

Tubular Functions

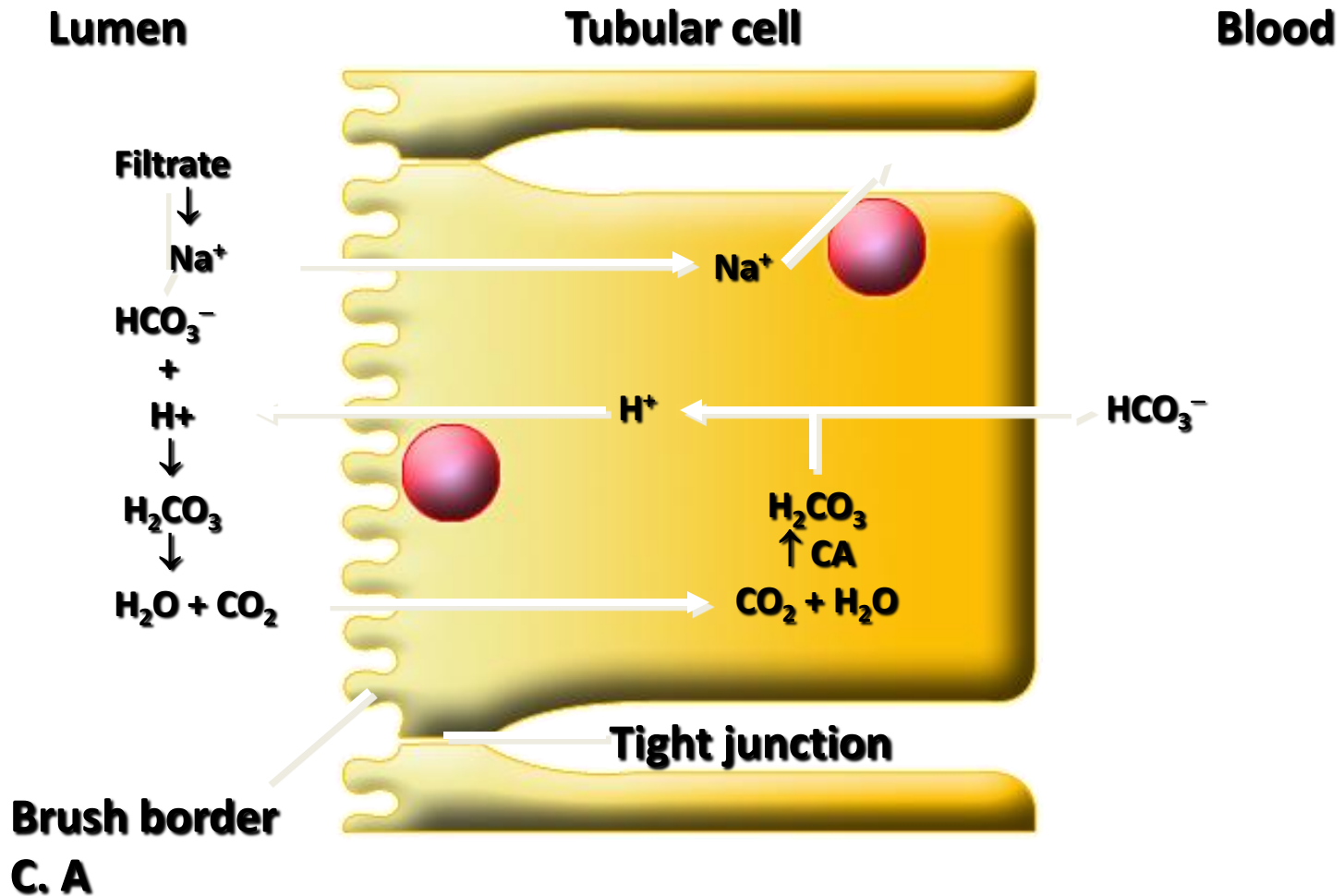
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Objectives

At the end of this lecture student should be able to describe:

- 1. Mechanism of Bicarbonate reabsorption**
- 2. Mechanism of Phosphate reabsorption**
- 3. Urea reabsorption**
- 4. Mechanism of Tubular secretion of K & H**

Bicarbonate reabsorption *cont.*



Bicarbonate reabsorption

- 90% of filtered is reabsorbed in PCT
- Filtered $\text{HCO}_3 + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3$
- $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$ in the presence of carbonic anhydrase enzyme
- CO_2 diffuses into the cell + $\text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$
- $\text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3$
- HCO_3 is reabsorped by simple diffusion
- H^+ is secreted in exchange for Na^+

Phosphate reabsorption

- **Bones, teeth & skeleton = 80%**
- **Intracellular P = 20%**
- **Plasma P = 1mmol/L freely filtered**
- **1/3 of filtered P is excreted in urine**
- **2/3 Reabsorbed cotransported with Na**
- **Rate of absorption is under the control of PTH & VD**

Urea reabsorption

- **Plasma urea concentration =15-40mg /100ml**
- **End product of protein metabolism**
- **40-50% of filtered urea reabsorbed**
- **Reabsorbed by Passive diffusion following Na and water**
- **50-60% excreted**

Urea reabsorption

- **↓GFR (renal disease; low renal blood flow)**
→ **↑urea concentration in plasma due:**
 - Reduction in urea filtration
 - more urea reabsorbed to blood due to slow flow rate of filtrate

Tubular secretion

- **From peritubular blood through peritubular space into renal tubular cell to tubular lumen**
- **Secretion:**
 - **Passive NH₃, salicylic acid**
 - **Active**
 - **Tubular maximum (T_m): creatinine; PAH**
 - **No T_m: K; H**

