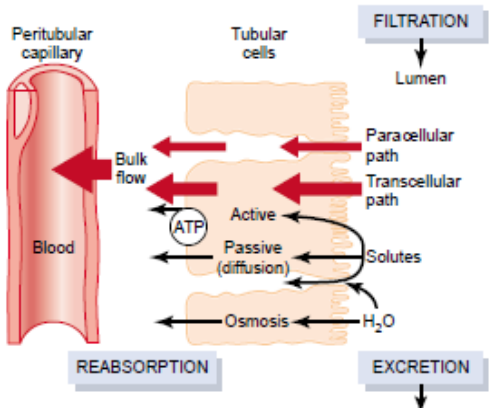
Tubular transport (reabsorption and secretion)

Reabsorption:

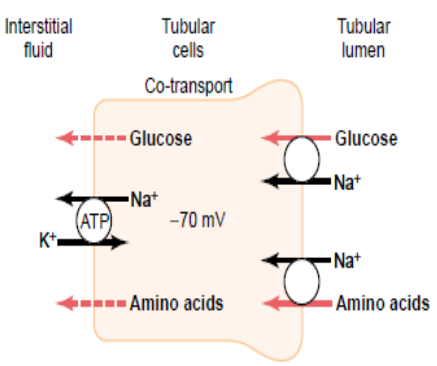
- is the process by which solutes and water are removed from the tubular fluid that was filtered in Bowman's space and transported into the blood , reabsorption rate is the amount reabsorbed per min (mg/min)
- Tubular reabsorption is highly selective ex: glucose and amino acids, are completely reabsorbed →urinary excretion rate is zero. Some waste products as creatinine are not reabsorbed and excreted in large amounts, other ions like Na ,Cl , HCO3 are reabsorped according to the body demands.
- There are two pathways for reabsorption :
  1. Para cellular pathway (passive diffusion through the tight junction)
  2. Transcellular pathway (movement of subs across the luminal epithelial membrane into the cell→ across the basolateral memb. of the cell→ ISF
- Then transport from ISF through peritubular capillary mem. back into the blood by ultrafilteration (bulk flow): mediated by hydrostatic and colloid pressure
- Reabsorption across the tubular epithelium into the interstitial fluid includes passive or active transport.

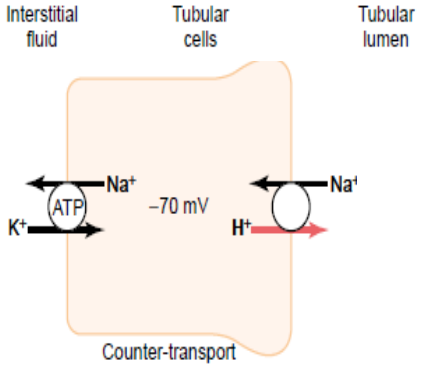


Solute transport :

- Passive transport: a movement of ions or molecules down their electro chemical gradient and does not required energy ex: urea , Cl and H2O.
- Active transport can move a solute against an electrochemical gradient and required energy
  - Primary active transport is the Transport that is coupled directly to an energy source (ATP).Ex: Na+ /k+ ATP ase pump, H+ ATP ase &H-K ATP ase pump
  - Secondary active transport is the transport that is coupled indirectly to energy source, that is due to an ion gradient, ex:

- Cotransport or symport reabsorption ex: Glucose or AA with sodium .
- Counter transport or antiport ex: secretion of hydrogen in exchange with sodium ion.





Filtered load of a sub (FL) : amount of a substance filtrated by all glomeruli /min
= concentration of a sub in the filtrate X volume of filtrate/min (GFR)
FL Glucose =100mg/100ml X 125ml/min=125mg/min

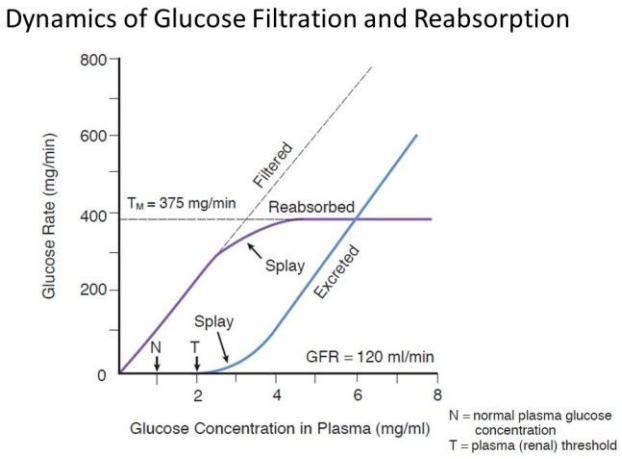
Transport maximum (Tm): is the maximum amount of the sub that can be reabsorbed when all transporters are **saturated** / min.

