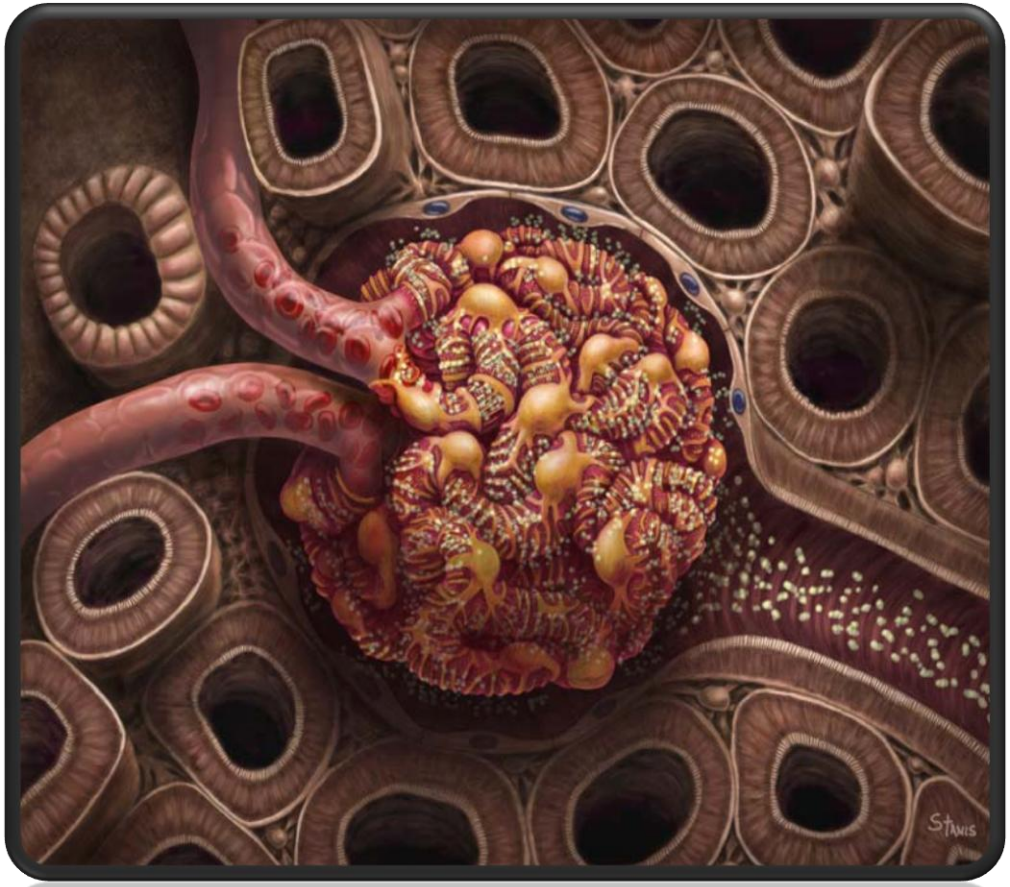
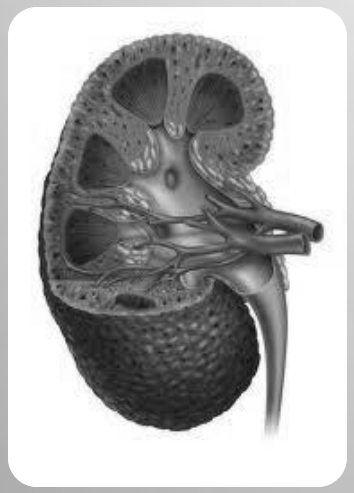
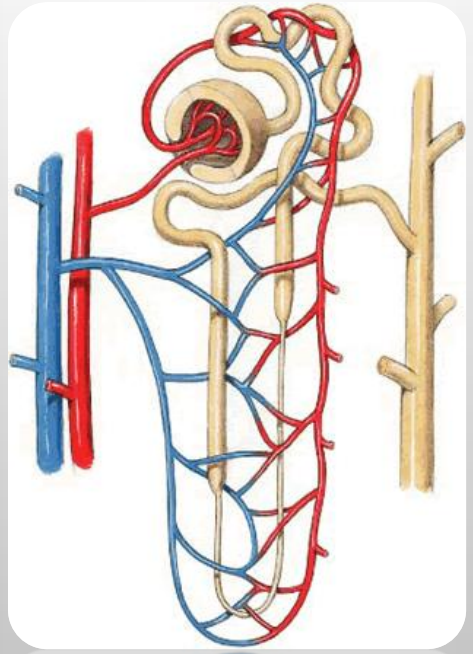
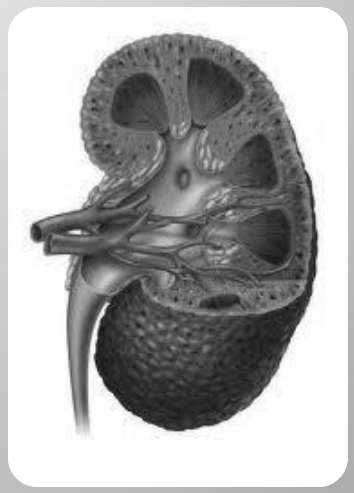
Physiology Team 431