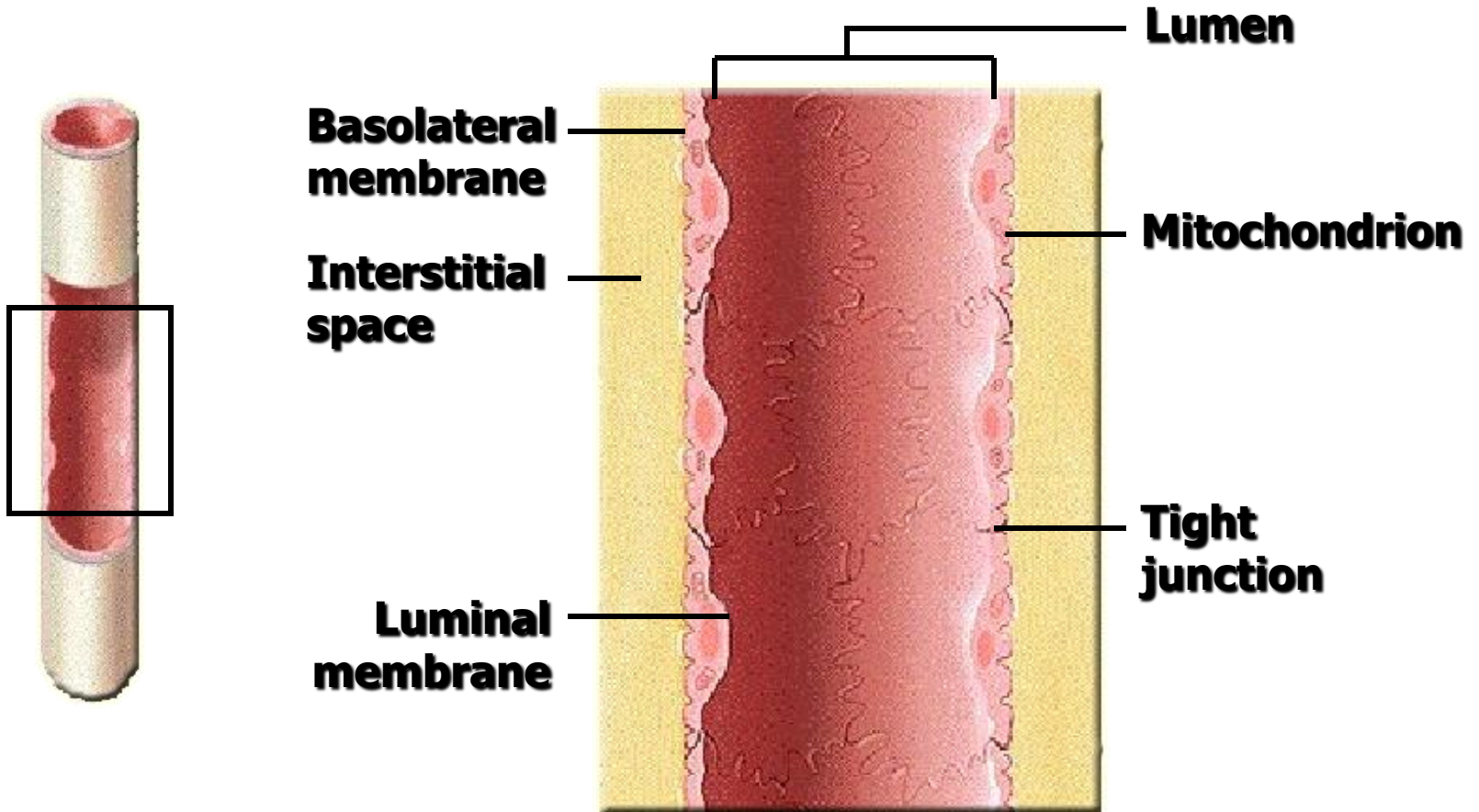
Tubular secretion *cont.*

- **Potassium**
 - 90% of filtered K is reabsorbed (PCT)
 - K is secreted in DCT in exchange for Na and under the control of Aldosterone hormone
- **Hydrogen**
 - Excretion exchange for Na

