Tubular Functions

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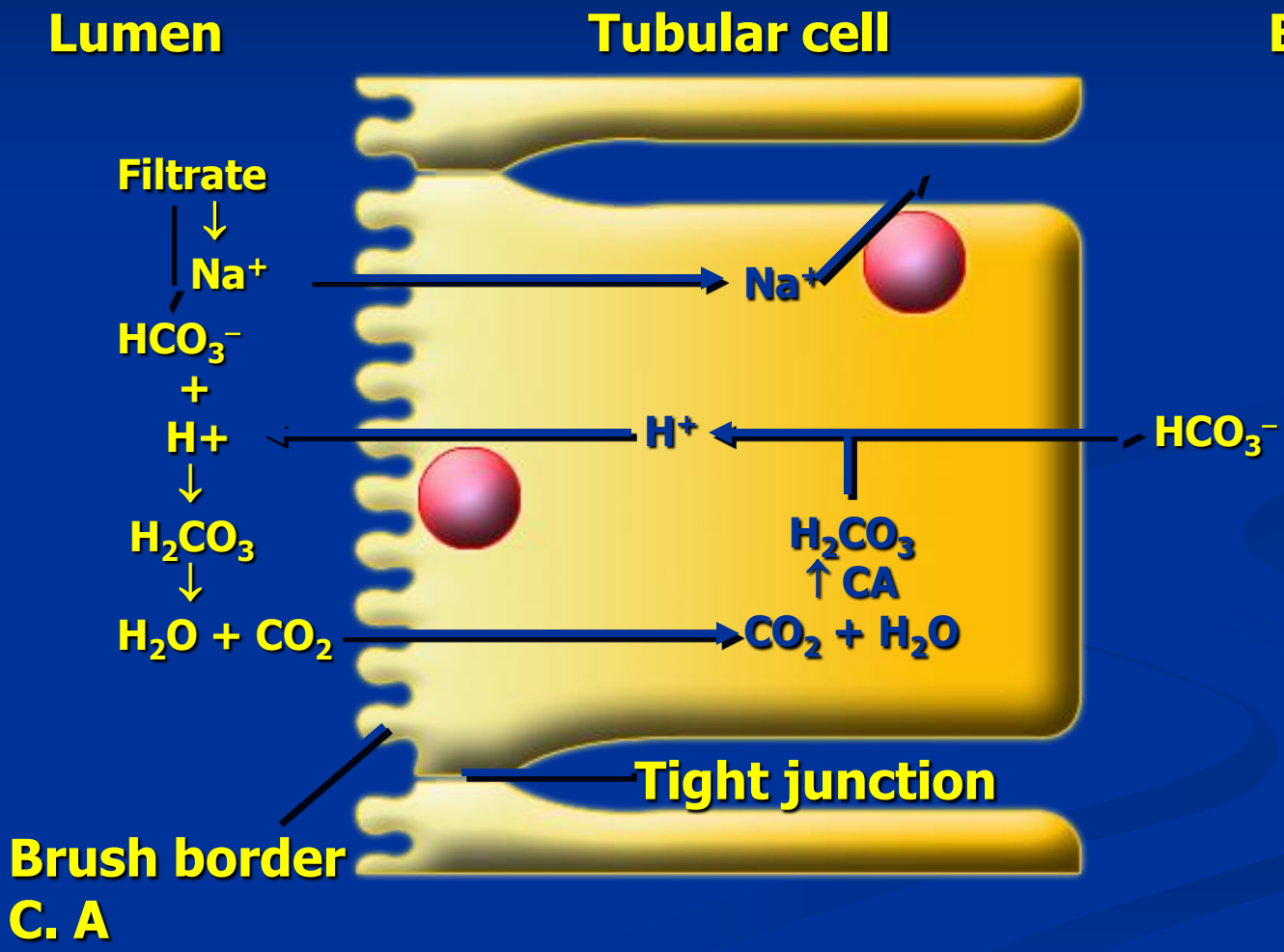
Objectives

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 $HCO_3 + H^+ \rightarrow H_2CO_3$
- $H_2CO_3 \rightarrow H_2O + CO_2$ in the presence of carbonic anhydrase enzyme
- CO_2 diffuses into the cell + $H_2O \rightarrow H_2CO_3$
- $H_2CO_3 \rightarrow H^+ + HCO_3$
- 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 (Tm): creatinine; PAH
    - No Tm: K; H

