Renal Transport Process

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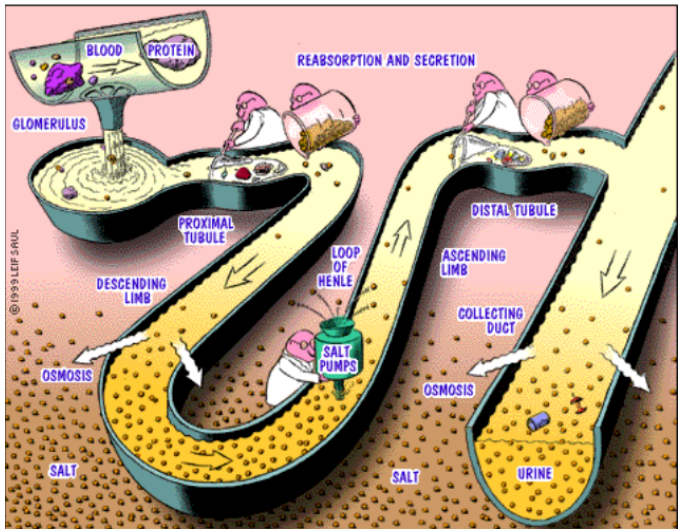
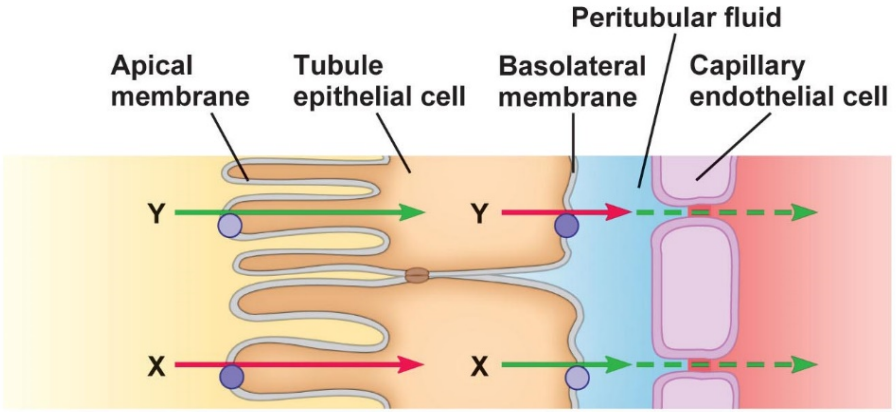


Learning Objectives:

- Define tubular reabsorption, tubular secretion, transcellular and paracellular transport.
- Identify and describe mechanisms of tubular transport
- Describe tubular reabsorption of sodium and water
- Identify and describe mechanism involved in Glucose reabsorption
- Identify the tubular reabsorption mechanisms of amino acids, HCO_3^-, and Urea

Tubular Reabsorption

- Transported substances move through three membranes
  - Luminal and basolateral membranes of tubule cells
  - Endothelium of peritubular capillaries
- Ca^{2+}, Mg^{2+}, K^{+}, and some Na^{+} can be reabsorbed via **paracellular** pathways.



(a) Active solute reabsorption

Tubular Reabsorption

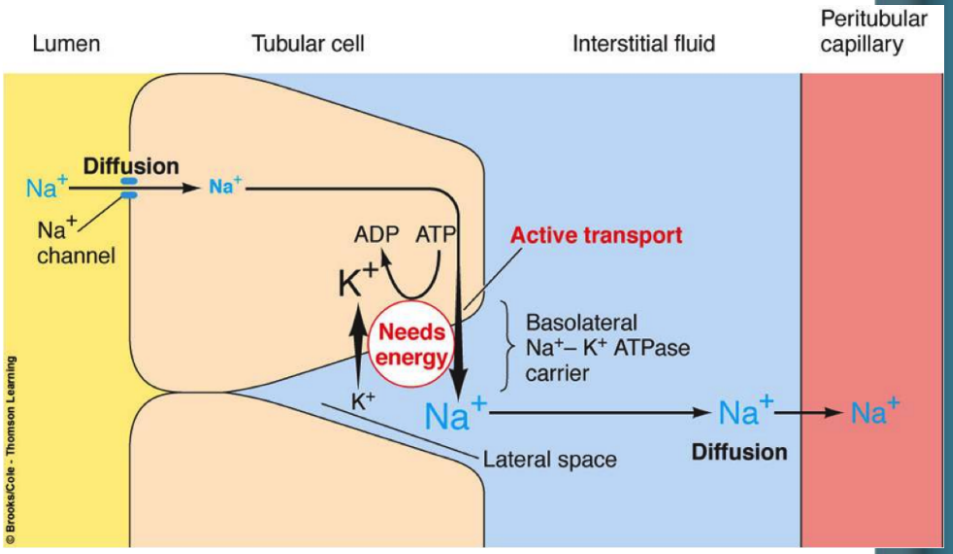
All **organic nutrients** are reabsorbed

