

## Chapter 4 - Urinary System

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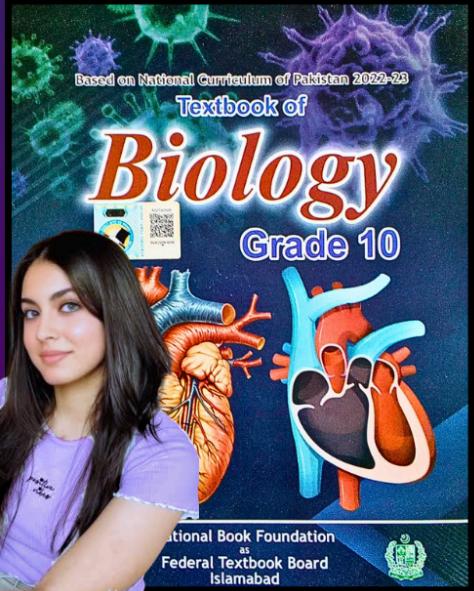
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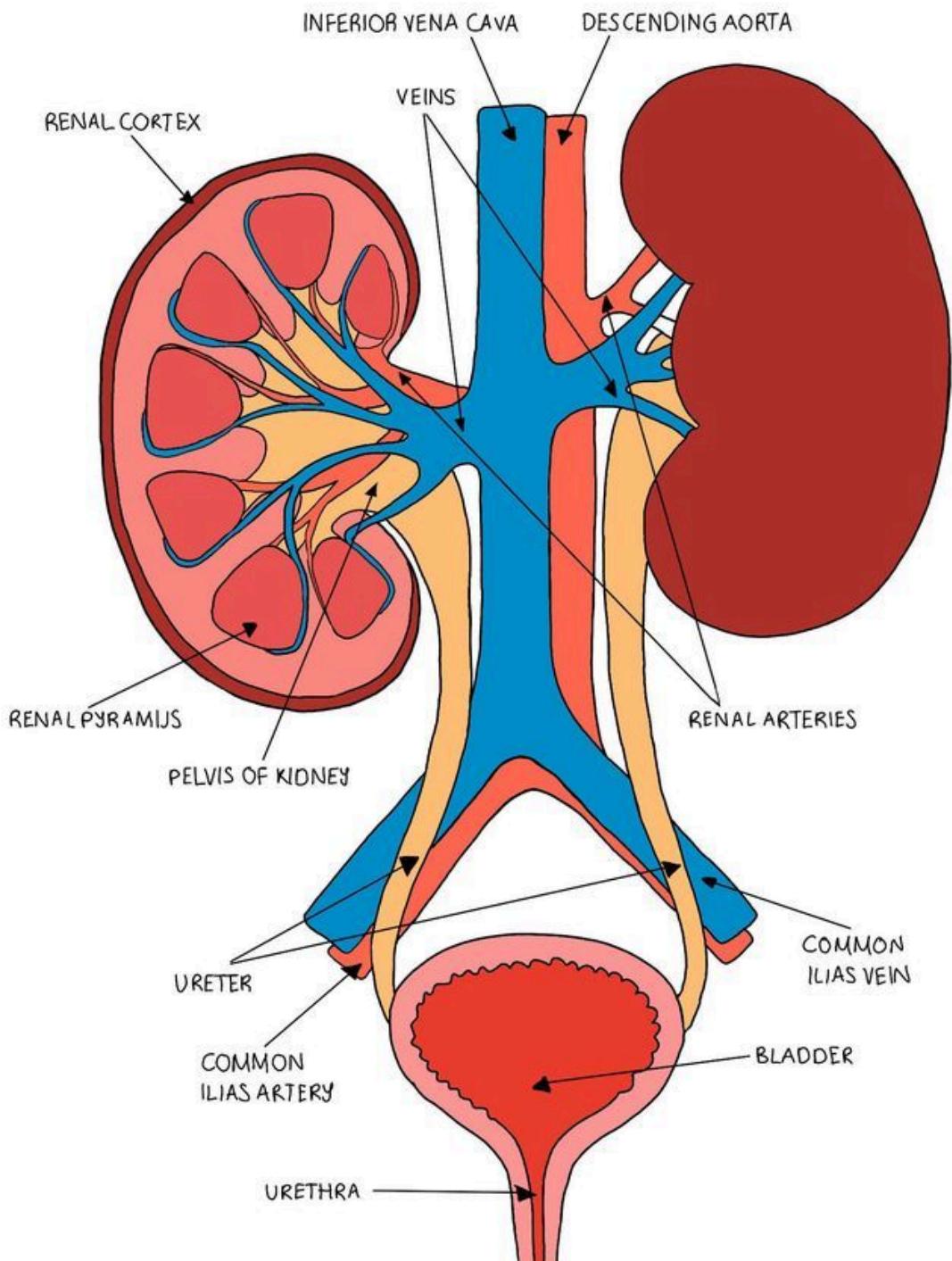
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### 4.1. Human Urinary System (Excretory System)