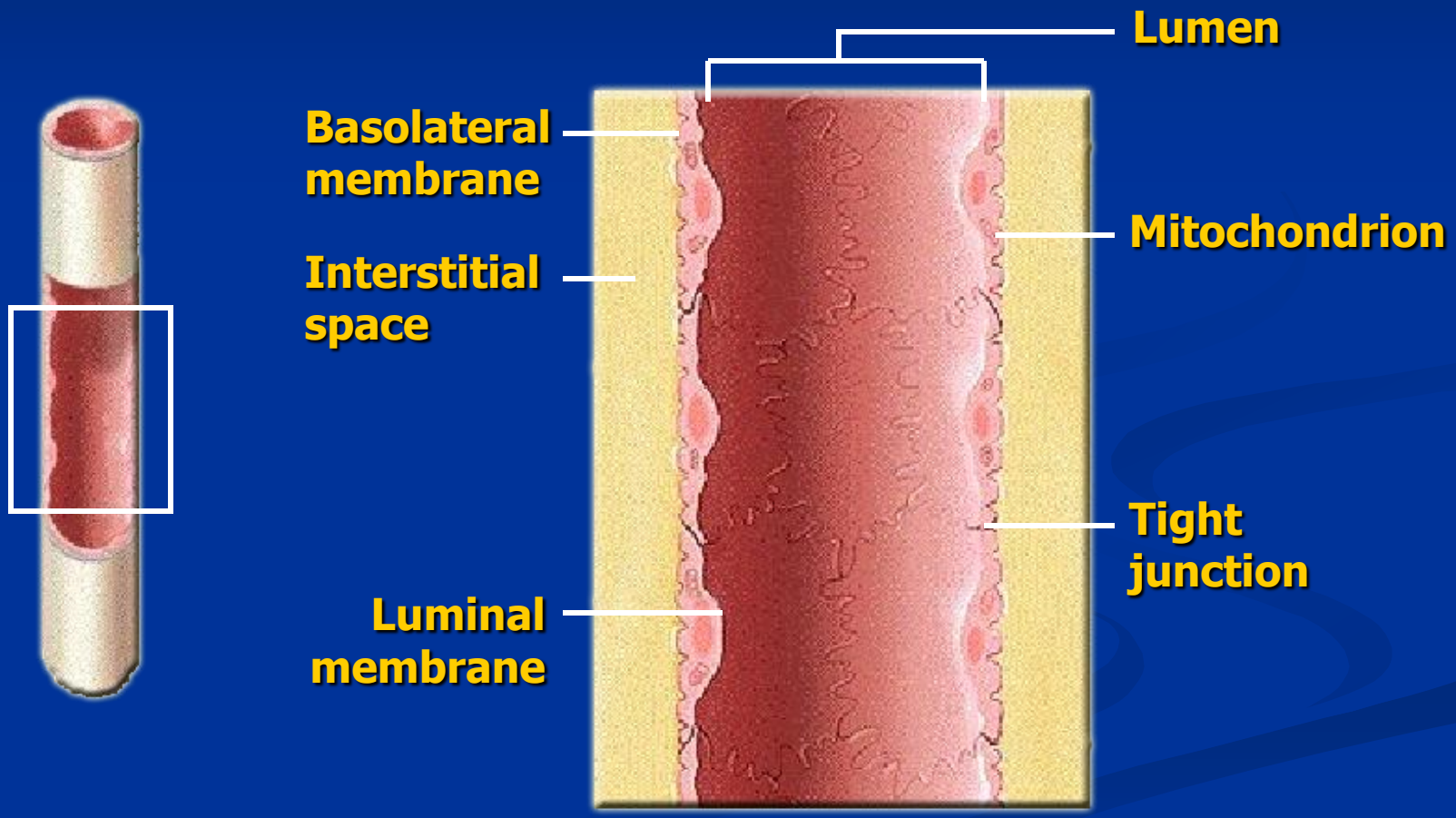
Tubular secretion *cont.*

- **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

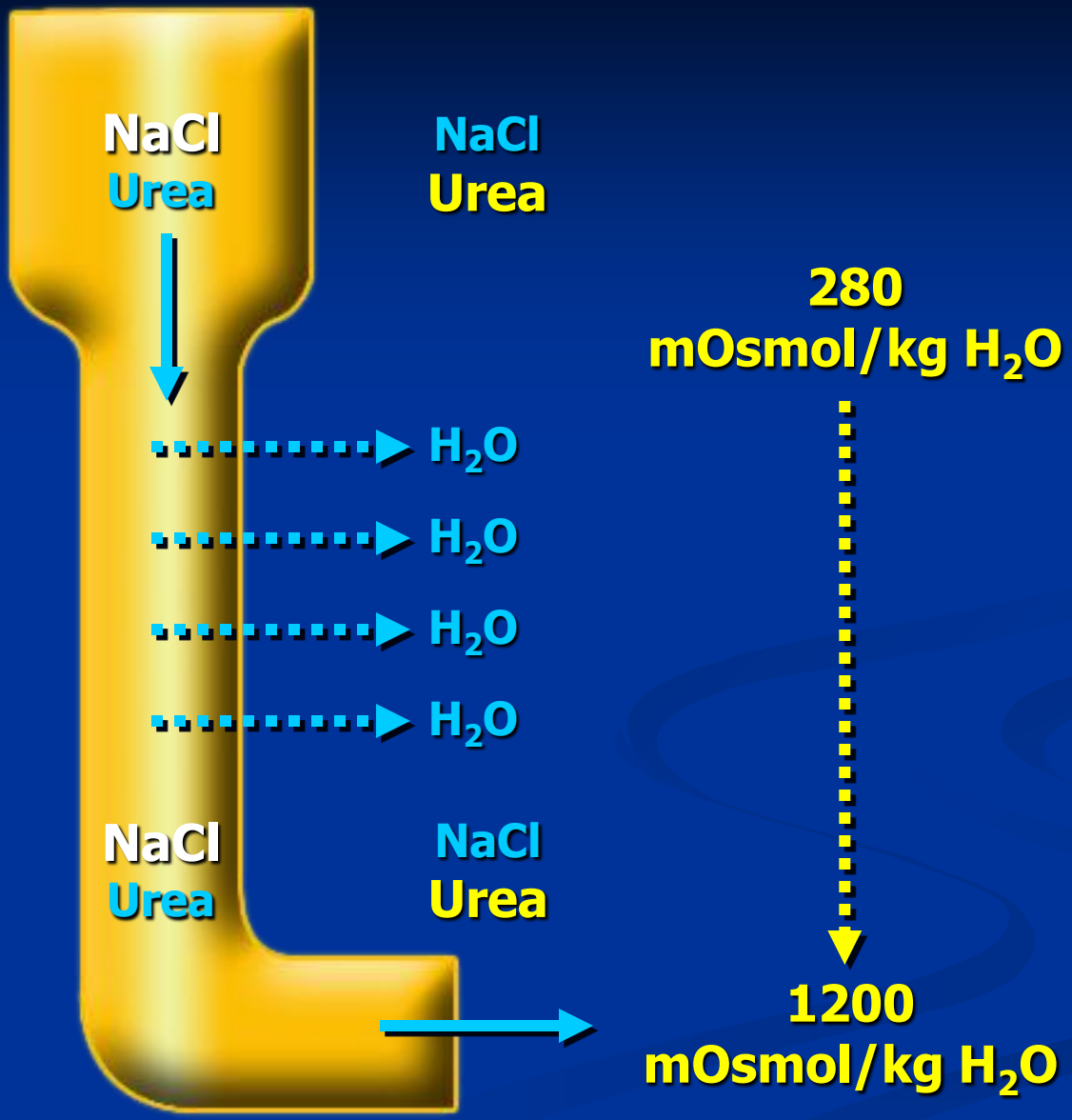
The Thin Loop of Henle

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



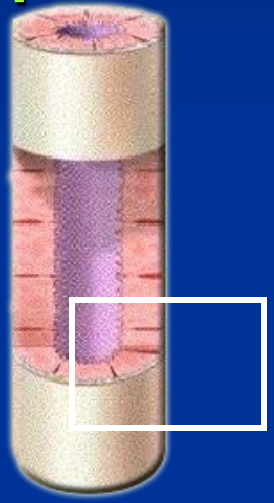
The descending Loop

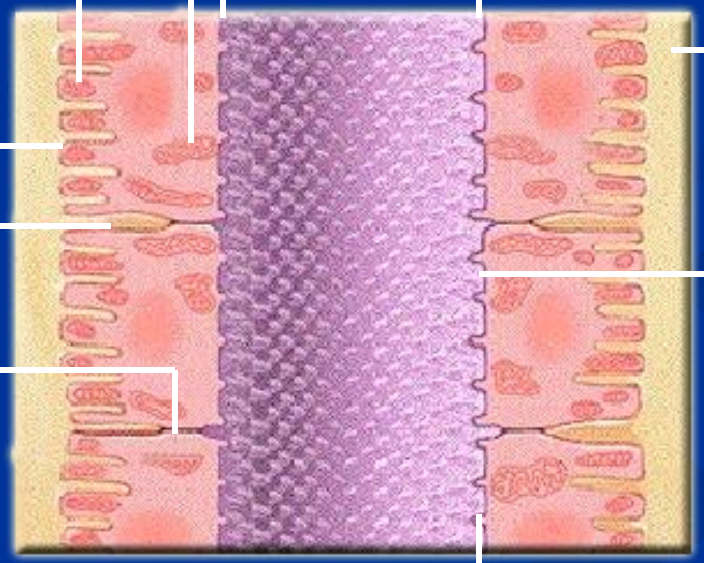
- Permeable to water but not for solute absorption
- 20% of filtered water is reabsorbed
- osmolality of filtrate increases from 290 to 1200 mOsm/l at the tip of the loop
- The increasing osmolality is due to only water reabsorption, ↑ NaCl and ↑Urea concentration in filtrate


NaCl
Urea
NaCl
Urea
H_2O
H_2O
H_2O
H_2O
NaCl
Urea
NaCl
Urea
280
mOsmol/kg H_2O
1200
mOsmol/kg H_2O

