Tubular Reabsorption

Guyton

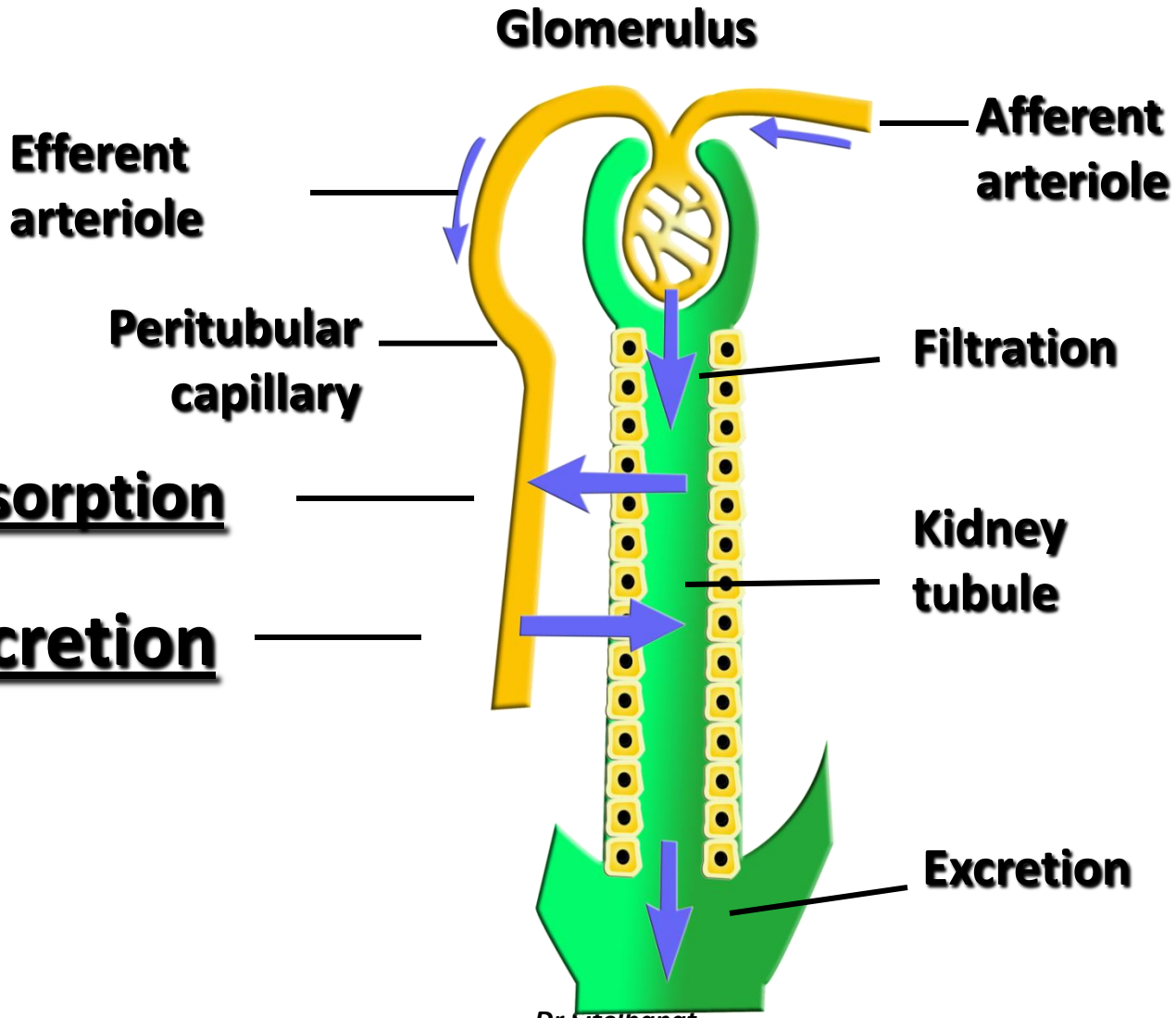
Dr Sitelbanat Awadalla

Objectives

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

- **Mechanism of urine formation**
- **Renal tubular transport**
- **Nacl re-absoption in PCT**
- **Water re-absoption in PCT**
- **Glucose and amino acid re-absoption in PCT**

