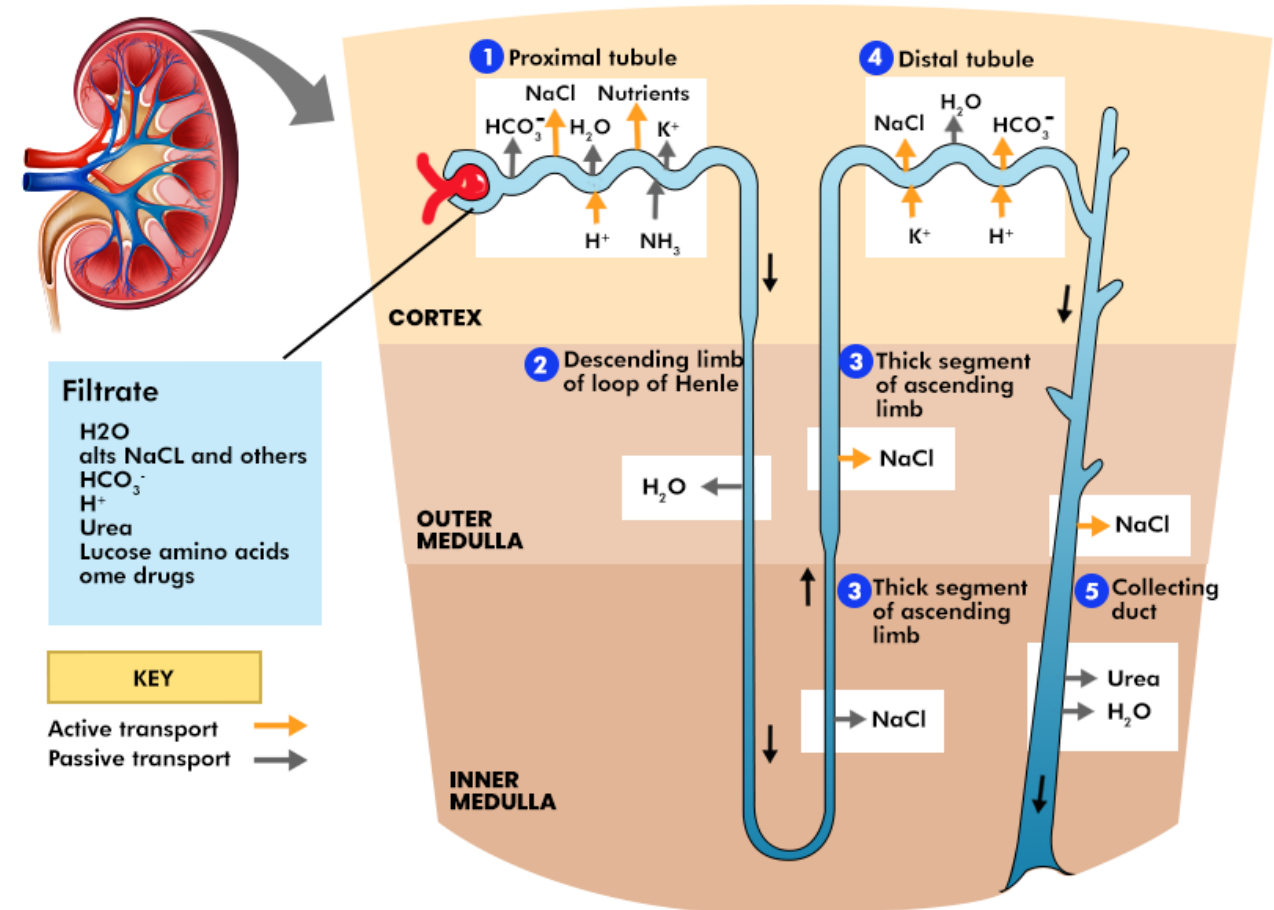
Unit: Physiology of Kidney
Topics: Tubular Reabsorption & Secretion

TUBULAR REABSORPTION & SECRETION

Tubular re-absorptive and secretory mechanisms modify the glomerular filtrate into the excretory product – urine

Urinary excretion = Glomerular filtration – Tubular reabsorption + Tubular secretion

Tubular reabsorption is selective & quantitatively large.





RENAL HANDLING OF SOLUTES



- Filtered and completely reabsorbed – e.g. **Glucose, Ions, Aminoacids**
- Filtered and partly reabsorbed – e.g. **Urea**
- Filtered and secreted – e.g. **Organic anions & cations**

Substance	Amount filtered/day	Amount excreted/day	Percent %
Water (L)	180	1.8	99
Sodium (meq)	630	3.3	99.5
Glucose (g)	180	0	100
Urea (g)	54	30	44

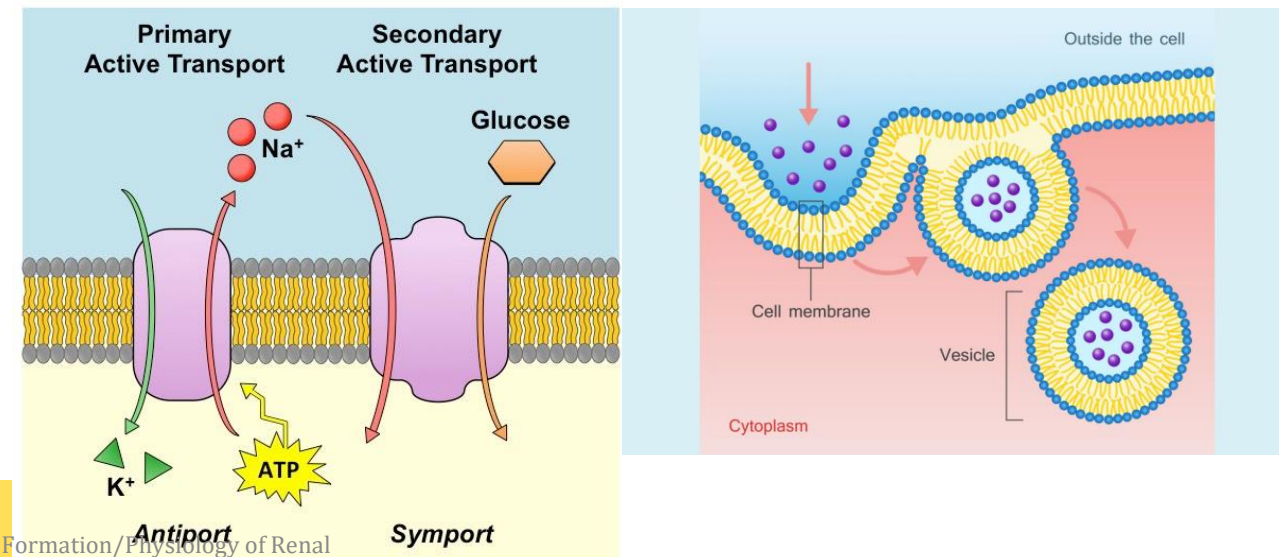
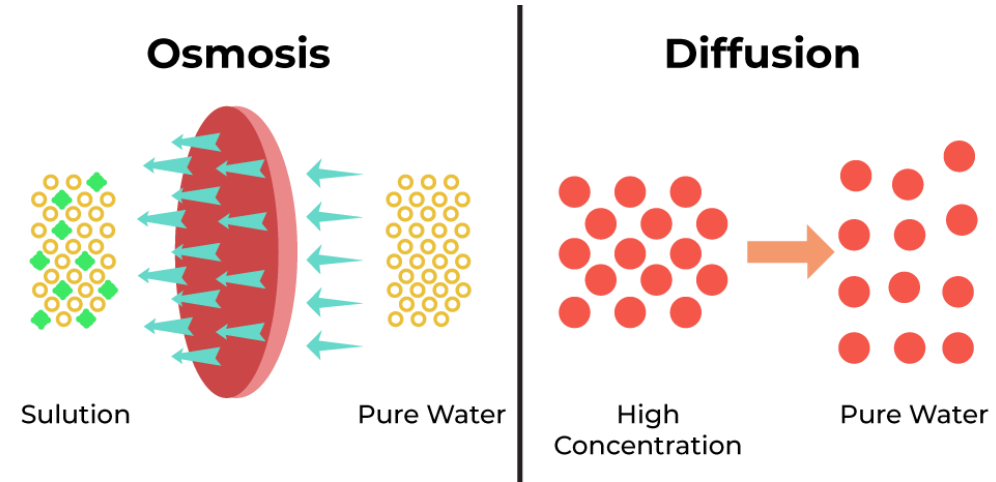
TUBULAR REABSORPTION OCCURS BY

Passive Mechanisms - Spontaneous, Gradient – No Energy Requirement down, An Electrochemical gradient.

