

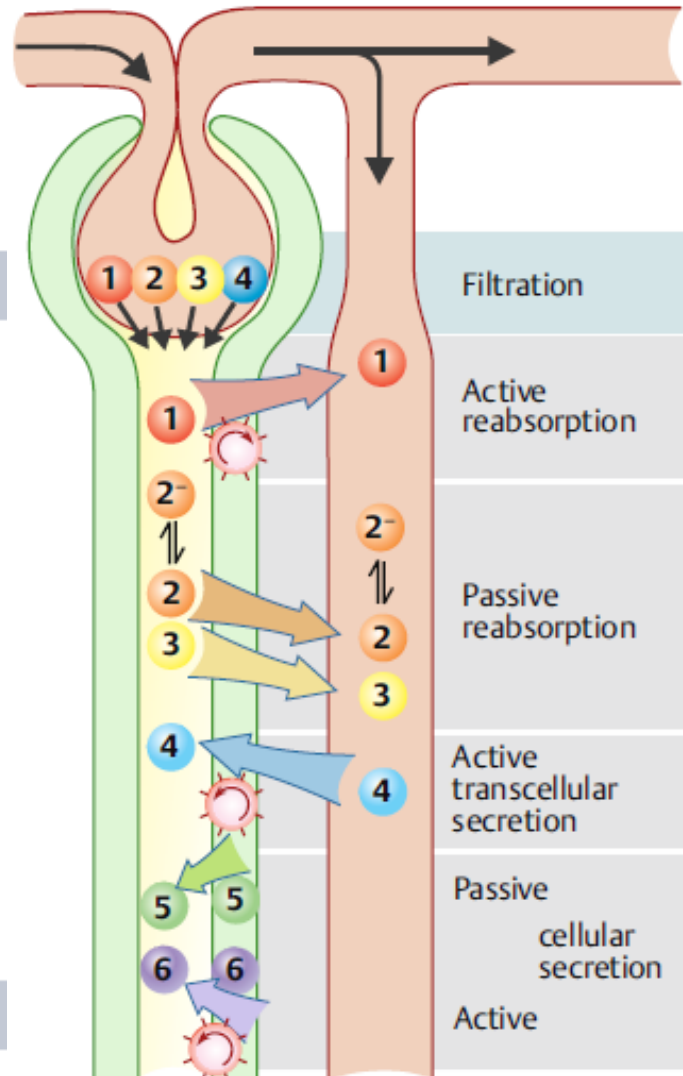
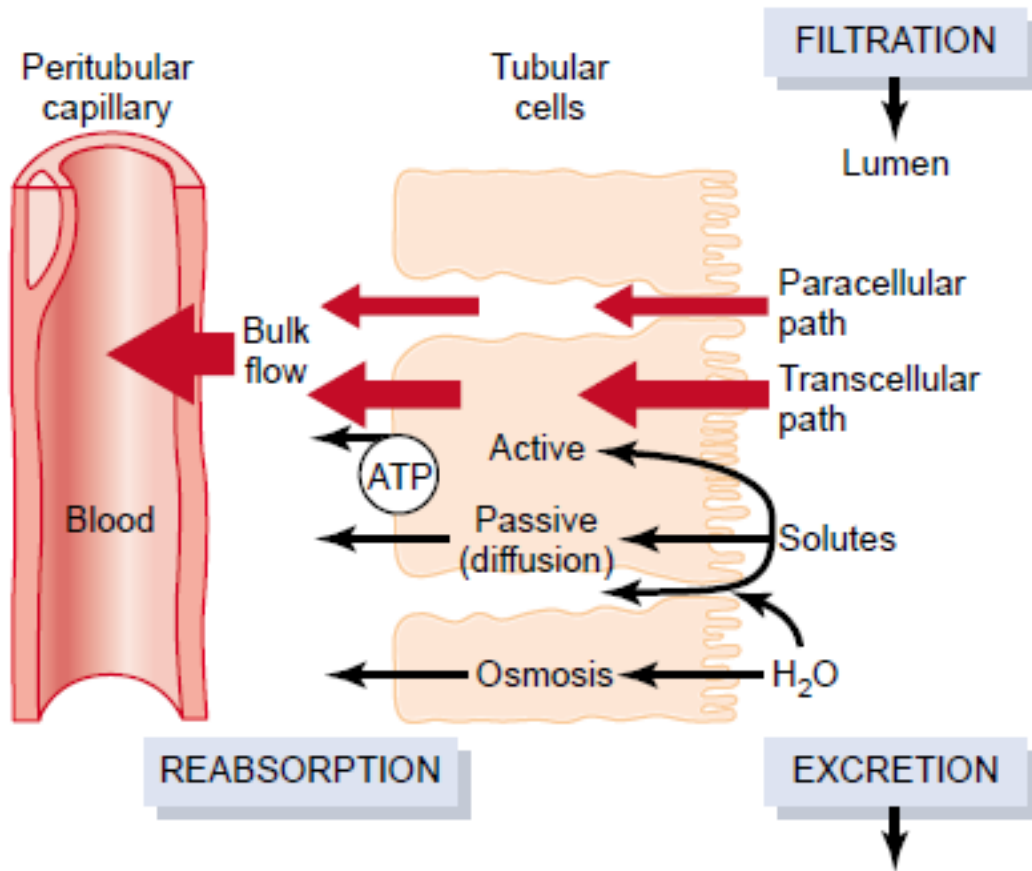