The Ascending Loop of Henle and Early DCT

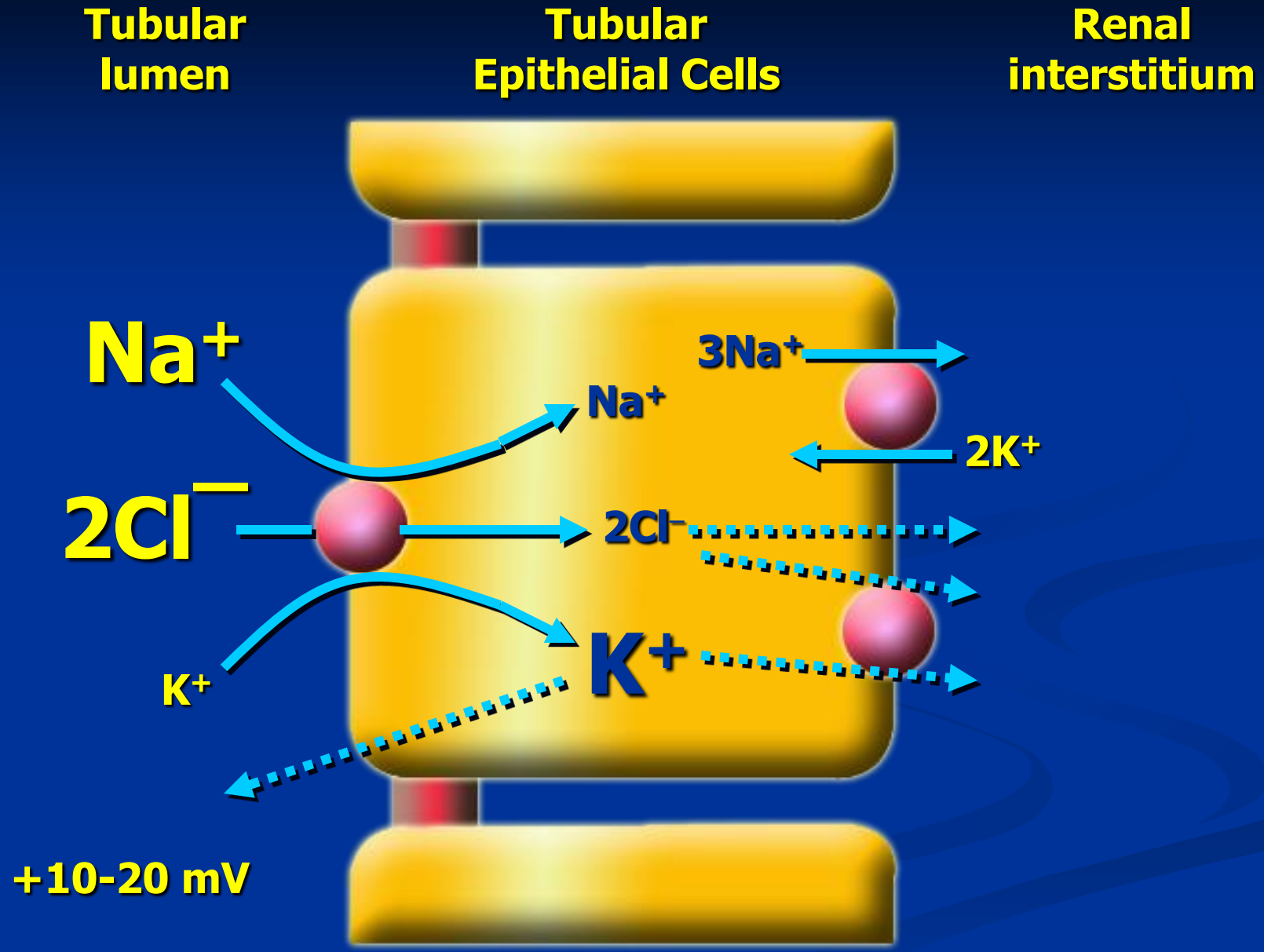
Cells are cuboidal epithelia; Highly permeable to solutes, particularly NaCl, but not to water





