(Renal Physiology 6)

Renal Transport Process 2

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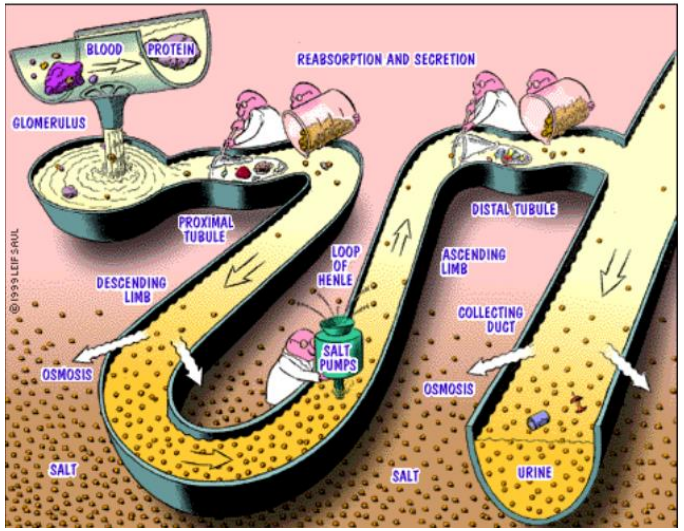


Loop of Henle

- 25% NaCl, K+ absorbed as well as Ca_2^+, HCO_3^-occurs in thick ascending limb (TAL)
- impermeable to water

- 15% water absorbed in thin descending limb
- permeable to water

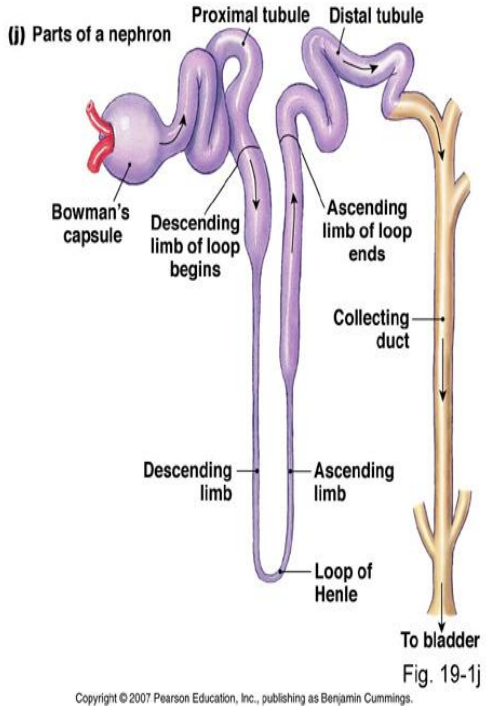


Fig. 19-1j

Loop of Henle

- Solute absorption (TAL):

1) **Transcellular** (50%)

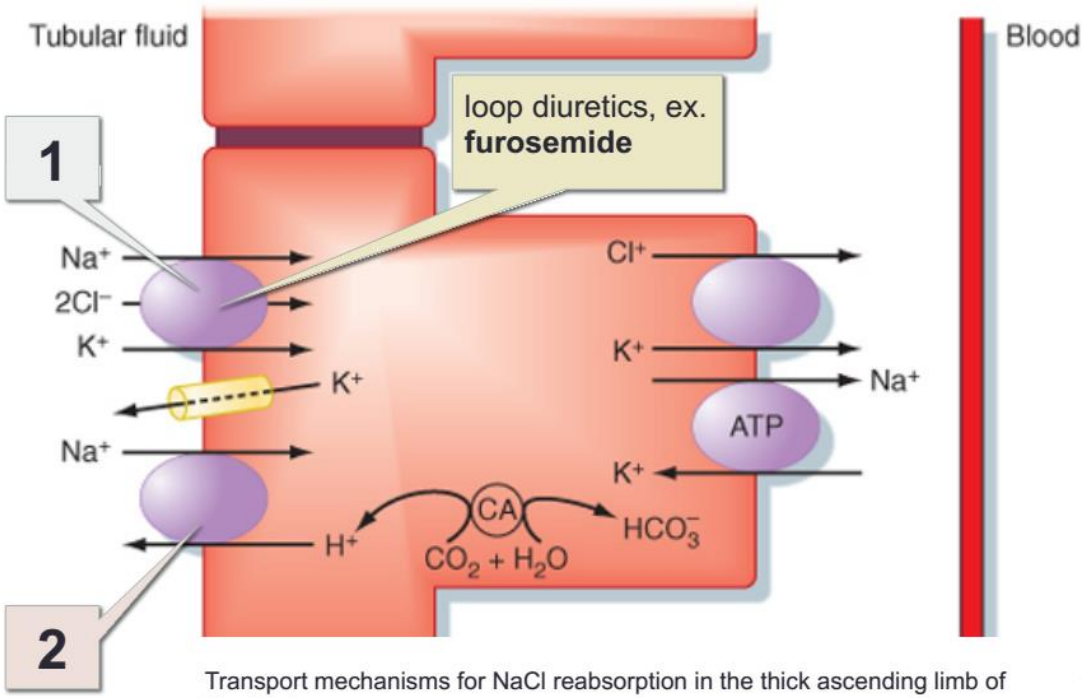
   a) Na+/2Cl-/K+ cotransporter/ symporter