TUBULAR REABSORPTION

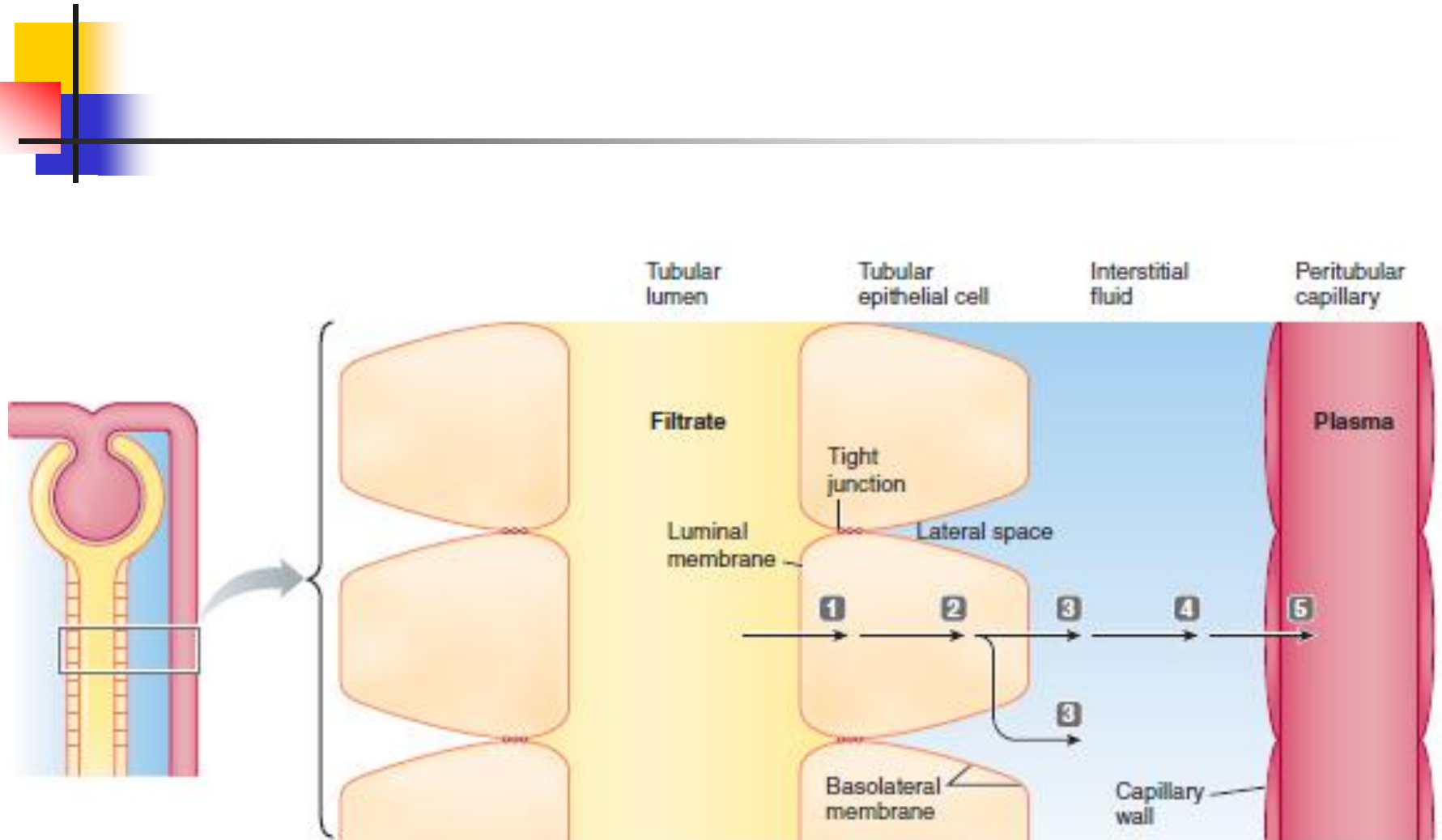
Tubular Processing of the Glomerular Filtrate



