RENAL PHYSIOLOGY (PART 2)

Dr. Hussein Salah Rebea

Lec. 2

Tubular reabsorption

- The process of **tubular reabsorption** is essential for the **conservation** of ***plasma constituents*** that are important to the body.
- This process is **highly selective**
- in that ***waste products*** **and** ***substances*** with **no physiological value** are **Not** reabsorbed but, instead, are *excreted in the urine*.
- Furthermore, the reabsorption of many substances, such as Na+ ions, H+ ions, Ca++ ions, and water, is **physiologically controlled**.
- The **volume**, **osmolarity**, **composition**, and **pH** of the ***extracellular fluid*** are **precisely regulated.**

Pathway of Reabsorption Substance

Filtrate within tubular lumen

↓

Across the luminal membrane of the epithelial cell

↓

Through the cytoplasm of the epithelial cell

↓

Across the basolateral membrane of the epithelial cell

↓

Through the interstitial fluid

↓

Across the capillary endothelium

↓

Peritubular capillary blood

❖There are two types of tubular reabsorption:

1. **Passive**
2. **Active**

➢***passive*** *when each of the steps in* ***transepithelial transport takes place*** **without the expenditure of energy.**

➢***Active reabsorption*** *occurs when the movement of a given substance across either the luminal surface or the basolateral surface of the tubular epithelial cell* **requires energy.**

Basic Renal Processes for Sodium and Water

- Both **Na** and **water** *freely filter* from the glomerular capillaries into Bowman's space **because** they have *low molecular weights* and *circulate in the plasma in the free form* (unbound to protein).
- They both undergo considerable reabsorption— normally more than 99% **But no secretion.**
- Most **renal energy utilization** *is used in this enormous reabsorptive task*.
- The bulk of **Na** and **water reabsorption** (**about two-thirds**) **occurs** in the **proximal tubule.**
- **But** the major hormonal control of reabsorption is **exerted on** the distal convoluted tubules and collecting ducts.

Mechanisms of Na and Water Reabsorption

❖**The mechanisms of Na and water reabsorption can be summarized in two generalizations:**

1. Na reabsorption is an active process **occurring in all tubular segments**

   except the *descending limb of the loop of Henle*.

2. Water reabsorption is by osmosis and is dependent upon Na reabsorption.

Sodium Reabsorption

- The **Na reabsorption** throughout the tubule is the primary active transport of Na out of the cells and into the interstitial fluid.
- This transport is achieved by **Na /K-ATPase pumps** in the basolateral membrane of the cells.
- The **active transport of Na** out of the cell keeps the intracellular concentration of Na low **compared to** the **tubular lumen.**
- So, **Na moves** "downhill" out of the tubular lumen **into** the tubular epithelial cells.

❖The **mechanism** of the downhill Na movement across the luminal membrane **into the** cell ***varies*** *from segment to segment of the tubule* **depending on** which channels and/or transport proteins are present in their luminal membranes.

➢**For example:**

✓***The luminal entry step*** *in the* ***proximal tubule cell*** *occurs by* ***cotransport*** *with a variety of organic molecules*, such as glucose, or by **countertransport** with **H+**.

❑**Thus**, in the proximal tubule, **Na reabsorption** *drives the reabsorption of the cotransported substances and secretion of* ***H+.***

