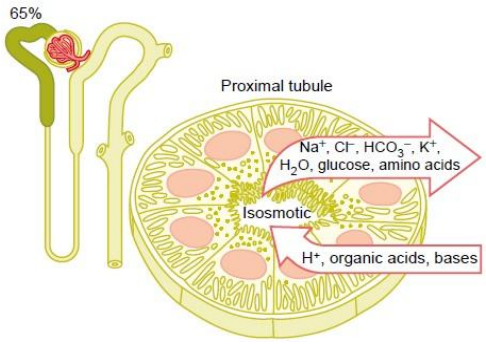
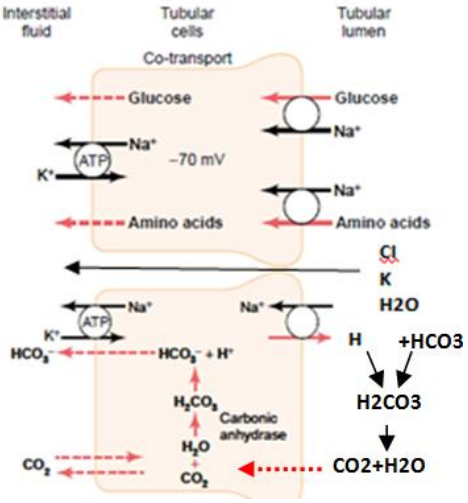
Regional transport :
Proximal tubule (PCT):

- PCT epithelial cells are highly metabolic and have large numbers of mitochondria to support potent active transport processes
- They have an extensive brush border on the luminal (apical) side of the membrane→↑surface area for rapid transport of Na and other substances.
- Filtered fluid that enters the proximal tubule is isotonic (300 mOsm/L).
- Na + is pumped out of the cells by **Na, K ATPase** at the basolateral side → maintains a low intracellular fluid Na+ → allow other solute to be reabsorbed with Na+ by secondary active transport ex :**Na-Glucose ,Na-amino acid ,** Na- phosphate and Na-lactate cotransporter**.**
- Normally All Glucose and amino acids are reabsorbed in PCT
- H ion is secreted with Na ions reabsorption by **Na- H counter-transport** mechanisms by which **80-90% of filtered HCO_3** is reabsorbed (H ion binds HCO_3 in the lumen →H_2CO_3→CO_2 and H_2O which are easily diffused)
- It is highly **permeable** to water.
- 2/3 of the filtered H_20 ,K+ ,Ca and Cl follow the Na ions mainly by passive diffusion through paracellular pathway and the osmolarity at the end of the proximal tubule remains 300 mOsm/L.
- Secretion: the kidneys secrete potentially harmful toxins, drugs and waste products of metabolism through the tubular cells into the tubules ex: oxalate,PAH and penicillin.

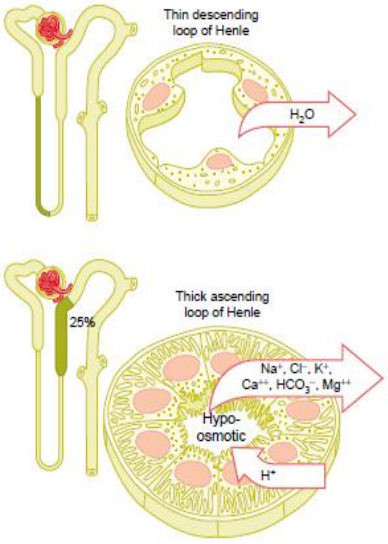


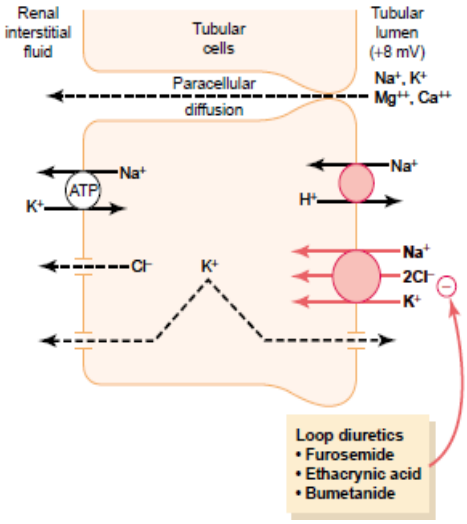


Loop of Henle:

- The filtered fluid that enters the loop of Henle is isotonic (300 mOsm/kg), but the volume is only 1/3the volume originally filtered into Bowman's space.

- Loop of Henle has countercurrent flow and it acts as a countercurrent multiplier (creates a concentrated medullary interstitium).The osmolarity of the inner medulla can reach a maximum of about 1200mOsm/L
- **Thin descending limb:** has thin epithelial membrane with no brush borders, few mitochondria, and low levels of metabolic activity. it is highly permeable to water and About 20 % of the filtered water is reabsorbed
- **Thick segment of the loop of Henle :** has thick epithelial cells that have high metabolic activity and are capable of active reabsorption of 25% of filtered load of Na ,Cl, and K by **Na- K -2Cl cotransporter(** loop diuretics like furosemide inhibits this transporter).
- There is back diffusion of K+ into the lumen creates a positive luminal potential, →promotes Paracellular reabsorption of Mg^{++}, Ca^{++}.
- **Na-H counter-transport** → H secretion and reabsorption of 10 % HCO_3
- it is **impermeable** to water and the tubular fluid in the ascending limb becomes dilute as it flows toward the distal tubule.