Tubular Function



Filtration, Reabsorption and excretion rate

	Filtered	Absorb.	Excreted	A/F %
Glucose (g/d)	180	180	0	100
HCO3 (meq/d)	4320	4318	2	99.98
Na (meq/d)	25560	25410	150	99.4
Cl (meq/d)	19440	19260	180	99.1
K (meq/d)	756	664	92	87.7
Urea (g/d)	46.8	23.4	23.4	50
creatinine (meq/d)	1.8	0	1.8	0

Calculation of tubular reabsorption or secretion from renal clearances

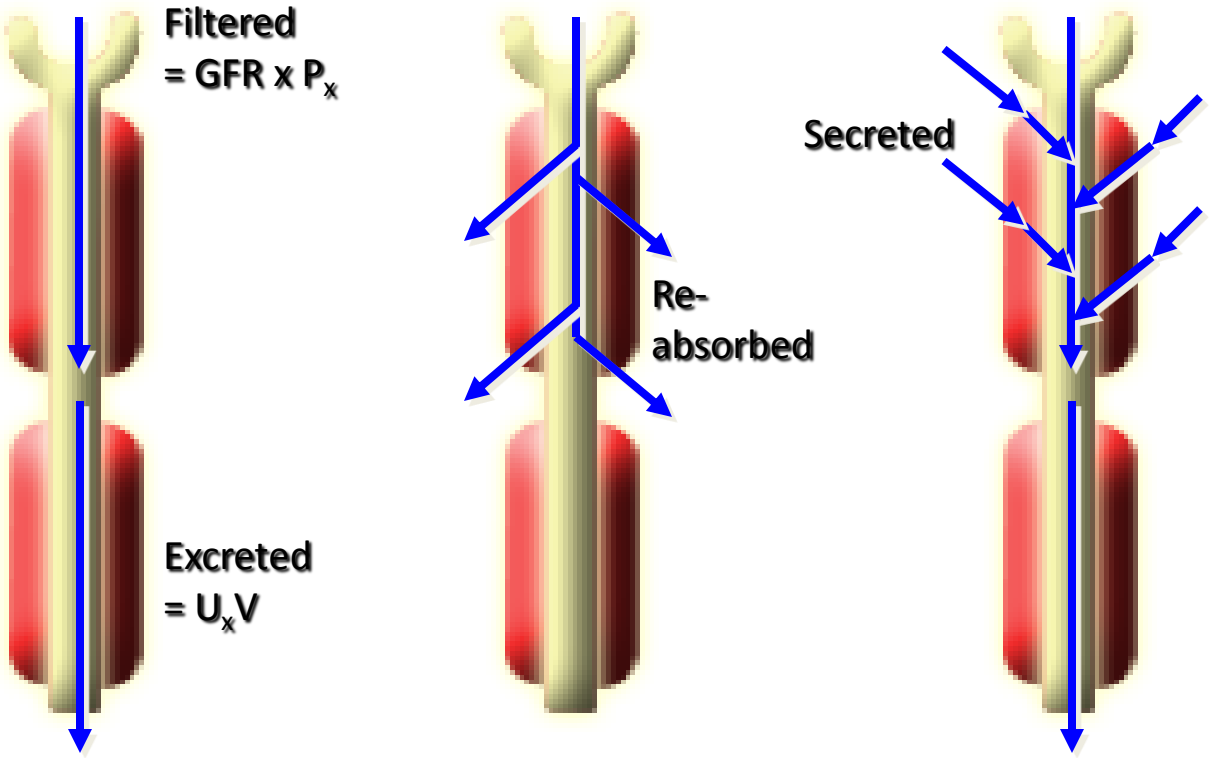
Reabsorption or secretion =
Quantity Filtrated – Quantity excreted