   b) NHE

      i) Na+ in

      ii) H+ out

      iii) HCO3- in



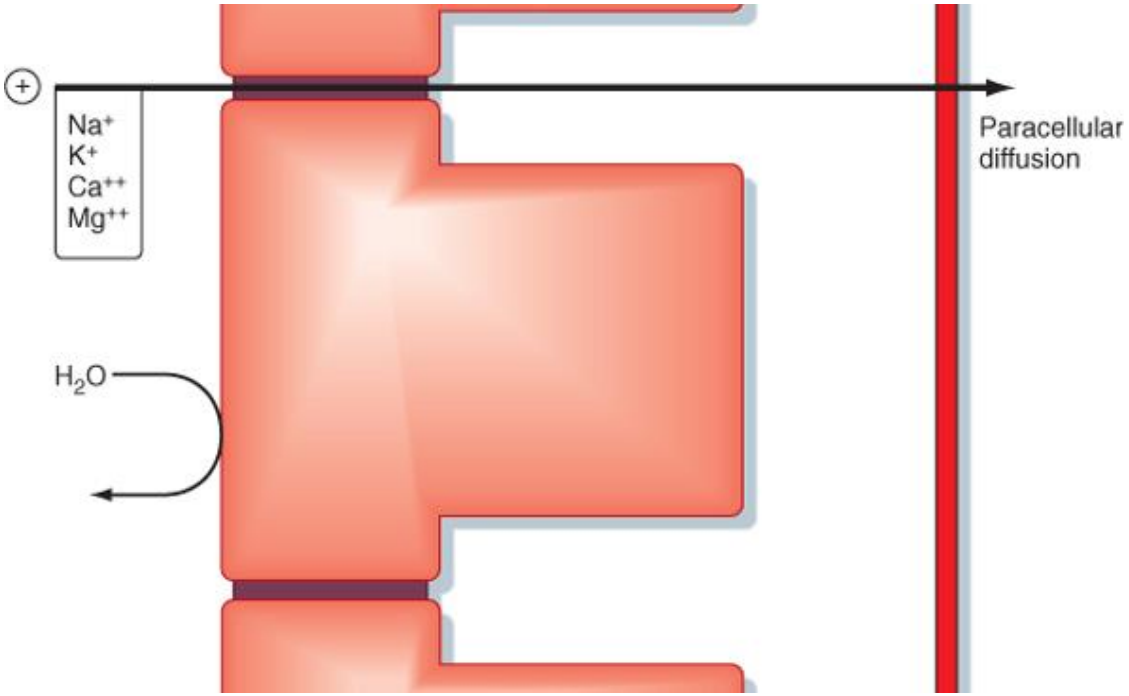
Transport mechanisms for NaCl reabsorption in the thick ascending limb of Henle's loop.

Loop of Henle

2) **Paracellular** (50%)

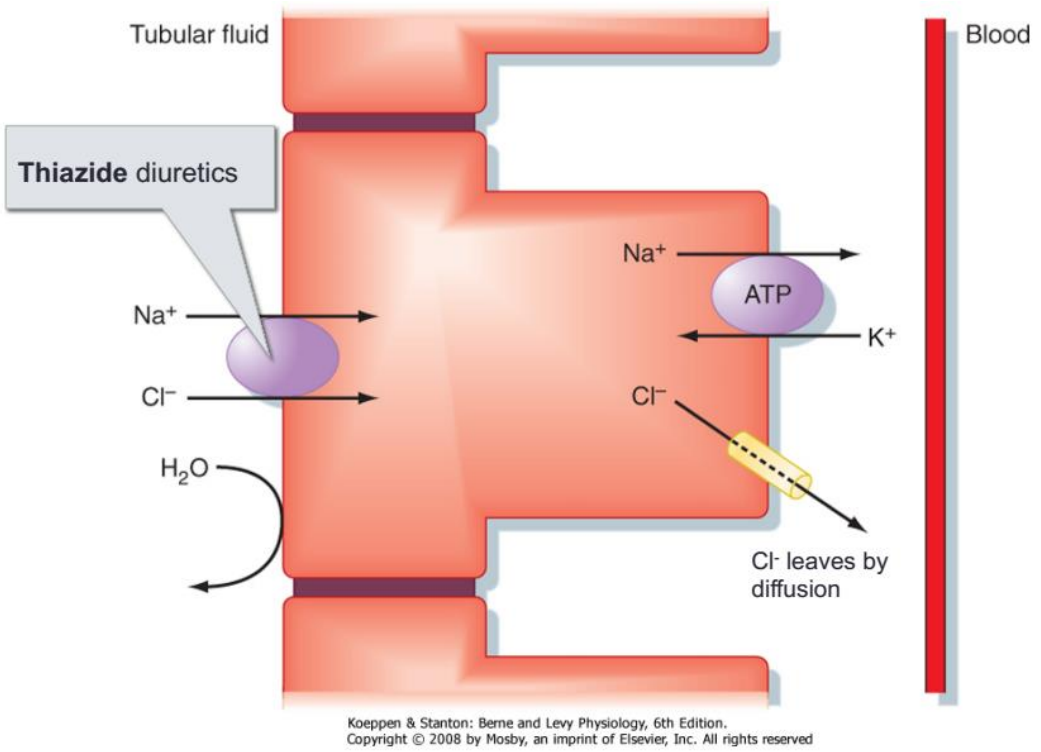
- Loss of NaCl in tubule

  $\Rightarrow \uparrow$ positive charge compared to blood drives absorption



Distal convoluted tubule (DCT) & collecting duct (CD)