Tubular Reabsorption Includes Passive and Active Mechanisms

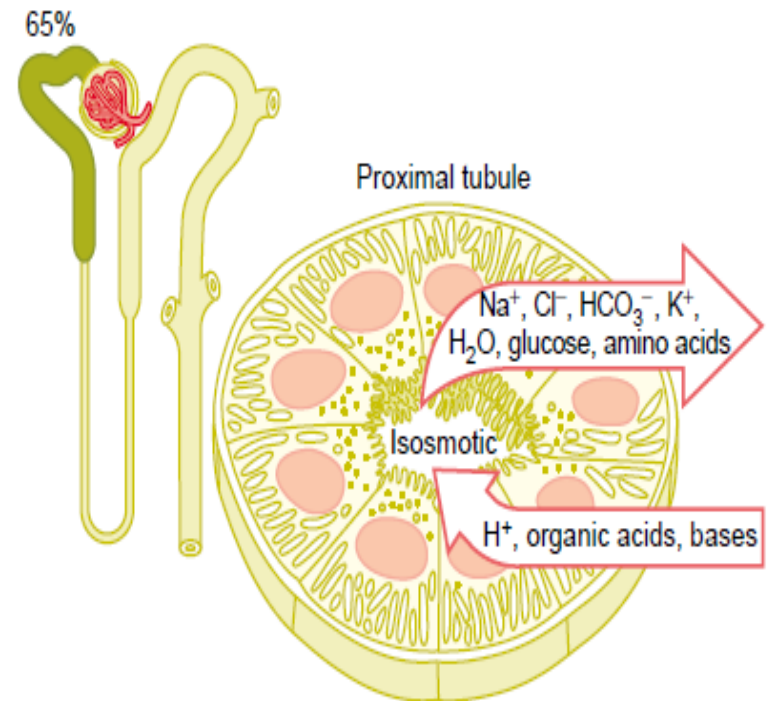


For a substance to be reabsorbed it must pass through

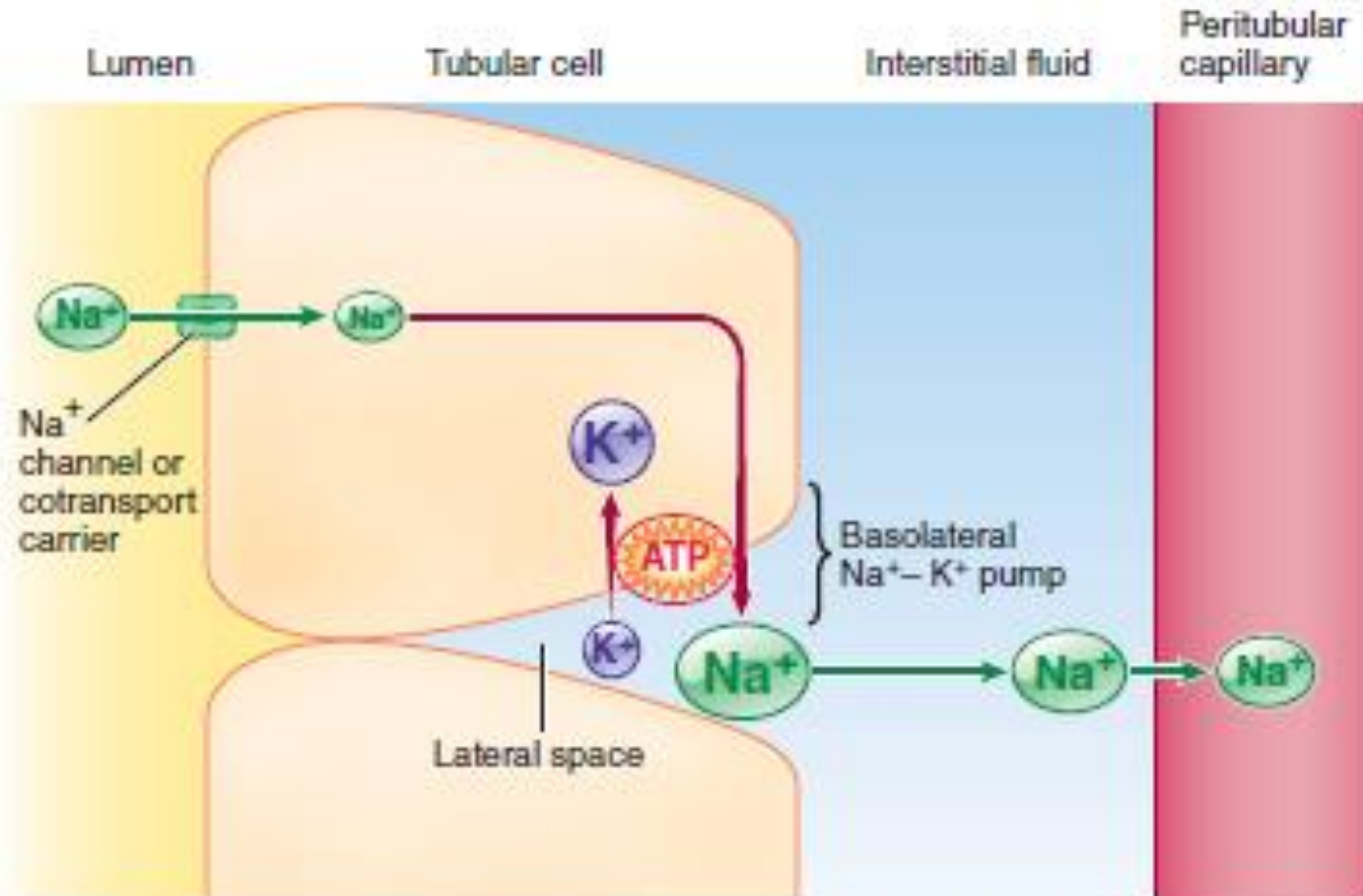


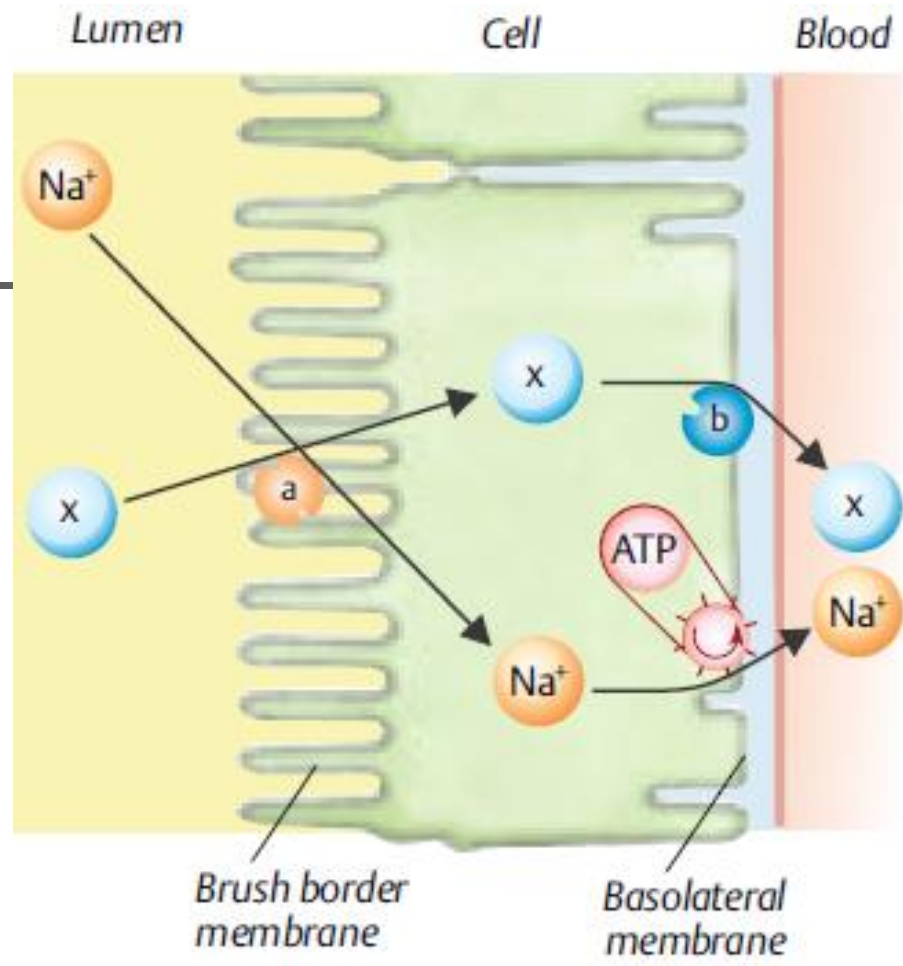
Proximal Tubular Reabsorption


- Reabsorption of 65% of filtered load (Na & water)
- Special cellular arrangement
- Large no of mitochondria
- Extensive brush-border
- Large no of carrier proteins for co-transport & counter-transport of Na
- Difference b/w reab. of Na in 1st & 2nd part of PT