Water and ion reabsorption is **hormonally controlled**

Reabsorption may be an **active** (requiring ATP) or **passive** process

Sodium Reabsorption: Primary Active Transport

- Sodium reabsorption is almost always by active transport
- Na^+ enters the tubule cells at the luminal membrane
- Is actively transported out of the tubules by a **Na^+-K^+ ATPase** pump



Mechanisms of tubular absorption & secretion

- Passive:
  Diffusion
  facilitated diffusion
  } Down chemical, electrical gradient

- Active transport
  endocytosis
  } Against chemical, electrical gradient, need energy

Proximal convoluted tubule
Na+ Reabsorption

- Leaky epithelium permeable to ions & water
- ~ 70 % of Na+, Cl-, K+, water absorbed passively (follows Na+)

- **Na+ Reabsorption (transcellular):**

Early PCT Na+ absorbed:

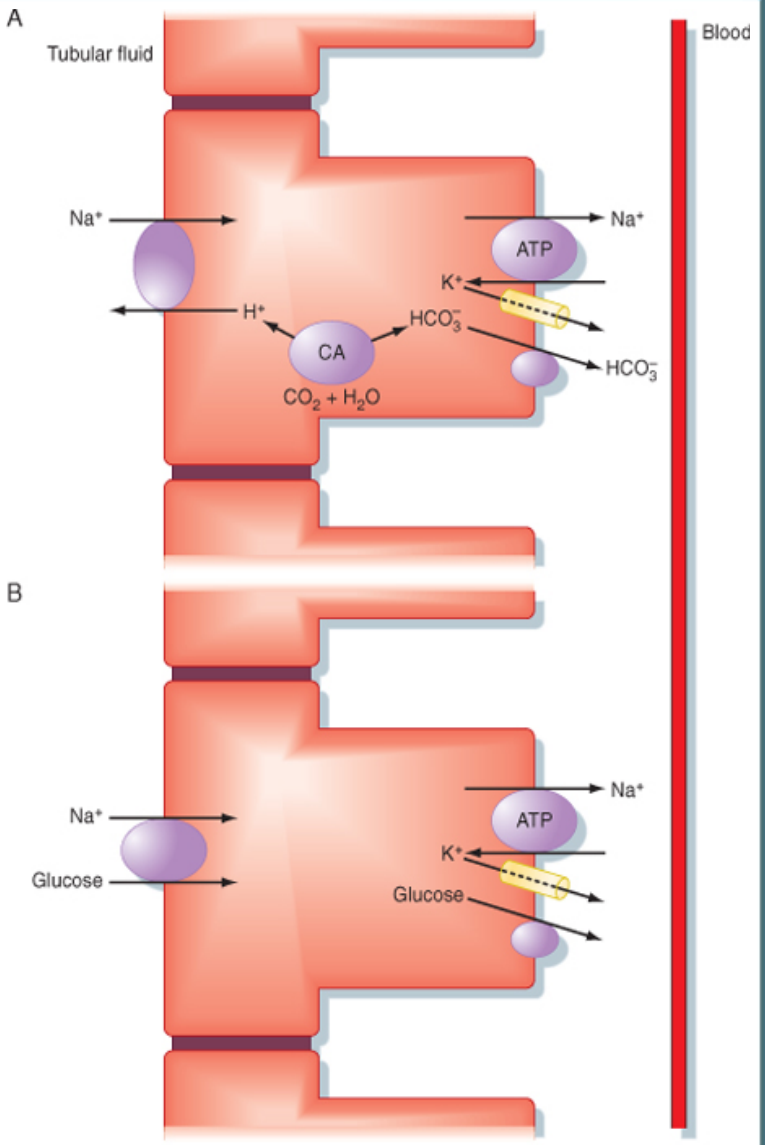
1) exchanged with H+,
   but HCO_3^- reabsorbed
2) with organic substances
   glucose, amino acids, lactate, Pi