The Ascending limb

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

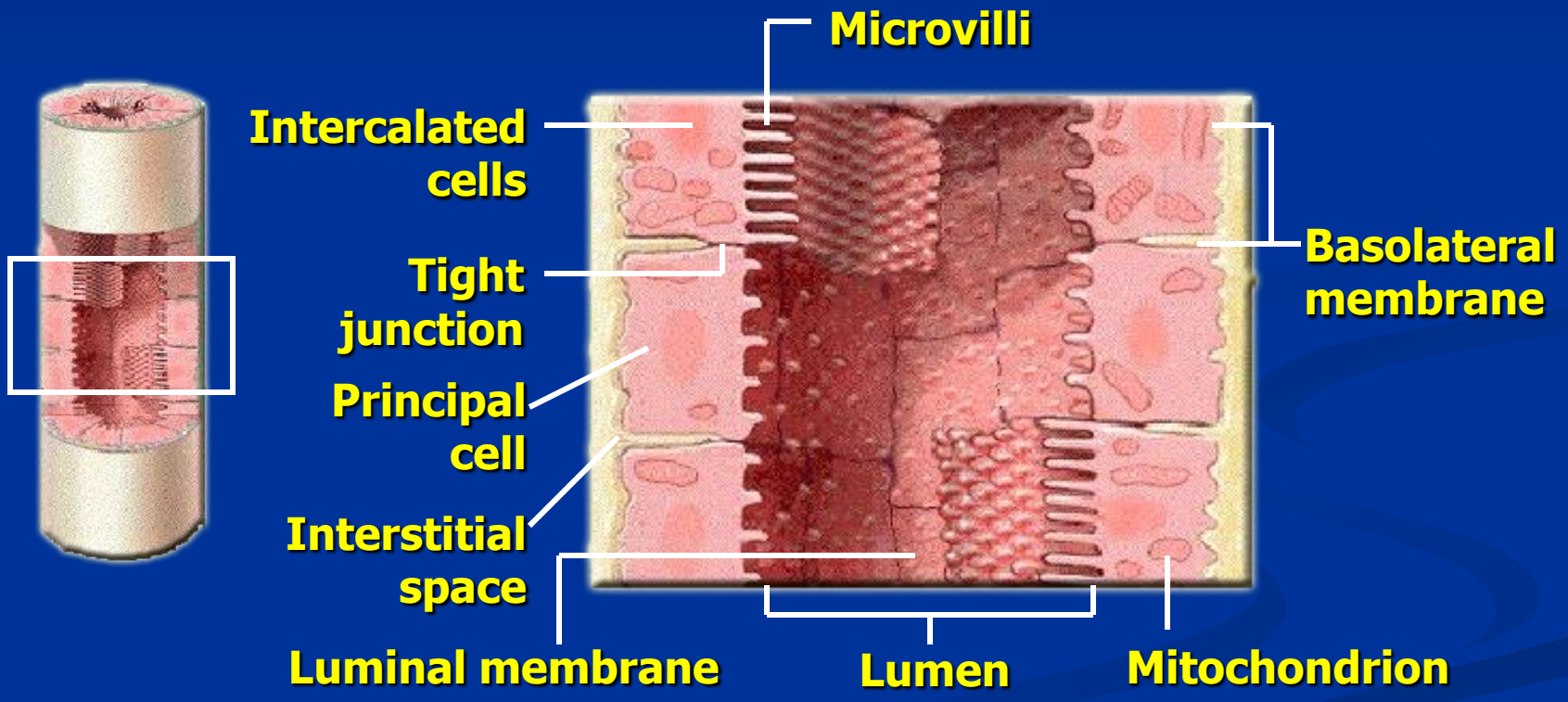

Tubular lumen
Tubular Epithelial Cells
Renal interstitium
Na+
2Cl−
K+
Na+
2Cl−
K+
3Na+
2K+
+10-20 mV

Thick ascending Loop

- The thick ascending limb is very sensitive to diuretic drugs (Furosamide). These diuretics block Na^+-K^+-$2Cl^-$ 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

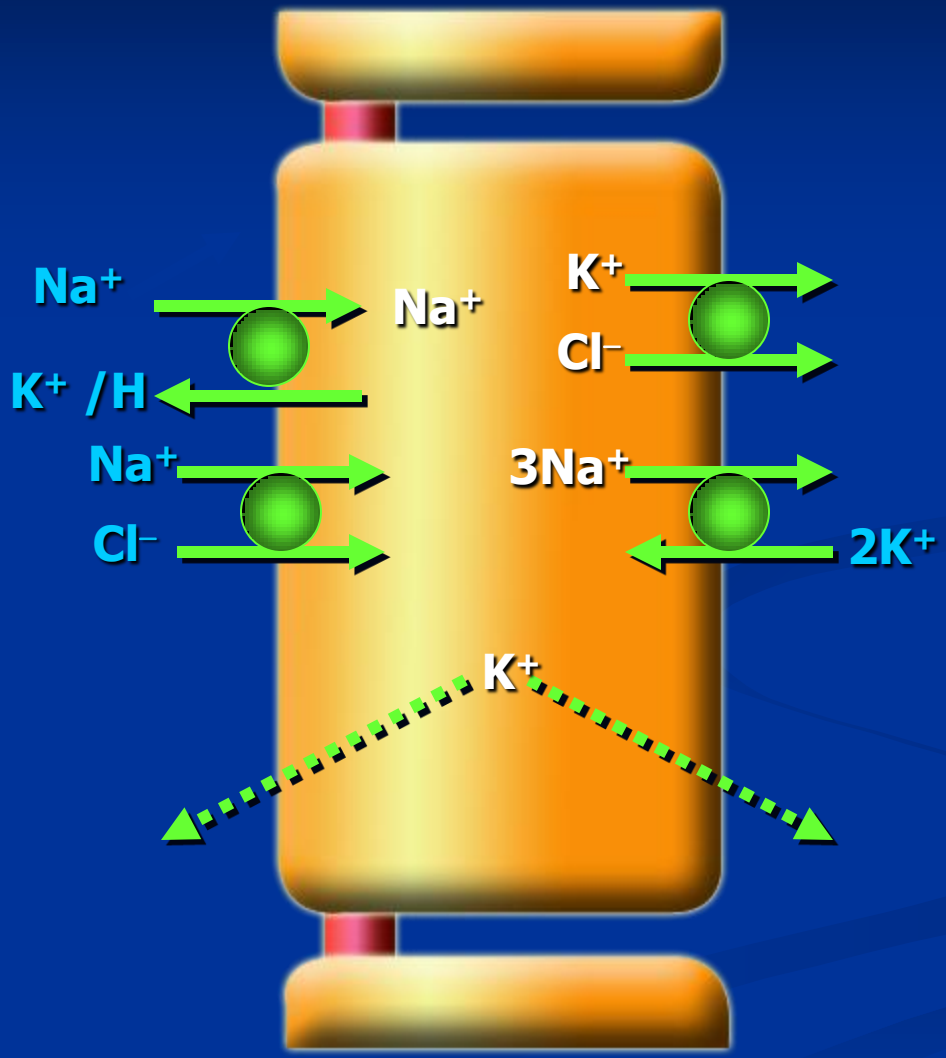
The Late DCT and Cortical Collecting Duct

- 19% of filtered H_2O is reabsorbed
- 9% of filtered Na^+ is reabsorbed in exchange of K^+ or H^+
- Cl^- also reabsorbed