Physiology Team

Team's Additions ☺

Tubular Reabsorption

Guyton

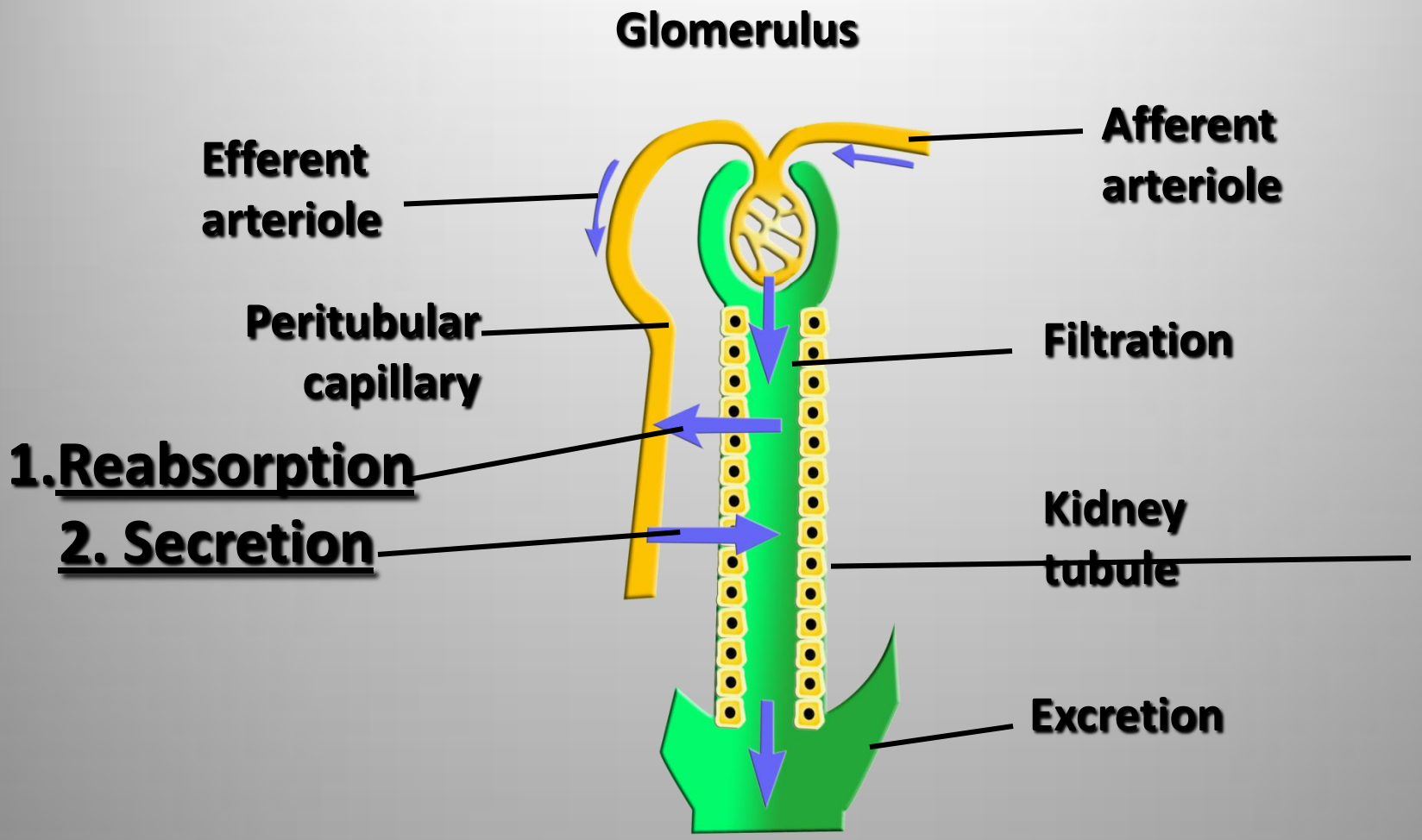
Dr Sitelbanat Awadalla

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



- **Re-absorption:** flow of filtrate from the tubules into the peritubular capillaries.
- **Secretion :** movement of substances(that didn't undergo filtration) from blood capillaries into the tubules.

