Physiology of Urinary System

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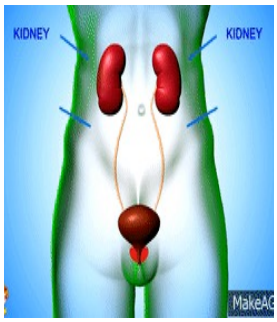

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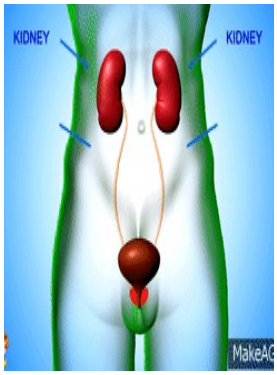
Contents:

- **Introduction to the Urinary system organs:**
  - The Kidneys and their parts
  - The Kidney Functions
  - The Ureters
  - The Urinary Bladder
  - The Urethra
  - Nephron
  - Urine Production



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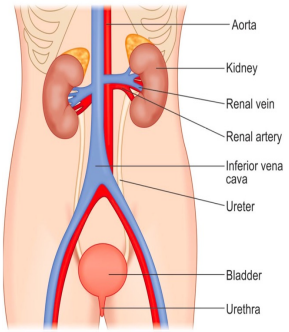
Learning Objectives:

By the end of this lecture, you will be able to:

- Identify the organs of the urinary system.
- Know the basic structures of the kidney.
- List the Functions of Kidney.
- Describe the Ureters.
- Describe the Bladder.
- Describe the Urethra.
- Know the Nephron
- Describe Urine Production



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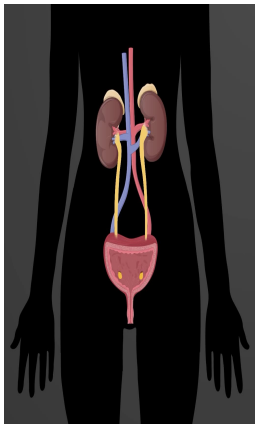
Introduction to the Urinary System:

- **Excretion** is the process by which the **unwanted substances** and **metabolic wastes** are eliminated from the body.
- **Various systems/organs** in the body are involved in performing the **excretory function**, one of these is the **renal system**.
- **Renal system** excretes **water** and **waste products** and **harmful foreign substances** through urine.



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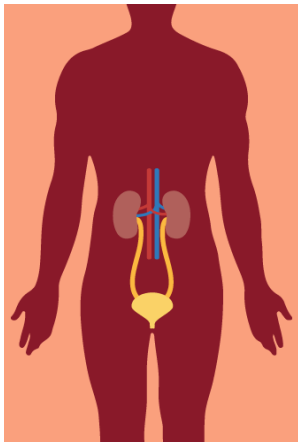
Urinary System Organs:

- The Urinary system consists of six separate organs:
  - Two kidneys
  - Two ureters
  - One bladder
  - One urethra



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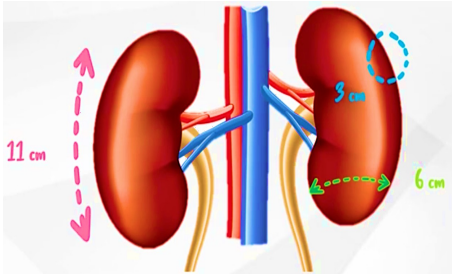
Urinary System Organs:

- The Kidneys:
- Dimensions of a typical adult kidney:
  - Length: 10 –12 cm (4–5 inches)
  - Width: 5 –7 cm (2–3 inches)
  - Thickness: 3 cm (1 inch)



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The Kidneys:

- **Weight and Size:**
- Each kidney of the adult human:
  - weighs **≈150 g**
  - has the size of a **clenched fist**
- Kidney weight is generally greater in men than in women, this difference is **partly related to greater body size in men**.