- Simple Diffusion
- Facilitated Diffusion
- Solvent Drag

Active Mechanism – Against an electrochemical gradient – energy required

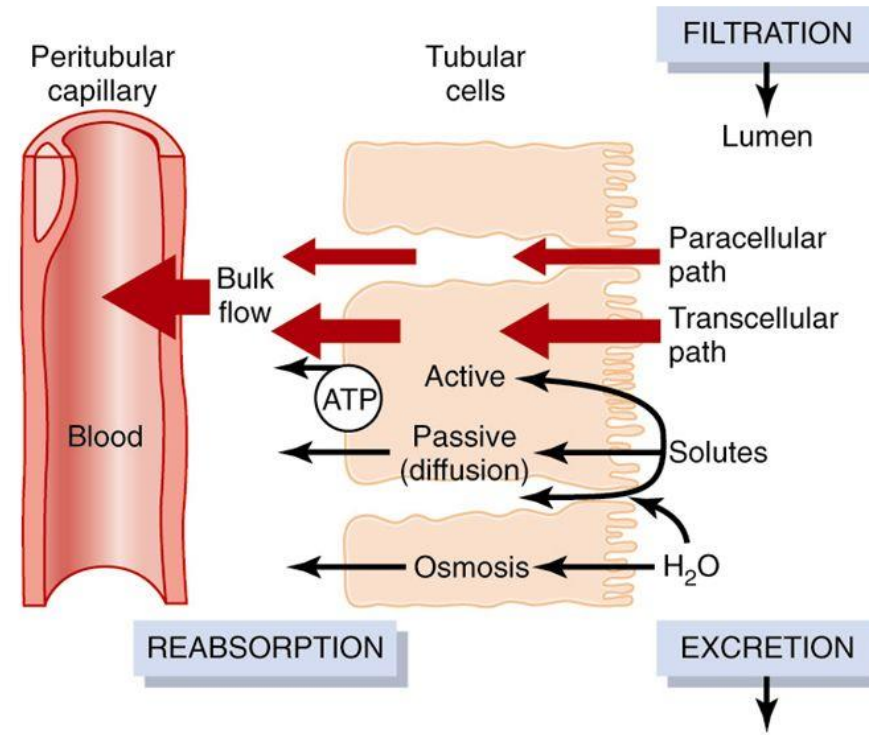
- Primary active transport (Na-K Pump)
- Secondary active transport – uniport, symport, antiport (NA-K-Cl-pump)
- **Osmosis & Endocytosis (pinocytosis)**



TUBULAR REABSORPTION ROUTES

Tubular Reabsorption

- **Transcellular** – substance travel from one cell to another
- **Paracellular** - substances across an epithelium by passing through the intercellular space between the cells
- **Bulk flow / ultrafiltration**

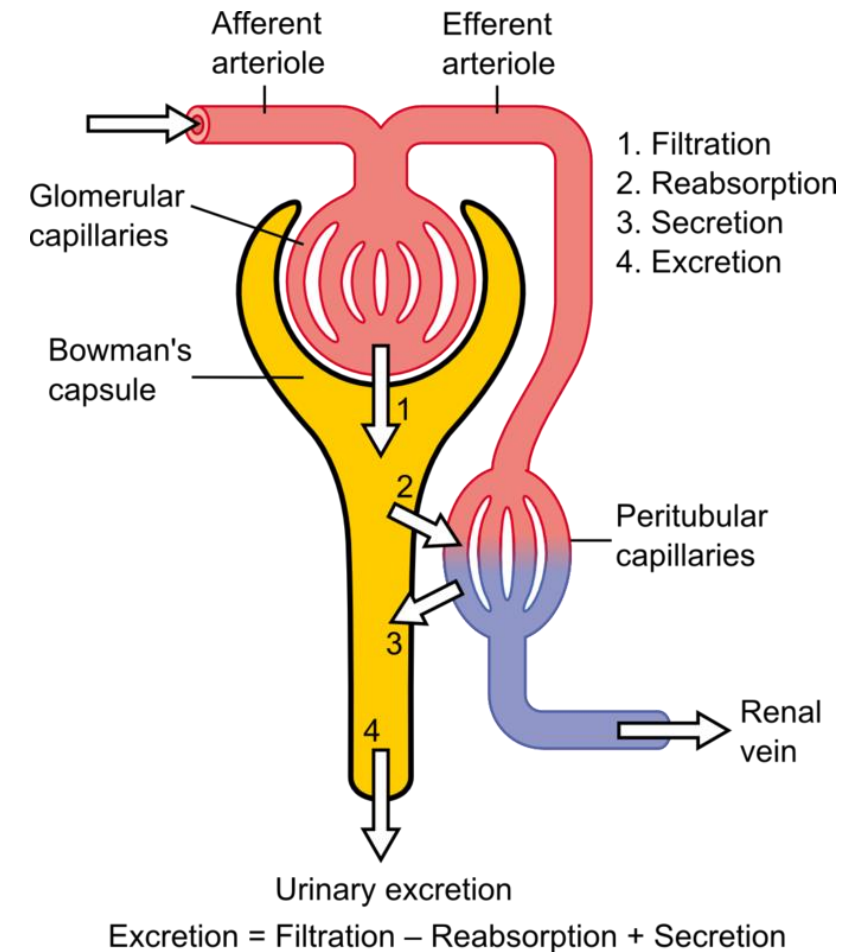




IMPORTANCE OF TUBULAR REABSORPTION



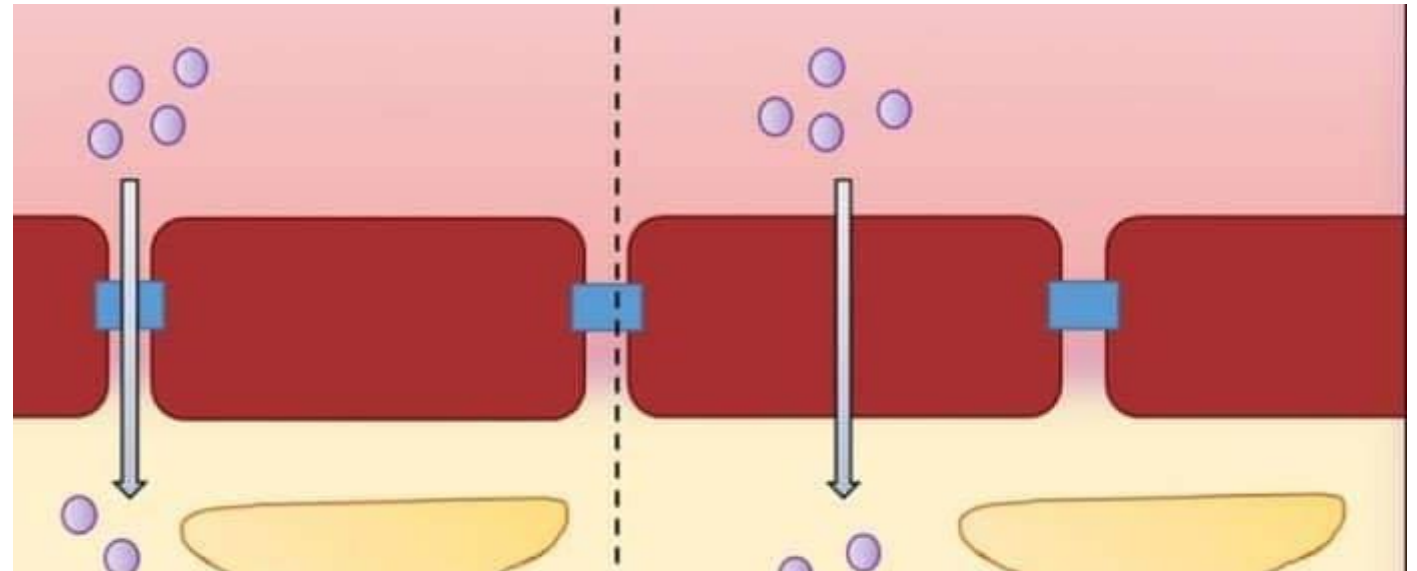
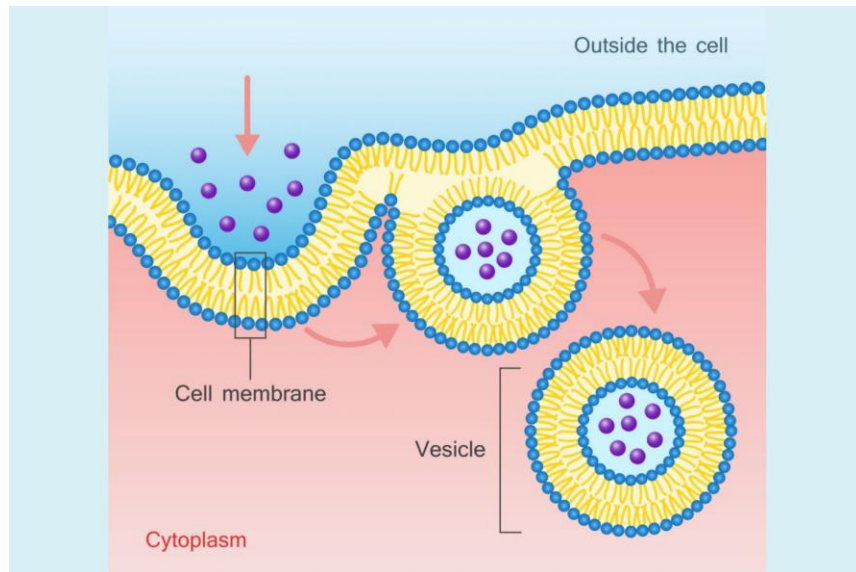
- Reabsorption helps to **maintain balance** in the body.
- Reabsorption can **reduce urine formation**.
- In absence of the Reabsorption process, 180 Liter/Day of urine will form. But Reabsorption reduces this amount to **1.8 Liter/Day amount**.
- This is the savings of the essential elements of the body using the Reabsorption process.