Sodium reabsorption

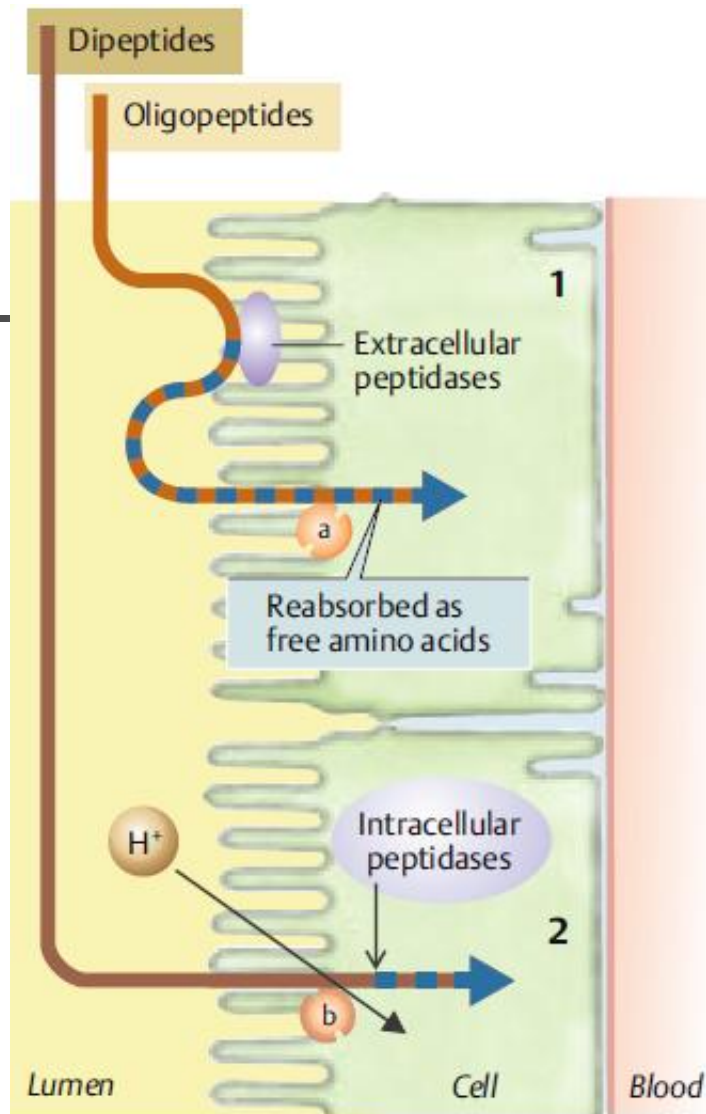




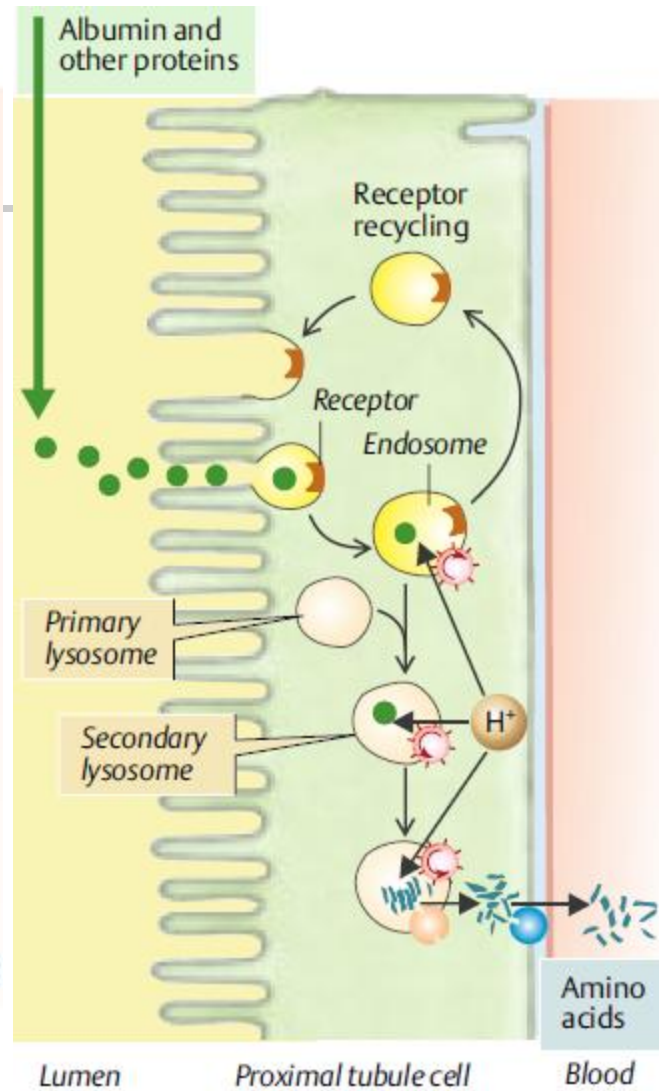

 Glucose, amino acids (several systems), phosphate, lactate, sulfate, dicarboxylates