- **Purpose:** Removes harmful metabolic waste products (like urea and uric acid), toxic substances (e.g. pesticides, drugs), excess salts and water.
- **Related Field:** Nephrology – study of kidney structure, function, and diseases.
- **Excretion:** Removal of metabolic waste from the body.



## Components of the Human Urinary System

1. **Kidneys** (pair):

- Reddish-brown, bean-shaped organs
- Enclosed in a tough membrane called a **capsule**
- The right kidney is slightly lower than the left.

**2. Ureters (pair):**

- Muscular tubes that carry urine from the kidneys to the bladder.

**3. Urinary Bladder:**

- Elastic muscular sac.
- Stores urine.

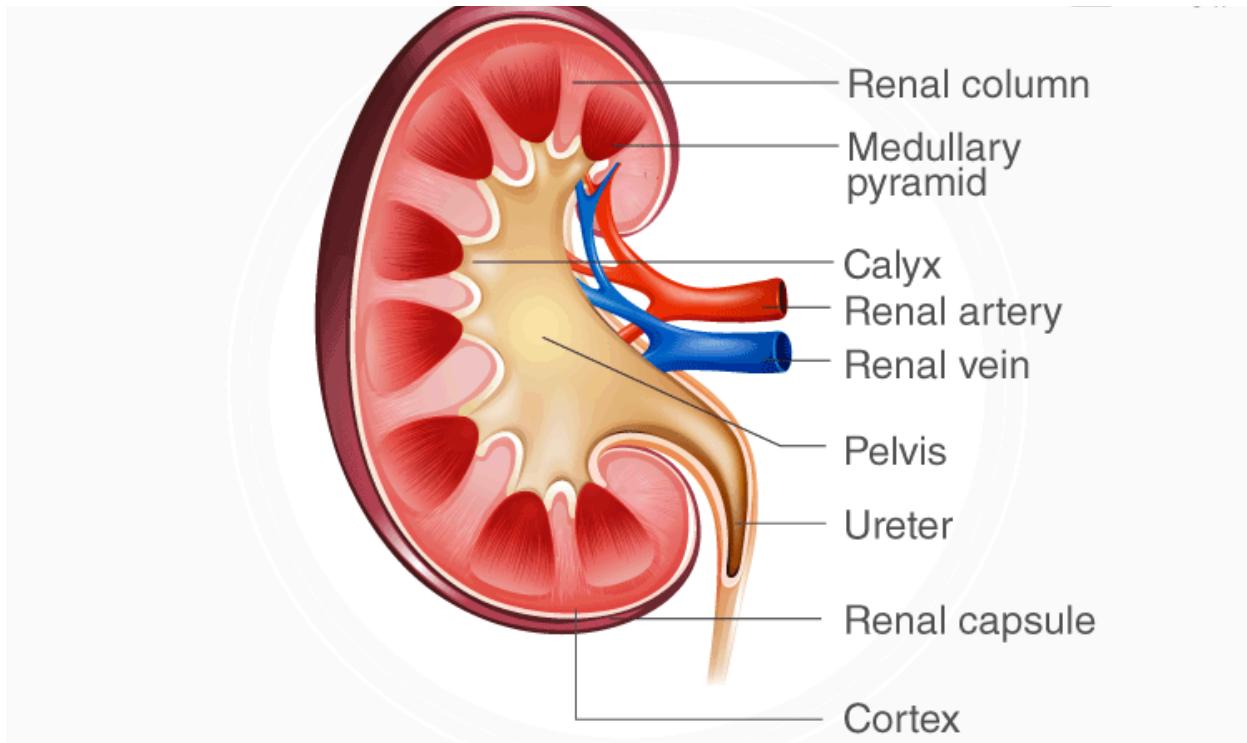
**4. Urethra:**

- The tube through which urine exits the body.