ASSESSMENT - I

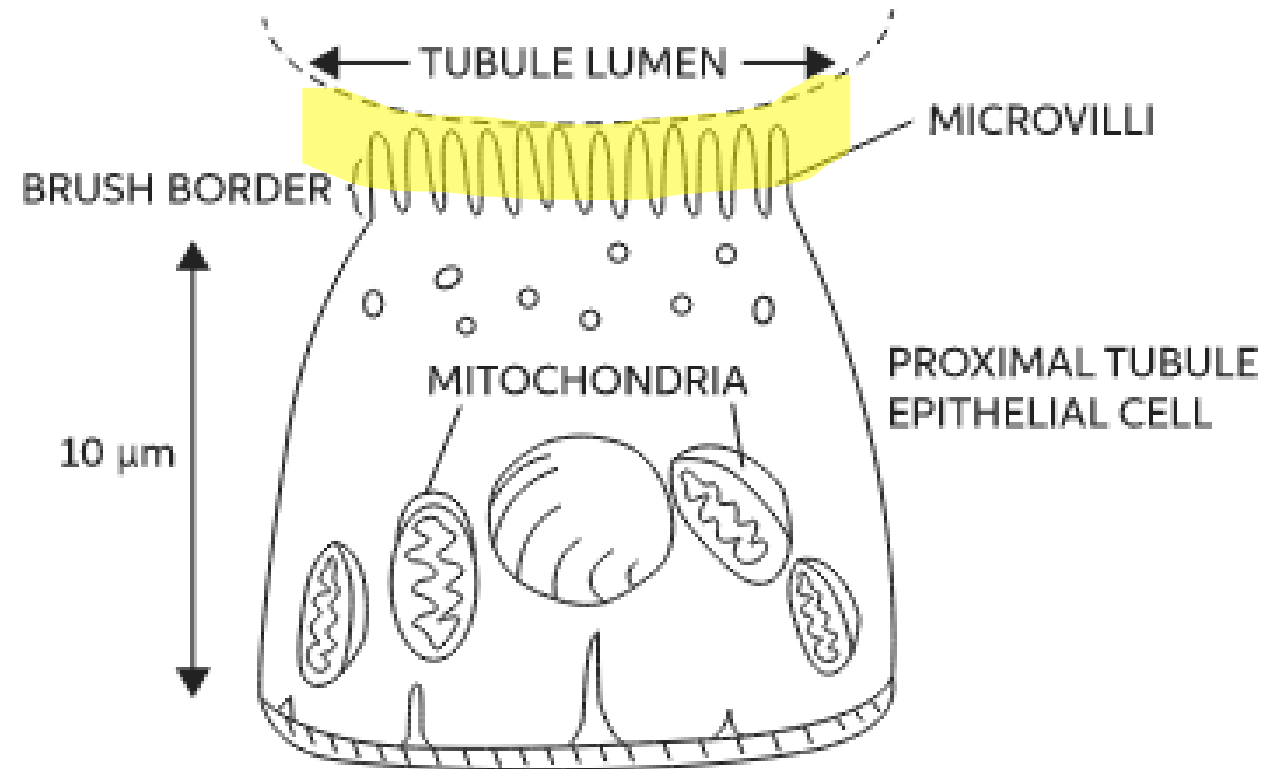
What this image represents ?

What transport this arrow mark indicates?



PROXIMAL CONVOLUTED TUBULE

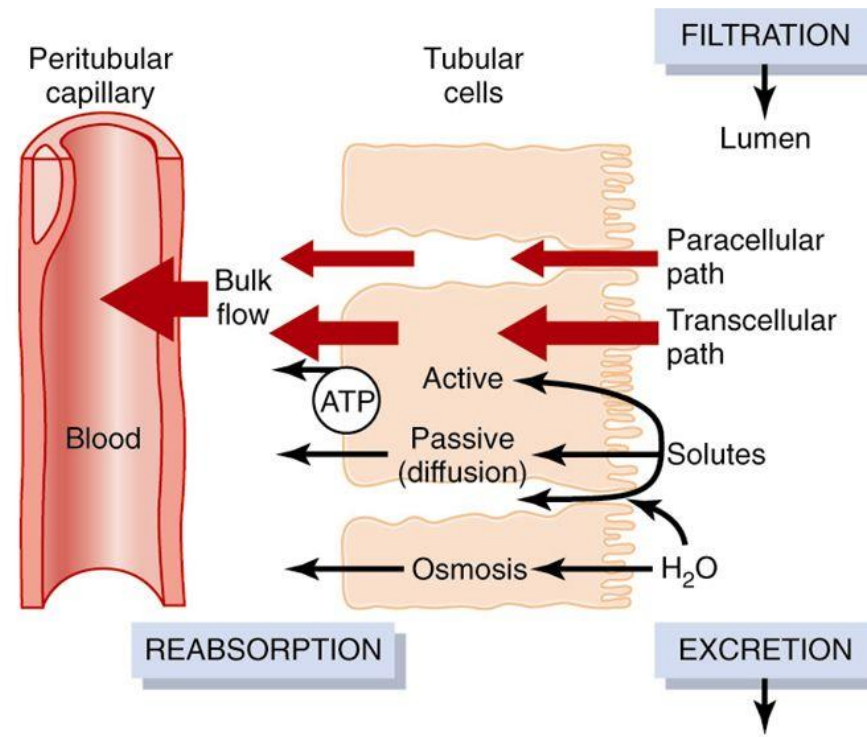
- Major site of **reabsorption**
- Structural features – large number of mitochondria, brush border, extensive intercellular and apical & basal channels
- Epithelial brush border contains abundant **protein carrier molecules (in apical part)**
- **Sodium pump** located in the basolateral border



HOW PCT DOES REABSORPTION?

- Way of transport from **apical to basolateral** membrane
- Transport occurs through **paracellular and transcellular route.**
- Reabsorption then occurs from basolateral space (interstitium) to peritubular capillaries (**bulk flow**)
- With the help of hydrostatic and colloid osmotic forces

Tubular Reabsorption

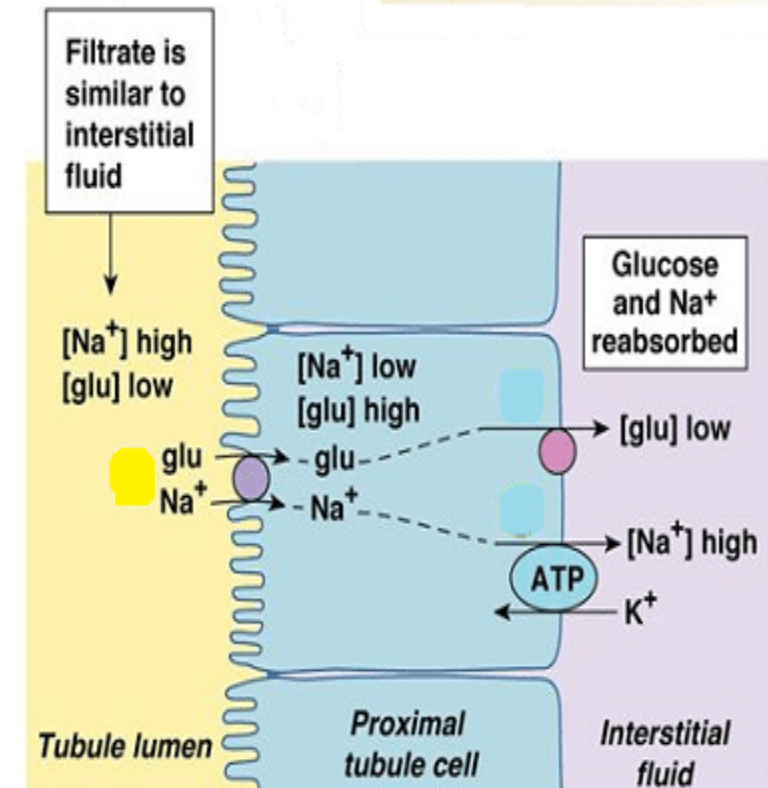




PCT – REABSORPTION STATUS



- **65%** of filtered water, Na^+ , Cl^- , K^+ and other solutes reabsorbed
- **100%** reabsorption of glucose and amino-acids
- Site of obligatory reabsorption of water
- Reabsorption of every substance linked to the **sodium pump**