Tubular lumen

Tubular Epithelial Cells

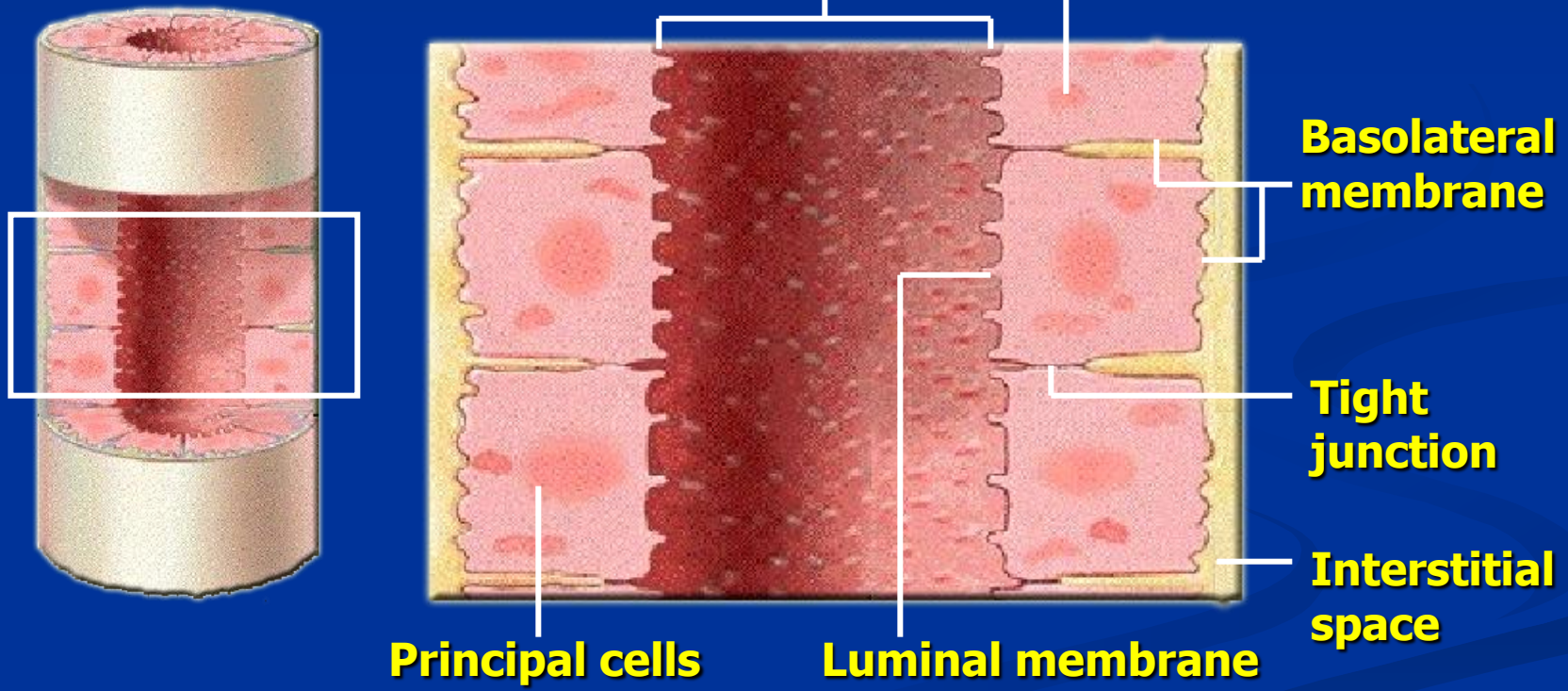
Renal interstitium



Distal Tubule

Cells of the Medullary Collecting Duct

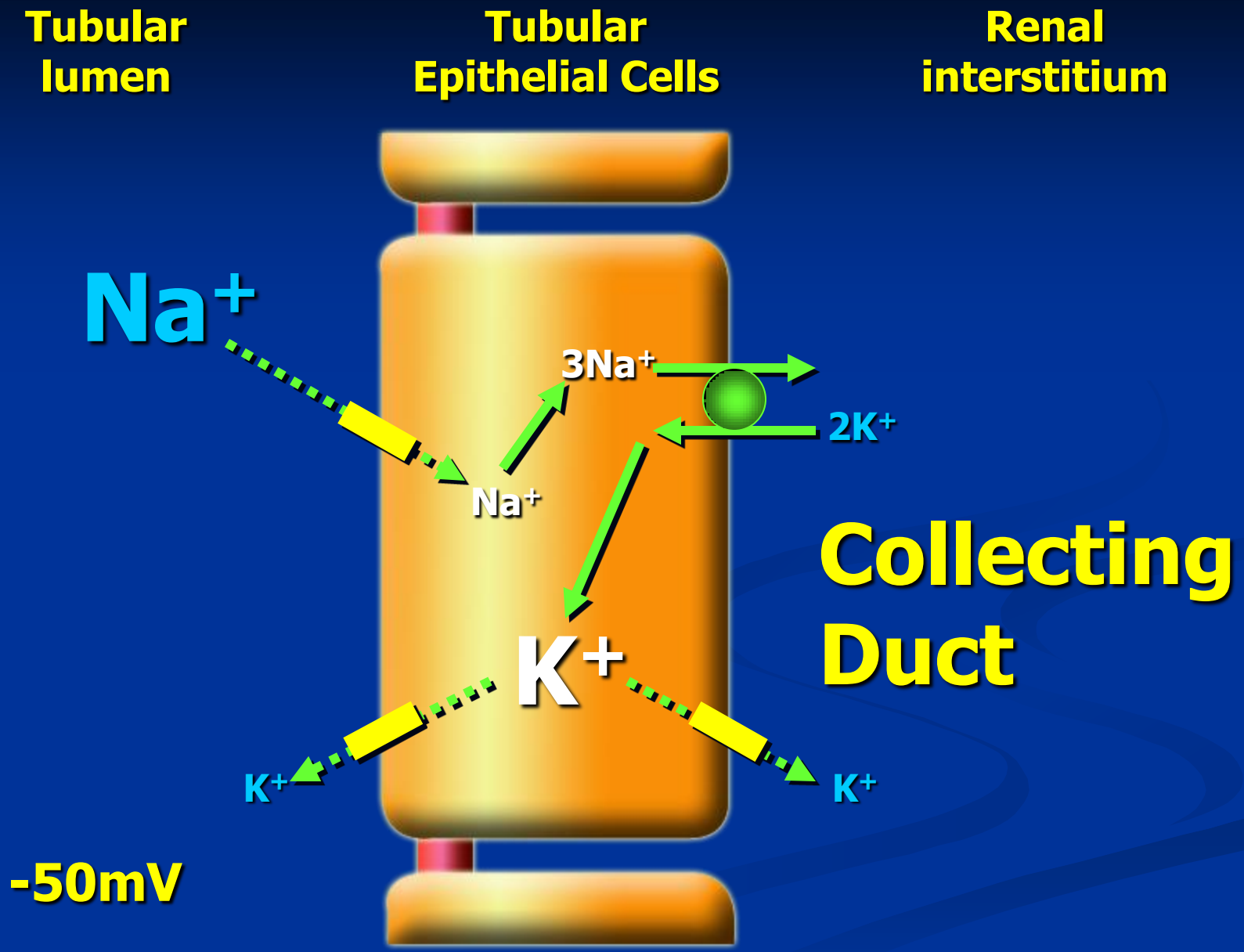
Cells are mainly principal cells.