## 4.2. Structure and Function of the Kidney

- **Location:** At the back of the abdominal cavity, on either side of the vertebral column.
- **Structure:**
  - The **concave side** of the kidney faces the vertebral column.
  - Blood supply:
    - **The renal artery** brings blood from the dorsal aorta.
    - **The renal vein** carries blood to the inferior vena cava.
  - **Hilus:** Depression on the concave surface where the renal artery, vein, and nerves connect.

### Structure of Kidney (Vertical Section)



- **Renal Cortex:**
  - Outer dark region.
  - Contains many blood capillaries.
- **Renal Medulla:**
  - Inner lighter region.
  - Contains cone-shaped **renal pyramids** and **renal columns**.
  - **Renal pelvis:** A funnel-shaped chamber collecting urine from the pyramids into the ureter.

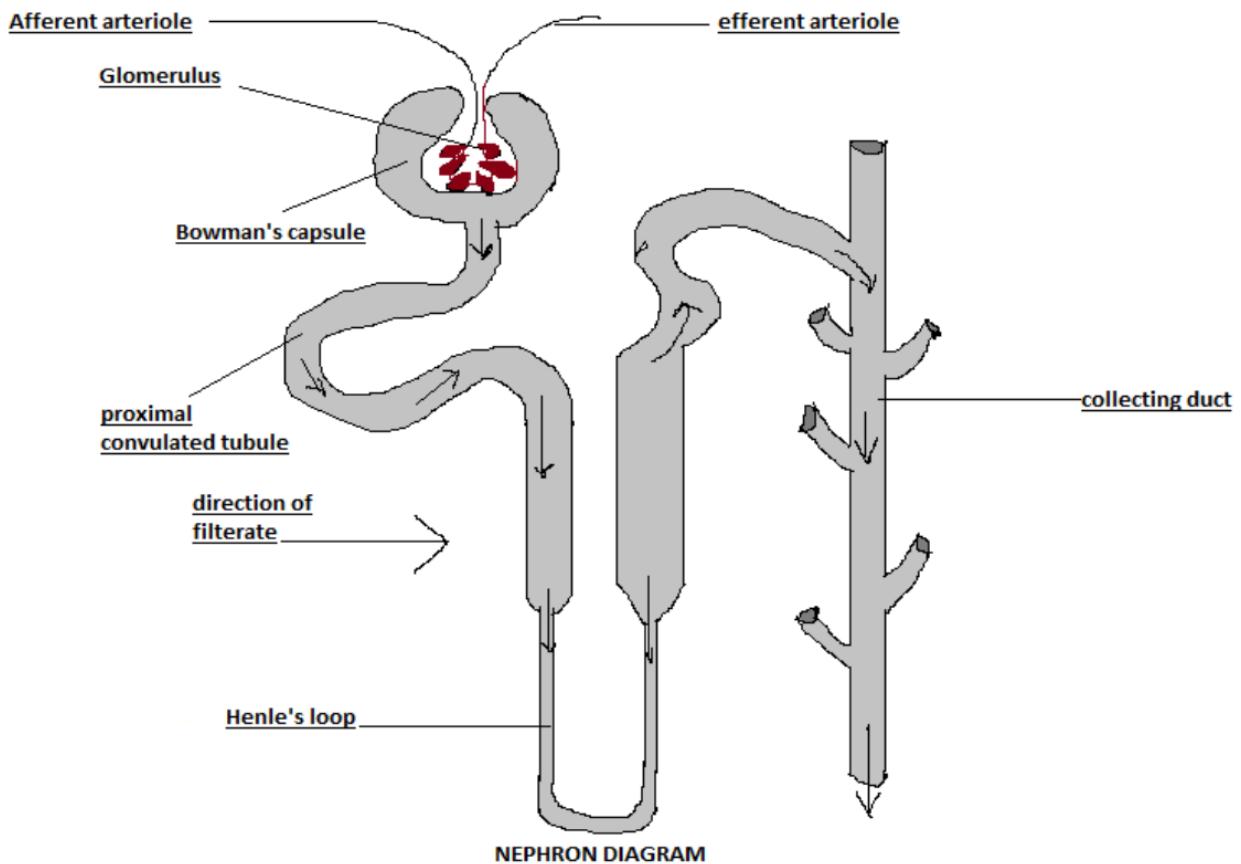
### 4.3. Nephron: Structural and Functional Unit of the Kidney

- **Each kidney contains ~1 million nephrons.**
- **Parts:**
  - **Renal Corpuscle:**
    1. **Bowman's capsule:** Double-walled cup.