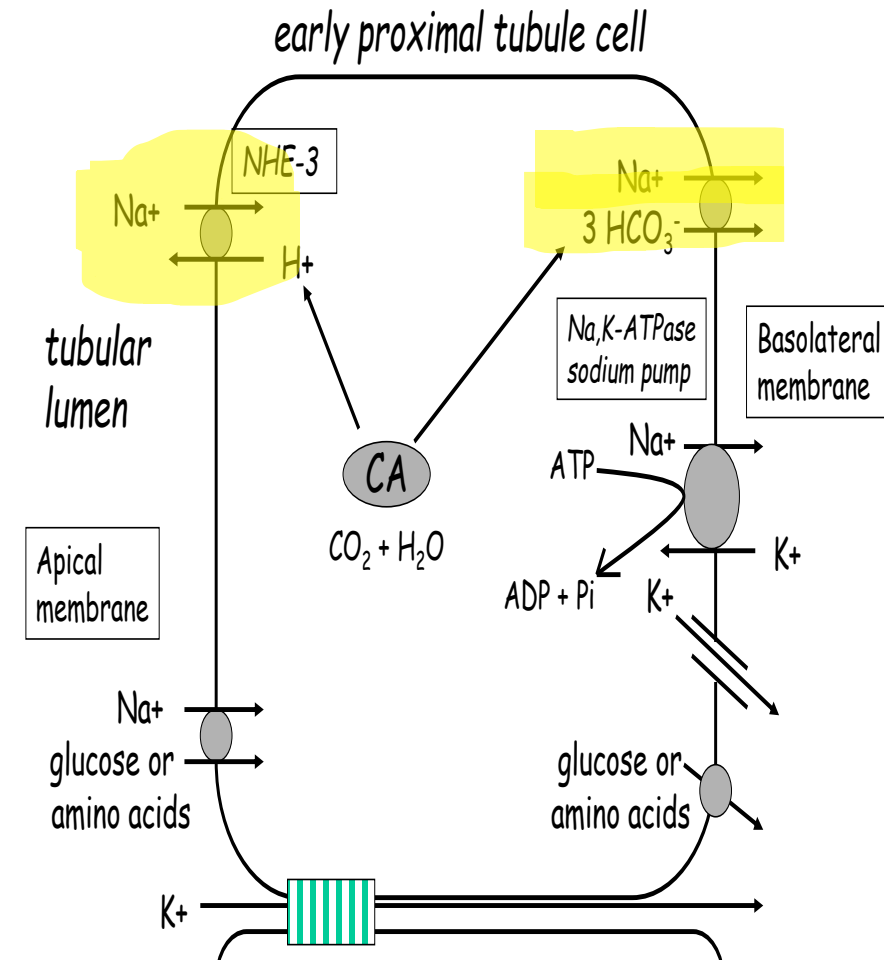


PROXIMAL CONVOLUTED TUBULE – REABSORPTION OF SODIUM



First half of PCT

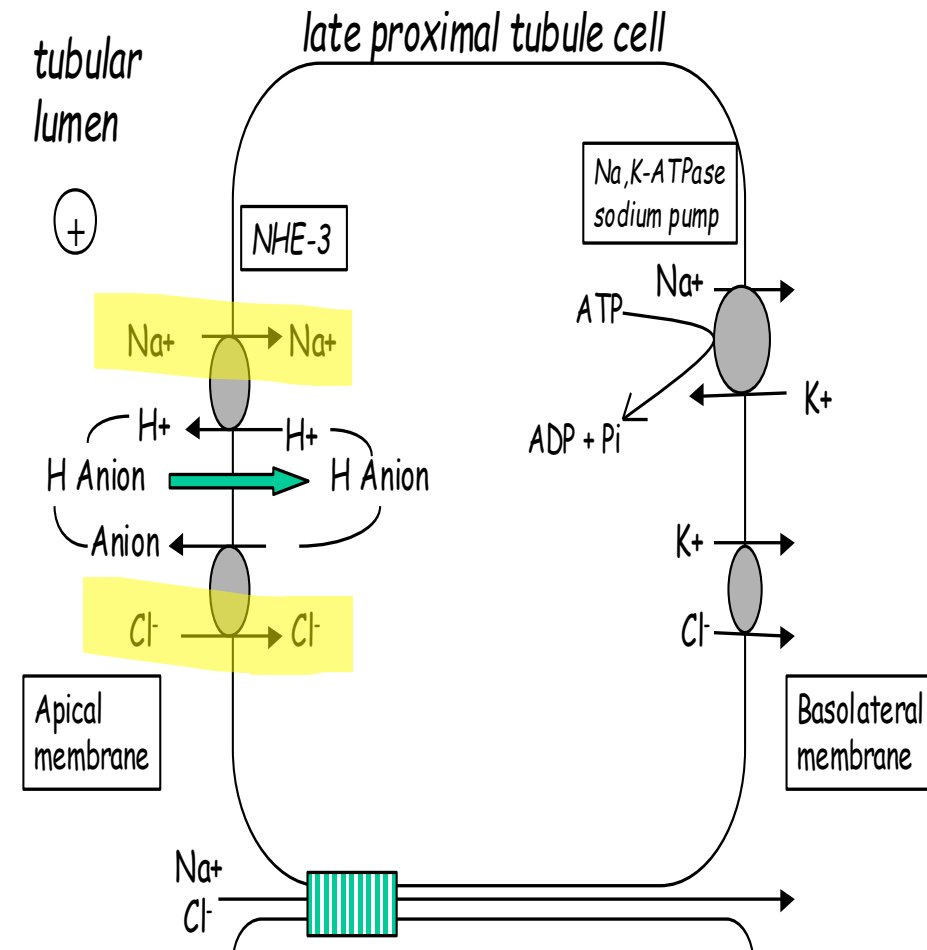
- **Na⁺** reabsorbed primarily with HCO₃⁻ and other organic molecules (Glu, amino acids, Pi, lactate) by transcellular route
- Mediated by specific symporters and antiporters
- **Symporters** – Na⁺-Glu, Na⁺-AA, Na⁺-Lac, Na⁺-Pi
- **Antiporter** – Na⁺-H⁺



PROXIMAL CONVOLUTED TUBULE - REABSORPTION OF SODIUM

Second half of PCT

- Mainly Cl^- driven Na^+ transport by paracellular way.
- 17,000 meq of 25,000 meq filtered, reabsorbed in PCT