Loop of Henle

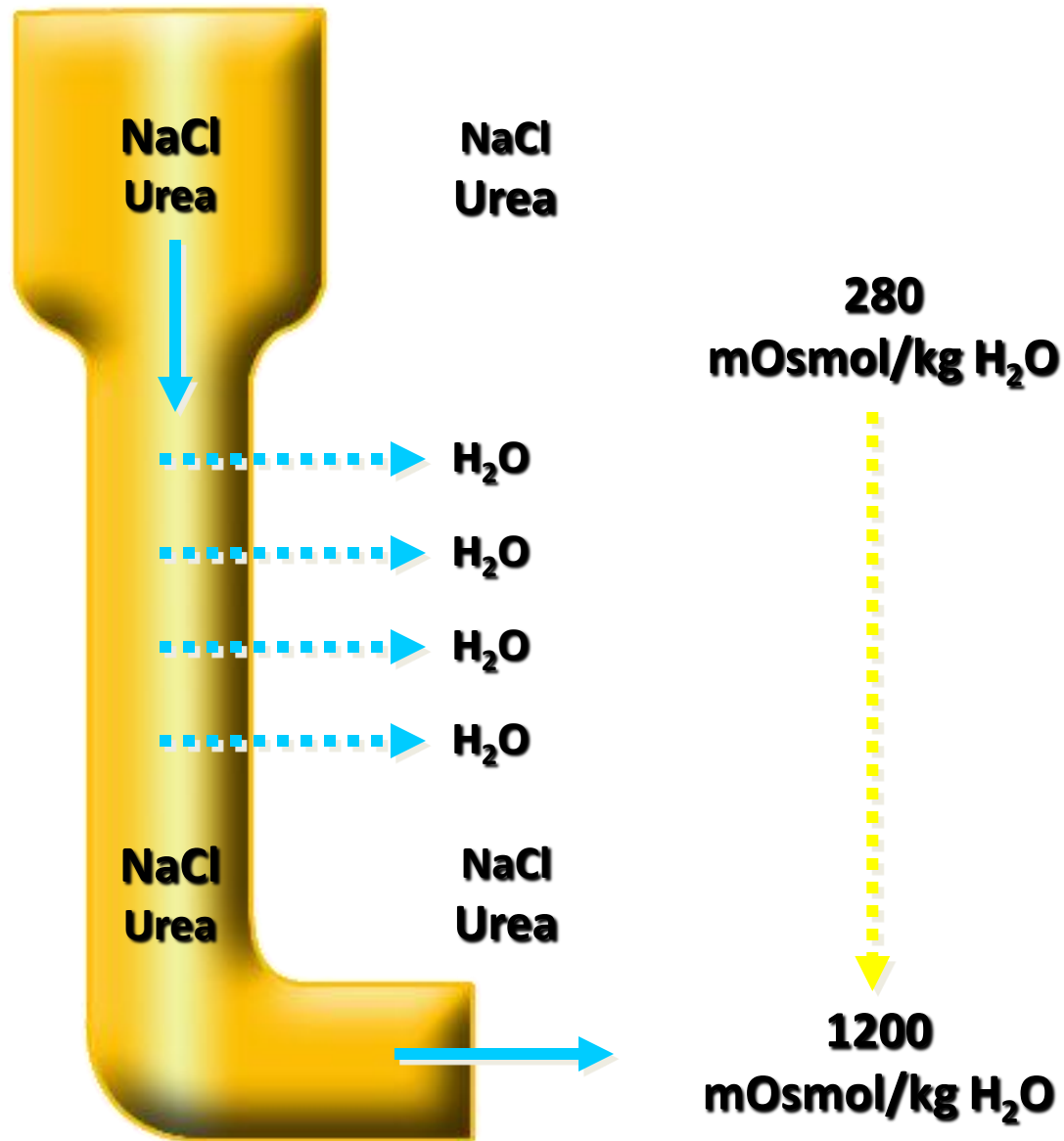
The Thin Loop of Henle

Cells simple squamous epithelial cells. Highly permeable to water but not to solutes



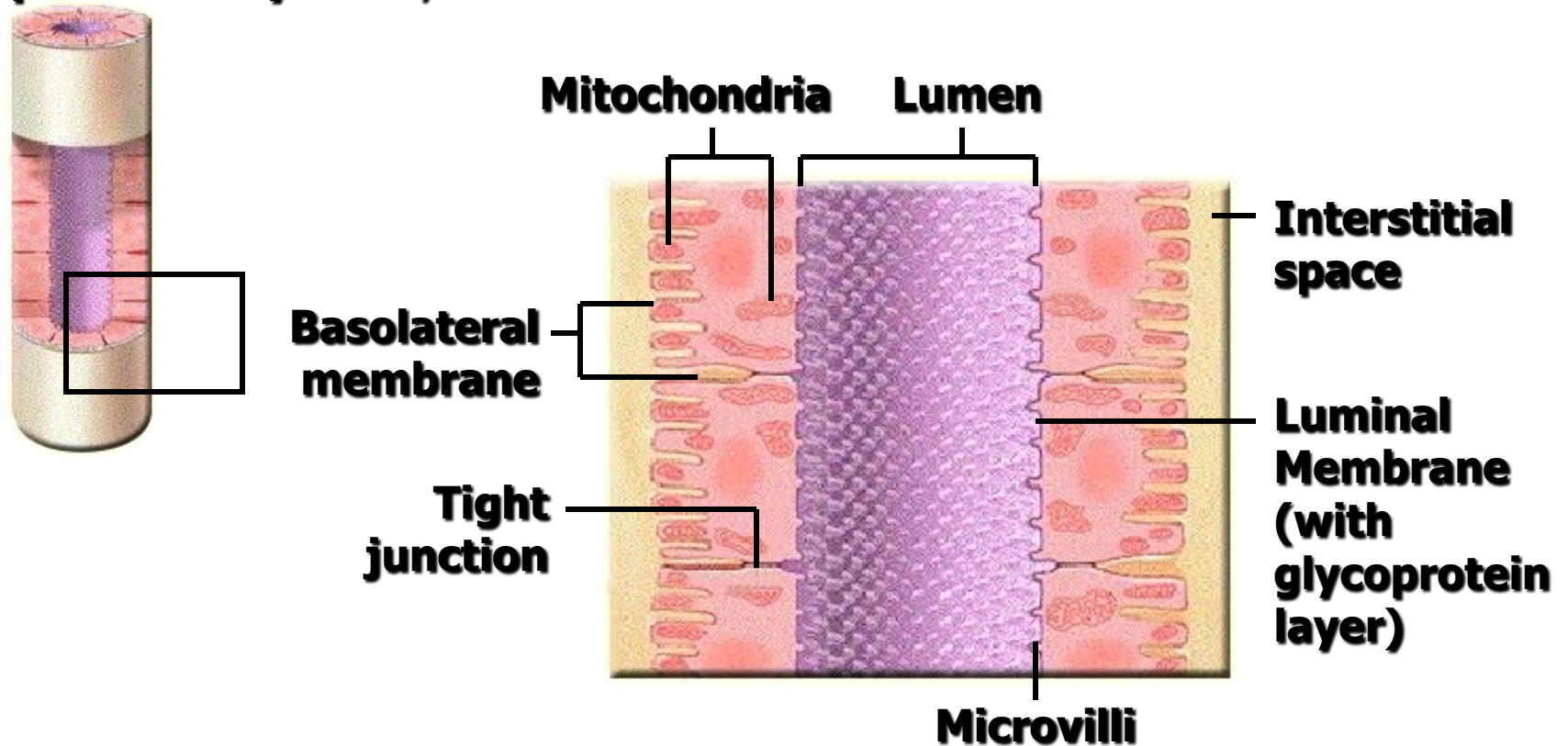
The descending Loop

- **Permeable to water but not for solute absorption**
- **20% of filtered water is reabsorbed**
- **osmolality of filtrate increases from 290 to 1200 mOsm/l at the tip of the loop**
- **The increasing osmolality is due to only water reabsorption, \uparrow NaCl and \uparrow Urea concentration in filtrate**