 Luminal Na^+ symport

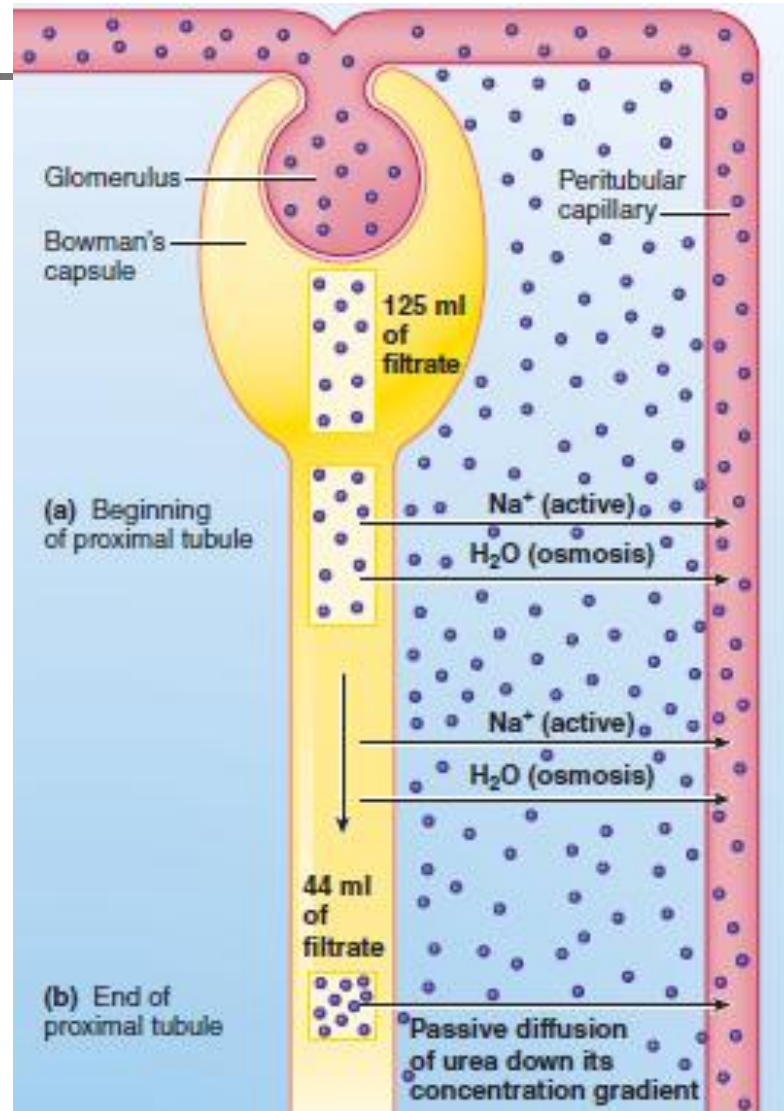

 Passive carrier transport



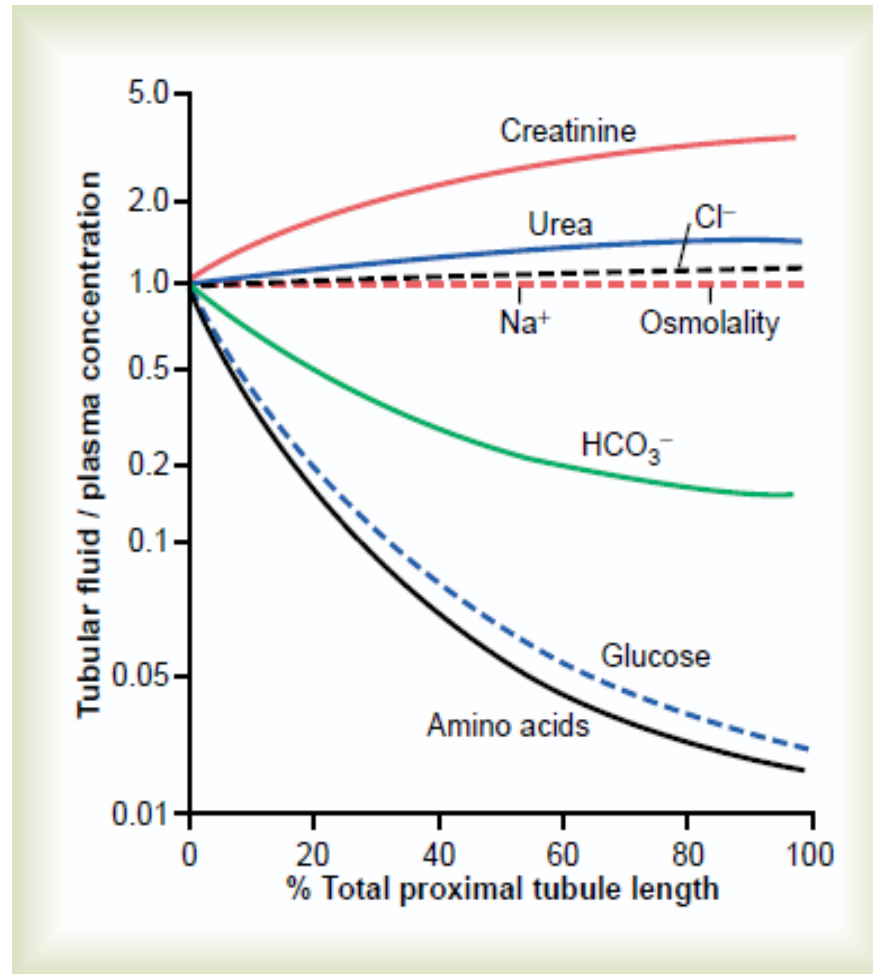
- a Na^+ symport carrier
- b H^+ symport carrier



Passive reabsorption of urea at the end of the proximal tubule



Concentration of solutes along PT





Secretion of organic acid & Bases

- Secretion of Bile salts, oxalate, urate & catecholamines
- Drugs & Toxins
- Rapid clearance of drugs may be a problem in maintaining adequate therapeutic levels
- PAH is also rapidly secreted by PT

Loop of Henle

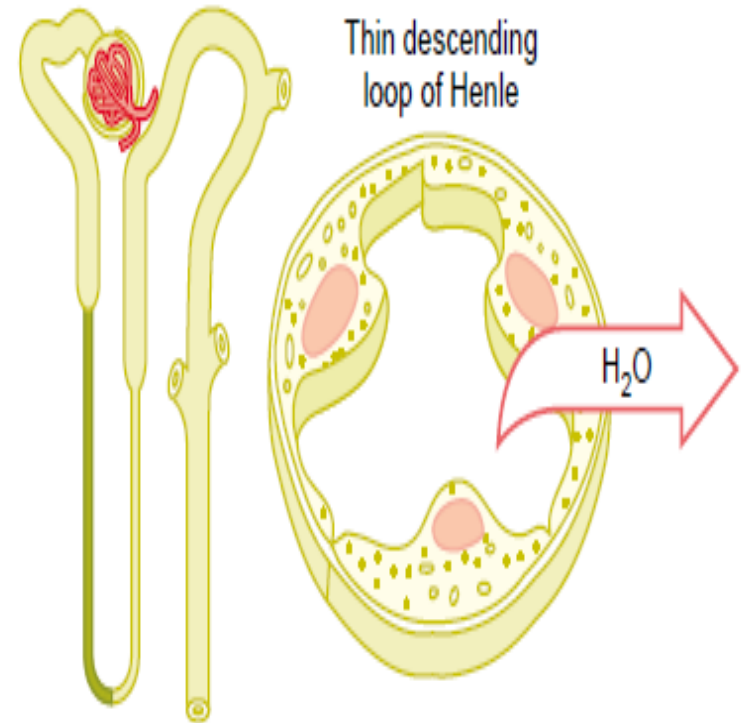
- Has three segments
 - Thin Descending segment
 - Thin Ascending segment
 - Thick Ascending segment

Thin Descending segment

- 20% of filtered load of water is reabsorbed
- Thin membrane
- Permeable to water, urea & Na