- 7% NaCl
- 8 – 15 % water reabsorbed (needs ADH)
- Some K^+, H^+ secreted **into** tubule
- **Early DCT**:
- Reabsorbs Na^+, Cl^- and Ca^{++} (impermeable to water)



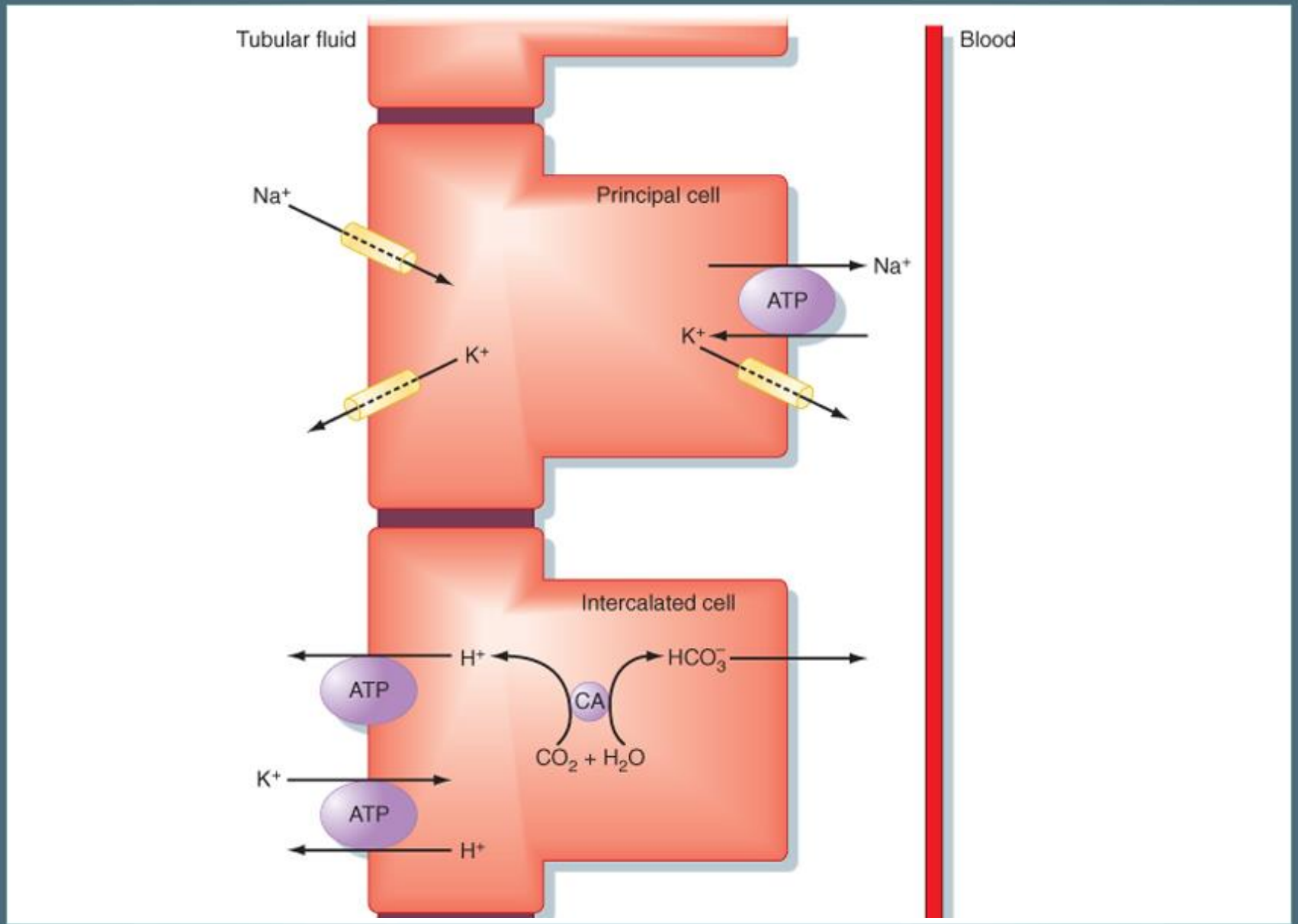
Distal convoluted tubule (DCT) & collecting duct (CD)

Late DCT:

- 2 cells:

1) principle cells: reabsorb Na^+, water, secrete K^+
2) intercalated cells: secrete or reabsorb H+ (inverse for HCO3-), reabsorb K^+

- Na^+ diffuses via selective channels
- K^+ secreted down concentration.