Quantity Filtrated = P_x x GFR

Quantity Excreted = U_x x V

Calculation of renal transport (Tx)

$$T_x = GFR \times P_x - U_xV$$



T_x = 0
GFR x P_x = U_xV
e.g. Inulin

T_x = positive
GFR x P_x > U_xV
e.g. glucose

T_x = negative
GFR x P_x < U_xV
e.g. PAH

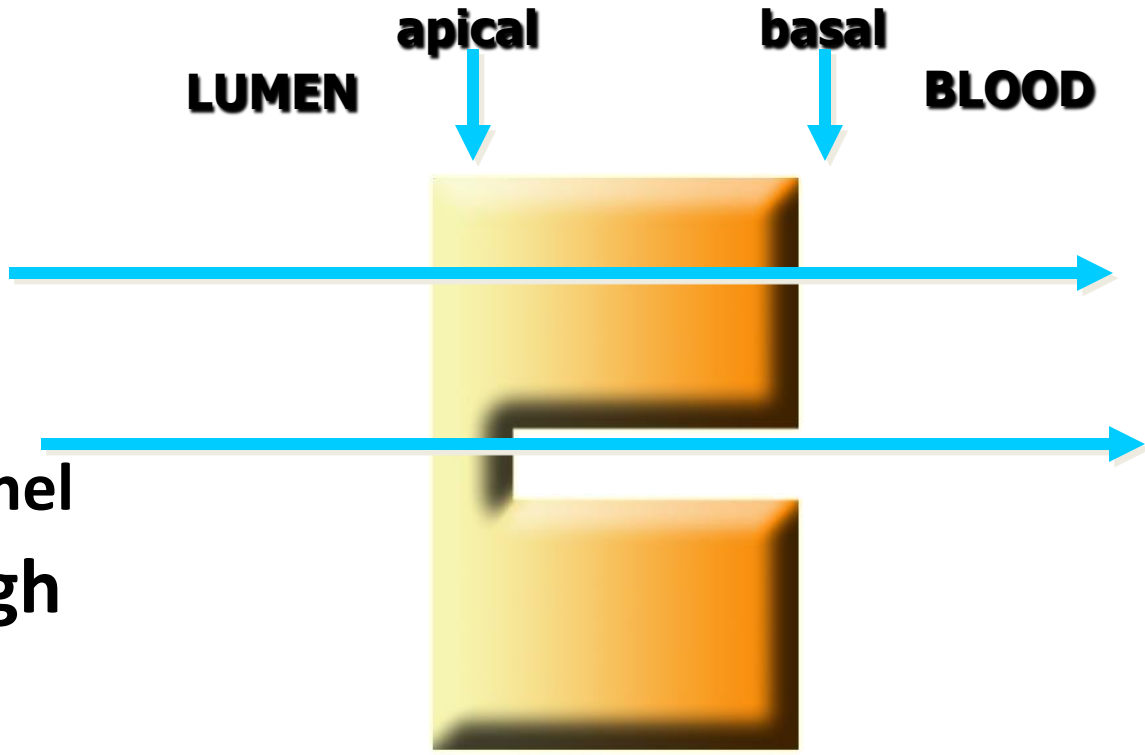
Calculation of Na reabsorption Example

- Plasma Na concentration = 140 mEq/L
- GFR (inulin clearance) = 125 ml/min
- Urine flow rate = 1 ml/min
- Urine concentration of Na= 70 mEq/L

Calculate the amount of Na transported

Types of transport

- Transcellular: Across renal cell
  - Primary active transport
  - Secondary active transport
  - Passive: ion channel
- Paracellular: Through tight junction
  - Passive diffusion