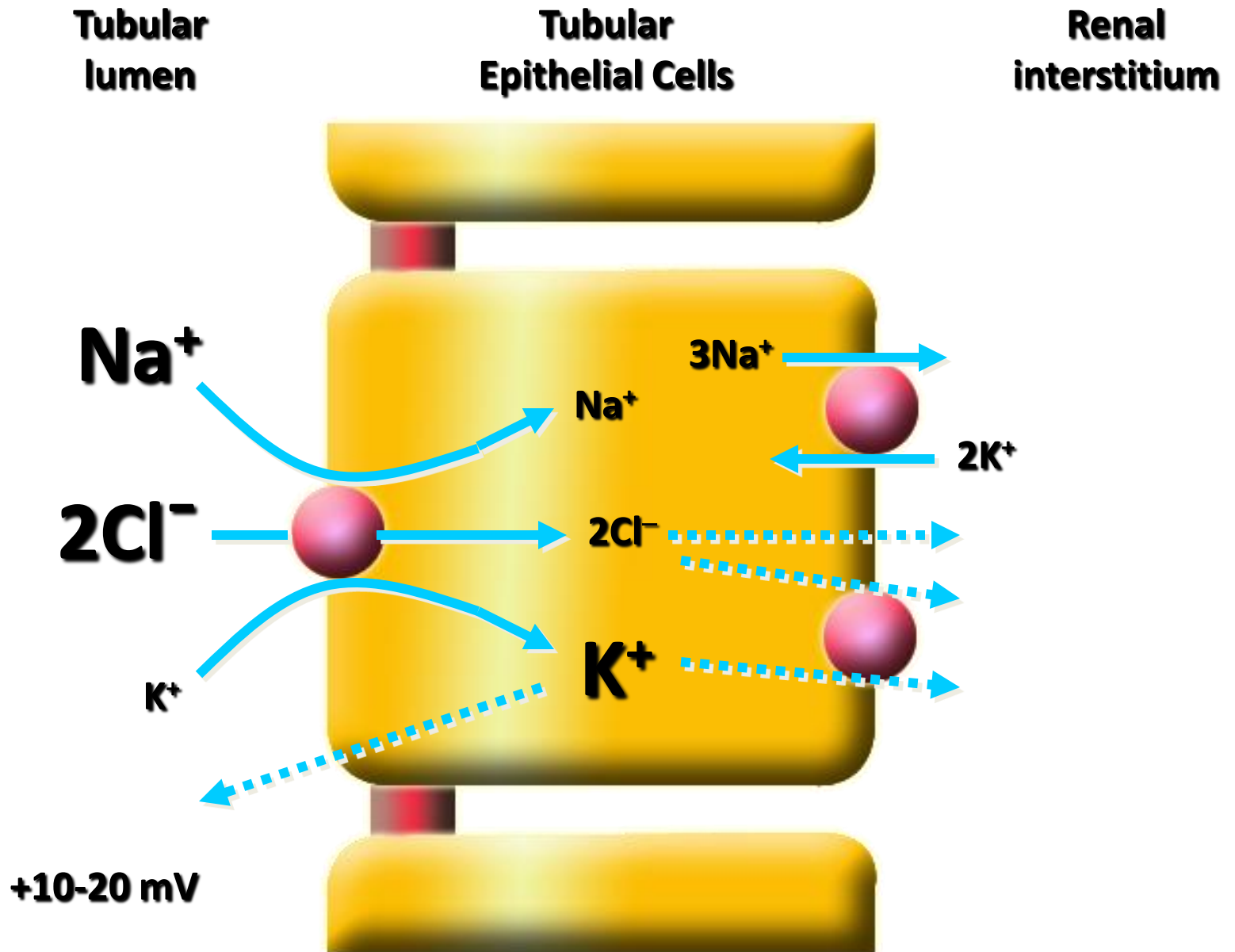
The Ascending Loop of Henle and Early DCT

Cells are cuboidal epithelia; Highly permeable to solutes, particularly NaCl, but not to water



The Ascending limb

- **1/3 Thin ?**
- **2/3 Thick**
 - Water impermeable
 - Na/K/2Cl reabsorption by cotransport (luminal)
 - Na/K ATPase in basolateral membrane
- **Filtrate diluted due to solute reabsorption not water**
- **Osmolarity drop from 1200 to 200mosm/l**