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

Dr. Sitelbanat mentioned that you don't need to memorize these numbers
But you have to get the general idea , **Glucose is** completely reabsorbed , **creatinine** is completely excreted.

Calculation of tubular reabsorption or secretion from renal clearances

- **Reabsorption or secretion =**

Quantity Filtrated – Quantity excreted

- **Quantity Filtrated = P_x x GFR**

Px is the concentration of the molecule X in the plasma.

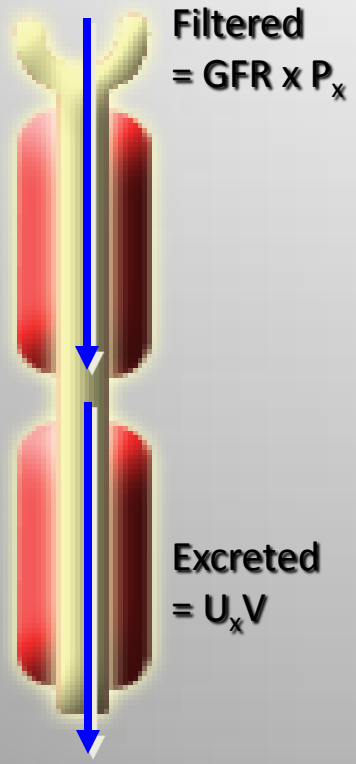
- **Quantity Excreted = U_x x V**

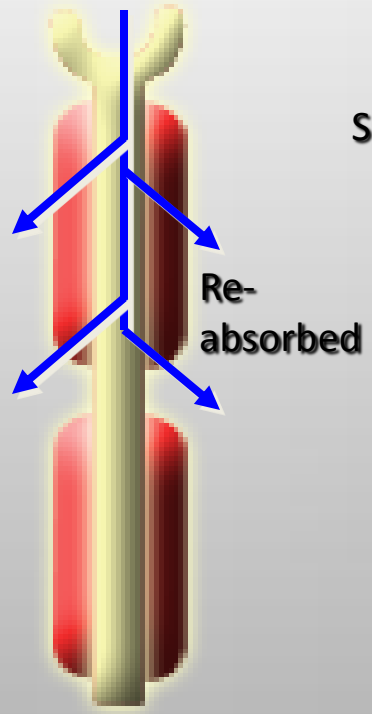
Ux is the concentration of molecule X in the urine.

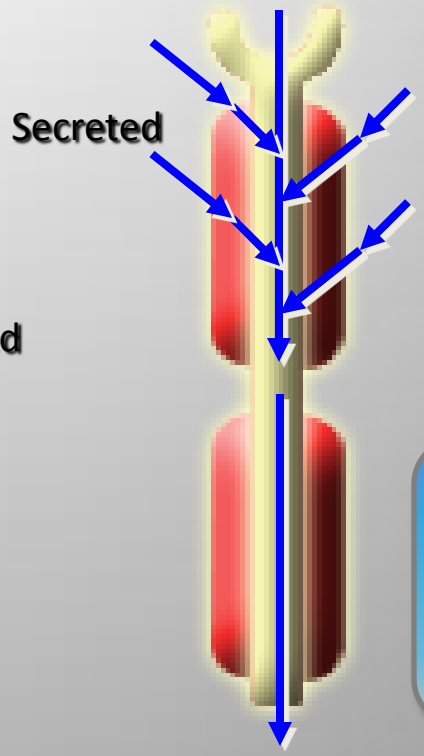
V is the volume of urine.

Calculation of renal transport (Tx)

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





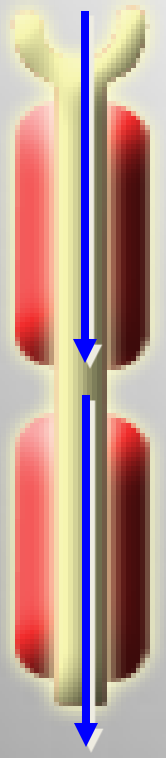


Each one has been explained in the next slides

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



Filtered
= GFR x P_x

$T_x = 0$

$GFR \times P_x = U_x V$

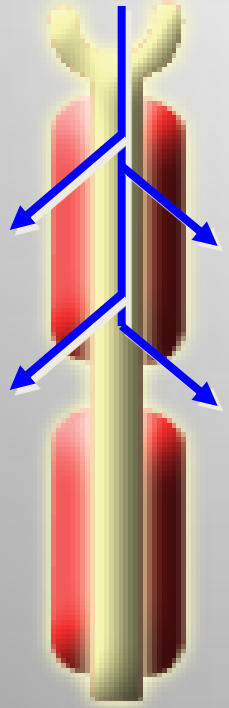
e.g. Inulin

Tx = the amount that is transported of molecule x.