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The Kidneys:

- **Shape and Location:**
  - The kidneys are large **bean–shaped** organs.
  - They are **bilateral organs** located **retroperitoneally** in the upper left and right abdominal quadrants.

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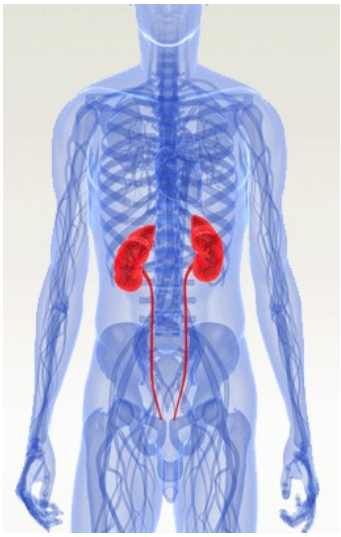
The Kidneys:

- The kidneys are partially protected by the **11th** and **12th pair of ribs**.



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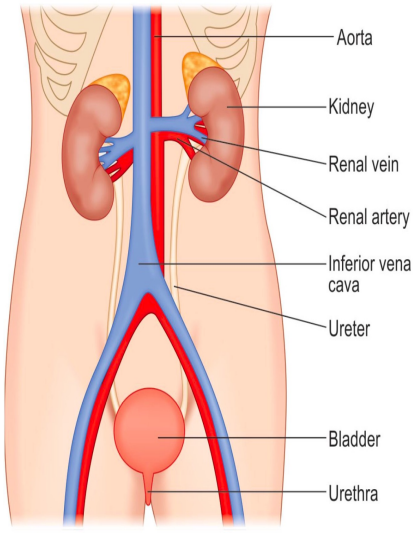
The Kidneys:

- The **left kidney is slightly higher than the right** **WHY?**

- **Because the liver occupies the space above the kidney on the right side.**



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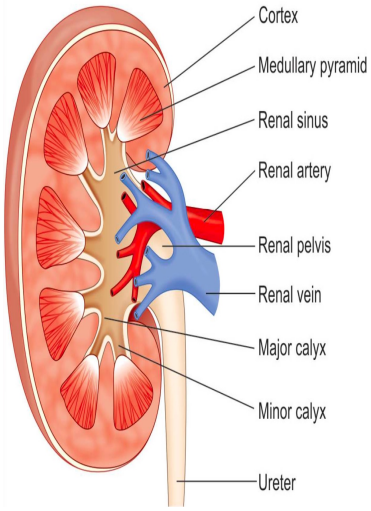
The Kidney Regions:

- **Kidney has 2 distinct regions:**
- **Renal Cortex**
  - Superficial,
  - Smooth-textured reddish
  - Exterior portion
- **Renal Medulla**
  - Deep,
  - Reddish-brown
  - Inner region



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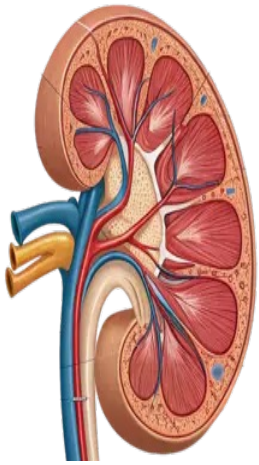
The Kidney Regions:

- **Renal Cortex:**
  - It refers to the smooth-textured area extending from the **exterior** (**renal capsule**) to the **bases** of renal pyramids and into the spaces between them.
  - The portions of the renal cortex that extend between renal pyramids are called **renal columns**.