} Na^+/K^+-ATPase important

PCT
Na+ Reabsorption

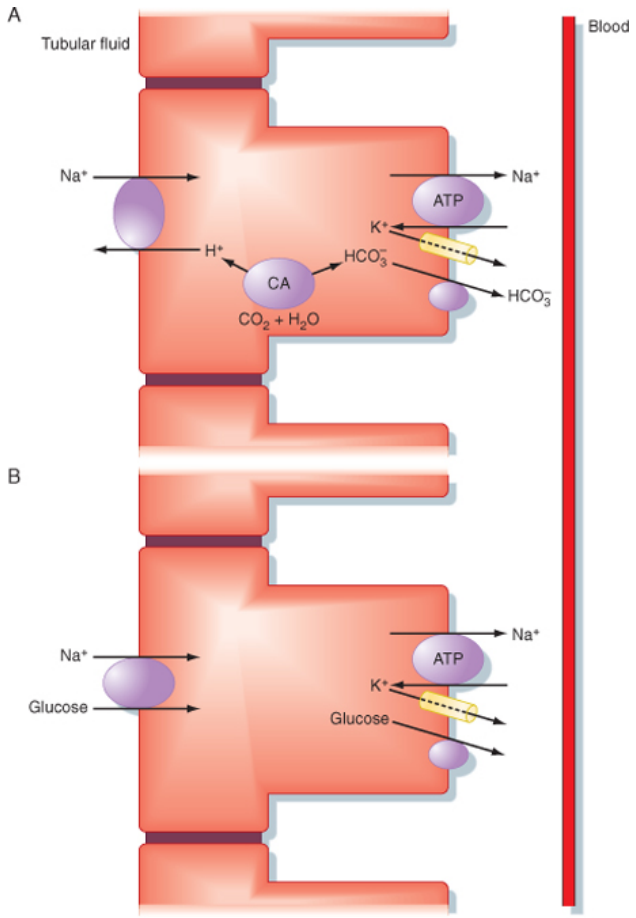
a) NHE takes up Na^+ for H^+
   - Causes reabsorption of HCO3-

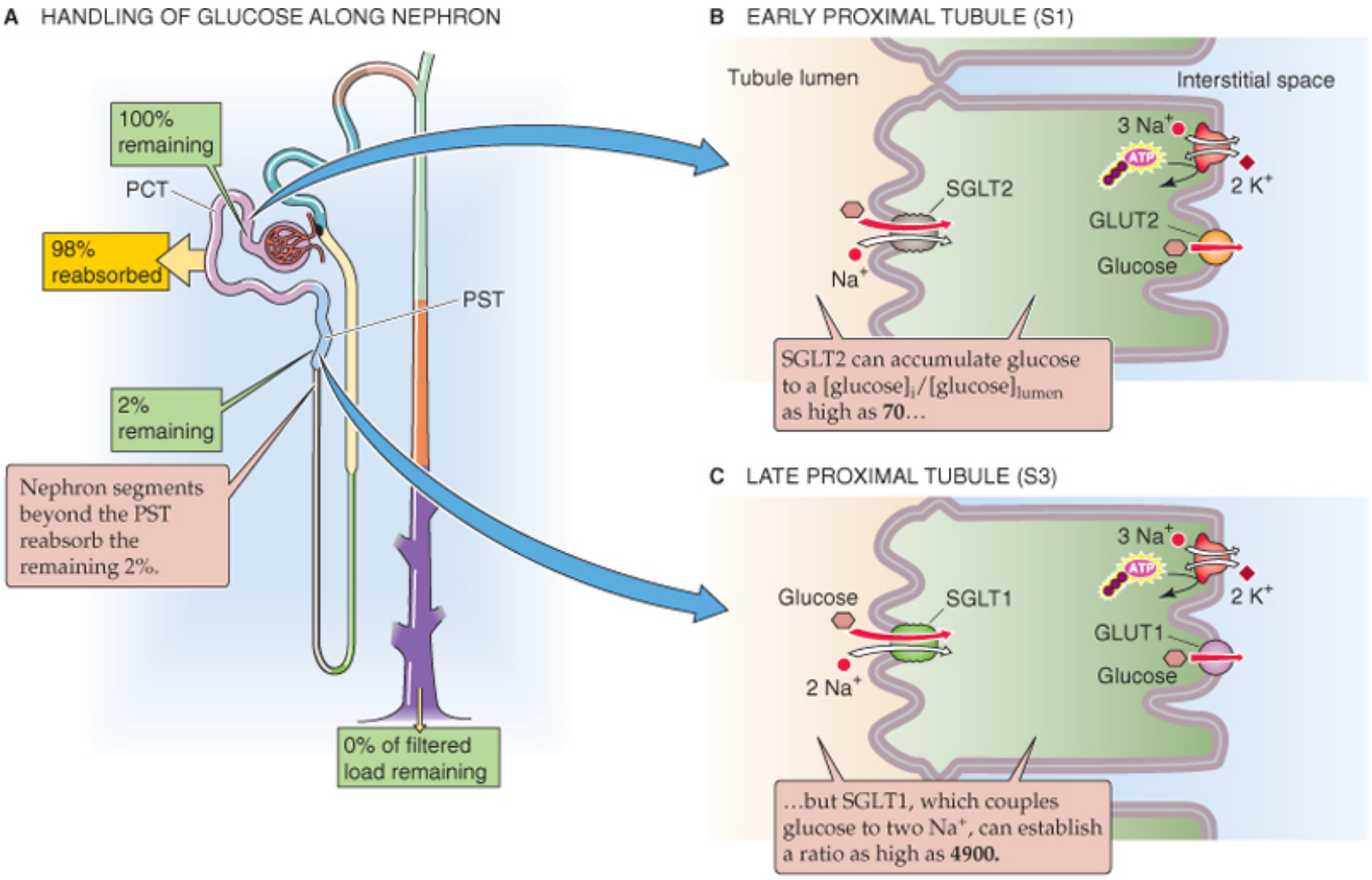
b) Symporters:
   - Na^+-glucose
   - Na^+-amino acid
   - Na^+-Pi
   - Na^+-lactate