What do we mean by Renal Tubular transport?
Renal Transport is the movement of material in both direction ,both Reabsorption (to blood from tubules) or secretion (from blood to tubules)

Why Tx =0 ?
Because there is no transport of molecule x (No Reabsorption , No secretion)

Inulin is freely filtered . Not Reabsorbed Not secreted.

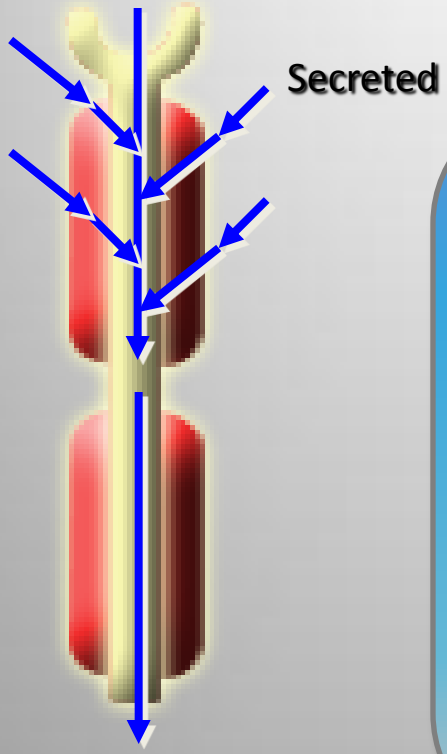


T_x = positive
GFR x P_x > U_xV
e.g. glucose

Remember :
Quantity Filtrated = P_x x GFR
Quantity Excreted = U_x x V

If the amount **Filtered** is more than the excreted the Transport is **Positive.**
It is less excreted because the molecule is **reabsorbed.**

Ex : Glucose , Glucose is Filtered , completely reabsorbed , Not Excreted (amount filtered is more than excreted {0}) so positive transport.



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

Remember :
Quantity Filtrated = P_x x GFR
Quantity Excreted = U_x x V

If the amount **Excreted** is more than the filtered the Transport is **Negative.**
There is more excretion because the molecule is **secreted.**

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?

- **Reabsorption or secretion =**

Quantity Filtrated – Quantity excreted

= (Px x GFR) - (Ux x V)