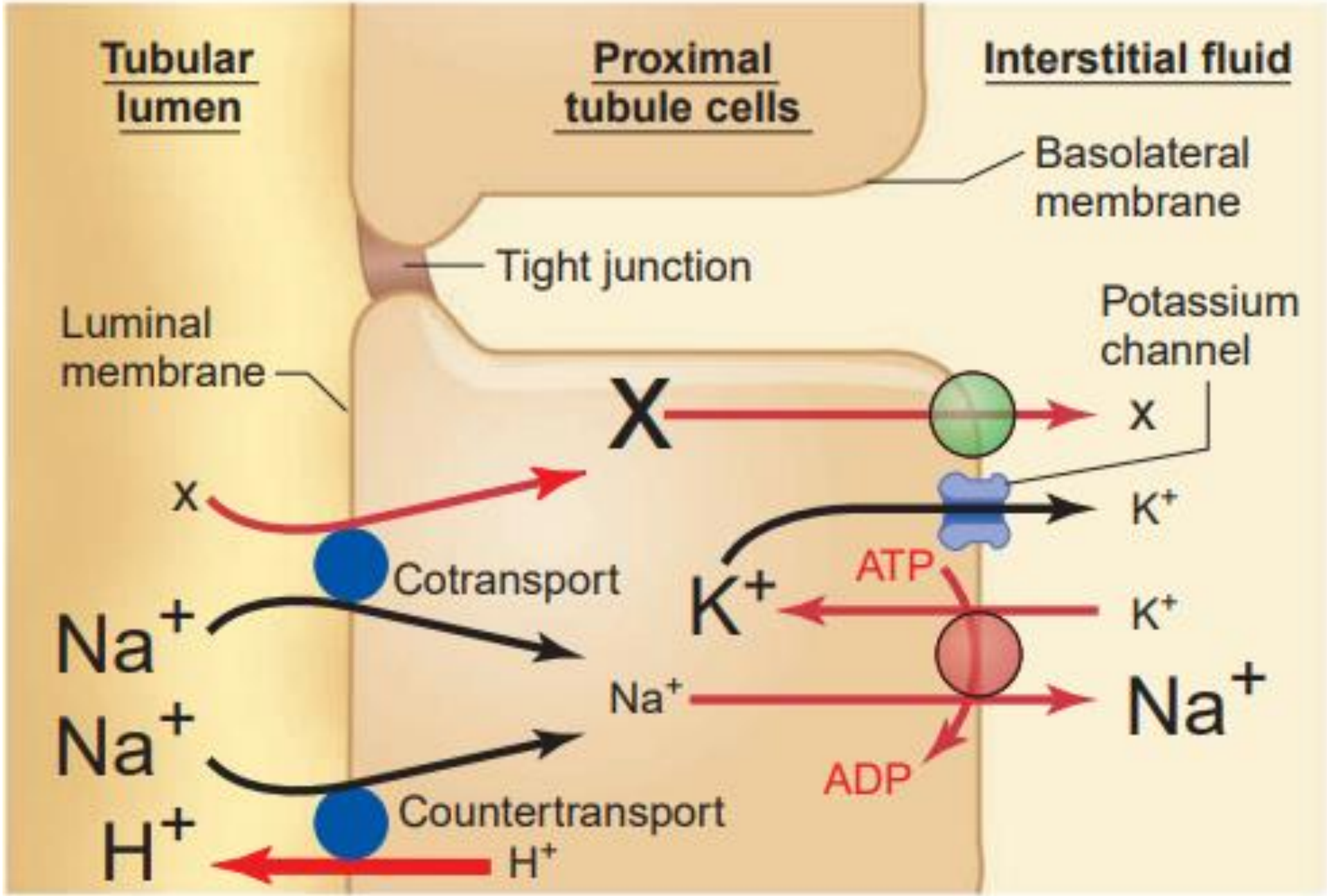
✓The **luminal entry step** for **Na** in the **cortical collecting duct** **occurs primarily by** *diffusion through* ***Na channels***.