Tubular fluid
Blood
Principal cell
Na+
Na+
ATP
K+
K+
Intercalated cell
H+
HCO3−
ATP
CA
CO2 + H2O
K+
ATP
H+

Factors affecting Na reabsorption

1. GFR: when increased causes an increase in filtration of Na which sensitise the macula densa.
2. Aldosterone.
3. Estrogens: Increase reabsorption of Na and decrease Na excretion.
4. Natriuretic hormone.
5. Osmotic diuresis (Increase Glucose, Mannitol and Urea) increase their conc. In the filtered load then causes a decrease in water reabsorption and Na.
6. Diuretic Drugs (Lasix)
7. Poorly reabsorbed anions causes retention of equal amount of Na.

Transport of potassium

- Most abundant cation in the body
- 3,500-4,000 mmol in blood.
- 98 % is intracellular, [150mM]
  - Regulates intracellular function such as Cell volume, Acid/base status, cell growth & division
- 2% K extra-cellular [3.5-5mM]
  - This regulates membrane potentials in excitable cells and diffusion potentials in transporting epithelia.

- K^+ Intake 80-120 mmol/day
- Tissue damage leading to cell lysis increases plasma $[K^+]$
- Both extracellular $[K^+]$ and total body potassium are tightly regulated.

HOW?

INTERNAL DISTRIBUTION

(This regulates extracellular $[K^+]$)

RENAL K^+ EXCRETION

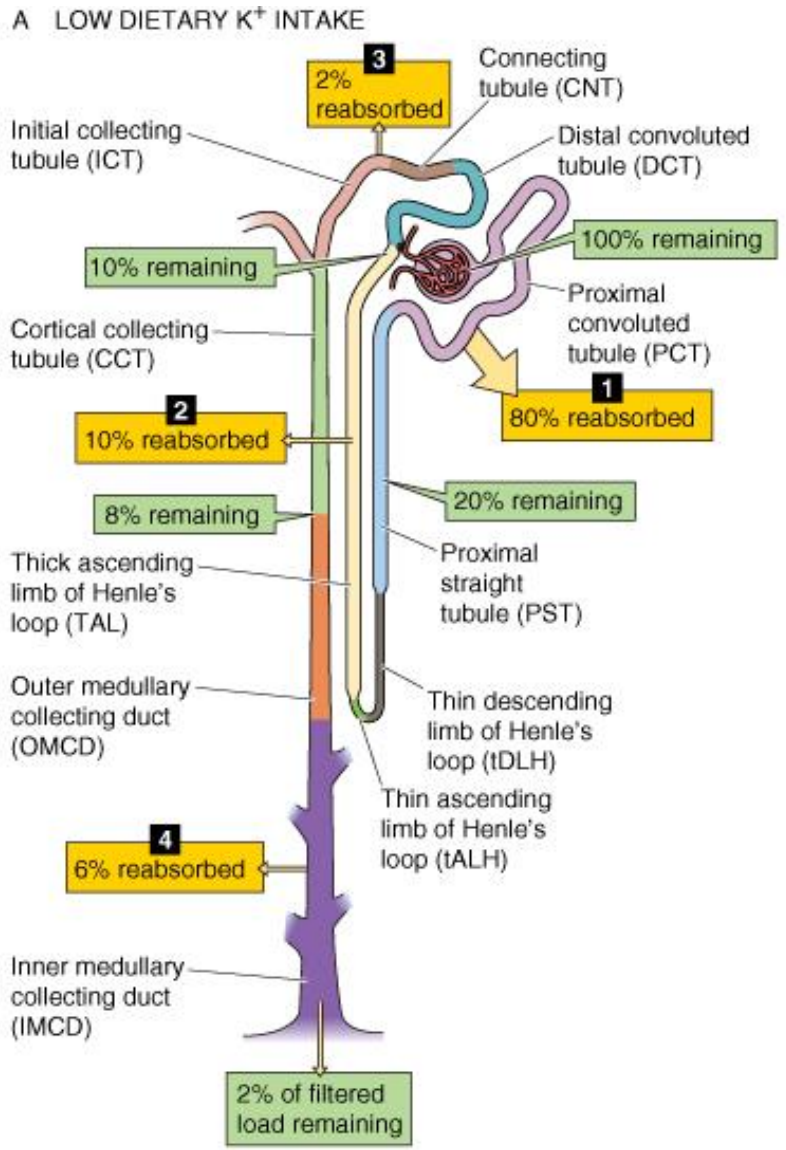
(This regulates total body potassium)