= (140 x 125) – (70 x 1) = 17430

Types of transport

- **Transcellular:**

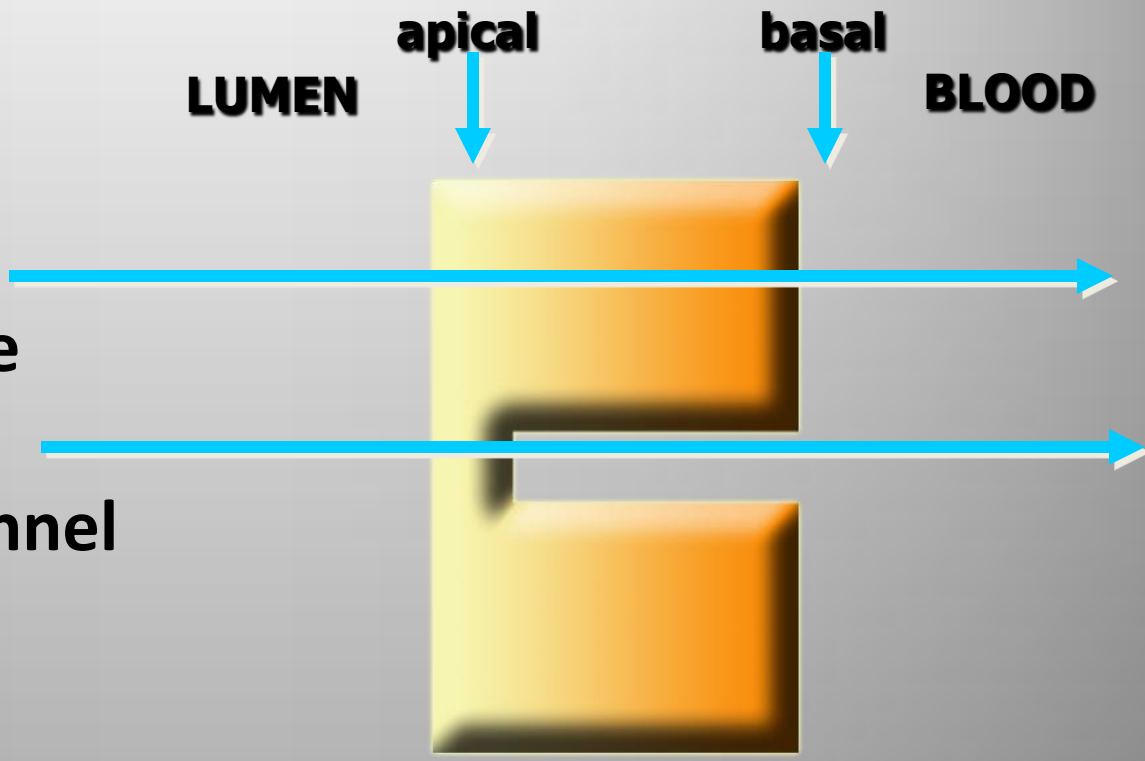
Across renal cell

  - **Primary active transport**
  - **Secondary active transport**
  - **Passive: ion channel**

- **Paracellular:**

Through tight junction

  - **Passive diffusion**



Which type is more difficult and why?

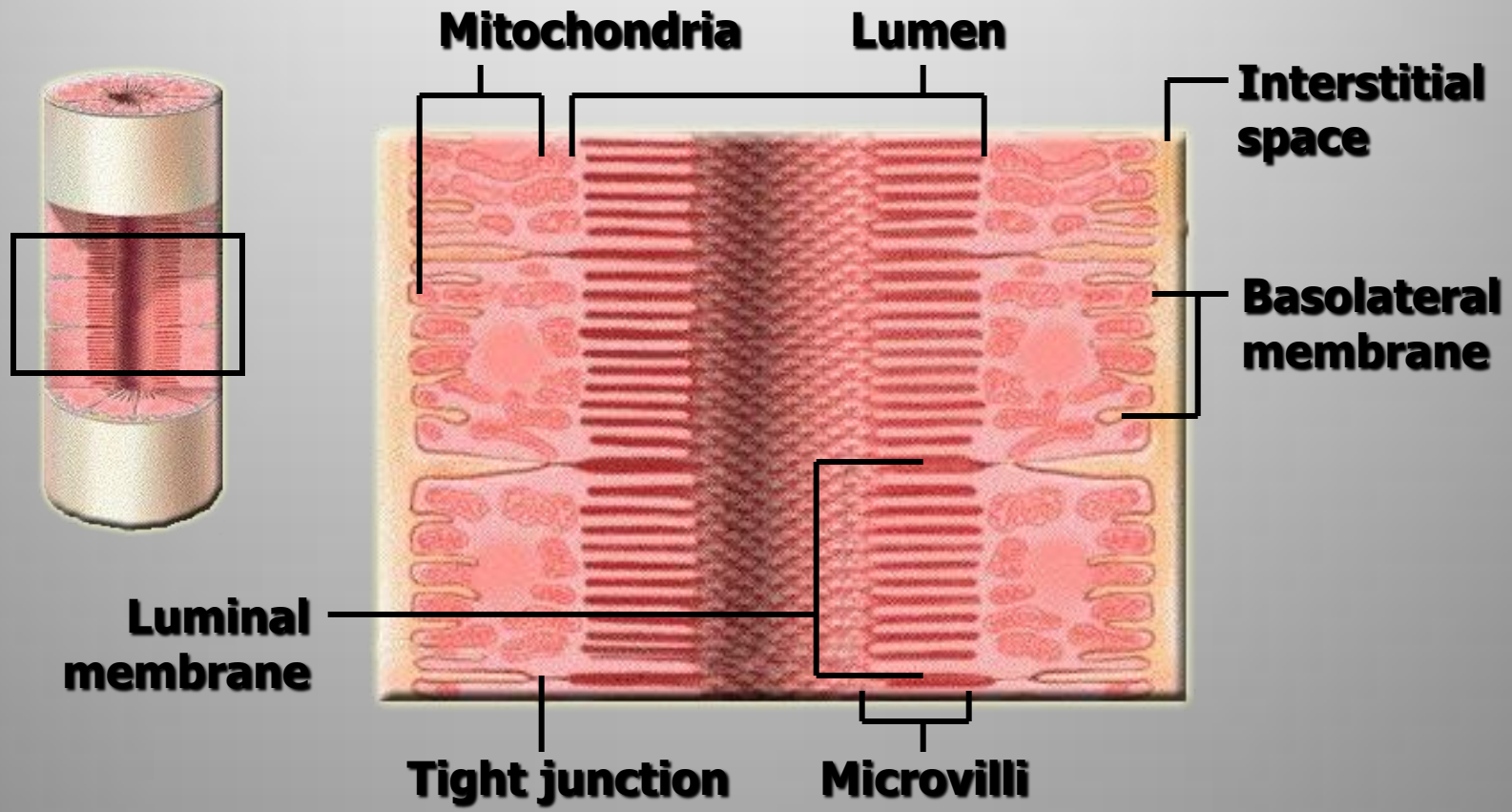
Transcellular , because the molecule should cross 2 membranes (Apical+ basal).