Hormonally regulated permeability to water and urea.

Collecting duct

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

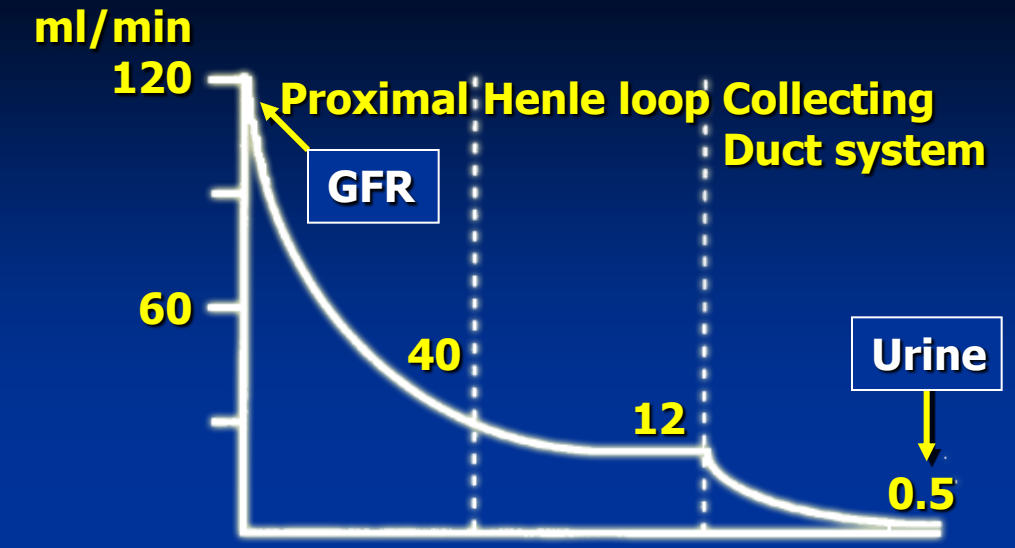

Tubular lumen
Tubular Epithelial Cells
Renal interstitium
Na+
3Na+
2K+
Na+
K+
K+
K+
-50mV
Collecting Duct