Glucose Reabsorption

- From tubular lumen to tubular cell: ***Sodium co-transporter (Carrier-mediated secondary active transport***).
- From tubular cell to peritubular capillary: ***Facilitated diffusion*** (***Carrier-mediated passive transport***)



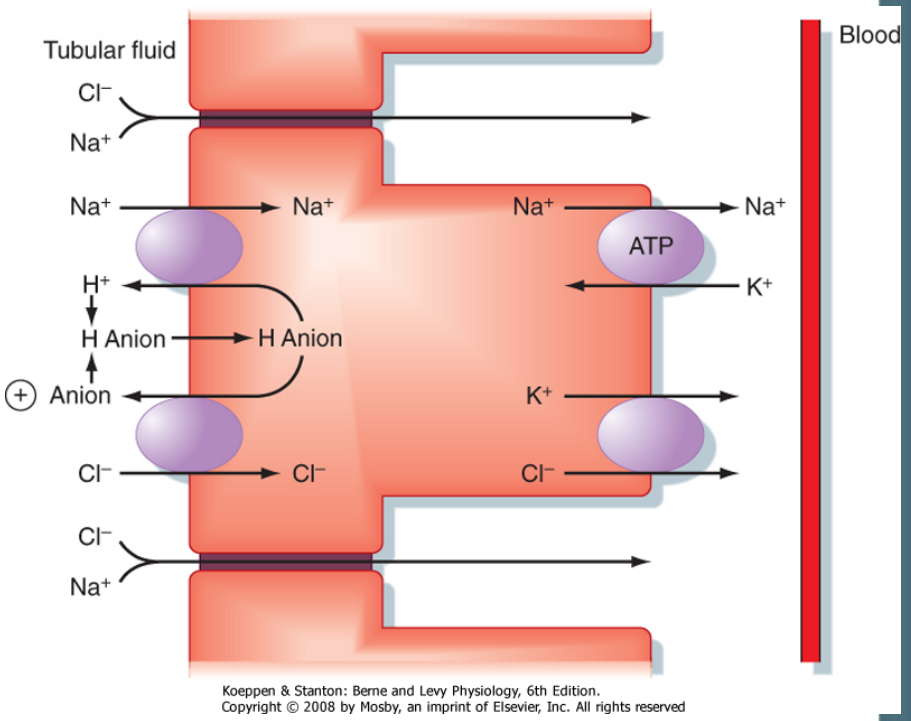


Boron & Boulpaep: Medical Physiology, 2nd Edition.

Late PCT
Na+ Reabsorption

- **Late PCT** Na+ Reabsorbed mainly with Cl-
- Why ? due to different transport mechanisms in late PCT, lack of organic molecules