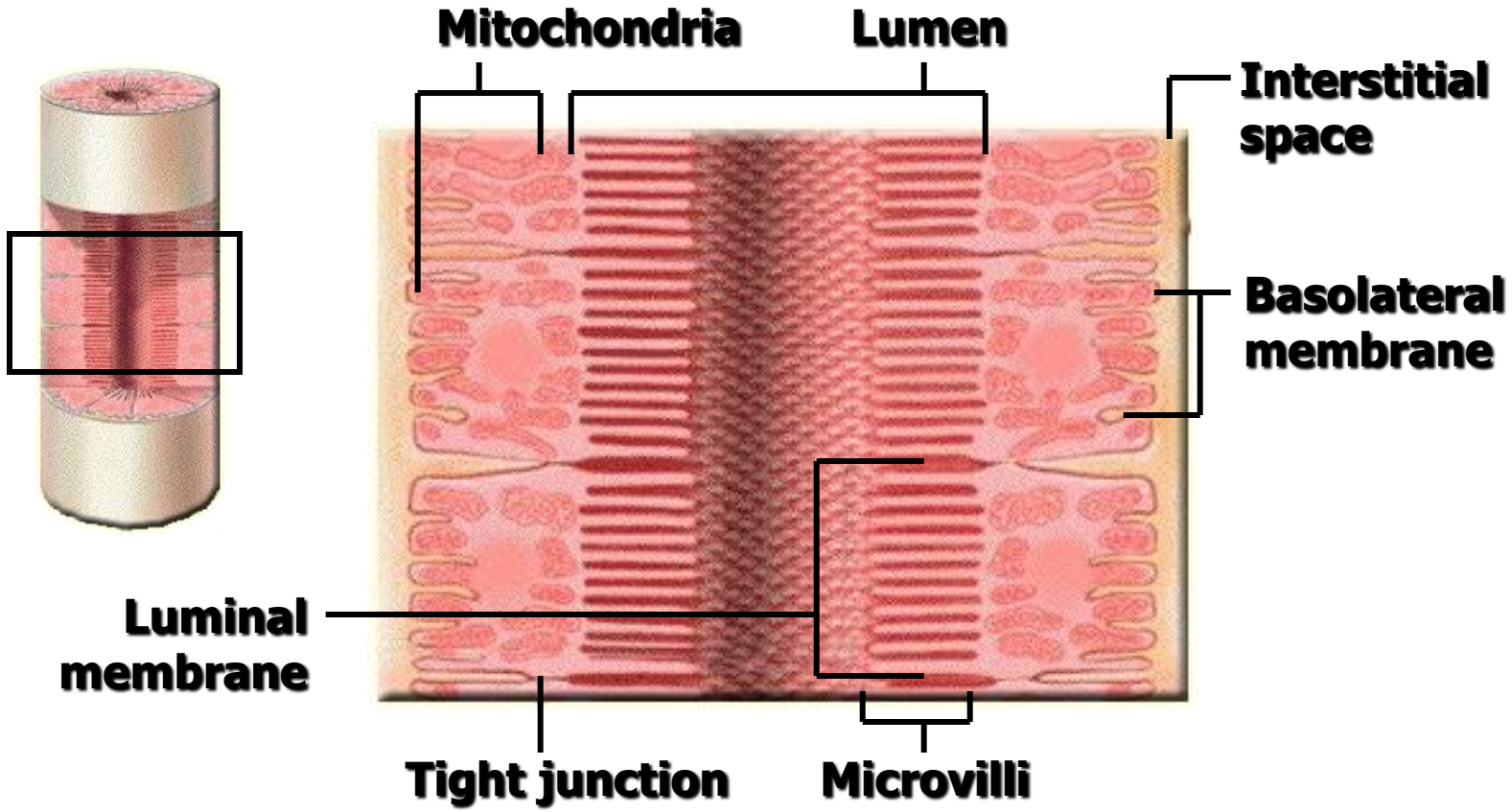


Proximal convoluted tubule

- **High capacity for reabsorption**
  - **Special tubular epithelial cell**
  - **Metabolically active (lot of mitochondria)**
  - **Brush border (surface area)**
  - **Tight junction is not so tight**
  - **Contain a lot of carrier protein**

Cells of the Proximal Convoluted Tubule (PCT)

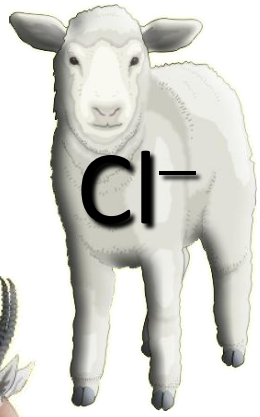
Simple cuboidal cells with brush border Highly permeable to water and many solutes.



