Organ Components:
- Kidneys, Ureters, Bladder, & Urethra

Function: *Homeostasis of Body Fluid*

Kidney Function: "Blood filter / modifier"
1. Regulates blood concentrations of
   - **Electrolytes** (Na⁺, Cl⁻, Ca²⁺, K⁺)
2. Regulates **Blood Volume & Pressure**
3. Regulates **blood pH**
4. Eliminates **Organic Waste**: Urea & uric acids
   - (protein), urobiligen
5. Secretes **Hormones**: Erythropoietin & renin
Produce blood filtrate: **Urine**
- Excess water
- Excess Electrolytes & Minerals
- Excess Organic waste & Nutrients

- Maintain: *Solute Concentration & Volume*

**NOTE:** Liver functions to maintain *Nutrient Concentration*: Glucose, Fatty Acids etc.

**Filtration**

- **Mechanism:**
  - a. Blood Filtration
  - b. Filtrate re-absorption

**GOAL:** Separate *valuable blood constituents* from *excess and waste*

- **Result:** **URINE FORMATION**

  - Urine: *Excess & waste*
  - Valuable constituents: Re-absorbed BACK into blood
• **Kidney Filtering Rate:**
  - Kidney Blood Perfusion Rate: 20–25% Cardiac Output
  - 1.2 liters Blood through kidneys per min
  - Filtrate formation: 180 liters/day

• **Kidney Urine Production Rate:**
  - Urine Produced: ~1 – 2 liters/day
  - Blood Volume filtered every 40 mins
Functional Kidney Unit: NEPHRON

- Human Kidney contains >1 million nephrons
  - Each manages a small volume of blood

Mechanism of Action: Three Step Process:

1. Filtration: Bulk separation by SIZE
   - Separate all LARGE blood components from small soluble
     - Blood Cells, Large (functional) Proteins
2. **Re-absorption:**
- Return to blood **all valuable small filtered components**
  - Glucose, fatty acids, minerals, electrolytes, etc

3. **Secretion:**
- Micromanage blood by adding back into filtrate unneeded components
  - Components added back will be excreted with urine
  - Primarily Potassium
**Blood Filtration: Separation by SIZE**

- Site: Renal corpuscle

**3 Layer Filter:**
- Glomerulus, Basement membrane, Podocytes

**Figure 1**

**Figure 2**

- Filtration processes of podocytes (blue and green)
a. **Glomerulus**: “Tuft of Fenestrated Capillaries”
   - **Fenestrae**: Pores within vessel wall

   ![Diagram of glomerulus]

   - Increases permeability by 100–400x
   - Increases VOLUME of filtrate

   ![Diagram of filtration]

   - **Hydrostatic pressure** forces separation
     - **LARGE valuable components** are NOT filtered
     - **Blood cells & LARGE & medium plasma proteins** remain in Blood
     - **Small components** filtered through fenestrae

   ![Diagram of filtration process]
b. **Basement Membrane** (Basal Lamina)
   - **Thick Glycoprotein** (Lamina Densa)
   - Prevent filtration of *medium & most small size proteins*

![Diagram of filtration membrane](image)

(c) **Podocytes with Interlacing pedicles:**
   - *Filtration slits* further retain *most small proteins*
Filtered Components referred to as FILTRATE

- Contains BOTH: valuable soluble constituents & waste
- “Caught” by Glomerular Capsule
- 180 /filtrate /day

Filtrate re-absorption:

- Reclaim valuable filtered components
- Site: Renal Tubule
- Return to blood through surrounding capillaries

Renal Tubule: Specifically reabsorb Filtrate components

a. Proximal Convoluted Tubule
   - ~99%: Nutrients Reabsorbed
   - ~65%: Salt & Water Reabsorbed

b. Loop of Henle
   - ~20%: Additional Salt & Water Reabsorbed
     ⇒ Total of ~85% Salt & Water
Filtrate Secretion:

a. **Distal Convoluted Tubule**
   - Secretion of excess ions ($K^+$) & minerals & toxins
   - Further **re-absorb** $Na^+$

• Nephron completion:
  - Filtrate remaining exits Distal convoluted Tubule
  - Referred to as **URINE**
  - NO further significant adjustments to urine composition are made EXCEPT water content
  - **Urine Collected by the Collecting Ducts**

• Collecting Ducts will **alter urine water composition**
  - **Urine Concentration**

PCT Epithelial Reabsorption

- Components Re-absorbed:
  - 65% Water & Salt
  - 99% Organic Nutrients

- Utilizes facilitated, primary & secondary active transport
- Accounts for ~6–10% of Basal metabolic Rate

1. Basolateral Cell surface:
   - Primary Active: \( \text{Na}^+ / \text{K}^+ \) Pump
   - Pumps \( 3\text{Na}^+ \) OUT & \( 2\text{K}^+ \) into cell

   ![Diagram of basolateral cell surface](image)

   - Goal: Decrease intracellular \( \text{Na}^+ \)
   - Goal: Create gradient for \( \text{Na}^+ \) diffusion INTO cell
2. Apical–Luminal cell surface:
   - Co-transport of Na⁺ & Cl⁻
     - Uses concentration gradient created by Na⁺/K⁺ pump
   - Na⁺ diffusion INTO cell
     - Creates positive Electrical Gradient
     - Draws in anion Cl⁻

3. Basolateral Cell surface:
   - Facilitated diffusion of Cl⁻
     - Uses concentration gradient to diffuse Cl⁻ out of cell

4. Apical–Luminal cell surface
   - Na⁺ & Cl⁻ inside cell increases cellular osmotic pressure
     - Stimulates Water absorption
Results: a. Reabsorbed $\text{Na}^+$, $\text{Cl}^-$, Water
b. Reduced filtrate volume by $1/3$

- **Glucose Reabsorption : PCT**

1. **Apical – Luminal Cell surface:**
   - **Co-transport** of $\text{Na}^+$ & GLUCOSE
     - Uses *concentration gradient* created by $\text{Na}^+/\text{K}^+$ pump
   
2. **Basolateral Cell surface:**
   - **Facilitated diffusion** of Glucose
     - Uses *concentration gradient* to diffuse glucose out of cell
       - GLUT2 Channels

- **Effectiveness:** 100% Glucose REABSORPTION
Clinical Application:

- **Normal Blood glucose concentration:**
  75–110mg/dL blood
  → Glucose Channels reabsorb ALL glucose

Glucose Reuptake

- **Diabetes Mellitus:** Elevated blood glucose
  > 180mg / dL blood
  → Glucose Channels can NOT reabsorb ALL glucose
  ✓ Glucose excreted in URINE: GLYCOSURIA
Following PCT Reabsorption:

- ~99% Nutrients Reabsorbed
- ~65% Salt & Water Reabsorbed

- Filtrate volume reduced by 2/3

Reabsorption in the Nephron