2. **Glomerulus:** Tuft of capillaries inside Bowman's capsule.

○ **Renal Tubule:**

1. **Proximal convoluted tubule**
2. **Loop of Henle**
3. **Distal convoluted tubule**
4. **Collecting duct** → Leads into the renal pelvis



#### 4.3.1. Functioning of the Nephron & Urine Formation

##### 1. Glomerular Filtration:

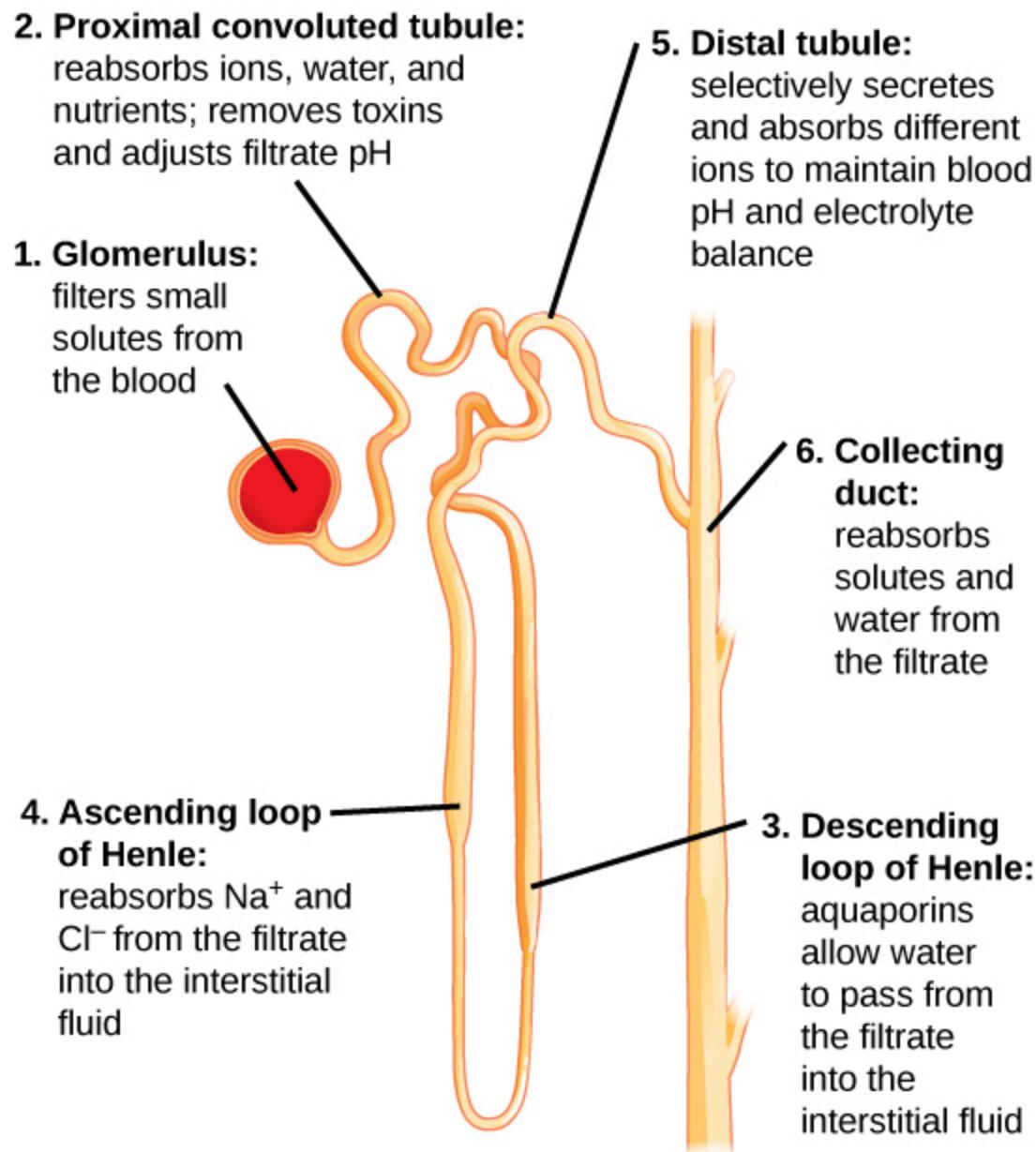
- Small molecules (water, salts, nutrients, waste) are filtered from the glomerulus into Bowman's capsule by blood pressure.
- Proteins and blood cells remain in the blood.