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**

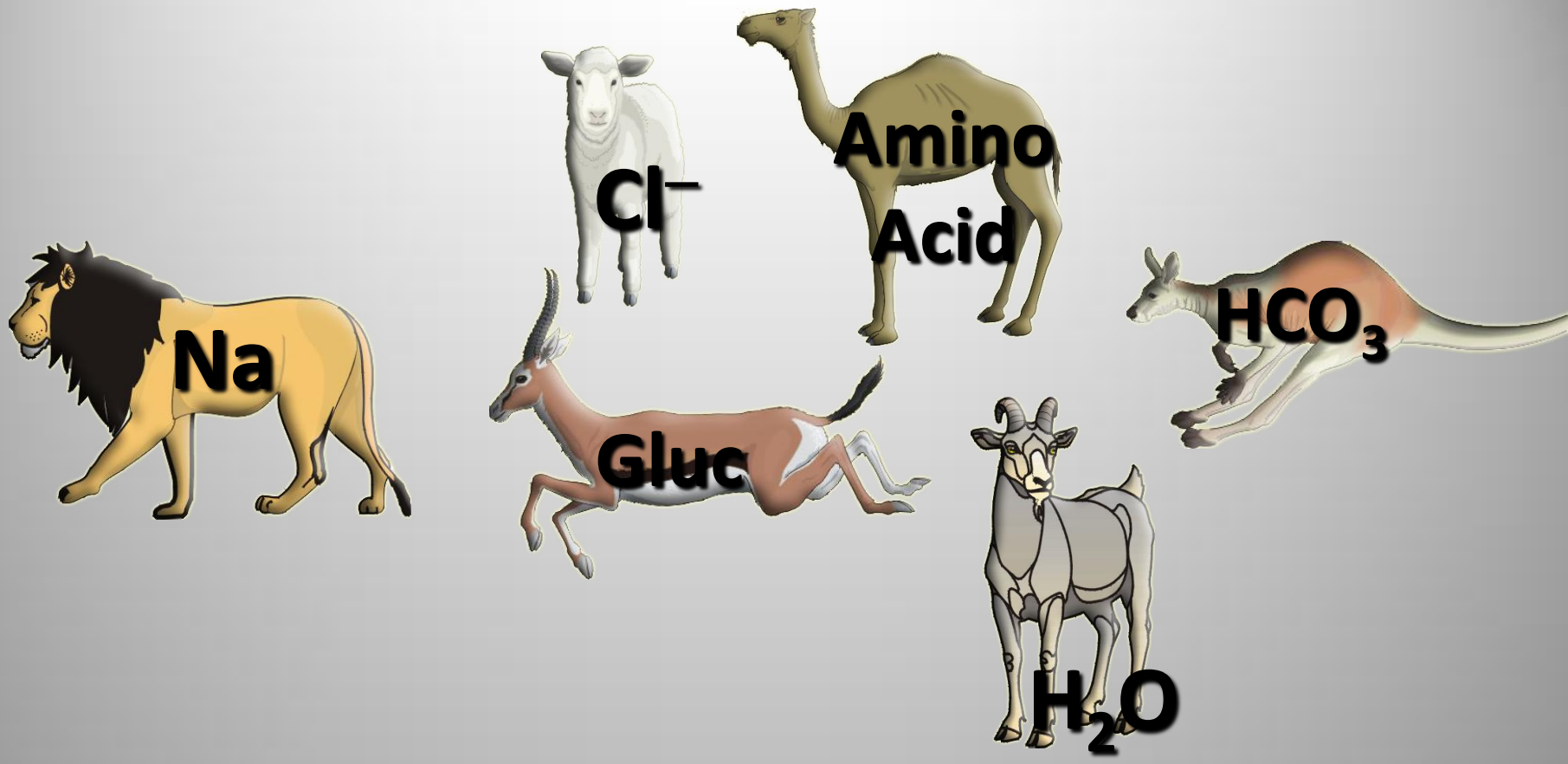
Cells of the Proximal Convoluted Tubule (PCT)

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**



Who is the leader of reabsorption ?