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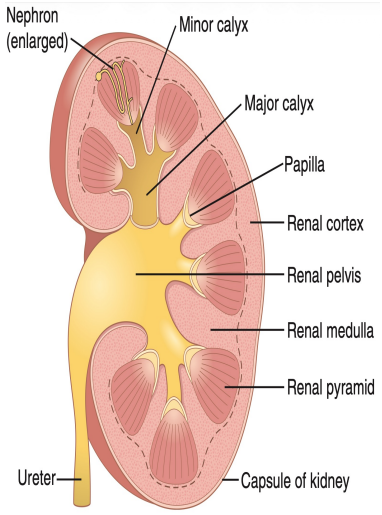
The Kidney Regions:

Renal Medulla:

- It contains **tubular** and **vascular** structures arranged in parallel radial lines.
- Medulla is divided into **8-18** striated cone-shaped structures called **renal** (medullary or Malpighian) **pyramids**.



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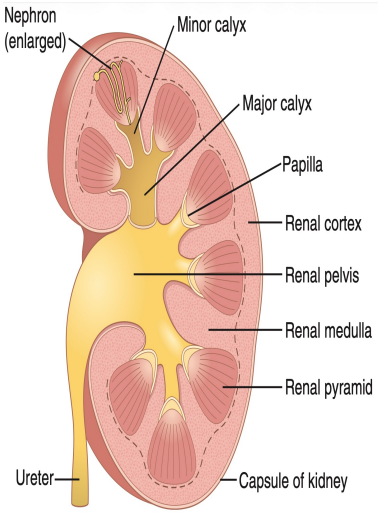
The Kidney Regions:

Renal pyramids:

- The **base** of each renal pyramid originates at the border between the cortex and medulla.
- The **apex** of each renal pyramid (**renal papilla**) pointing towards the minor calices (the renal pelvis).



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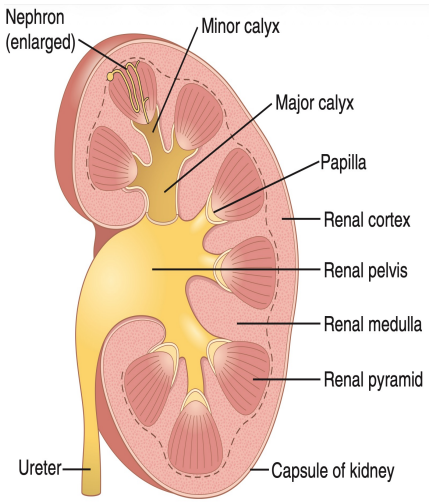
The Kidney Regions:

- **Renal Pelvis:**
  - a **funnel-shaped continuation** of the upper end of the ureter.



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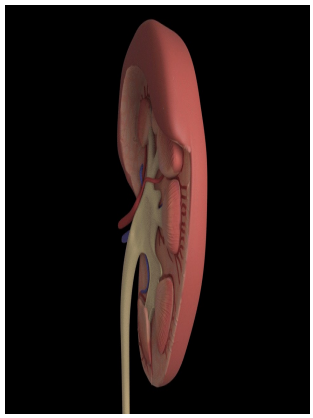
The Kidney Regions:

- **Renal Pelvis:**
  - The outer border of the pelvis is divided into open-ended pouches called **major calyces** that extend downward and divide into **minor calyces**, which **collect urine from the tubules of each papilla**.



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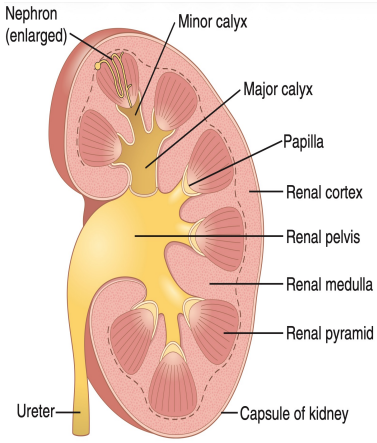
The Kidney Regions:

- **Renal Pelvis:**
  - The walls of the calyces, pelvis, and ureter contain contractile smooth muscle, that propel the urine toward the bladder, where urine is **stored** until it is emptied by **micturition**.