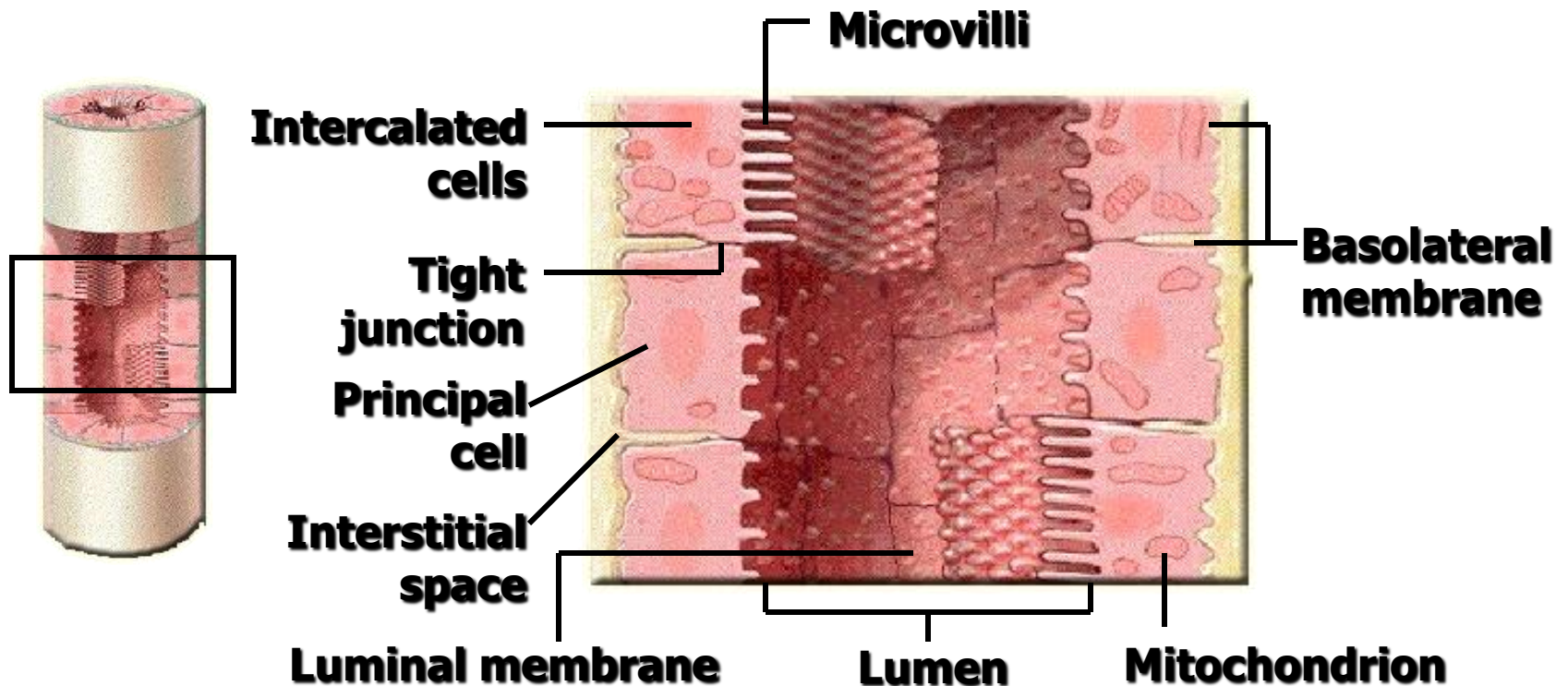


Thick ascending Loop

- **The thick ascending limb is very sensitive to diuretic drugs (Furosamide). These diuretics block $\text{Na}^+\text{-K}^+\text{-2Cl}^-$ cotransporter:**
 - Decreased NaCl reabsorption
 - Isotonic fluid delivered to distal tubule instead of a hypotonic fluid
 - Increased fluid excretion – “diuresis”
 - These drugs are called “Loop” diuretics

The Late DCT and Cortical Collecting Duct

Cuboidal cells are of two distinct functional types principal and intercalated cells.



- Principal cells permeability to water and solutes is regulated by hormones
- Intercalated cells secretion of hydrogen ions for acid/base balancing

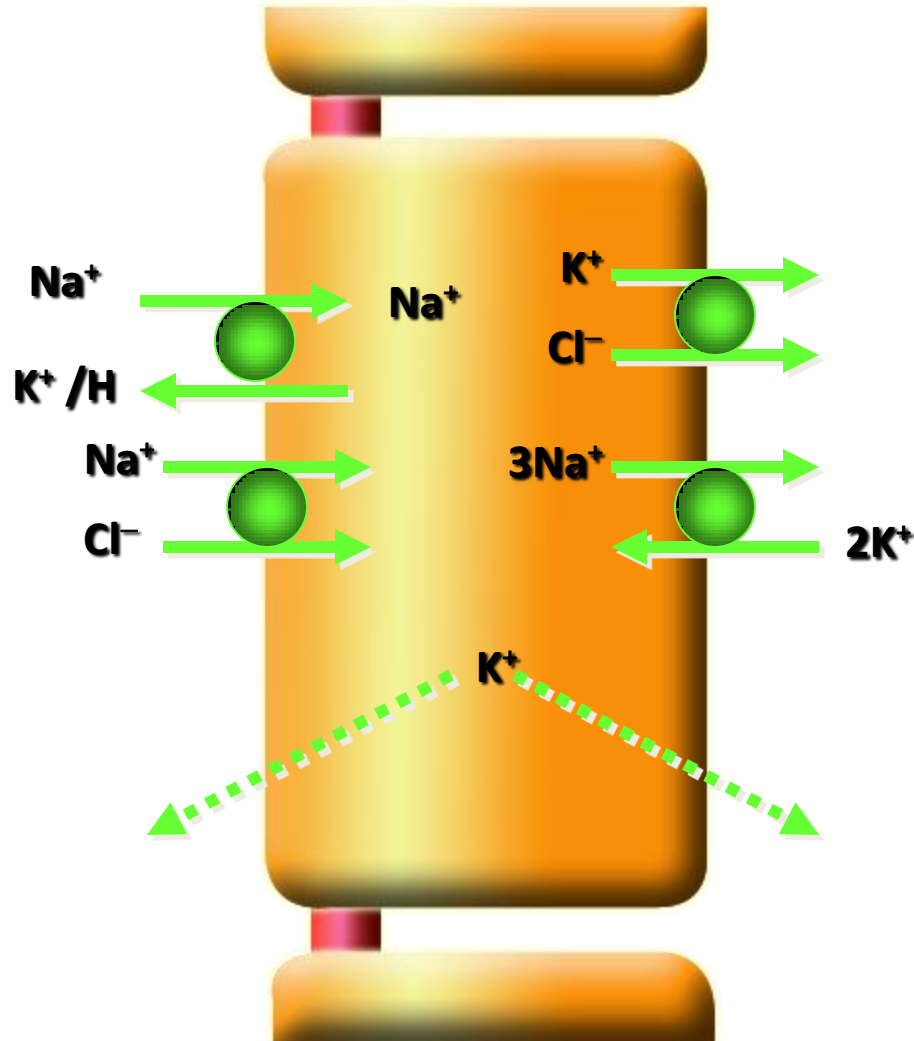
The Late DCT and Cortical Collecting Duct