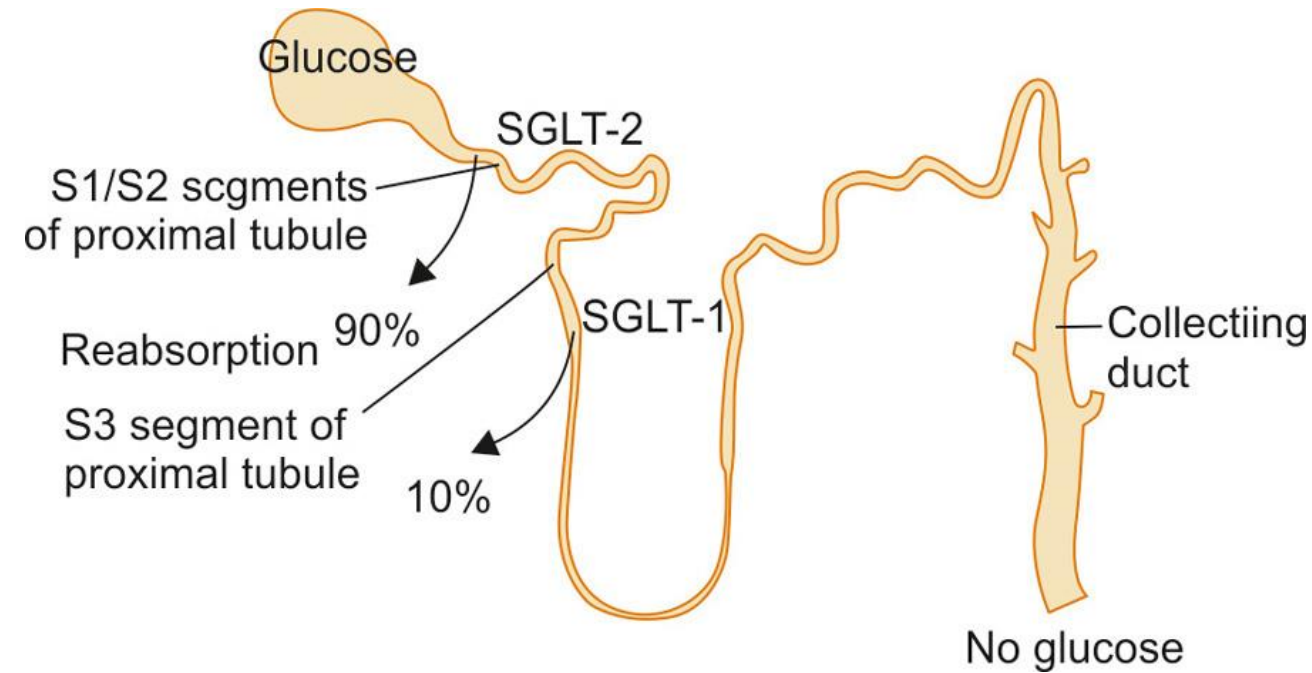




TUBULAR REABSORPTION OF GLUCOSE



- **100% reabsorption** in PCT by secondary active co-transport.
- Glucose enters the cell from lumen by cotransport with sodium by **(Sodium Glucose Linked Transporter) SGLT-2** in early PCT & **SGLT-1** in late PCT.
- Glucose moves out through basolateral membrane by facilitated diffusion by **GLUT-2** in early PCT & **GLUT-1** in late PCT.





TUBULAR REABSORPTION OF GLUCOSE



Essentially all glucose is reabsorbed

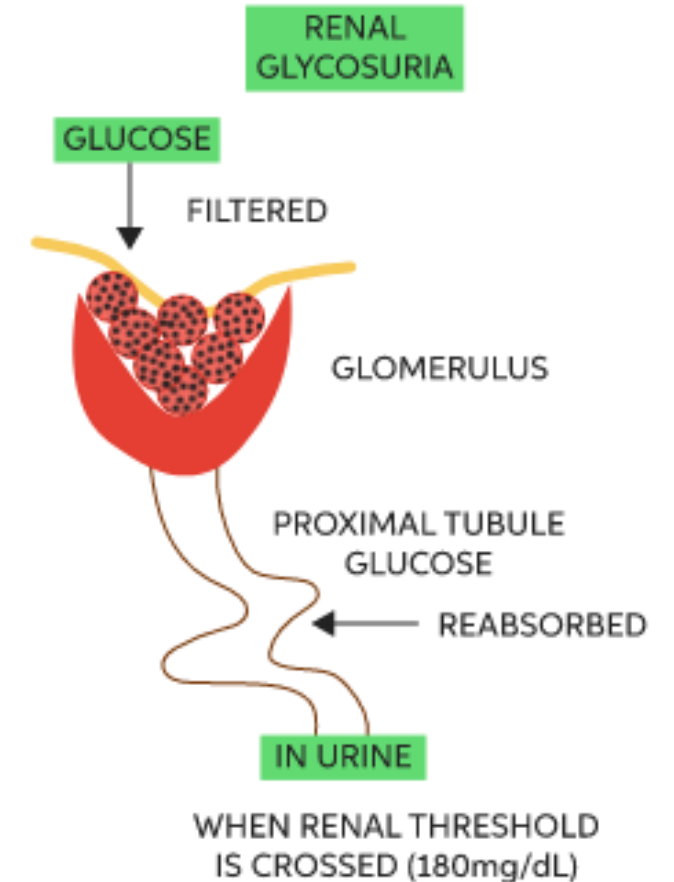
The renal threshold for glucose= 180 mg/dl

the tubular transport maximum for glucose $T_{mg} = 375$ mg/min in men and 300 mg/min in women.

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”

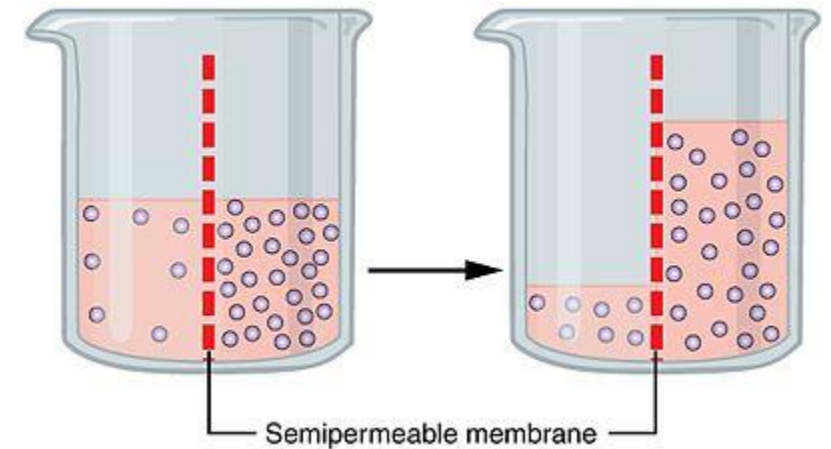




TUBULAR REABSORPTION OF WATER

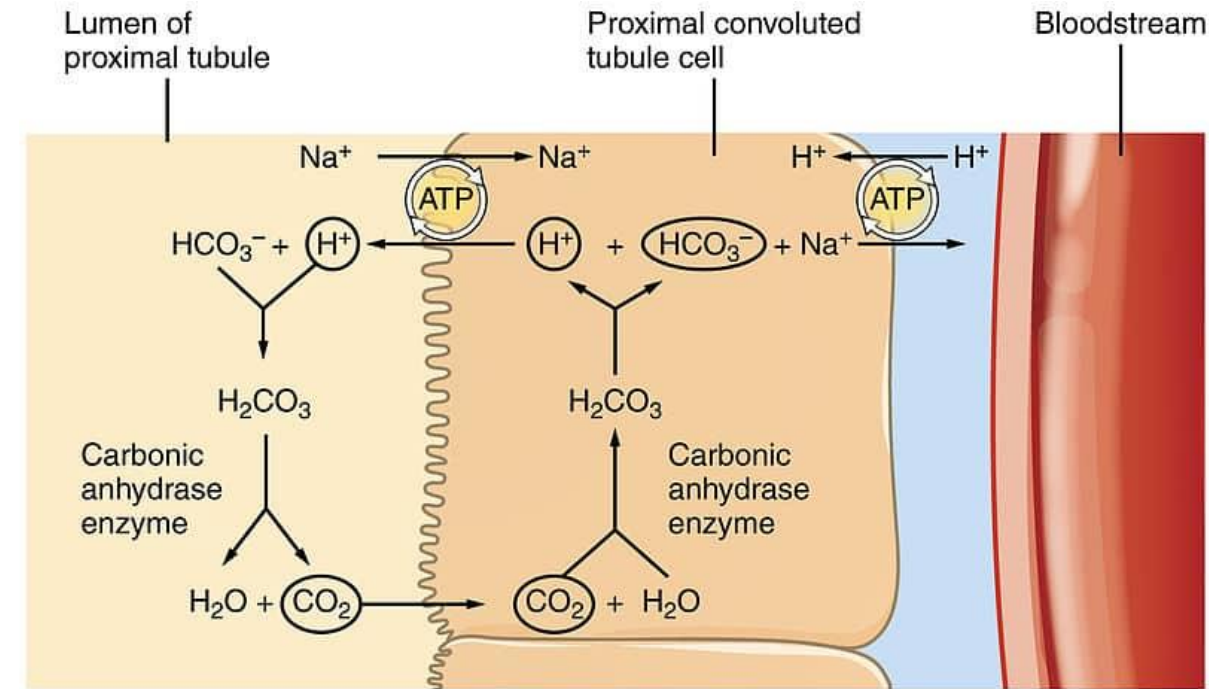


- Water reabsorption coupled to Na^+ reabsorption
- Trans-tubular osmotic gradient
- Osmolality of intercellular spaces higher – **water flow passively across tight junctions by osmosis**
- Solvent drag – K^+ & Ca^{2+}
- Changes in Na^+ reabsorption influence water reabsorption