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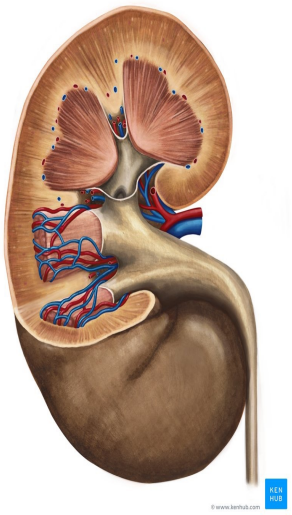
The Kidney (Renal) Capsule:

- **Renal capsule:**
  - A **tough fibrous, dense, connective** tissue covering the kidney.
  - It is the membrane that **surrounds** the surface of the kidney.
  - It protects the kidneys delicate inner structures.



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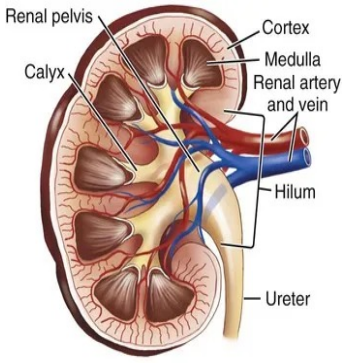
The Kidneys:

- The **medial side** of each kidney contains an indented region called the **hilum**, through which pass the:
  - **Renal artery and vein,**
  - **Lymphatics,**
  - **Nerve supply,**
  - **Ureter.**



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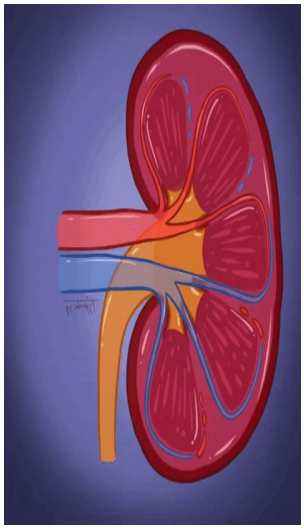
The Kidneys:

- The kidneys receive **~20–25%** of the resting cardiac output.
- Normal Renal Blood Flow is **~1000 - 1200** mL/min
- The blood comes from the heart through the **abdominal aorta** and the **renal artery** into the kidney.



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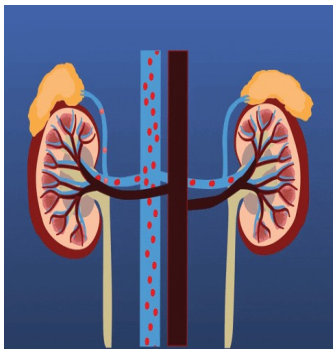
The Kidneys:

- Most of the blood, **after filtering**, flows back into the body through the **renal vein** and the **inferior vena cava**.



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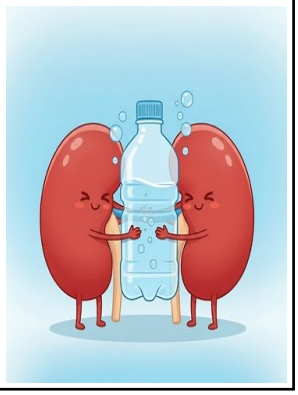
The Kidneys:

- The two kidneys filtrate the blood continuously to **remove waste** and to **regulate the amount of water in the body** (**the water balance**).



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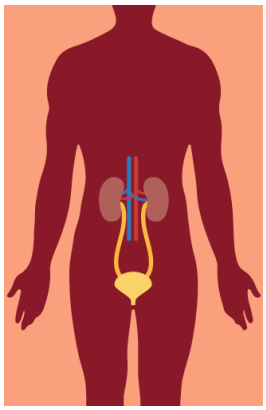
Urinary System Organs:

- **The Ureters:**

- The ureters are **long narrow tubes carrying urine from the kidneys to the bladder**.

- **Muscles** in the ureter walls continually tighten and relax **forcing urine downward, away from the kidneys**.