- **19% of filtered H₂O is reabsorbed**
- **9% of filtered Na⁺ is reabsorbed in exchange of K⁺ or H⁺**
- **Cl⁻ also reabsorbed**

Tubular lumen

Tubular Epithelial Cells

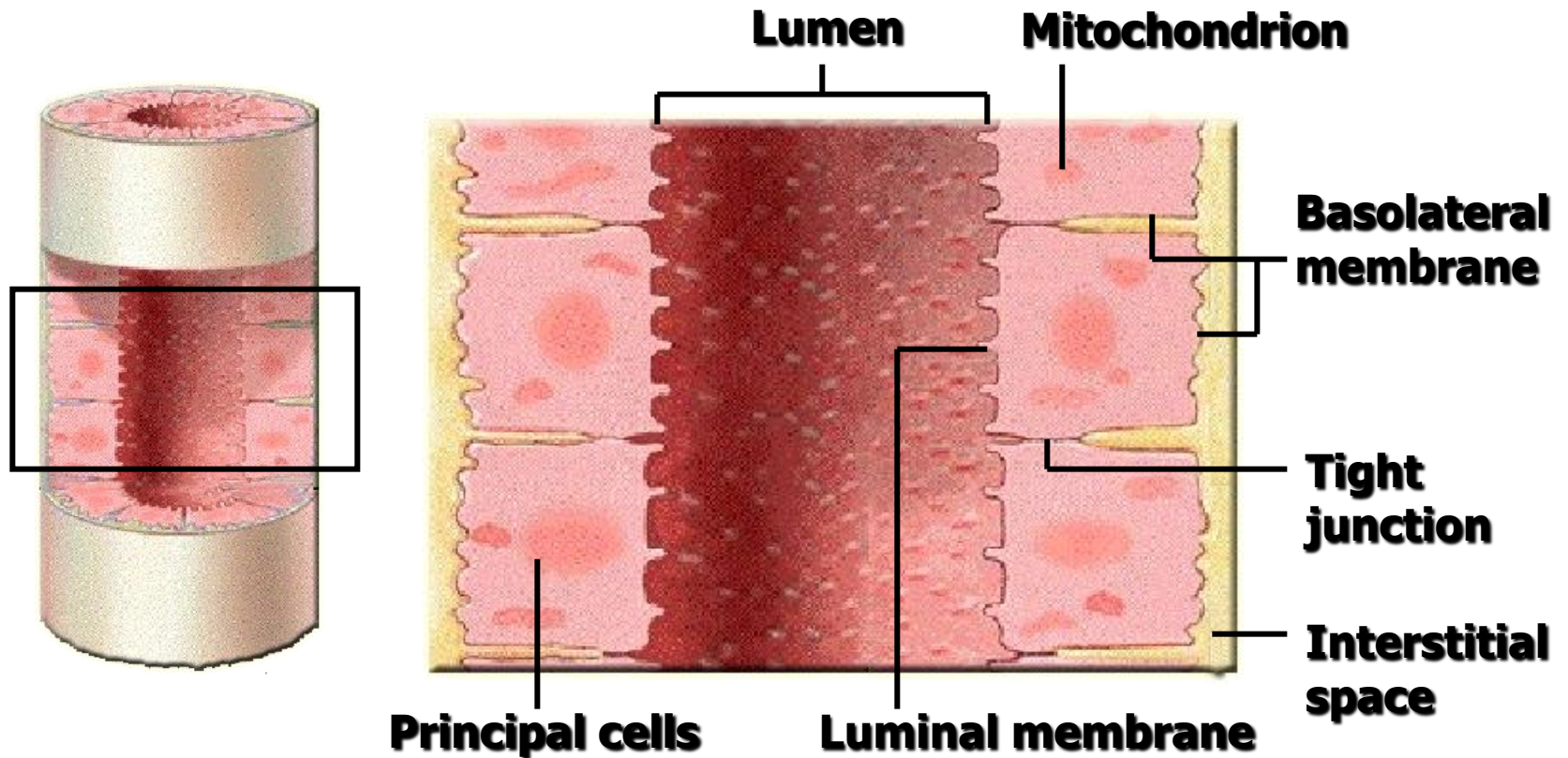
Renal interstitium



Distal Tubule

Cells of the Medullary Collecting Duct

Cells are mainly principal cells.



Hormonally regulated permeability to water and urea.