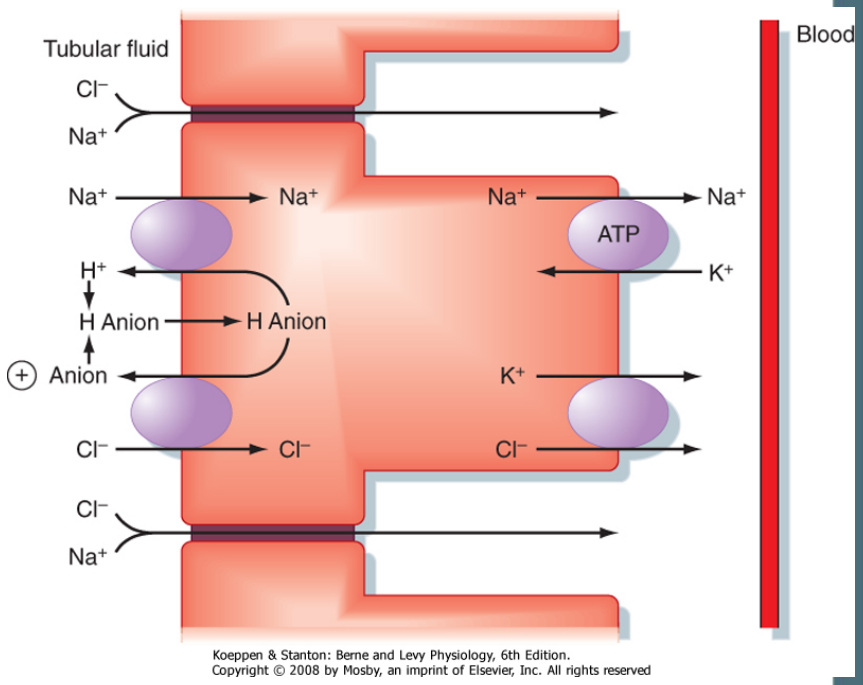
a) Transcellular: Na+ entry using NHE



Late PCT
Na+ Reabsorption

b) Paracellular (passive diffusion) With Cl-

- driven by high [Cl-] in tubule
- This conc. gradient favors diffusion of Cl- from the tubular lumen a cross the tight junction into the lateral intercellular space.