Urea Recirculation

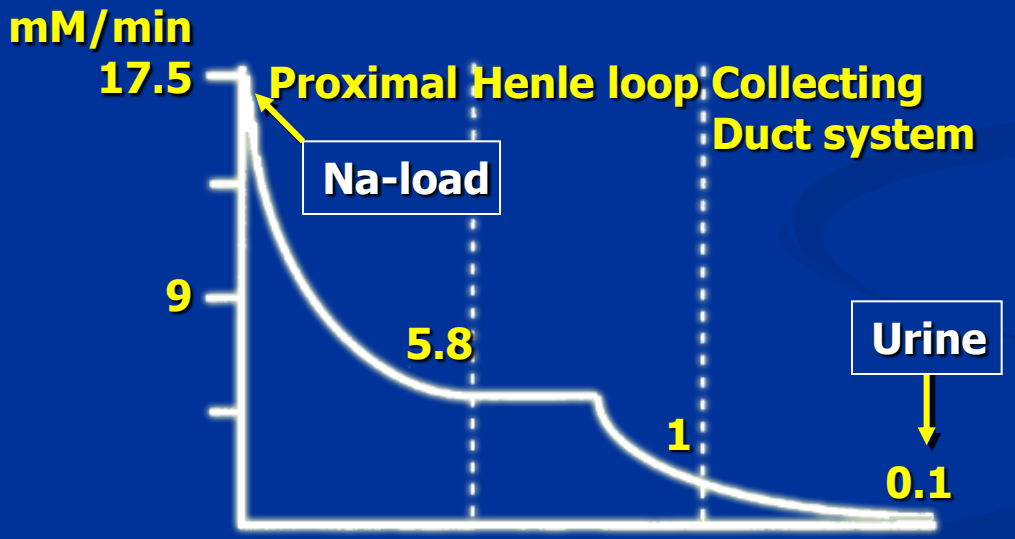
- Urea is passively reabsorbed in proximal tubule.
- In the presence of ADH, water is reabsorbed in distal and collecting tubules, concentrating urea in these parts of the nephron
- The inner medullary collecting tubule is highly permeable to urea, which diffuses into the medullary interstitium.
- ADH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

Summary of Water transport along the nephron

Segment	% filtered load reabsorbed	Mechanism of H_2O reabsorption	Hormones that regulate H_2O 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



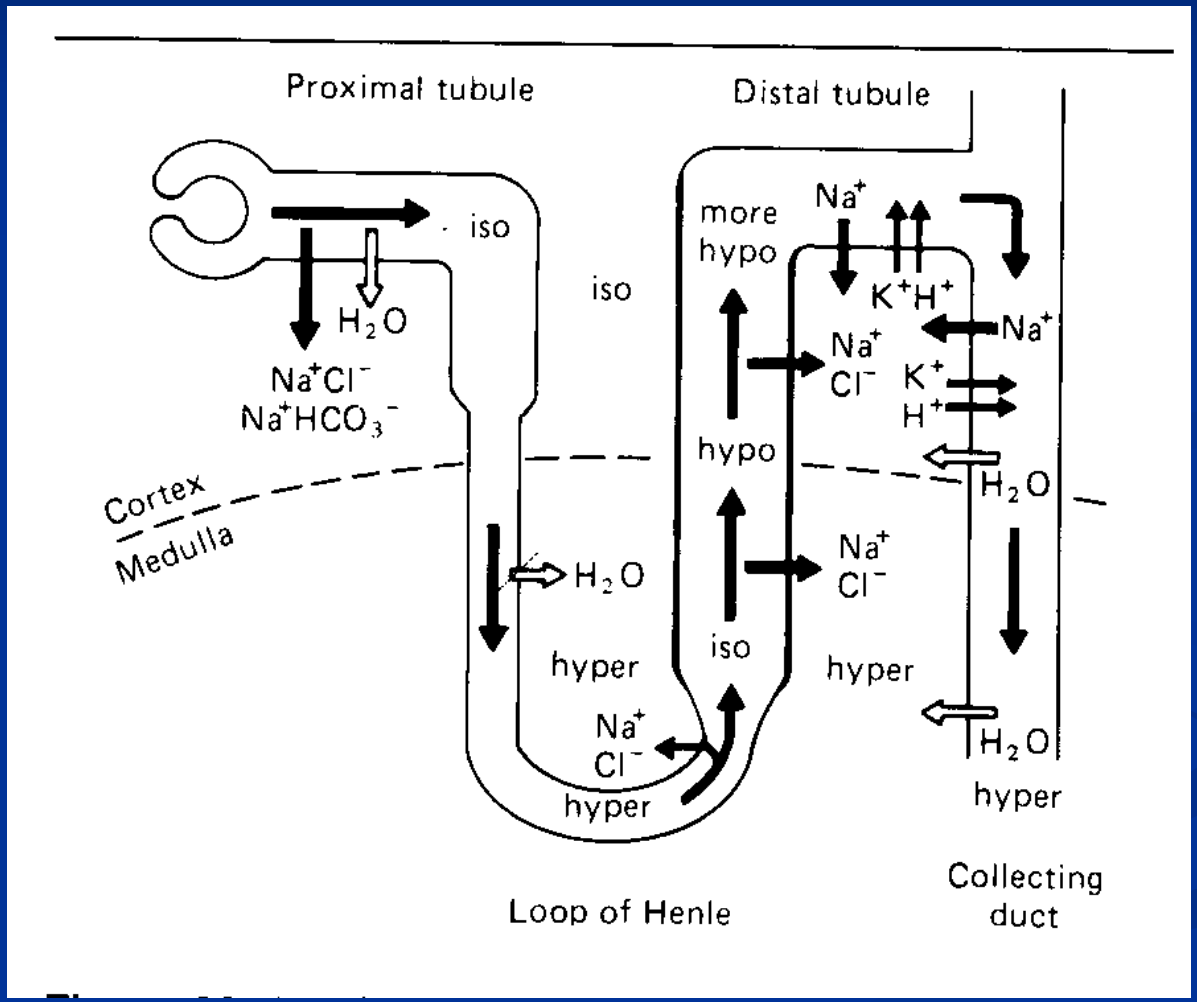
Water



Sodium

[Na] mEq/l	145	145	40	200

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 ↑ 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**