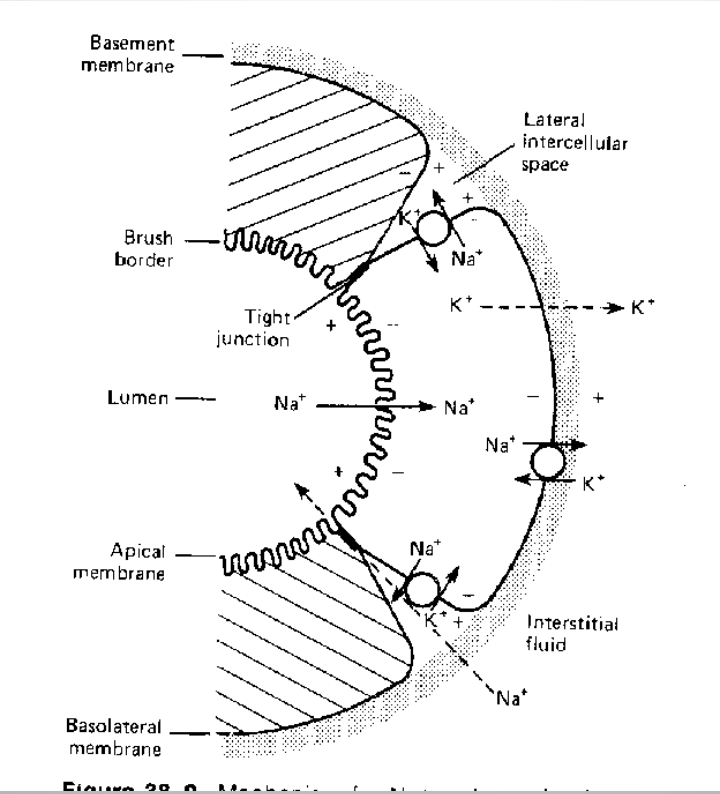
Sodium Na is the leading substance , If Na is reabsorbed , the rest of substances will follow , even water.

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**

Na reabsorption is important for Glucose reabsorption . If Na is not reabsorbed , Glucose will not be reabsorbed.

Passage of sodium absorption

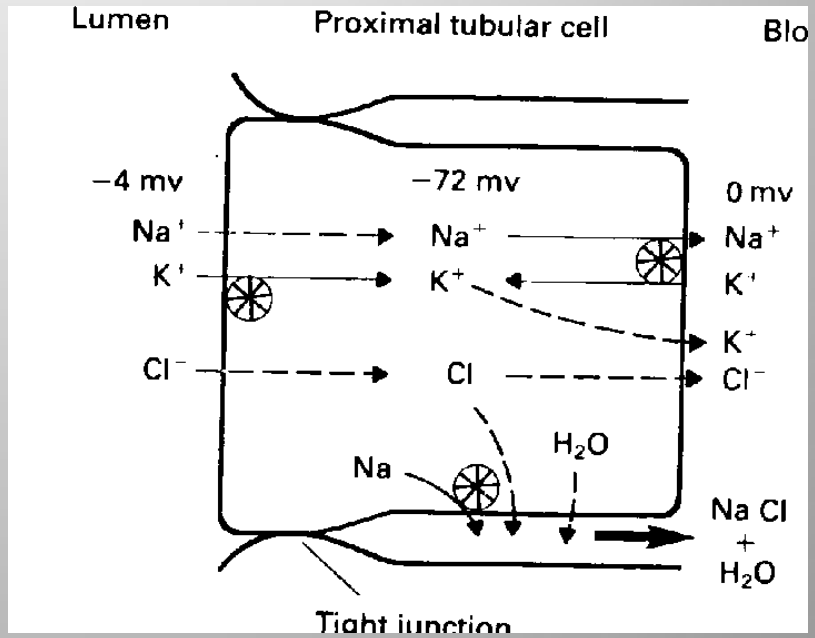


Na first passes from the lumen to the Renal Cell → then from the renal cell to the peritubular capillary.

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**



Na/K Atpase will pump 3 Na out and 2 K in , this will lead to low intracellar Na concentration in the renal cell , this low concentration will help Na to pass passively from the lumen(where Na concentration is high) to the renal cell (where Na concentration is low because of the pump) .

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**

Do not Get confused :

Tubulo-glomerular Feedback	Glomerulo-tubular Feedback
•decrease GFR → slow flow → increase Nacl reabsoption→ decrease Nacl at macula densa .. This will lead to : 1.Renin production →angiotensin II →efferent vasoconstriction → increase GFR + Afferent dilation → increase GFR (mechanism unknown)	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**