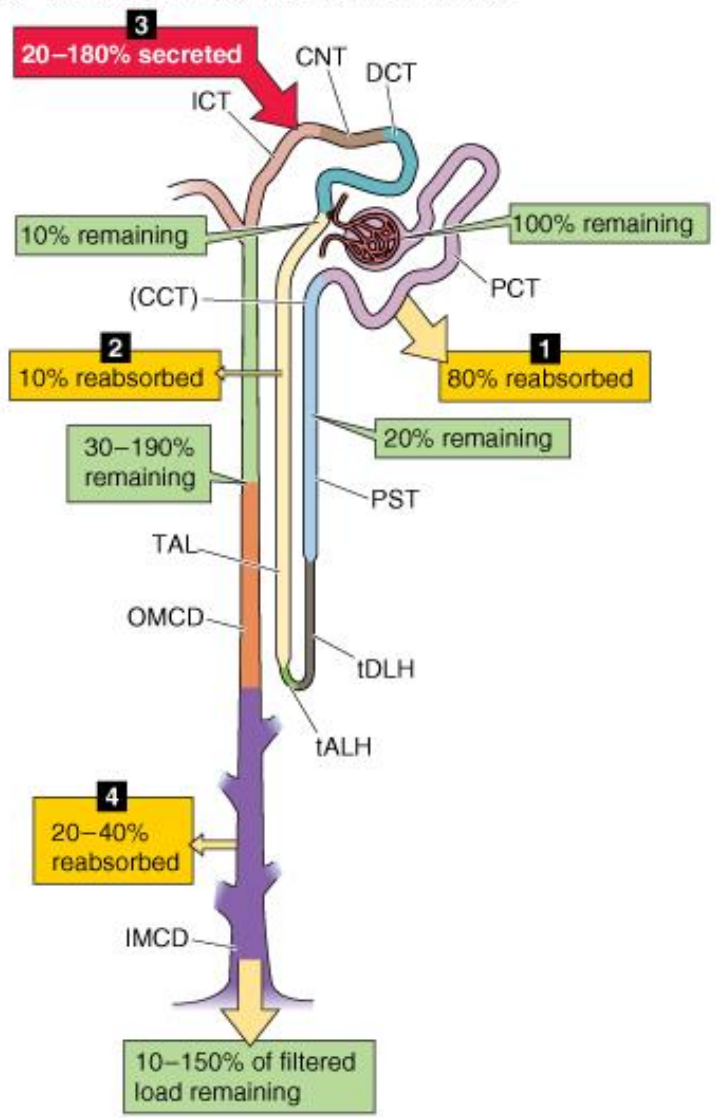
Internal potassium distribution

- Potassium content of average meal is 30-40mmol. This is rapidly absorbed.
- Renal elimination is slow. It can take up to six hours eliminate this load.
- If nothing happened then this absorbed load would cause Plasma [K^+] to rise by ~ 2-5mmol which is potentially lethal.
- Buffering of the load occurs by increased intracellular uptake via Na^+/K^+ pump into Skeletal Muscle, Liver, Bone RBCs etc.
- Loss of K^+ from exercising muscle can seriously increase plasma K^+ ,trained athletes show accelerated uptake after exercise

Renal excretion of potassium

- 90-95% of Dietary K excreted via the kidneys
- 5-10% in Sweat & Feces (This is unregulated and may become significant in diarrheas)
- In normal individual intake is matched by excretion and potassium balance is maintained.
- Filtered load of potassium ~ 720 mmol/day
- Bulk absorbed by proximal tubule and loop of Henle.