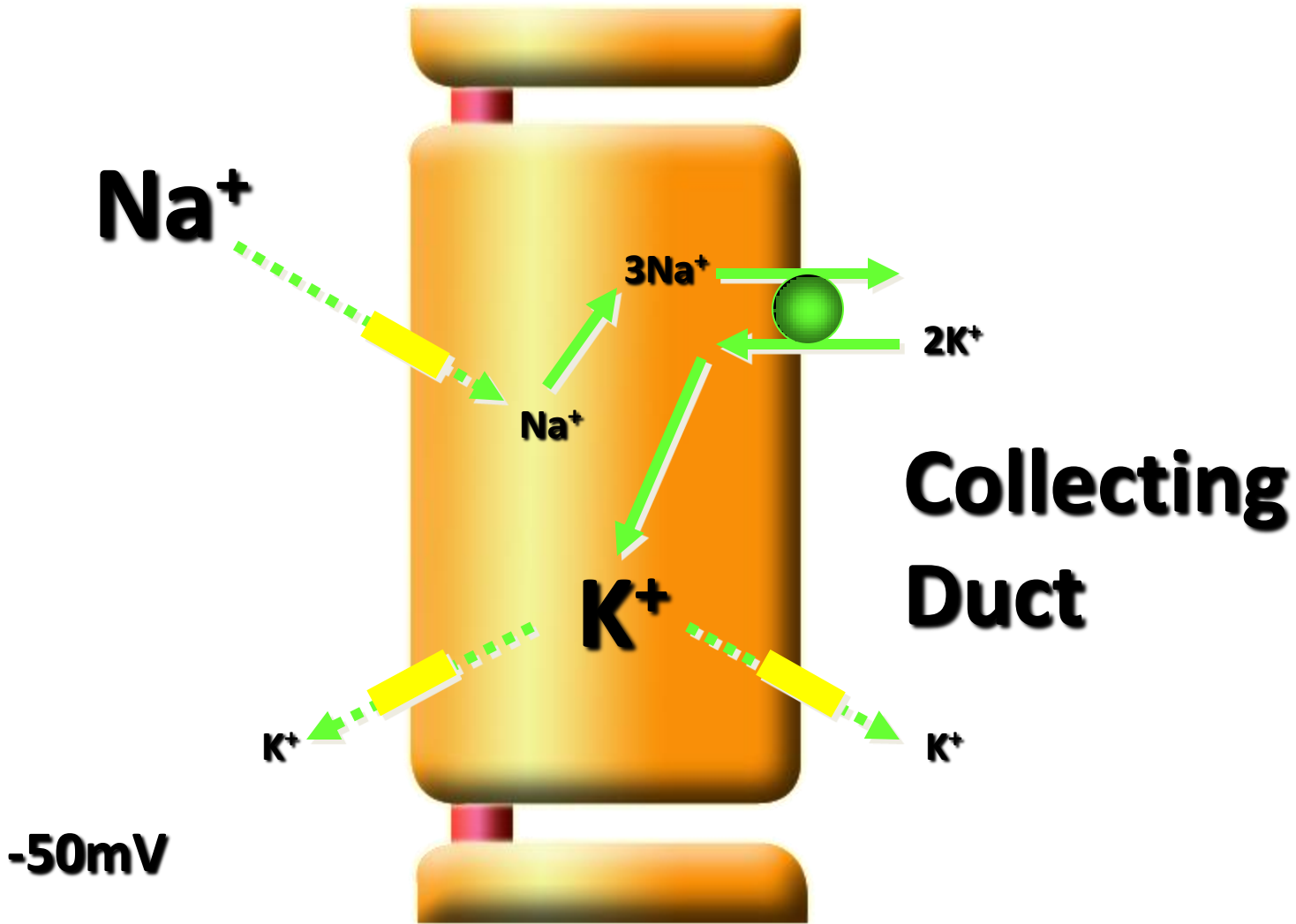
Collecting duct

- **Water permeable under ADH**
- **Urea is reabsorbed in the presence of ADH**
- **Na reabsorbed in exchange for K under the influence of aldosterone**

Tubular lumen

Tubular Epithelial Cells

Renal interstitium

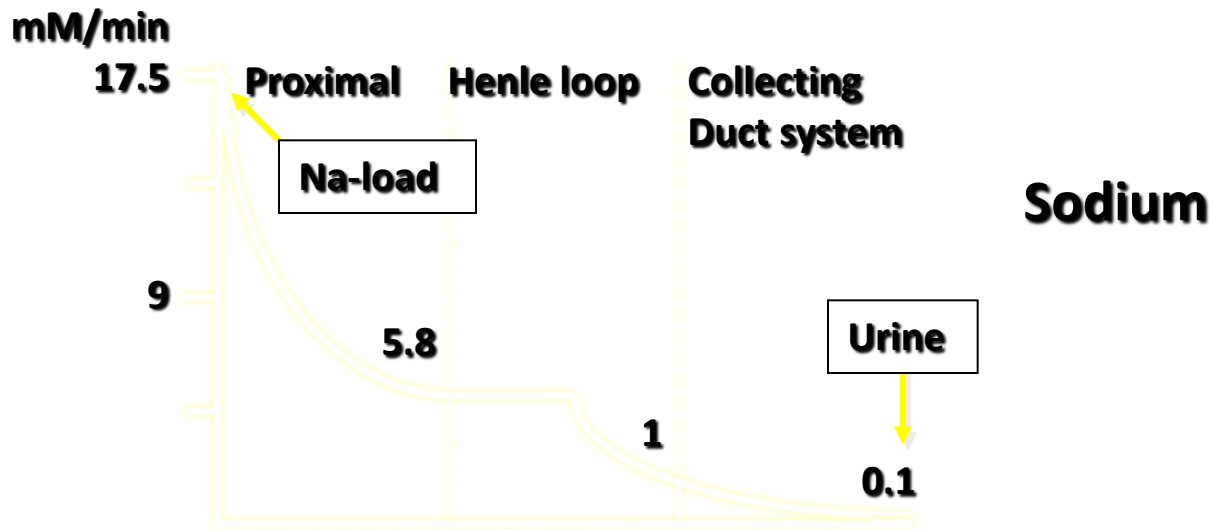
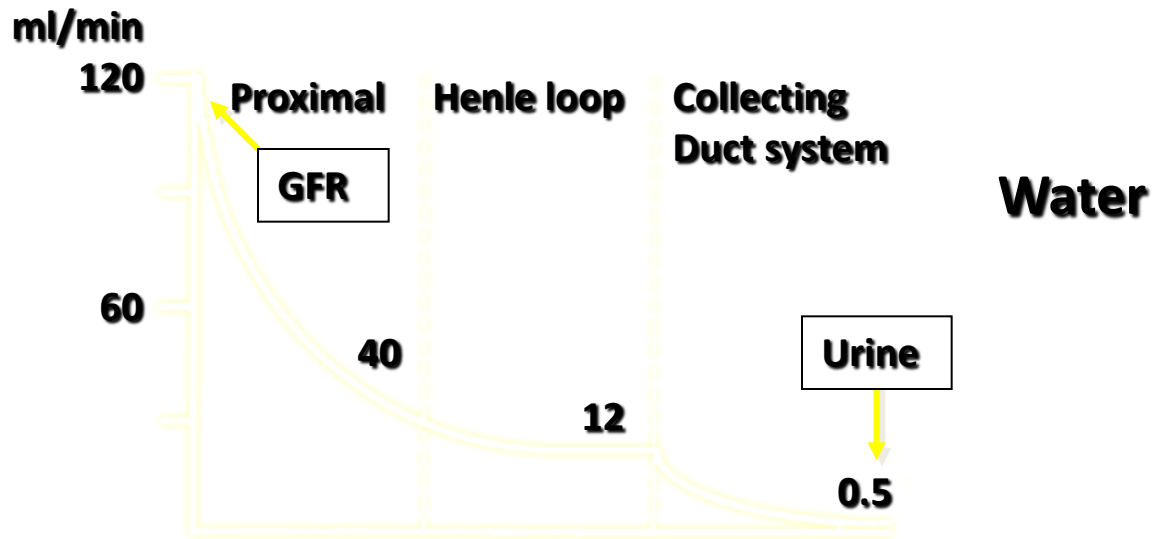