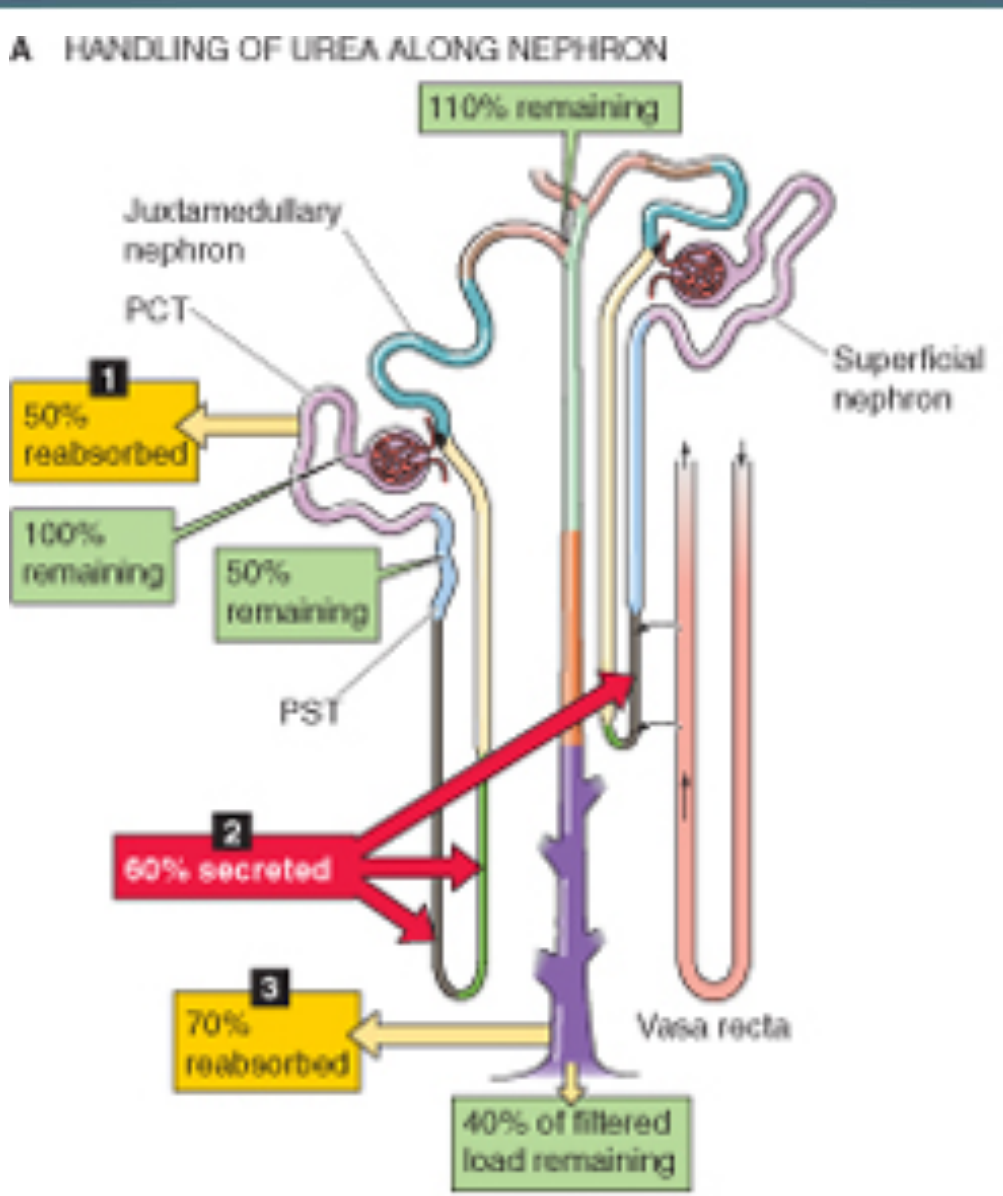


Urea Reabsorption

- Normal plasma level of urea 2.5-6.5 mM/L (15-39 mg/ 100ml)

Mechanism of urea reabsorption:

- About **40-70%** of filtered load of urea is reabsorped in:
  - Second half of PCT.
  - Medullary CT and CD (ADH dependent)
- Due to water reabsorption in the first half of PCT, the conc. of urea is increased in the second half and urea is reabsorbed by simple diffusion (downhill)