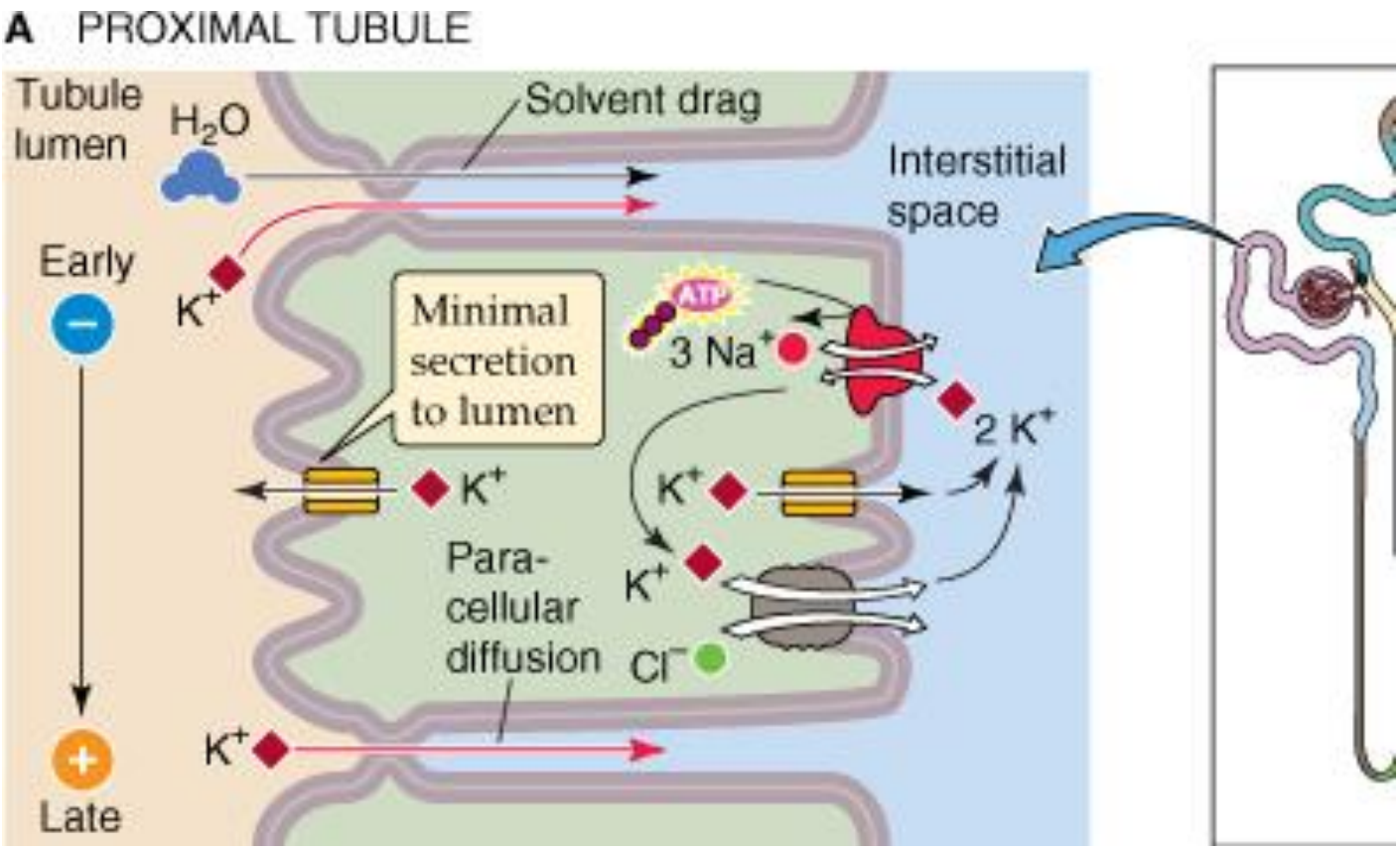




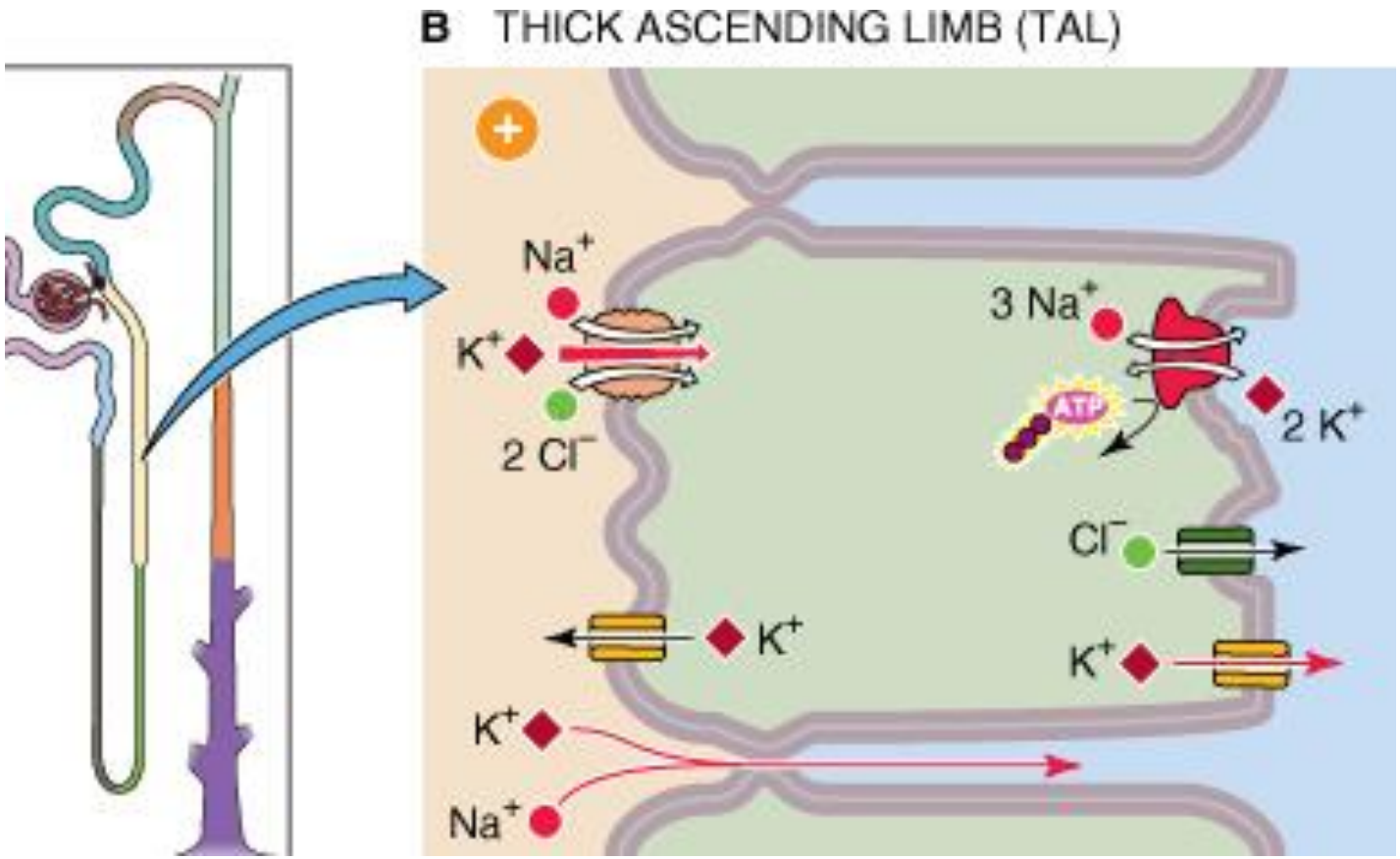
Renal K^+ Transport mechanisms

- Cell membrane transporters
  - Na^-K ATPase, H^-K ATPase
  - K^+ channels, K:Cl cotransport
  - Na:K:2Cl cotransport
- K^+ is Reabsorbed in PT, TAL & intercalated cell in CCD