## **2. Selective Reabsorption:**

- 99% of water and useful substances (e.g. glucose, amino acids) are reabsorbed into the bloodstream.
- Occurs via osmosis, diffusion, and active transport.
- Mainly in the **proximal tubule**, the loop of Henle, and the **distal tubule**.

## **3. Tubular Secretion:**

- Active removal of unwanted substances (e.g.  $H^+$ ,  $K^+$  ions, uric acid, drugs) from blood capillaries into the tubule.



#### Urine Pathway (From Blood to Excretion):

Liver → Urea → Blood → Kidney → Nephron → Glomerulus → Bowman's capsule → Proximal tubule → Loop of Henle → Distal tubule → Collecting duct → Ureter → Bladder → Urethra → Urine leaves body

#### 4.5. Osmoregulatory Function of the Kidney

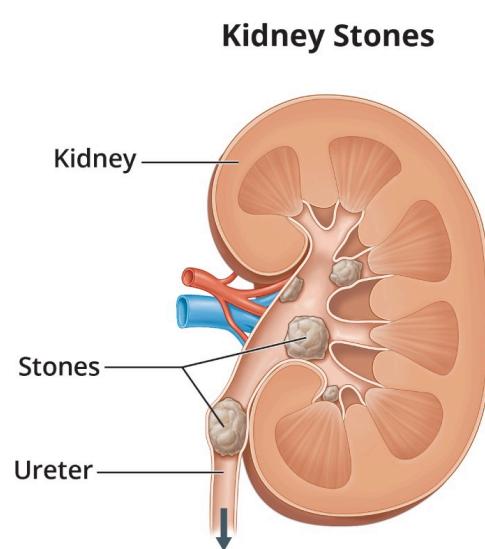
- Regulates water and salt concentration in blood.

- **Dilute blood** → Less water reabsorbed → More urine formed.
- **Concentrated blood** → More water reabsorbed → Less urine.
- The hypothalamus detects blood concentration, stimulates thirst, and releases the **antidiuretic hormone (ADH)**.
- **ADH** increases water reabsorption in the kidneys.