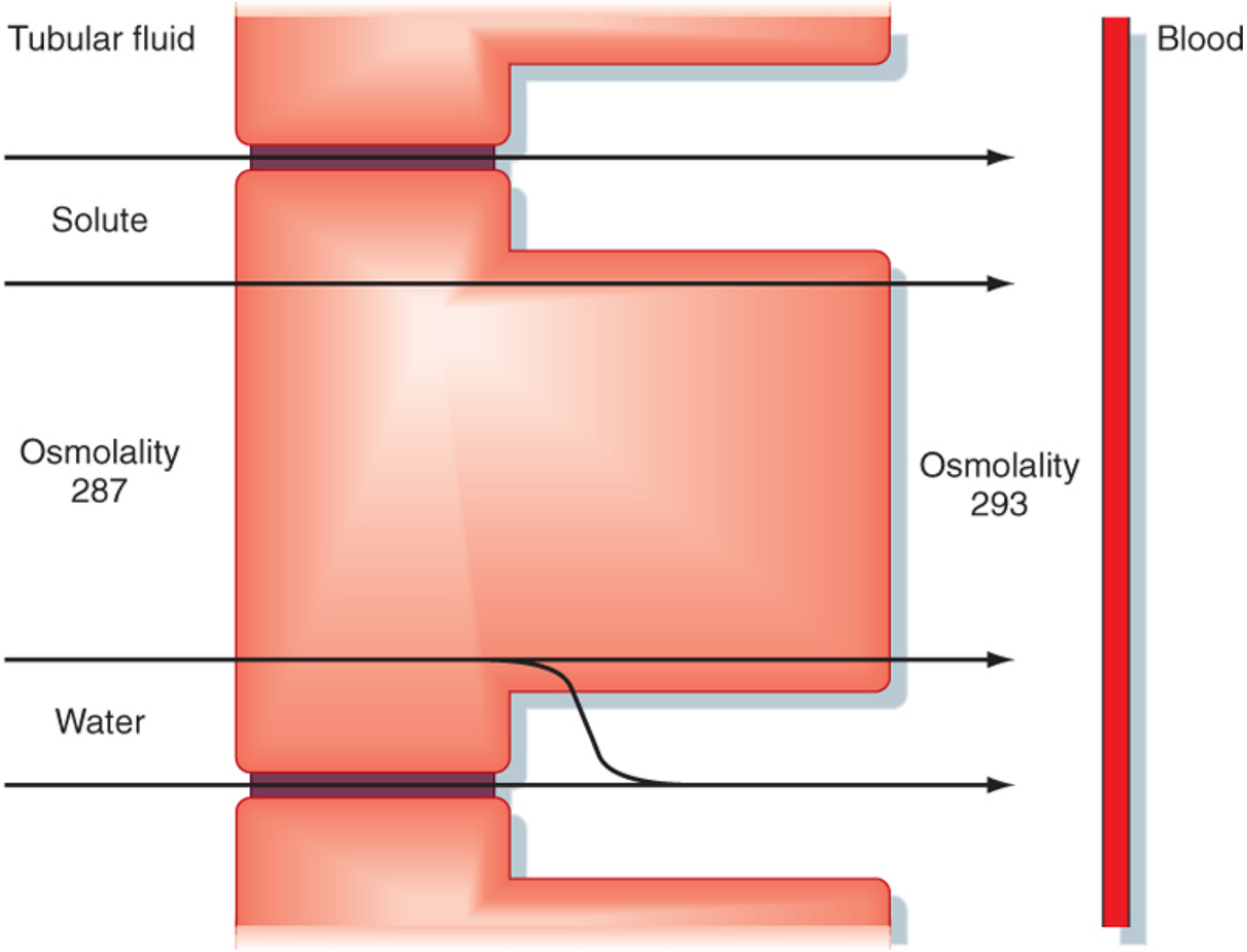

A HANDLING OF UREA ALONG NEPHRON
110% remaining
Juxtamedullary nephron
PCT
Superficial nephron
1
50% reabsorbed
100% remaining
50% remaining
PST
2
60% secreted
3
70% reabsorbed
Vasa recta
40% of filtered load remaining

Water reabsorption

- PCT cells permeable to water
- PCT Reabsorbs 67% of filtered water.
- Transtubular Passive (osmosis), due to osmotic active substances that are absorbed e.g. **Na+**, glucose, HCO3-, Cl-

  ⇒ ↓ tubule osmolality

  ↑ intracellular space osmolality



Water reabsorption

- Solvent drag: K+, Ca2+, carried with water & hence reabsorbed
- The accumulation of fluid and solutes within the lateral intercellular space increases hydrostatic pressure in this compartment
- The increased hydrostatic pressure forces fluid and solutes into the capillaries. Thus, water reabsorption follows solutes.
- The proximal tubule reabsorption is isosmotic

Protein reabsorption

- Peptide hormones, small proteins & amino acids reabsorbed in PCT
- Undergo Endocytosis into PCT, either intact or after being partially degraded by enzymes.
- Once protein inside the cell, enzyme digest them into amino acids, which leave the cell to blood.
- Has a maximum capacity

  - too much protein filtered = proteinuria

Organic ion/cation secretion

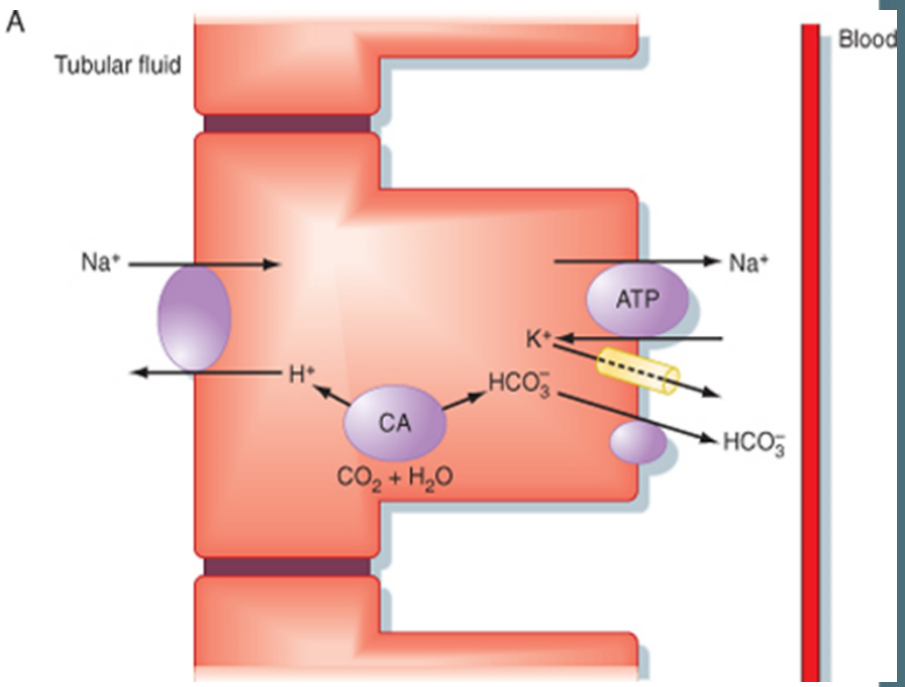
- **Endogenous compounds:**
  - End products of metabolism
  - Bile salts
  - Creatinine
  - Catecholamines (adrenaline, noradrenailne)

- **Exogenous compounds:**
  - Penicillin
  - NSAIDs (e.g. ibuprofen)
  - Morphine