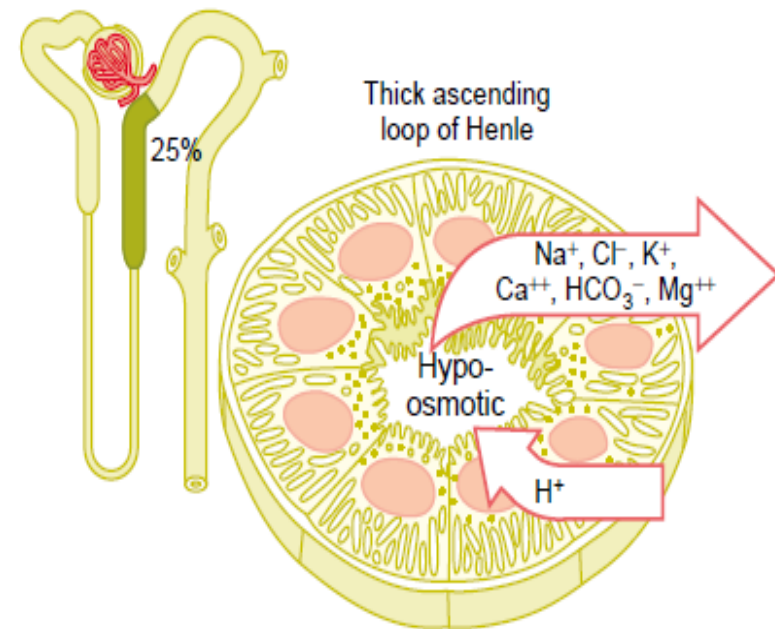
Thin Ascending segment

- Impermeable to water & very low permeability for solutes

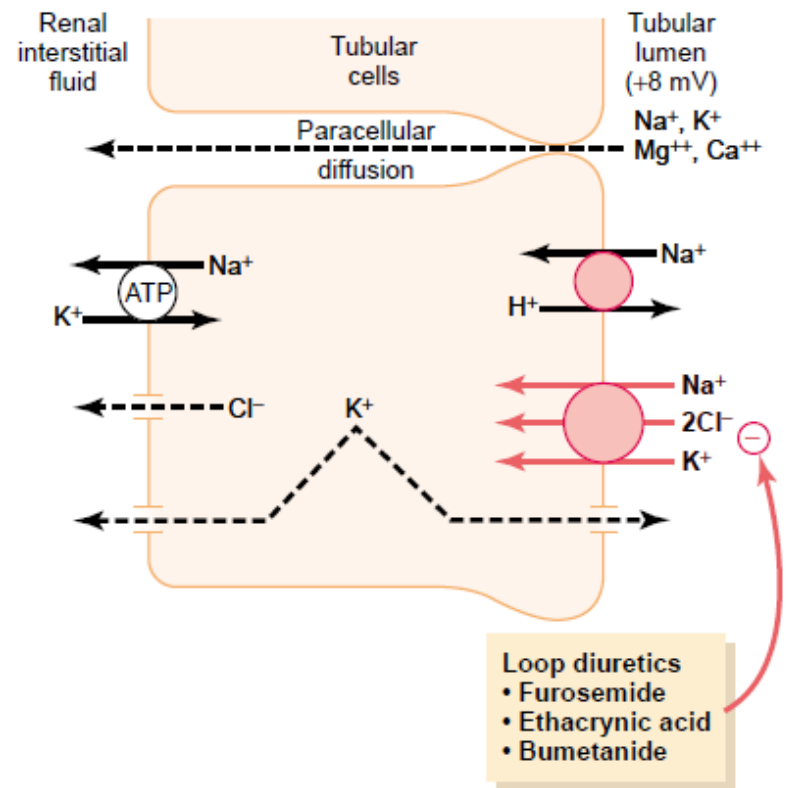


Thick Ascending segment

- Reab of 25% of filtered load of Na, Cl, K
- Impermeable to water
- Thick, metabolically active cells
- Na-K ATPase Pump
- **1-Na, 2-Cl, 1-K**
- **Co- Transporter**
- Site of action for Loop Diuretics (Frusemide, Bumetanide, Ethacrynic acid)

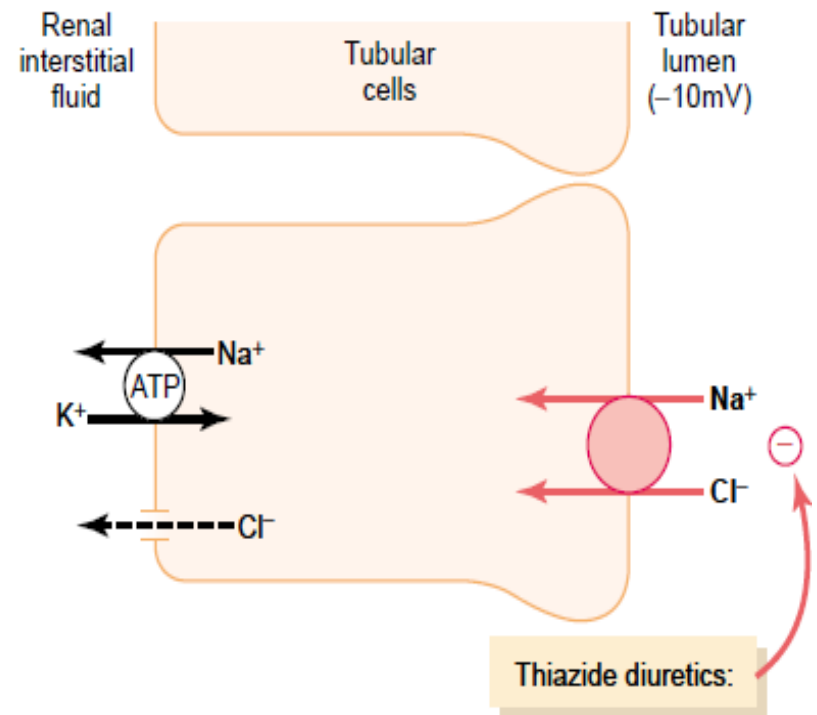


- Reabsorption of ions through paracellular pathway due to increased no of +ve charges
- Counter-transport of Na-H
- Due to reabsorption of large no of solutes the tubular fluid becomes dilute in the ascending segment



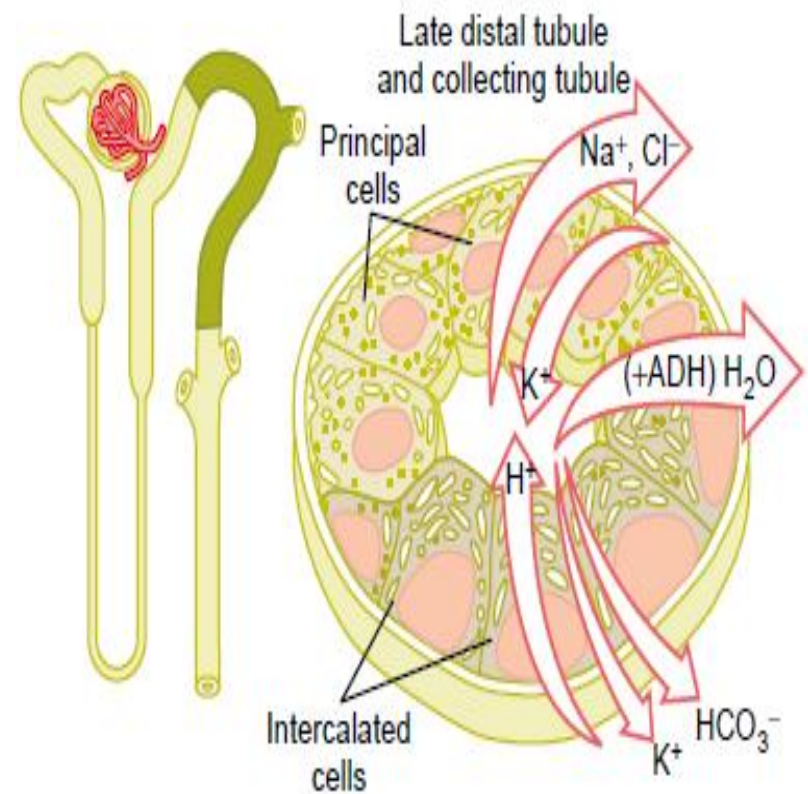
Distal Tubule

- Early part of DT has same reabsorptive properties as Thick segment
- Impermeable to water
- Reab of 5% of filtered load of Na & Cl
- **Na-Cl Co-Transport**
- Site of action for thiazide diuretics



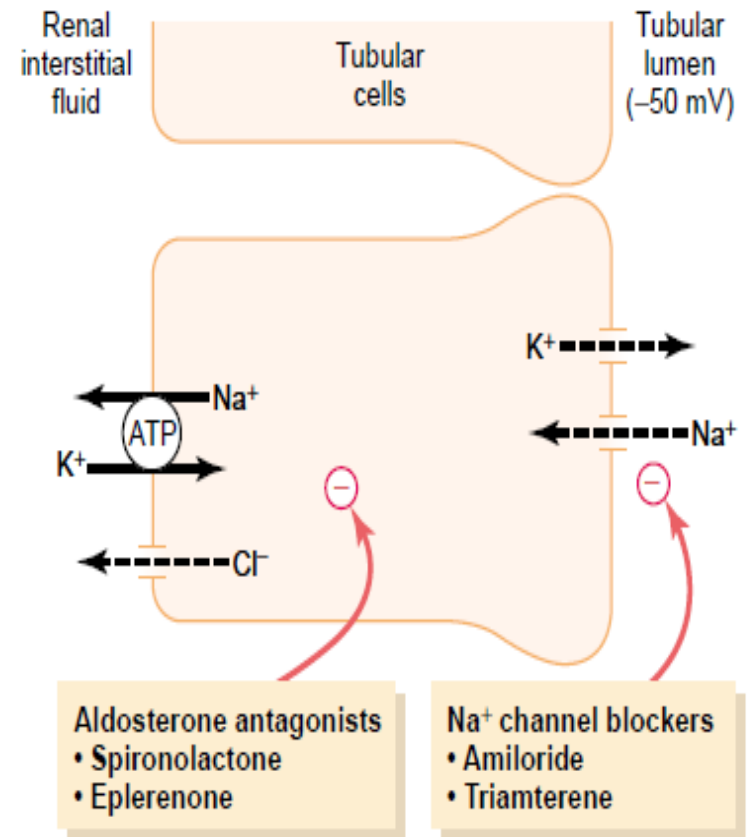
Late Distal Tubule & Cortical Collecting Ducts