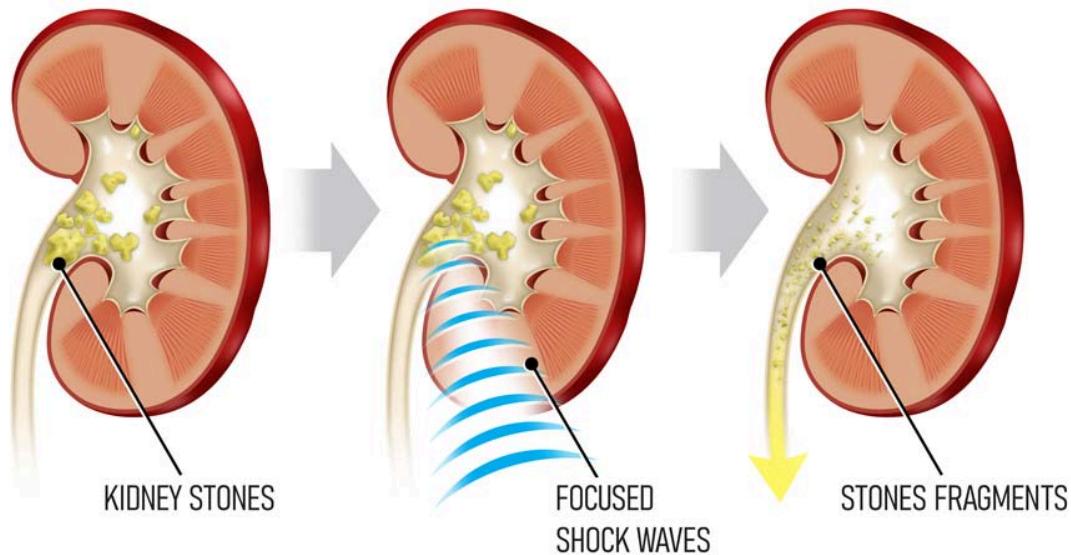
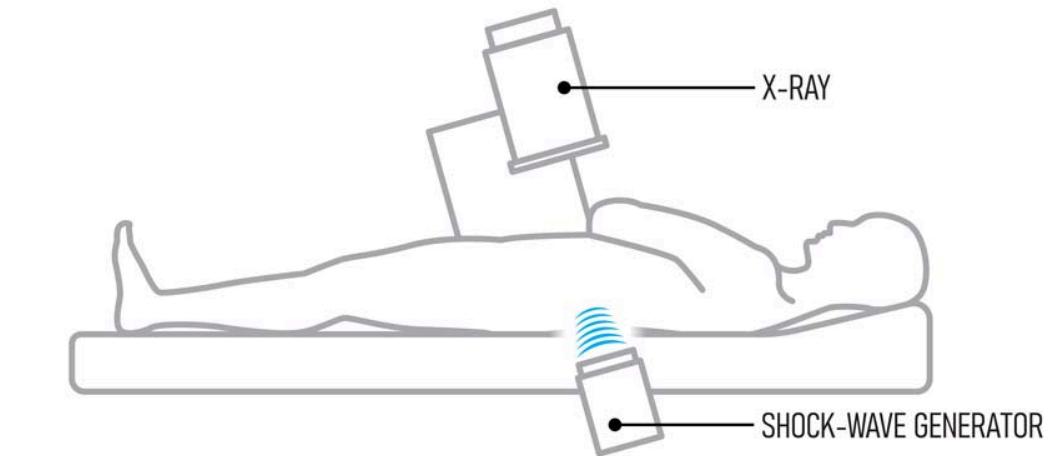
## 4.6. Disorders of the Human Urinary System

### Kidney Stones & Treatment

- Formed by uric acid, calcium oxalate crystals.
- Causes:
  - High calcium levels.
  - Low water intake.
  - Infections.
  - Genetics.
- **Treatment:**
  - **Lithotripsy:** Breaks stones using shock waves.
  - Surgery (if needed).



## ESWL - EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY



### Kidney Failure

- **If one kidney fails**, a person can survive.
- **Both fail** → Fatal if untreated.
- **Acute failure**: Sudden, reversible.
- **Chronic failure**: Permanent loss of function.