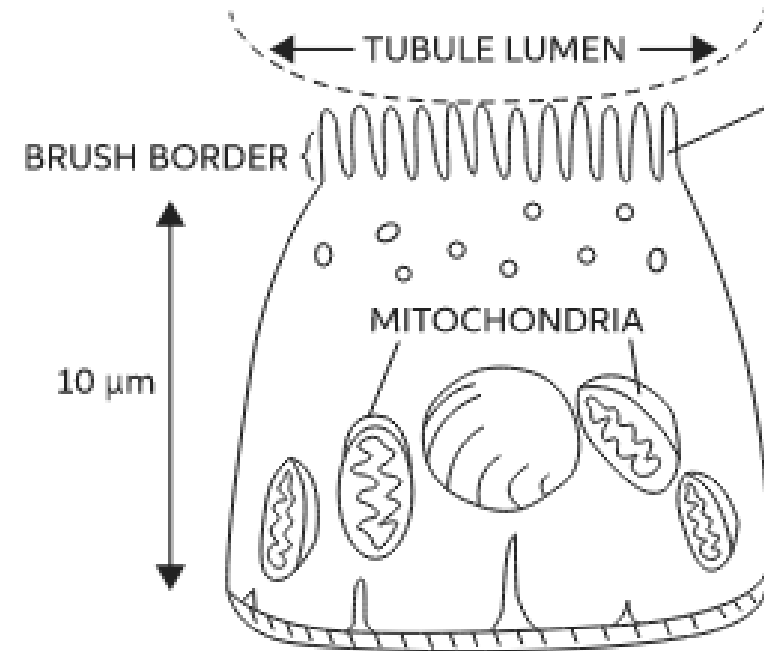
TUBULAR REABSORPTION OF BICARBONATE

- Bicarbonate (HCO_3^-) attaches itself with hydrogen (H^+) then it becomes H_2CO_3 in the lumen
- Carbonic Anhydrase will break H_2CO_3 down to water (H_2O) + carbonic dioxide (CO_2) which diffuses into the proximal tubule
- Carbonic Anhydrase will convert the water (H_2O) + the carbon dioxide (CO_2) to $\text{HCO}_3^- + \text{H}^+$
- Hydrogen will transport out and sodium (Na) will come in the proximal tubule
- Lastly, the HCO_3^- will go into the blood



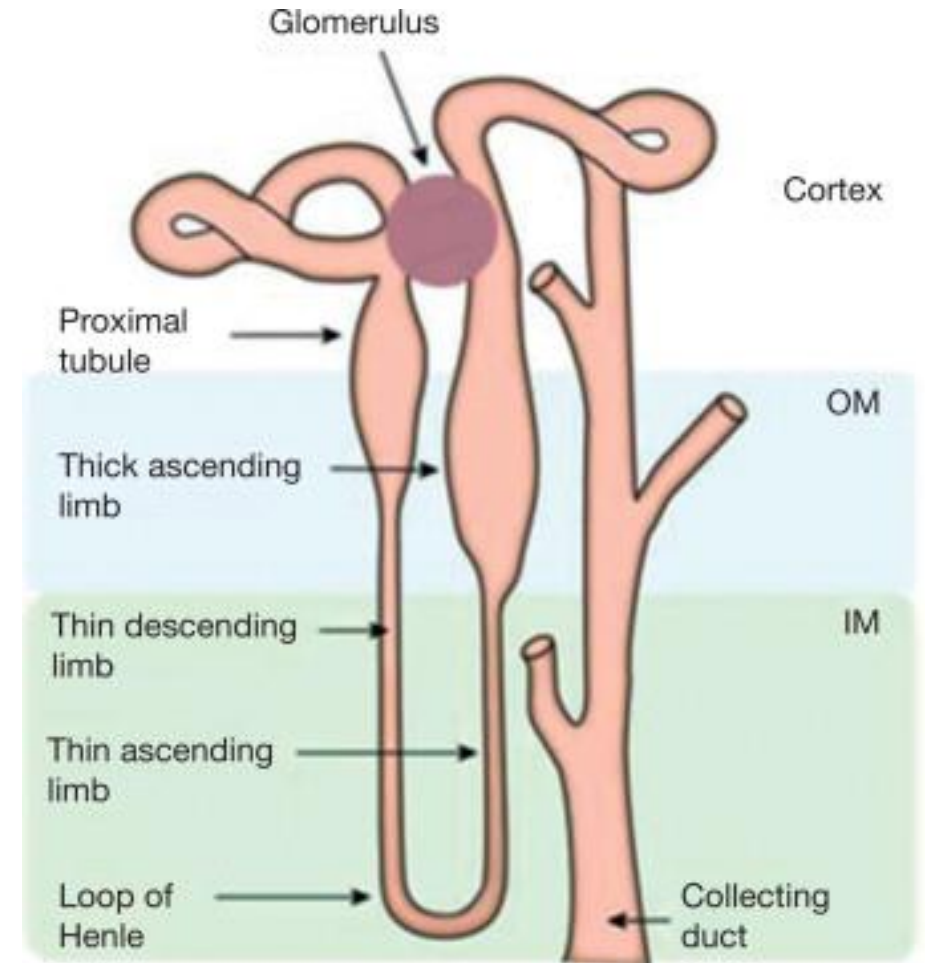
ASSESSMENT - II

- This image represents which part of Nephron?
- Which pump is present in PCT for reabsorption?
- name of the glucose co-transporter?
- Water reabsorption is done by?



LOOP OF HENLE

- The loop of Henle consists of a **thin descending limb, as well as a thick and thin ascending limb.**
- Roughly 40% of filtered sodium is reabsorbed in the loop of Henle, primarily in the thick ascending limb.
- 25% of Sodium, Calcium, Potassium, and 55% of Magnesium are reabsorbed
- Descending loop of Henle has **Na-K-Cl Co-transporter (NKCC)**





REABSORPTION IN THE DISTAL CONVOLUTED TUBULE (DCT)



- It is the region where there is **little presence of the Reabsorption process**
- Na^+ , K^+ , and HCO_3^- are reabsorbed from this region by 10%
- After the **concentration of the urine**, there is no chance to more reabsorb from that concentrated element.
- It is now becoming ready to remove from the kidney
- **Sodium-Chloride Co-transporter (SLC) present in small amount**



REABSORPTION IN THE DISTAL CONVOLUTED TUBULE (DCT)

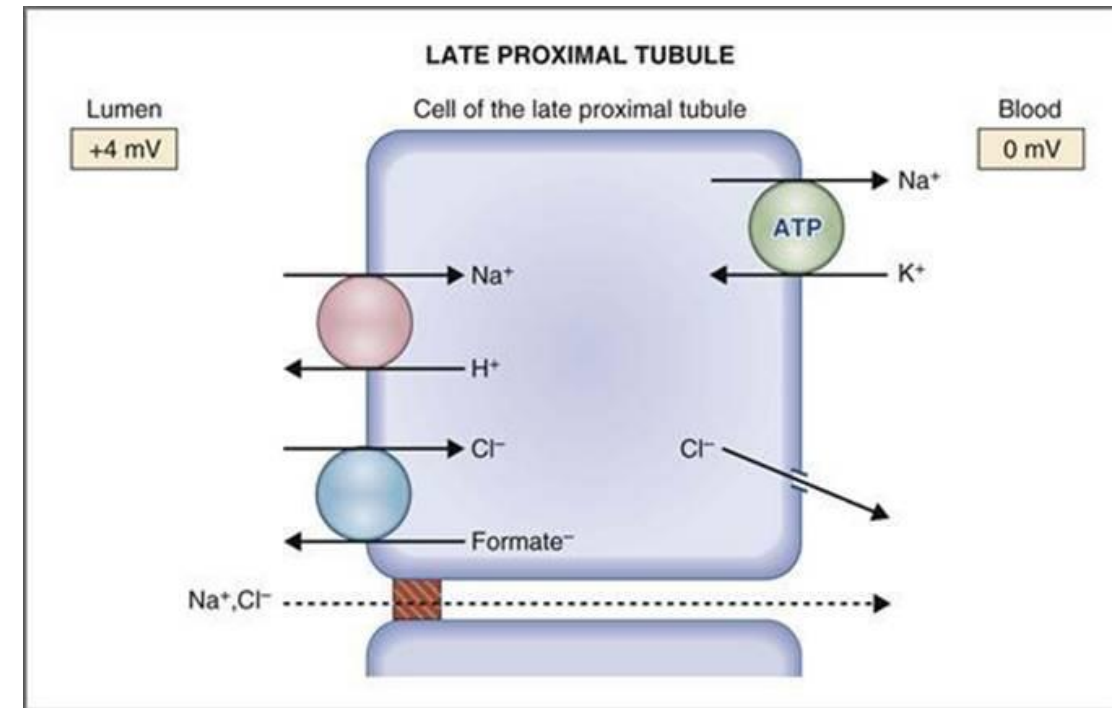


- The **first portion of DCT forms part of Juxtaglomerular Apparatus**, that provides feedback control of GFR and RBF of the same nephron.