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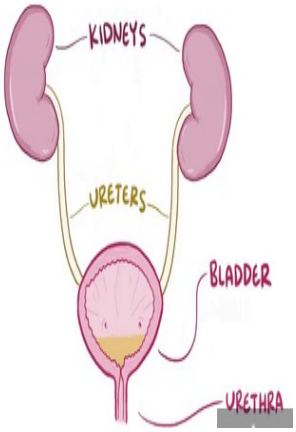
Urinary System Organs:

- **The Ureters:**

- About every **10-15 seconds**, small amounts of urine are emptied into the **bladder** from the ureters.

- The **waste** and any **excess water** are secreted through the ureters as **urine**.



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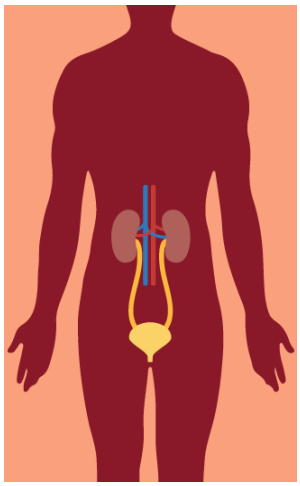
Urinary System Organs: Urinary Bladder:

- **Urinary Bladder:**
  - It is a **triangle-shaped**, **hollow** organ located in the **lower abdomen**.
  - The bladder's walls **relax and expand to store urine**, and **contract and flatten to empty urine** through the urethra.



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Urinary System Organs:

- **Urinary Bladder:**
  - The typical healthy adult bladder can store up to **500 ml** of urine for **2-5 hours**.

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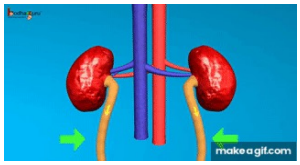
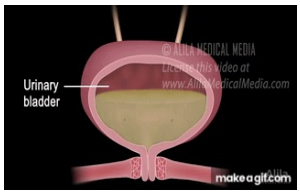
Urinary System Organs:

- **Urethra:**
- The **muscular tube** that **transports urine from the bladder to the outside of the body**.





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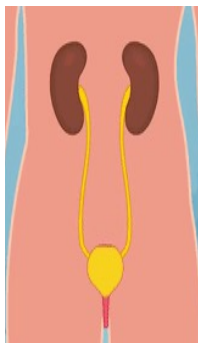
Urinary System Organs:

- **Urethra:**
- The **brain signals the bladder muscles** to **tighten**, which **squeezes** urine out of the bladder.
- At the same time, the **brain signals the sphincter muscles to relax** to let urine exit the bladder through the urethra.
- When all the signals occur in the correct order, **normal urination occurs**.



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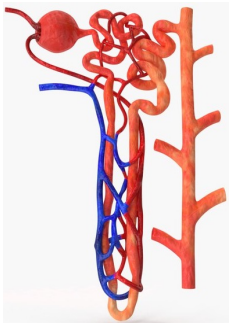
The Nephron:

- are the **functional units** of the kidneys.
- approx. **1 million** nephrons per kidney
- **Each nephrone consists of 2 parts:**

❶ **Renal corpuscle:**

❷ **Renal tubules:**



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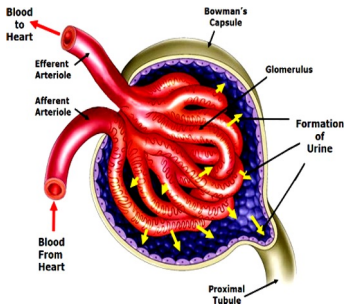
The Nephron:

❶ **Renal corpuscle:** composed of:

- **Glomerulus (capillary network):**
- **Glomerular (Bowman's) capsule:**
  - ✓ a double-walled epithelial cup
  - ✓ surrounds the glomerular capillaries.