### Causes of Kidney Failure

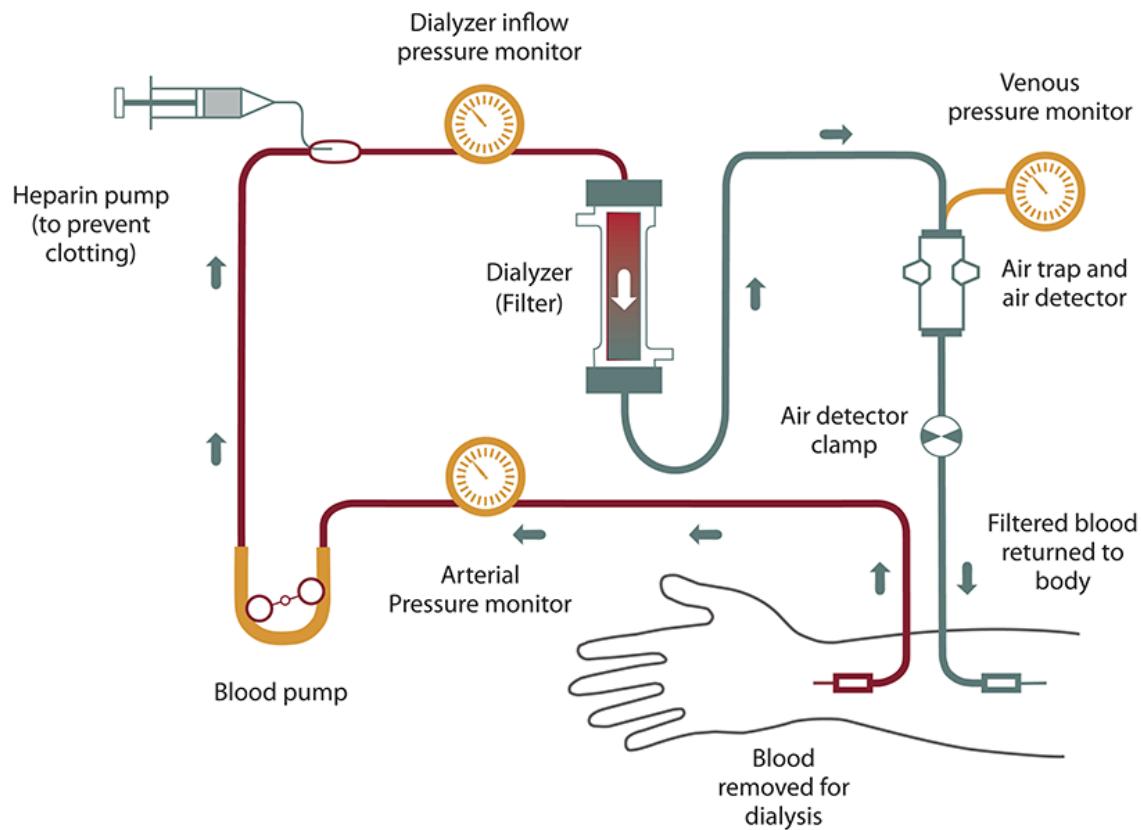
1. **Diabetes** damages nephrons.
2. **High blood pressure** damages the kidney blood vessels.
3. **Autoimmune diseases** – e.g. lupus.
4. **Genetic diseases** – e.g. polycystic kidney disease.
5. **Urinary tract problems** – blockage.
6. **Medications** – e.g. lithium.
7. **Dehydration**
8. **Kidney trauma** – physical injury.
9. **Processed Foods** – can increase the risk of kidney damage

## Dialysis

- **Purpose:** Dialysis removes nitrogenous wastes and excess water from the blood when the kidneys fail.
- **Types of Dialysis:**
  1. **Haemodialysis**
  2. **Peritoneal Dialysis**

### a. Haemodialysis

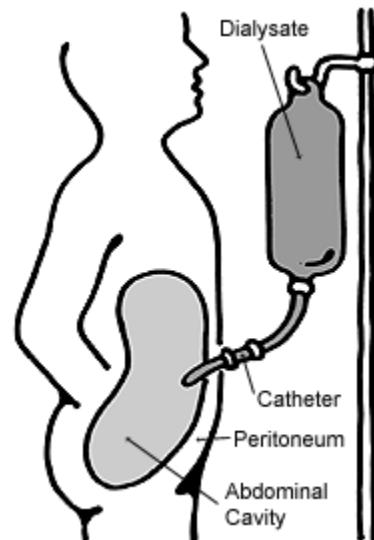
- **Process:**
  - A **catheter** is inserted into a vein (usually in the arm).
  - Blood is passed through a machine called a **dialyser**.
  - Inside the dialyser, blood flows along a **semi-permeable membrane** (dialysis membrane).
  - The membrane allows **urea and other wastes** to diffuse out into the **dialysis fluid**.
  - Dialysis fluid already contains **sugars and salts**, so these do not diffuse from the blood.
  - **Clean blood** is returned to the body through another vein.
  - **Fresh dialysis fluid** enters from one end and **waste-filled fluid** leaves from the other.



### b. Peritoneal Dialysis

- **Process:**

- **Dialysis fluid** is pumped into the **peritoneal cavity** (space around the gut).
- The **peritoneum** acts as the dialysis membrane.
- Waste products from the blood diffuse across the peritoneal membrane into the dialysis fluid.
- The fluid is left inside the abdomen for a few hours and then drained.
- Can be done **at home**, but must be done **regularly (3–4 times a day)**.



### Kidney Transplant

- **Definition:** Transplanting a healthy kidney from a donor into a patient with kidney failure.
- **Source:** Kidney can be from a **living** or **deceased donor**.
- **Compatibility:**
  - The donor's **tissue and blood chemistry** should match the recipient's to reduce the risk of **tissue rejection**.
  - Immunosuppressive drugs are often needed to prevent rejection.
- **Benefit:** Offers a long-term solution compared to regular dialysis.



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