The next early portion has the same characteristics as ascending limb of Henle that is

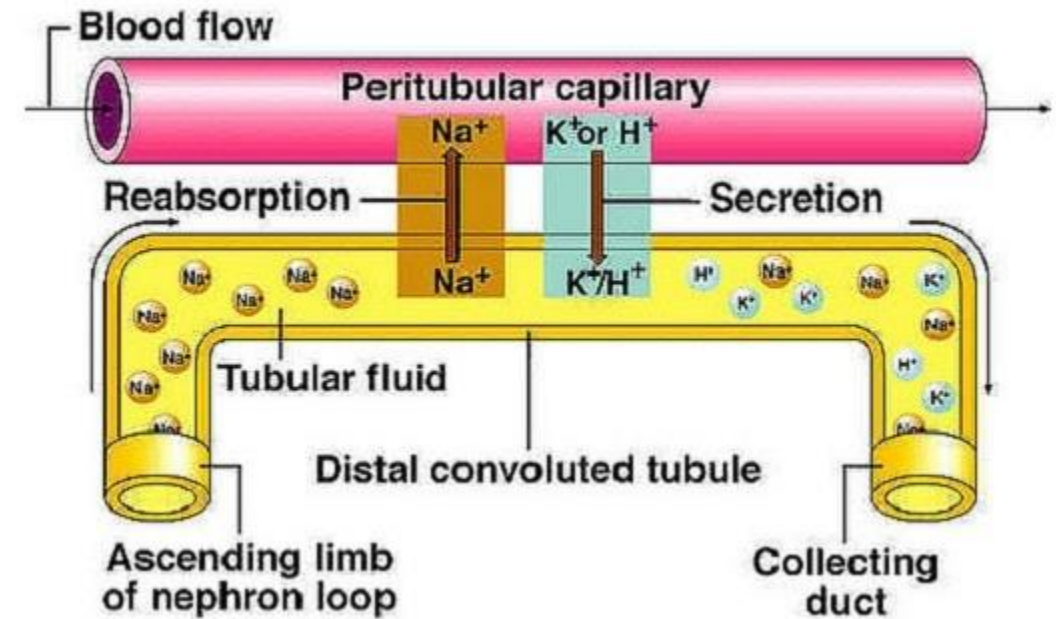
- **Impermeable to water**
- **Absorbs solutes**

So it is called the **diluting segment**



REABSORPTION IN THE COLLECTING DUCT

- The collecting ducts are composed of two cell types: **principal and intercalated cells.**
- The collecting Duct **doesn't perform in the Reabsorption process**
- 4% of the remaining substances are reabsorbed from here
- Some ions like Na^+ , K^+ , Cl^- , and HCO_3^- are reabsorbed here





ASSESSMENT – III



- Na-K-Cl Co-transporter (NKCC) is present in -----
- What is the function of DCT?
- What are the cells present in Collecting Duct?



TUBULAR SECRETION



- Substances transported from blood into tubular lumen.
- Most imp substances secreted by renal tubules- **H^+ , NH^3 , K^+ . (Hydrogen, Ammonia & Potassium)**
- H^+ ion secretion responsible for acidification of urine.
- This step is usually used to remove drugs, toxins and poisons



SUBSTANCE SECRETED



- **Potassium** is secreted actively by sodium potassium pump in proximal and distal convoluted tubules and collecting ducts
- **Ammonia** is secreted in the proximal convoluted tubule
- **Hydrogen ions** are secreted in the proximal and distal convoluted tubules. Maximum hydrogen ion secretion occurs in proximal tubule
- **Urea** is secreted in loop of Henle.



IMPORTANCE OF TUBULAR SECRETION



Tubular secretion is important for:

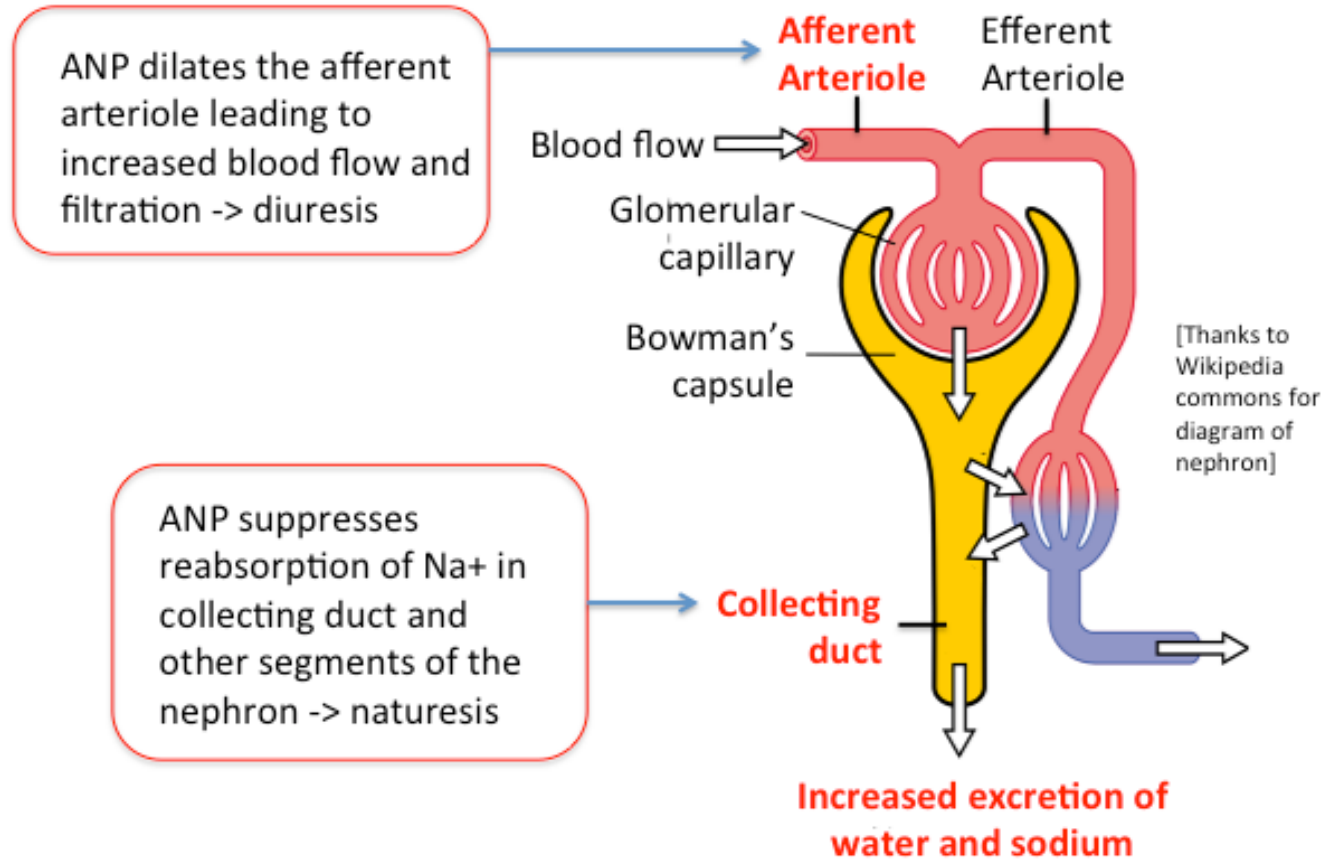
- Disposing of substances not already in the filtrate
- Eliminating undesirable substances such as urea and uric acid
- Ridding the body of excess potassium ions
- Controlling blood pH



ATRIAL NATRIURETIC PEPTIDE (ANP)