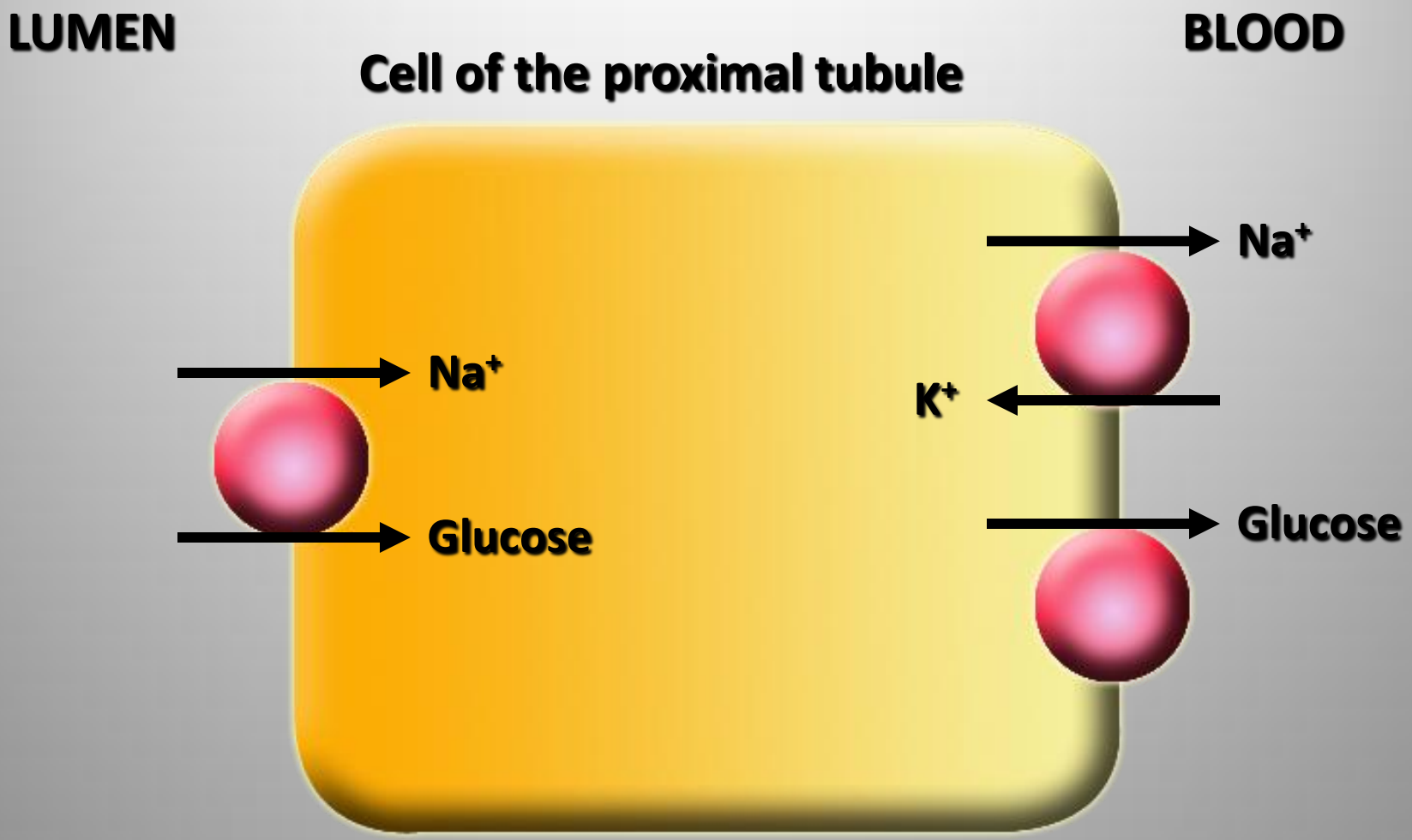
Glucose reabsorption

- **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**

GLUT membrane proteins that facilitate the transport of glucose.



Cellular Mechanism for Glucose Reabsorption

Amino acid reabsorption

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

SUMMARY

- 65-70% of filtered sodium is reabsorbed in PCT ,Iso-osomotic absorption (equal quantity of solute & water)

- Sodium Na is the leading substance
- Types of transport: 1) Transcellular: Across renal cell
  2)Paracellular: Through tight junction

- Renal transport :T_x = GFR x P_x - U_xV = the amount that is transported of molecule

- (Tm_G)= The amount of reabsorped glucose at very high filtered glucose= 375 mg/min (female 300mg/min)

- Reabsorption or secretion =

Quantity Filtrated – Quantity excreted = (Px x GFR) - (Ux x V)

- All filtered AAs are reabsorbed in PCT

- vegetarian pass alkaline urine
- sodium, potassium depends on your diet intake
- does the loop of henle contain glucose, portion, or amino acid normally? no
- simpe diffusion: without carrier
- •facilitated diffusion: with carrier
- •primary active transport: use energy directly by atp
- •secondary active transport:energy is indirectly by co and counter transport
- glucose and amino acid transported from cell to interstitium by facilitated diffusion