- K^+ Secreted in late distal tubule and in principal cells of late DT & CCD

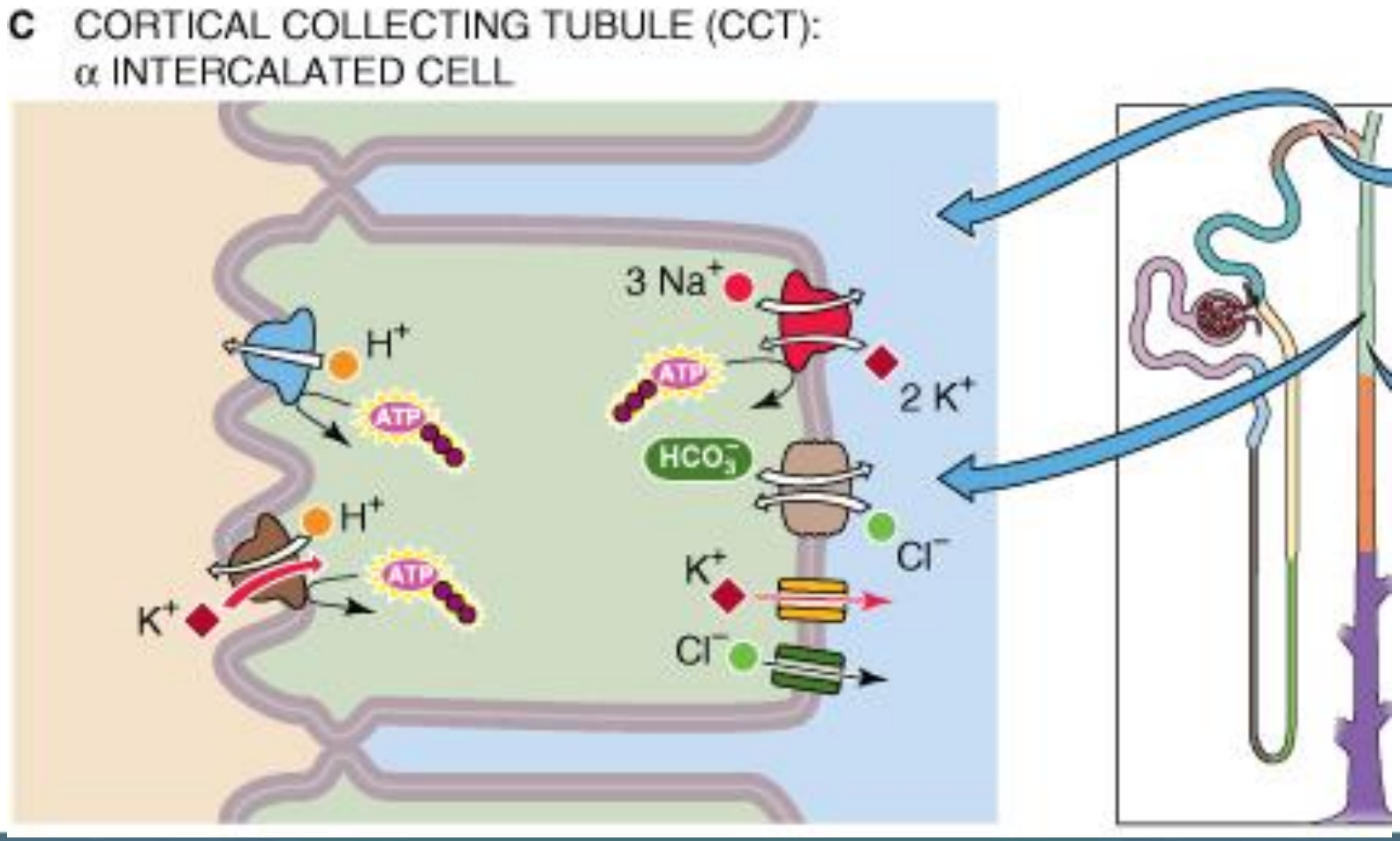
- **Proximal Tubule:** K^+ is absorbed by intercellular solvent drag whereby fluid movement driven by Na^+ absorption entrains K^+ ions