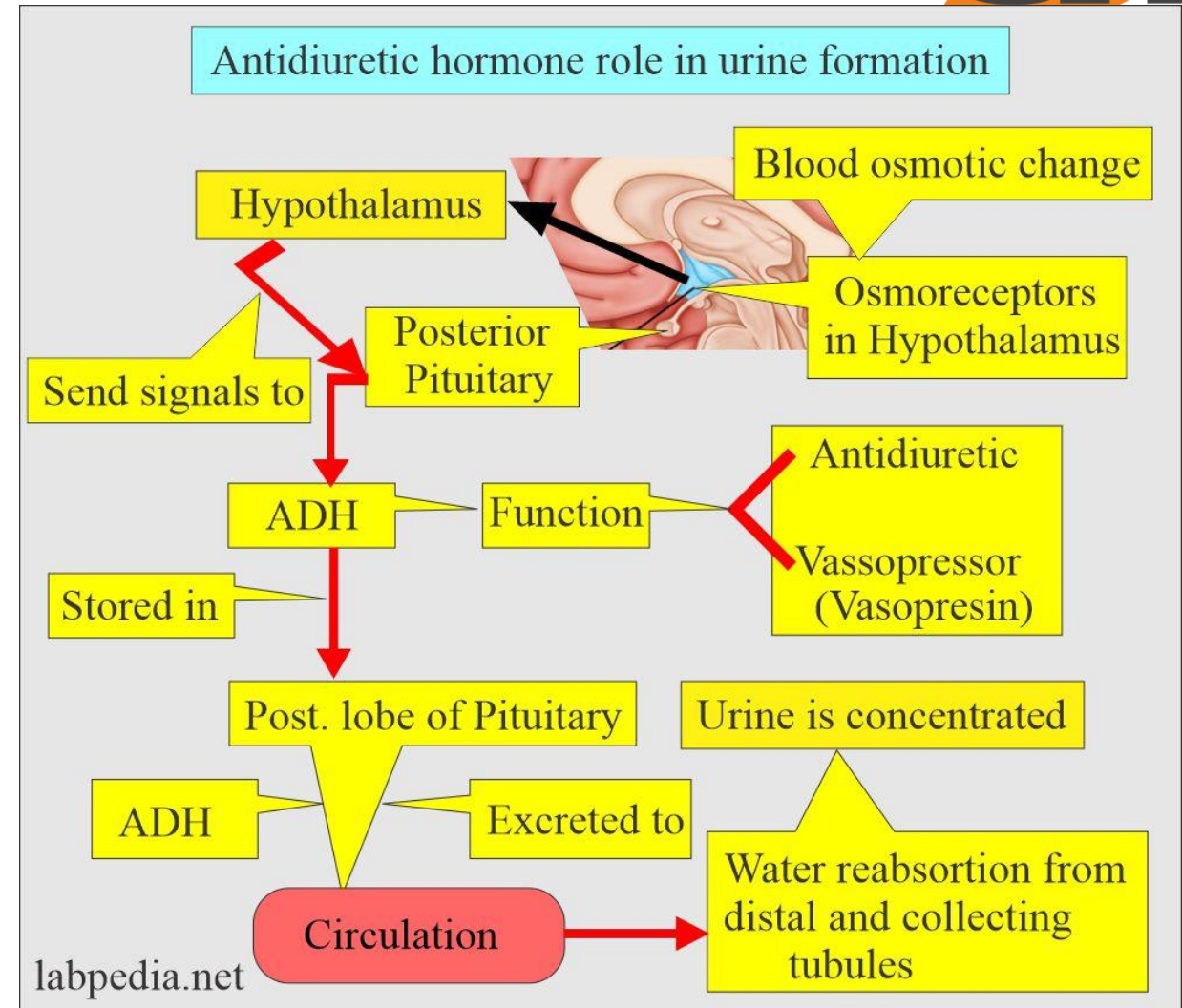


- Atrial natriuretic peptide (ANP) is a cardiac hormone
- It regulates salt-water balance and blood pressure by promoting renal sodium and water excretion and stimulating vasodilation.



ANTI-DIURETIC HORMONE (ADH)

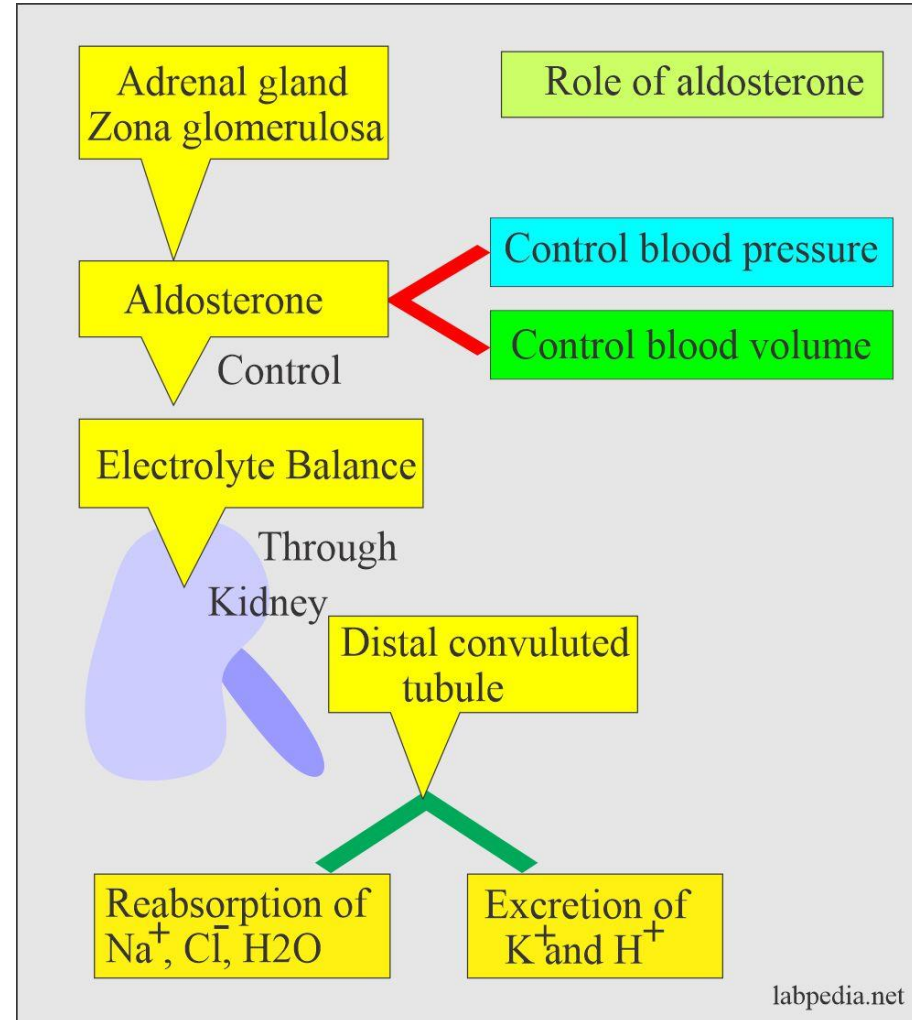
- ADH Hormone is also called as **Vasopressin**
- A hormone that helps blood vessels constrict and helps the kidneys control the amount of water and salt in the body.
- The main function is on **Osmoregulation**
- ADH Maintains **water homeostasis.**





- Function – Increase Na⁺ Reabsorption , Stimulates K⁺ Excretion
- Secretion Site – Zona Glomerulosa cells of adrenal cortex

ALDOSTERONE





COUNTERCURRENT FLOW



- A countercurrent system is a system of 'U' shaped tubules (tubes) in which, the flow of fluid is in opposite direction in two limbs of the '**U**' shaped tubules.
- Countercurrent system has two divisions:
Countercurrent multiplier formed by loop of Henle
Countercurrent exchanger formed by vasa recta.



COUNTERCURRENT FLOW



- **Osmolarity** - The number of solute particles dissolved in 1L of water
- Body fluids are measured in milliosmoles (mOsm)
- The kidneys keep the solute load of body fluids constant at about 300 mOsm
- The solute concentration in the loop of Henle ranges from **300 mOsm to 1200 mOsm**

Loop of Henle: Countercurrent Multiplication

- **The descending loop:** relatively impermeable to solutes, highly permeable to water
- **The ascending loop:** permeable to solutes, impermeable to water
- Collecting ducts in the deep medullary regions are permeable to urea



THANK YOU



- <https://www.onlinebiologynotes.com/physiology-urine-formation/>
- <https://www.kidney.org/atoz/content/gfr>
- K.S. Girish, DOSR in Biochemistry, Tumkur University
- <https://www.researchgate.net/figure/Nephron-physiology-for-urine-formation-179-Schematic-of-urine-formation-consisting-of-fig2-320459545>
- <https://books.lib.uoguelph.ca/human-physiology/chapter/kidney-filtration-and-reabsorption/>
- <https://labpedia.net/antidiuretic-hormone-adh-vasopressin-arginine-vasopressin-hormone-diabetes-insipidus/>