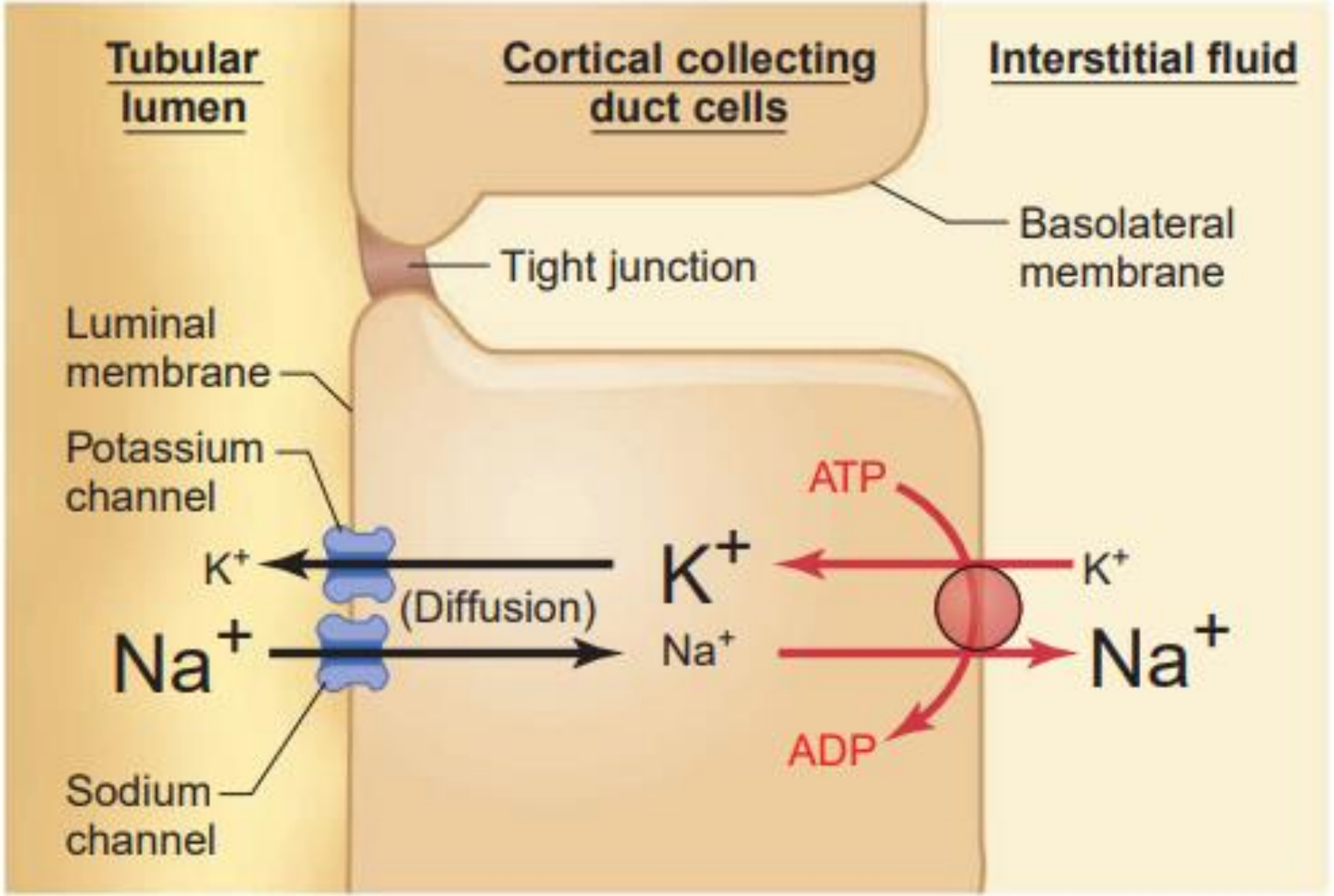
➢*NOT:*

I. The movement of Na downhill from lumen into cell across the luminal membrane **varies** *from one segment of the tubule to another.*

II. **By contrast**, the *basolateral membrane step* is the **same in all Na -reabsorbing tubular segments**—*the primary active transport of* ***Na*** *out of the cell is* ***via*** *Na/K- ATPase pumps in this membrane.*

III. It is this transport process that decreases intracellular Na concentration and so **makes possible** the downhill luminal entry step.


Tubular lumen
Proximal tubule cells
Interstitial fluid
Basolateral membrane
Tight junction
Luminal membrane
Potassium channel
X
x
x
K+
ATP
Cotransport
K+
K+
Na+
Na+
Na+
Na+
ADP
Countertransport
H+
H+


Tubular lumen
Cortical collecting duct cells
Interstitial fluid
Basolateral membrane
Tight junction
Luminal membrane
Potassium channel
Sodium channel
K+
Na+
(Diffusion)
K+
Na+
ATP
ADP
K+
Na+

❖**The amount of sodium reabsorbed from the *proximal tubule* and from the *Loop of Henle* is:**

1. **Proximal tubule**: **65%** of the filtered sodium is reabsorbed
2. **Ascending limb of the Loop of Henle**: **25%** of the filtered sodium is reabsorbed

❑This reabsorption occurs **regardless** of the **sodium content** of the body.

❑**The reabsorption of the remaining 10% of the filtered Na+ ions from the distal tubule and the collecting duct is physiologically controlled by *two hormones*:**

1. **Aldosterone**
2. **Atrial natriuretic peptide (ANP)**

Aldosterone

- ***Aldosterone***, released from the *adrenal cortex*, ***promotes*** *the reabsorption of* ***sodium*** from the **distal tubule** and the **collecting duct**.

❖**The mechanisms of action of aldosterone include:**

a) **Formation** of **Na+ channels** in the *luminal membrane* *of the tubular epithelial cells* (facilitates the passive diffusion of Na+ ions into the cell)

b) **Formation** of **Na+-K+-ATPase carrier molecules** in the *basolateral membrane* *of the tubular epithelial cells* (promotes the extrusion of Na+ ions from the cells and their movement into the plasma by way of the peritubular capillaries; **enhances** the *concentration gradient* for passive diffusion through the Na+ channels in the luminal membrane)

Atrial natriuretic peptide

❖***Atrial natriuretic peptide* (*ANP*),** released from myocardial cells in the atria of the heart

❖It ***inhibits*** *the reabsorption of sodium* from the **collecting duct**.

❖**The mechanisms of action of ANP include:**

1. Inhibition of aldosterone secretion
2. Inhibition of Na+ channels in the luminal membrane of the tubular epithelial cells

❖**Note:** the regulation of sodium reabsorption is important in the **long-term** regulation of **blood pressure**.