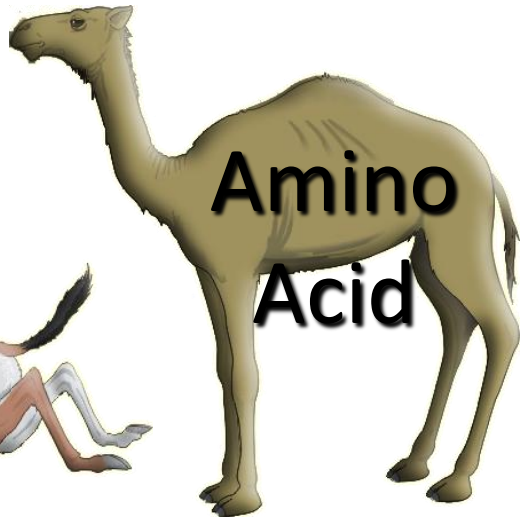
Substances absorbed in PCT

- **Tubular absorption**
  - **Sodium**
  - **Chloride**
  - **Glucose**
  - **Water**
  - **Amino acid**
  - **Bicarbonate**
  - **Phosphate**
  - **Urea**
- **Secretion**
  - **PAH**
  - **H^+**
  - **K**

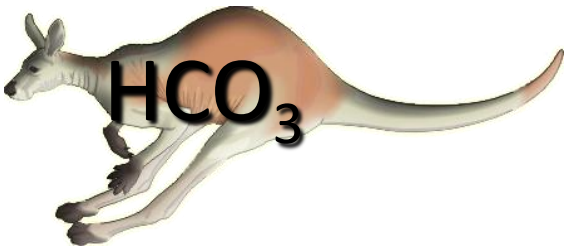

Na


Cl⁻


Glue


Amino
Acid

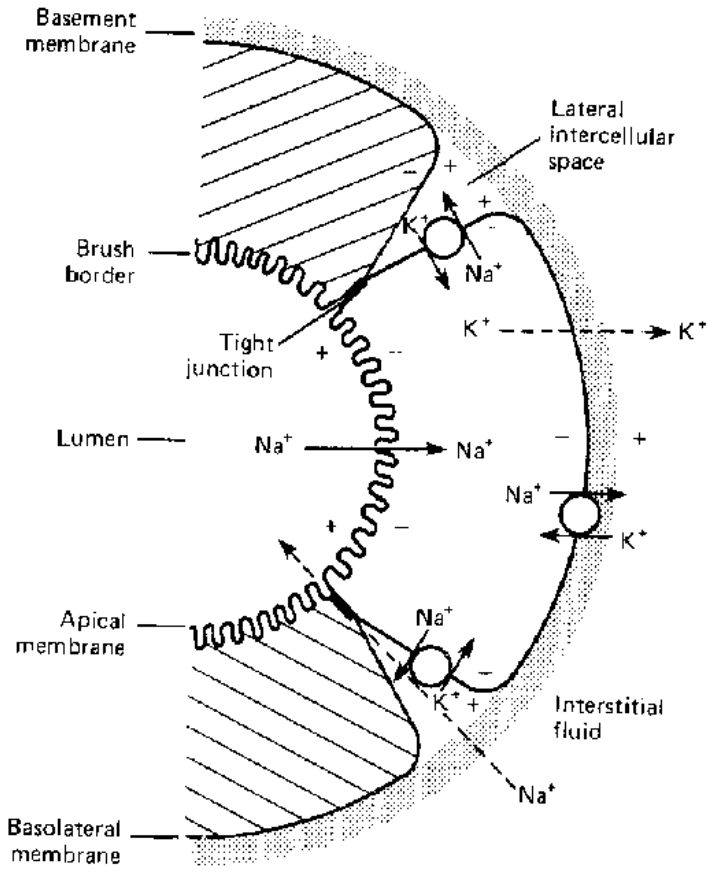

H2O


HCO3

Sodium reabsorption in PCT

- 65-70% of filtered sodium is reabsorbed in PCT
- Followed by water & chloride
- Iso-osomotic absorption (equal quantity of solute & water)
- Important for the absorption of
  - Glucose
  - Amino acids
  - phosphates