- Similar cellular anatomy & functions
- Two specialized types of cells
 - Principal Cells
 - Intercalated Cells



Principal Cells

- Reabsorb Na & secrete K ions
- Site of action for K-sparing diuretics





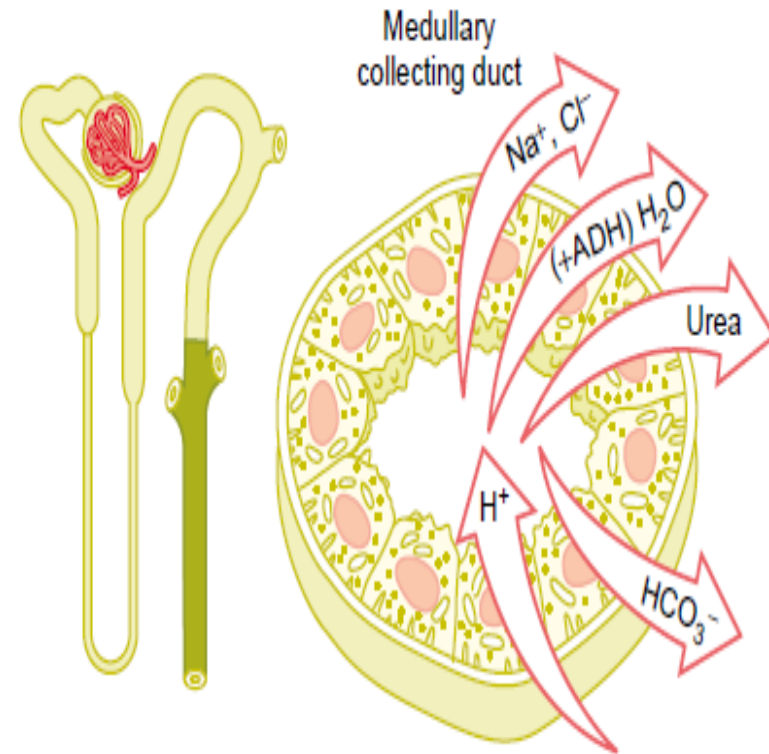
Intercalated Cells

- Reabsorb K & secrete H ions
- Carbonic Anhydrase

- Summary:
 - Reabsorption of Na & secretion of K ions in Late DT & CCD is Aldosterone dependant
 - Water Reabsorption is ADH dependant
 - Impermeable to Urea

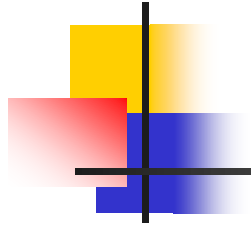
Medullary Collecting Ducts

- Reabsorption of less than 10% of filtered of Na & water
- Cuboidal cells, smooth surface, very few mitochondria
- Permeability to water is controlled by ADH secretion
- High permeability for urea
- Can secrete H ions





Regulation of Tubular Reabsorption

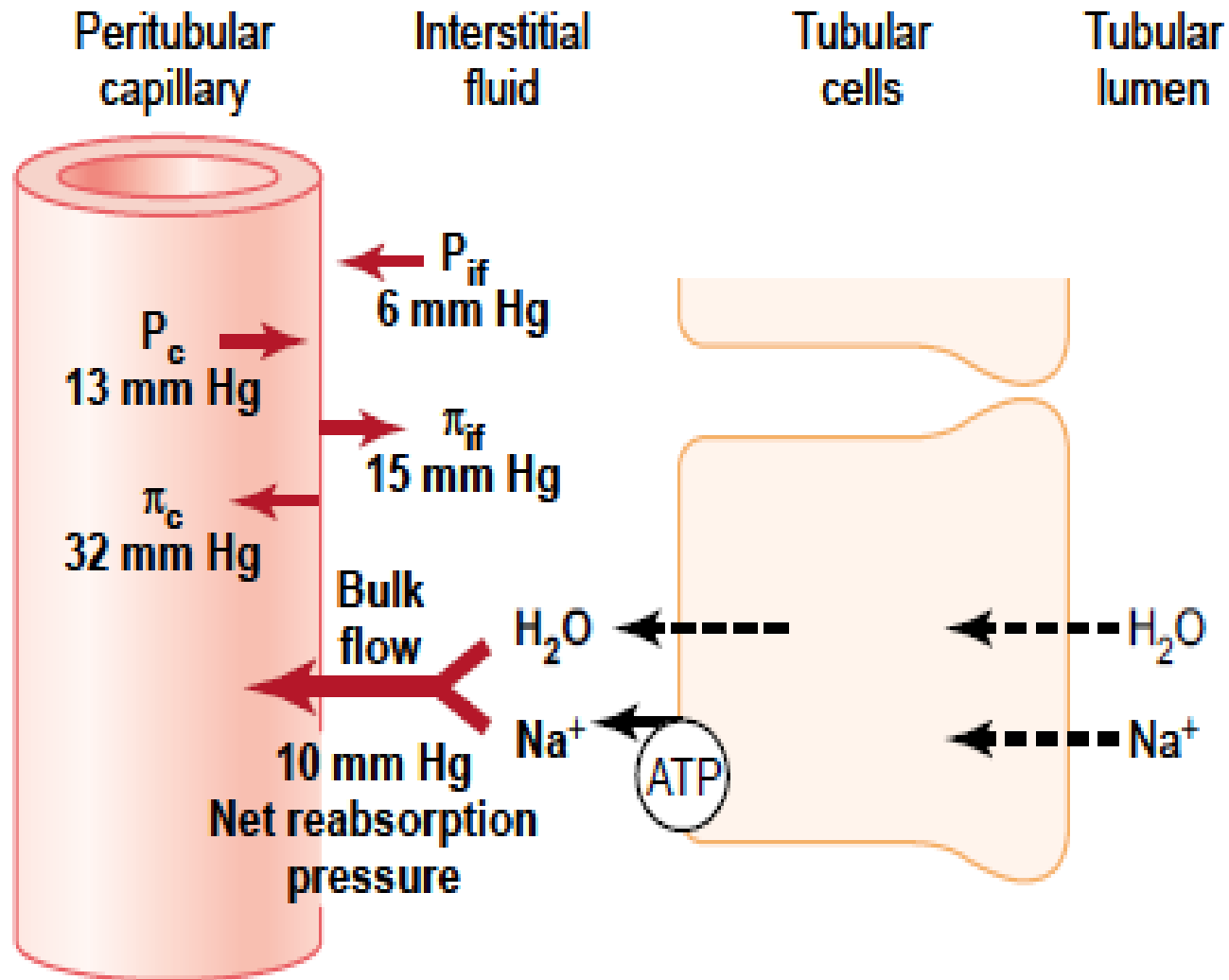
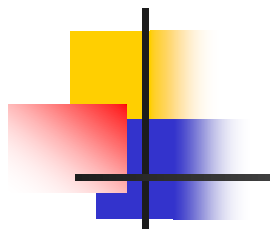