HCO_3^- Reabsorption

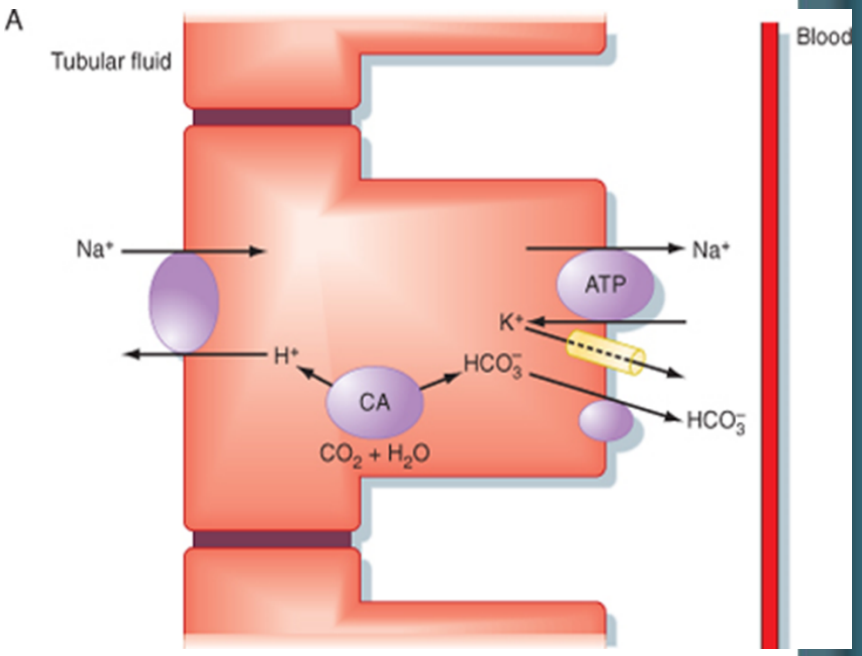
- The renal tubules are poorly-permeable to HCO_3^-. However, it is still reabsorbed but in the form of CO_2 (to which the tubules are very highly permeable).

1. H^+ is formed inside the cells then secreted in the tubular fluid.
2. H^+ combines with HCO_3^- in the tubular fluid forming H_2CO_3.



HCO_3^- reabsorption

3. By activity of the **carbonic anhydrase enzyme (C.A.)** in the tubular cells, H_2CO_3 dissociates into CO_2 & H_2O.
5. CO_2 diffuses into the cells where it combines with H_2O (by activity of an intracellular C.A.), forming H_2CO_3 which dissociates into HCO_3^- & H^+.
7. HCO_3^- passively diffuses into the interstitial fluid (then to the blood) while H^+ is secreted into the tubular fluid to help more reabsorption of HCO_3^-.



HCO_3^- reabsorption

- Factors affecting **HCO_3^-** reabsorption:

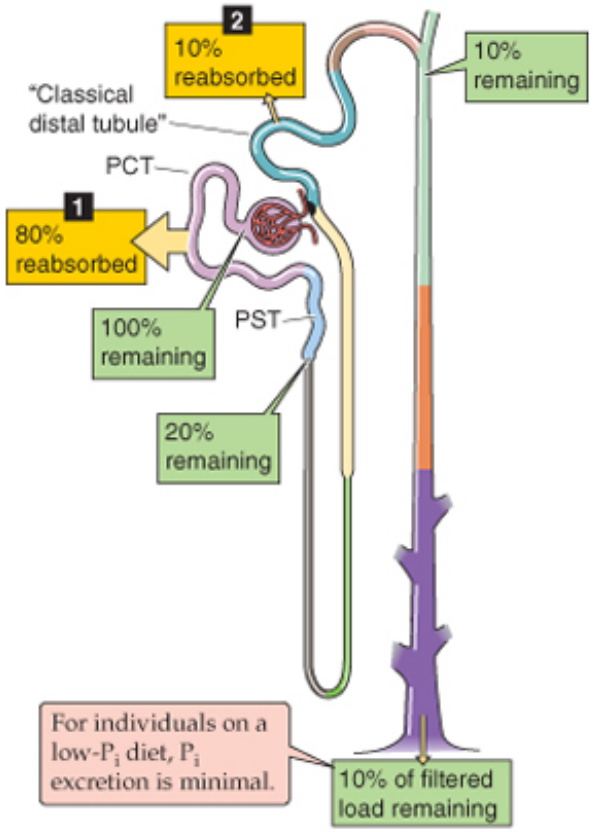
1. Arterial Pco_2
2. Plasma[K^+]
3. Plasma Aldosterone.
4. Plasma [cl^-]

References

- Guyton and Hall Textbook of physiology
  - Chapter 27


Thanks

A HANDLING OF PHOSPHATE ALONG NEPHRON



B PROXIMAL TUBULE