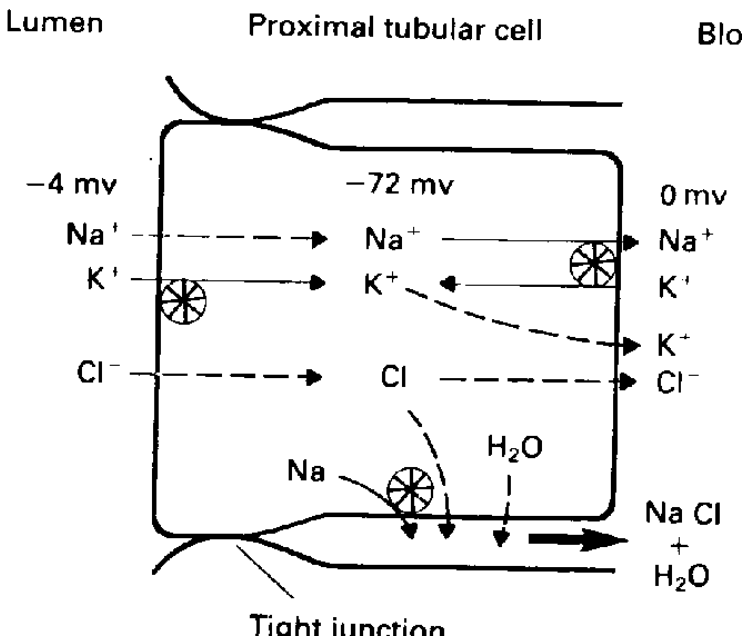
Passage of sodium absorption



Mechanism of sodium reabsorption

- **Basolateral membrane**
  - **Na+/K+ Atpase**
    - **3 Na / 2 K**
    - **K leak out of the cell**

    Results in
  - **Low intracellular Na Concentration**
  - **high peritubular osmolality**



Mechanism of sodium reabsorption

- Na enter the cell passively following
  - Electrical difference (inside the cell -70mv, lumen -4mv)
  - Na concentration differences (140 mEq/L to 12mEq/L)
- Na enter the cell across the luminal membrane:
  - Cotransport with glucose, amino acids
  - Na in exchange H (counter transport)
  - Na channel

Chloride reabsorption

- **Cl reabsorbed down concentration gradient following the positively charge Na**

Water reabsorption

- **60-70% of filtered water is reabsorped in PCT**
  - **Active pump of Na from renal cell to peritubular space results in increases the osmolality of peritubular space**
  - **Drag water by osmosis**
- **Filterate remain iso-osmotic (~equal quantity of water & solute are absorbed)**

Glomerulo-tubular balance

- **Feed back mechanism to keep a fixed percentage of reabsorbed glomerular filtrate**
- **The higher the filtration in the glomerulus → the higher oncotic pressure in efferent & peritubular capillaries → ↑ reabsorption in PCT**