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- Intrinsic Renal Regulation
 - Hormonal Regulation
 - Nervous Regulation



PTC & Renal I.F. Physical Forces

- Reabsorption = $K_f \times$ Net reabsorptive force
- Net absorptive force is the sum of:
 - Peritubular capillary hydrostatic pressure (P_c)
 - Peritubular capillary colloid osmotic pressure (π_c)
 - Interstitial fluid hydrostatic pressure (P_{if})
 - Interstitial fluid colloid osmotic pressure (π_{if})
- Normal rate of Reabsorption : 99% of GFR or 124ml/min





Regulation of forces across PTC

- PTC hydrostatic & COP directly influenced by Renal hemodynamic changes
- PTC hydrostatic pressure is regulated by
 - Arterial Pressure &
 - Afferent & Efferent arteriolar resistance
- PTC Colloid Osmotic Pressure is regulated by
 - Systemic Plasma COP
 - Filtration Fraction
- Filtration coefficient increases Reabsorption



Factors That Can Influence Peritubular Capillary Reabsorption

$\uparrow P_c \rightarrow \downarrow$ Reabsorption

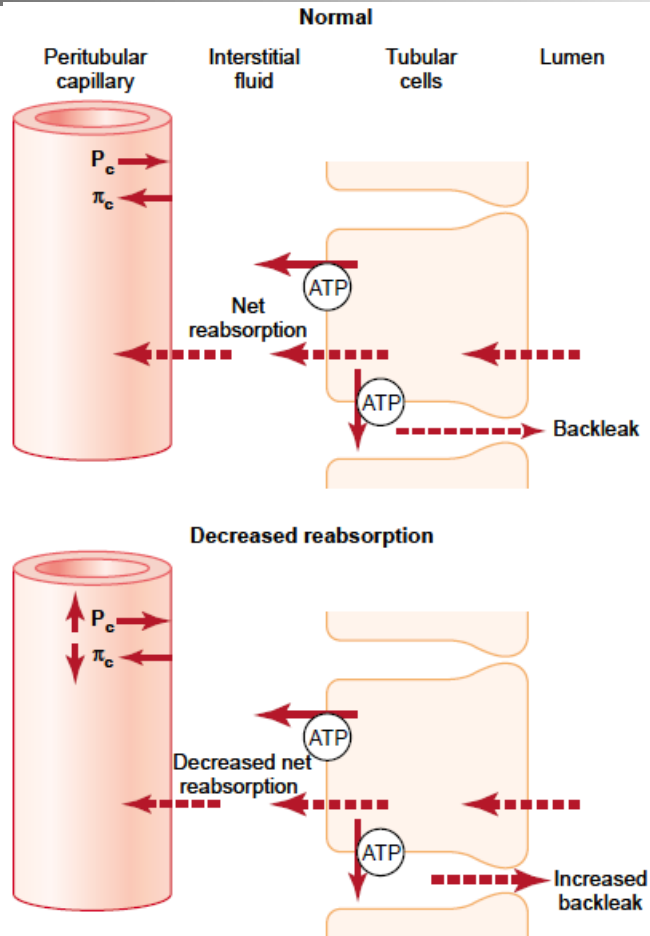
- $\downarrow R_A \rightarrow \uparrow P_c$
- $\downarrow R_E \rightarrow \uparrow P_c$
- \uparrow Arterial Pressure $\rightarrow \uparrow P_c$

$\uparrow \pi_c \rightarrow \uparrow$ Reabsorption

- $\uparrow \pi_A \rightarrow \uparrow \pi_c$
- $\uparrow FF \rightarrow \uparrow \pi_c$

$\uparrow K_f \rightarrow \uparrow$ Reabsorption

Renal Interstitial hydrostatic & COP





Hormonal Regulation of reabsorption



ALDOSTERONE

- Zona glomerulosa cells of adrenal cortex
- Increases reabsorption of Na & secretion of K ions
- Site of action: Principal cells of CCT
- Mechanism: Increased Na-K ATPase activity & Increased Na permeability on luminal side
- Addison's Disease: Reduced or absent secretion
- Conn's Syndrome: Increased secretion



Angiotensin II

- Most potent Na retaining Hormone
- Increases Na & water reabsorption
- Mainly acts by three ways
 - Increases ALDOSTERONE secretion
 - Constriction of efferent arterioles
 - Stimulates Na reabsorption in PT, LOH, CT



Antidiuretic Hormone

- Released from Posterior Pituitary
- Site of action: DT, CT, CCT, MCD
- Specific receptors V_2 in epithelial cells
- Aquaporins --- Intracellular protein
- AQP-2, AQP-3, AQP-4



ANP

- Released from cardiac Atria
- Stimulus for release --- Increased Atrial stretch due to increased plasma volume or raised AP
- Inhibits reabsorption of Na & water from CD



PTH

- Most powerful Ca regulating Hormone
- Increases tubular reabsorption of Ca from DT & LOH
- Also inhibits Phosphorus reabsorption from PT & increase s reabsorption of Mg



Sympathetic Nervous System

- Decreases Na & water excretion by constricting renal arterioles
- Also increases Na reabsorption from PT, Ascending thick segment of LOH, Distal tubules
- Increases renin & Angiotensin release



Hormone	Site of Action	Effects
Aldosterone	Collecting tubule and duct	↑ NaCl, H ₂ O reabsorption, ↑ K ⁺ secretion, ↑ H ⁺ secretion
Angiotensin II	Proximal tubule, thick ascending loop of Henle/distal tubule, collecting tubule	↑ NaCl, H ₂ O reabsorption, ↑ H ⁺ secretion
Antidiuretic hormone	Distal tubule/collecting tubule and duct	↑ H ₂ O reabsorption
Atrial natriuretic peptide	Distal tubule/collecting tubule and duct	↓ NaCl reabsorption
Parathyroid hormone	Proximal tubule, thick ascending loop of Henle/distal tubule	↓ PO ₄ ⁻ reabsorption, ↑ Ca ⁺⁺ reabsorption