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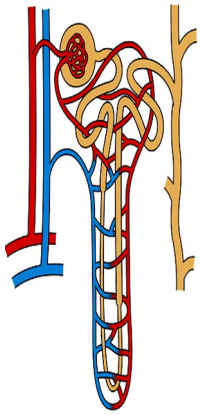
The Nephron:

❷ **Renal tubules:**

- into which the filtered fluid (glomerular filtrate) passes.

1. **Proximal convoluted tubule** (PCT):
   - attached to the glomerular capsule.
2. **Nephron loop** (loop of Henle):
3. **Distal convoluted tubule** (DCT).
   - further away from the glomerular capsule.



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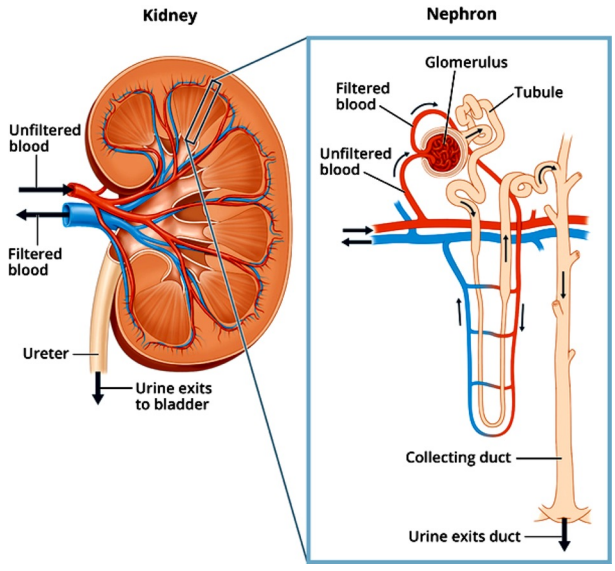
The Nephron:



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Urine Production (Formation):

- **To produce urine, nephrons and collecting ducts perform three basic processes:**
  - **Glomerular filtration,**
  - **Tubular reabsorption,**
  - **Tubular secretion.**

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Urine Production (Formation):

1. Glomerular filtration:

- **Water** and **most solutes** in blood plasma move across the wall of **glomerular capillaries**, where they are **filtered** and move into the **glomerular capsule** and then into the **renal tubule**.

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Urine Production:

2. Tubular reabsorption:

- Tubule cells reabsorb **~99%** of the filtered water and many useful solutes.
- The **water** and **solutes** return to the blood as it flows through the peritubular capillaries and vasa recta.

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Urine Production:

3. Tubular secretion:

- The renal tubule and duct cells **secrete** other materials, such as **wastes**, **drugs**, and **excess ions**, into the fluid.

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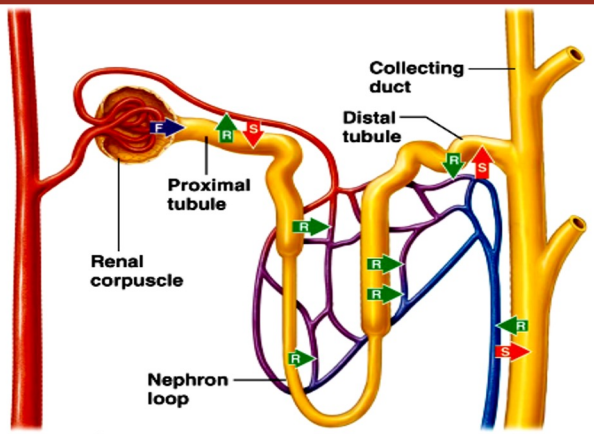
Urine Production:



F **Glomerular filtration:**
Blood is filtered at the glomerulus.

R **Tubular reabsorption:**
Fluid and solutes are reabsorbed from the filtrate and returned to the blood.

S **Tubular secretion:**
Substances are secreted from the blood into the filtrate.

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Questions and Comments

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