Glucose reabsorption

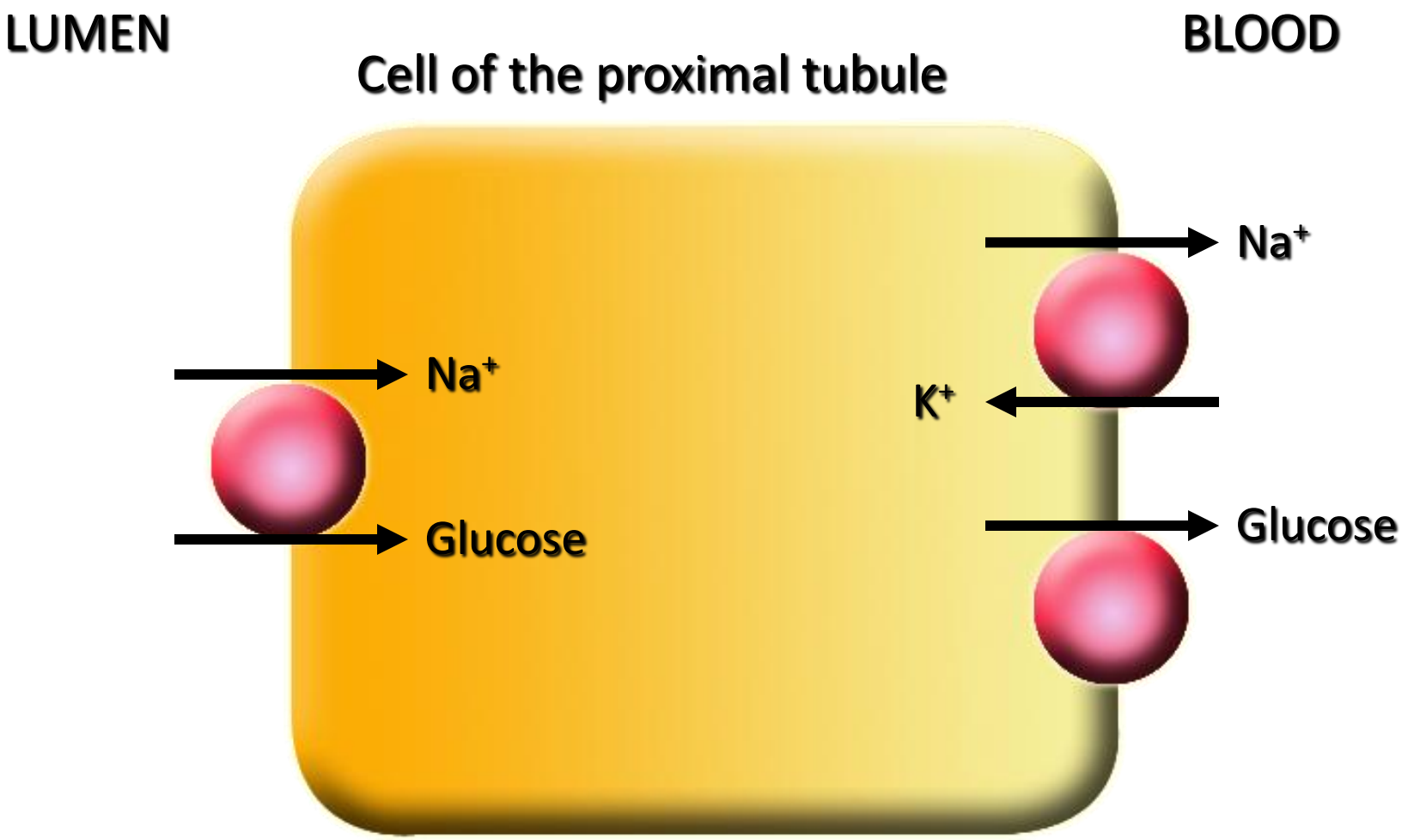
- **In healthy adult all filtered glucose is reabsorbed and no glucose will appear in urine**
- **If plasma glucose (P_G) reach 200 mg/dl, glucose appear in the urine – this level is the "Renal threshold"**
  - **200mg/dl in arterial; 180 mg/dl in venous**

Glucose reabsorption

- **The amount of reabsorped glucose at very high filtered glucose, remains constant, this is called tubular transport maximum for glucose (Tm_G)= 375 mg/min (female 300mg/min)**
- **At this maximum transport, all the glucose carriers are saturated and no more glucose can be transported**

Mechanism of Glucose reabsorption

- Secondary active transport
- Luminal membrane
  - Cotransport with Na
- Basolateral membrane
  - GLUT 1 & 2



Cellular Mechanism for Glucose Reabsorption

Amino acid reabsorption

- **All filtered AAs are reabsorbed in PCT**
- **Luminal membrane**
  - **Cotransport with Na**
- **Basolateral membrane**
  - **diffusion**