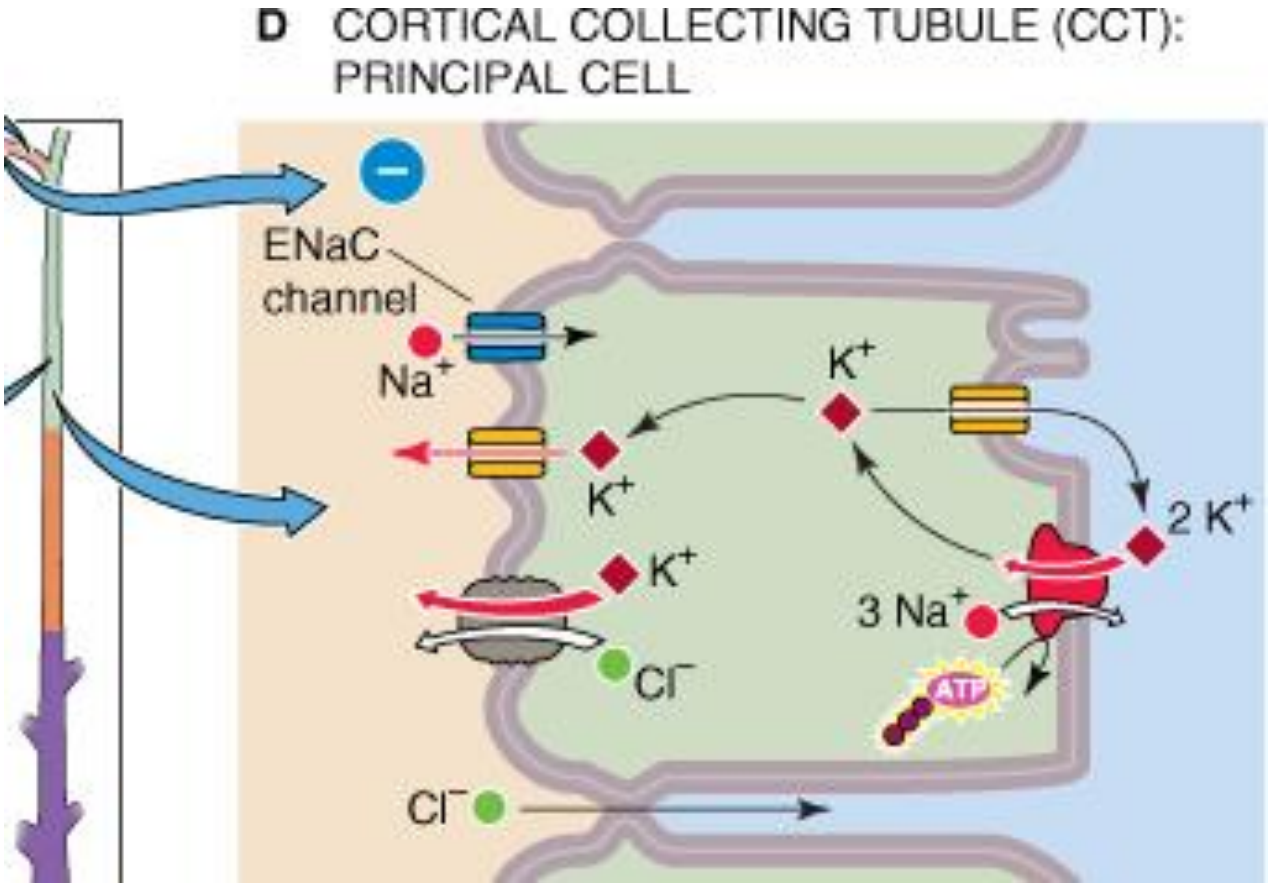
- **TAL:** Na:K:2Cl in luminal membrane
- K:Cl co-transport in baso-lateral membrane



CD: K reabsorption is by the intercalated cells via a luminal H-K ATPase.



- **CD:** K+ secretion in the principal cells (via luminal K channels and basolateral Na-K ATPase).



Factors affecting potassium secretion

Peritubular factors:

1.Hyperkalemia: increase K in tubular cells, increase chemical gradient of K between tubular cell and tubular lumen which lead to increase in the secretion and excretion of K.

2.Hyper-aldosteronism: increase aldosterone increase secretion and excretion of K.

3.Alkalosis: increase H-K exchange at baso-lateral membrane then increase secretion and excretion of K.

Factors affecting potassium secretion

Luminal factors:

1.Diuresis: increase volume of urine and decrease conc of K in lumen which causes secretion via chemical gradient. (increase secretion and excretion)

2.Increased urinary excretion of Na: increase in Na-K exchange at luminal membrane causes an increase in secretion and excretion of K.

3.Increased urinary excretion of bicarbonate, phosphate, sulphate and ketone acids: increase negativeness of lumen then increase electrochemical gradient between cell and lumen causes secretion and excretion of K.