Urea Recirculation

- Urea is passively reabsorbed in proximal tubule.
- In the presence of ADH, water is reabsorbed in distal and collecting tubules, concentrating urea in these parts of the nephron
- The inner medullary collecting tubule is highly permeable to urea, which diffuses into the medullary interstitium.
- ADH increases urea permeability of medullary collecting tubule.

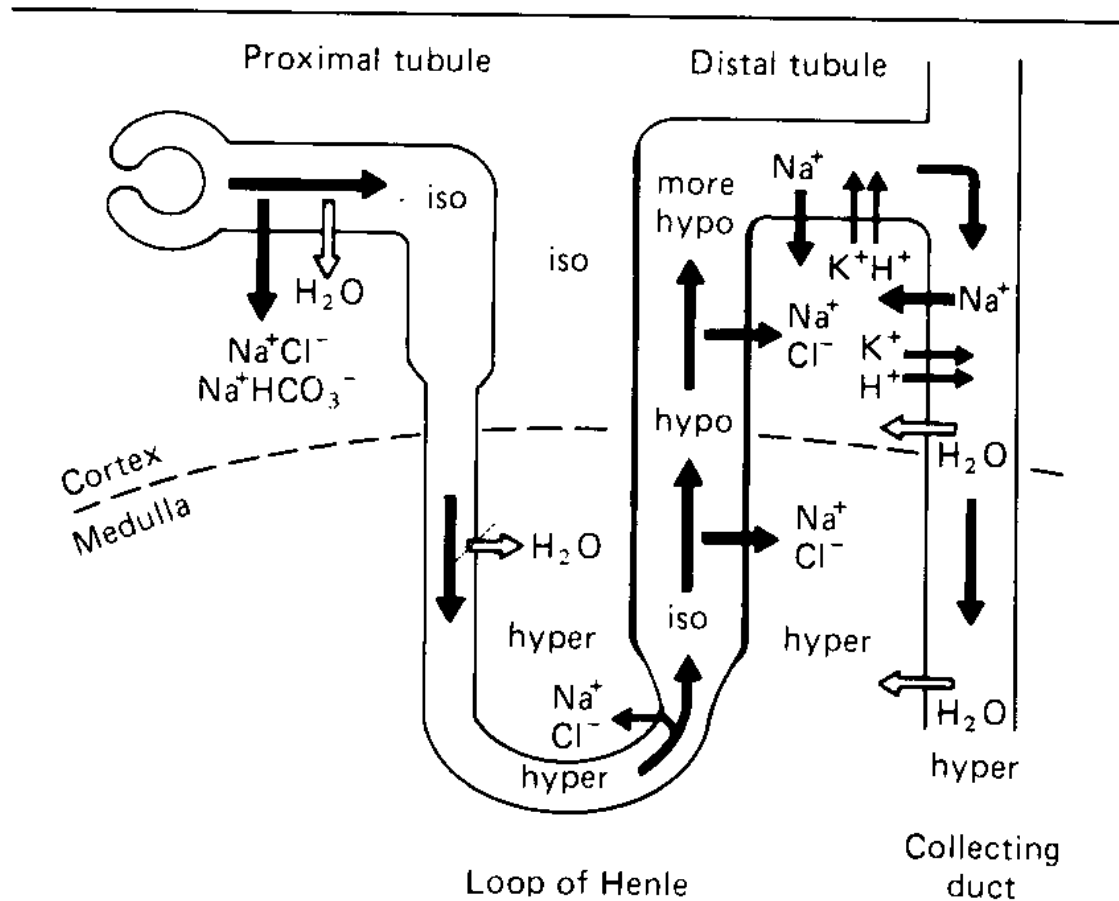
Summary of Water transport along the nephron

Segment	% filtered load reabsorbed	Mechanism of H ₂ O reabsorption	Hormones that regulate H ₂ O permeability
Proximal tubule	67	Passive	None
Henle's loop	15	DL only; passive	None
Distal tubule	0	No water reabsorption	None
Late distal tubule & collecting duct	~8-17	Passive	ADH



[Na] 145 145 40 200
mEq/l

Osmolality of the filtrate along the nephron



Osmolality of the filtrate along the nephron *cont.*

- **Osmolality of filtrate in PCT:**
 - similar to plasma ~290 mosm
 - Due to reabsorption of equal portion of solute & water
- **Osmolality of filtrate in D loop:**
 - graded \uparrow in osmolality from 300 mosm. To maximum of 1200 mos. at the tip of loop
 - Due to only water reabsorption

Osmolality of the filtrate along the nephron *cont.*

- **Osmolality of filtrate in A Loop:**
 - graded ↓ in osmolality 1200-150
 - Due to only solute reabsorption
- **Osmolality of filtrate in Collecting D**
 - Osmolality depend on ADH
 - ↑ADH → ↑ water reabsorption → concentrate urine 1200 mosm
 - No ADH → no water reabsorption → dilute urine 50mosm