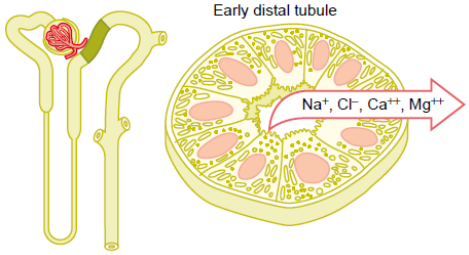


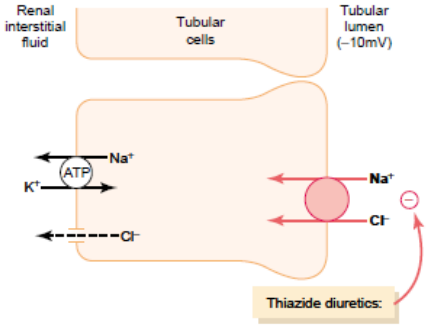


Distal tubule :

- The first portion of the distal tubule forms **juxtaglomerular apparatus.**
- **Early distal tubule** ,similar to thick ascending limb, is impermeable to water →it is referred to as the **diluting segment** because it dilutes the tubular fluid.

- **5%** of the filtered load of Na, Cl ions is reabsorbed in the early distal tubule by **Na-Cl co-transporter** which moves sodium chloride from the tubular lumen into the cell, and the **Na-K ATPase pump** transports Na out of the cell across the basolateral membrane.
- Cl diffuses out of the cell into the renal ISF through Cl^- channels in the basolateral membrane.
- Thiazide diuretics inhibits the Na-Cl co-transporter.
- Ca ions enters the cell from the luminal fluid passively through calcium channels which is primarily regulated **parathyroid hormone (PTH).**
- Ca ion is actively transported into the peritubular fluid via Ca^2 –ATP ase or 3Na –Ca Antiporter.



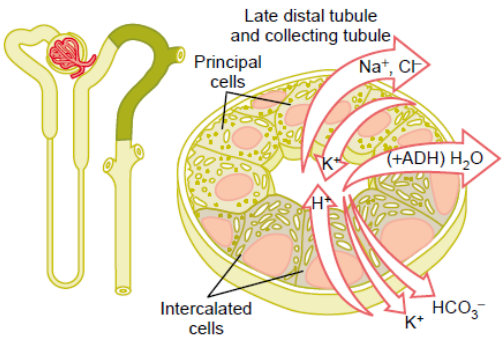


Collecting duct :

- The late distal tubule and the cortical collecting duct have similar functional characteristics. They are composed of two distinct cell types, the **principal cells and the intercalated cells** .

1- **The principal cells**: reabsorb Na and water and secrete K ions :

- Na reabsorption through epithelial Na channels (ENaC), by the help of Na –K pump in the basolateral membrane .
- K diffuses down its concentration gradient across the luminal membrane through K channels into the tubular fluid
- Aldosteron acts on these cells to :
  - ↑Na absorption by ↑ number of luminal ENaC and stimulates Na-K Pump ,↑ K secretion
- Aldosteron (miniralocorticoid) is stimulated by
  - ↑plasma K (hyperkalemia),
  - Angiotensin II : caused by ↓Plasma Na ,↓ECF and low blood pressure



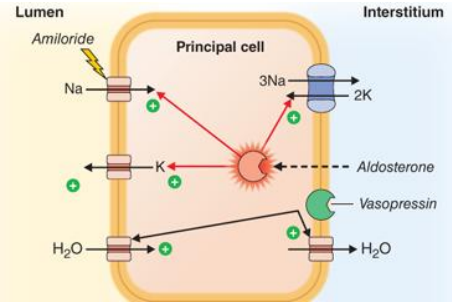
- Water reabsorption is through aquaporin channels by the action of ADH on V2 receptores . Aquaporin channels are stored in vesicles in the cytoplasm of principal cells. Vasopressin causes rapid insertion of these vesicles into the apical membrane of cells.

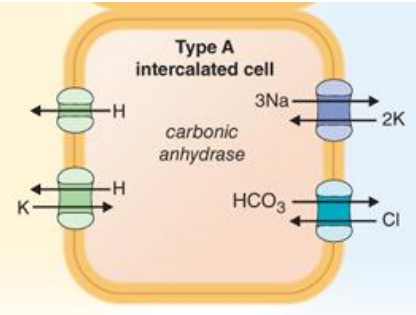
Note : abnormal↓in aldosteron secretion→loss of Na in urine and hyperkalemia while abnormal ↑Aldosteron→Na retention & hypokalemia.

K sparing diuretics act as aldosteron antagonist→ inhibits Na reabsorption and ↓K secretion

2- **The intercalated cells** : secrete H & reabsorb HCO_3 also reabsorb K ions

- Intercalated cells are involved in acid-base regulation.
- **H -ATPase** in the luminal membrane which pumps H+ into the lumen and reabsorb HCO_3 . Aldosteron stimulates the secretion of H ions
- **H-K ATPase** in the luminal membrane that secretes H ion out and reabsorb K ions.
- HCO_3 is reabsorbed with H ion : secreted H ions bind to luminal HCO_3 to form $H_2CO_3 \rightarrow CO_2$ and H_2O (as in proximl tubule)





Medullary collecting duct :

- play an extremely important role in determining the final urine output of water and solutes ,its main function :
  - Unlike the cortical collecting tubule, the medullary collecting duct is permeable to urea which is reabsorbed into the medullary interstitium, →↑the osmolarity in this region of the kidneys and contributing to the kidneys ability to form a concentrated urine.
  - Na and Water reabsorption : ADH →↑water reabsorbed into the medullary interstitium, →↓the urine volume .
  - secrerting H ion against a large concentration gradient like cortical collecting duct→acid base regulation.