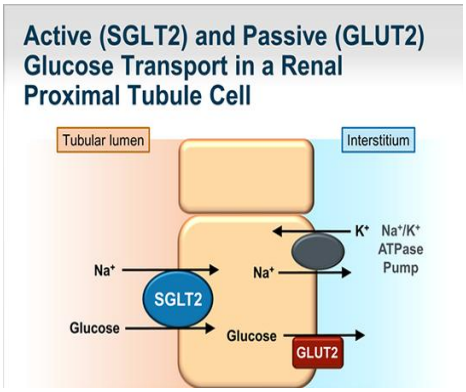
- Occur for most actively **absorbed or secreted** substances.
- There is a limit for solute transportation rate caused by saturation of the solute transporters. It occurs when the amount of solute delivered to the tubule (*filtered load*) exceeds the capacity of the carrier proteins
- Tm can only be increased by ↑ number of transporters. Ex: glucose .

Glucose transport mechanism :

- Normally all filtered glucose is reabsorbed and no glucose appears in urine
- Glucose and Na^+ bind to the **Na-dependent glucose transporter (SGLT2)** in the apical membrane (secondary active transport), and glucose is carried into the cell as Na^+ moves down its concentration gradient.
- Tm Glucose =375mg/min.
- At low plasma levels, the filtration and reabsorption rates of glucose are equal, thus glucose does not appear in the urine (clearance is zero) .
- If FL more than Tm for glucose⟶ it appears in urine

- It should be noticed that Glucose appears in urine before the Tm is reached (TLG= 200/100 X 125=250 mg/min) forming a deviation from ideal curve called **splay** (because not all nephrons have the same Tm and some nephrons reach Tm before others → Tm of the entire kidney is not reached until after the splay region.
- Renal threshold of glucose is the plasma level at which the glucose first appears in the urine. For glucose is 180-200mg/dl.





<u>Regulation of tubular absorption :</u> it is essential to maintain a balance between tubular reabsorption and glomerular filtration

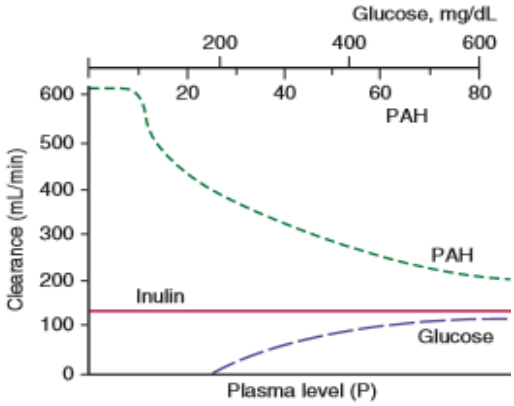
1. **<u>Glomerulotubular Balance</u>**: is the intrinsic ability of the tubules to ↑ their reabsorption rate in response to increased tubular load →percentage of GFR reabsorbed in the proximal tubule remains relatively constant at about 65 %
2. **Sympathetic activation** : ↑Na reabsrption and stimulate JGA to secret rennin
3. **Hormones:**

Hormone	Site of action	Effect
Aldosterone	Collecting duct	↑Na reabsorption, ↑K, H+ secretion
Angiotensin II	Proximal tubule, thick ascending loop of Henle/distal tubule.	↑Na, H2O reabsorption, ↑ H+ secretion
Antidiuretic hormone	Distal tubule/collecting tubule and duct	↑ H2O reabsorption
Atrial natriuretic peptide	Distal tubule/collecting tubule and duct	↓ Na reabsorption
Parathyroid hormone	Proximal tubule, thick ascending loop of Henle/distal tubule	↓PO4 reabsorption, ↑ Ca^{++} reabsorption

Secretion :

Tubular secretion is the transport of materials from peritubular capillaries to the renal tubular lumen. Secretion rate is the amount (mg) that is secreted into the filtrate / min (mg/min)

P-aminohippuric acid (PAH) secretion :



- It is an example of transport maximum system Tm=80mg/min
- PAH is freely filtered and not reabsorbed →all of filtered in the 125 ml/min GFR is excreted
- Another 475 ml/min is delivered to the peritubular capillaries where PAH will be secreted into tubule (clearance = ERPF)
- If the plasma concentration is 0.17mg/ml →the PAH load to the peritubular capillaries is 0.17 x 475 ml/min = 80 mg/min = TM
- If PAH load <Tm →all the 475 ml will be cleared and no PAH in the venous blood
- If PAH load >Tm →not all the 475 ml will be cleared and some of PAH will appear in venous blood
- If the concentration is 80mg/ml → only 1ml of the 475 ml RPF will be cleared (80/80=1ml/min) →↓clearance to be close to GFR

Excretion rate :

urinary excretion is the result of of three renal processes :

Urinary excretion = (Filtration - Reabsorption) + Secretion

So excreted substances could be :

A. Filtered , neither reabsorbed nor secreted. →excretion rate = filtered rate . ex: inuline
B. Filtered ,partly reabsorbed from the tubules back into the blood. →urinary excretion < filteration rate ex: urea ,.many electrolytes : Na, K ,Ca
C. Filtered and all the filtered substance is reabsorbed ex: glucose→ filtered rate = reabsorption rate → excretion is zero
D. Filtered, not reabsorbed, secreted into the renal tubules → The excretion rate =filtration rate+ tubular secretion rate. (PAH)