Urinary System

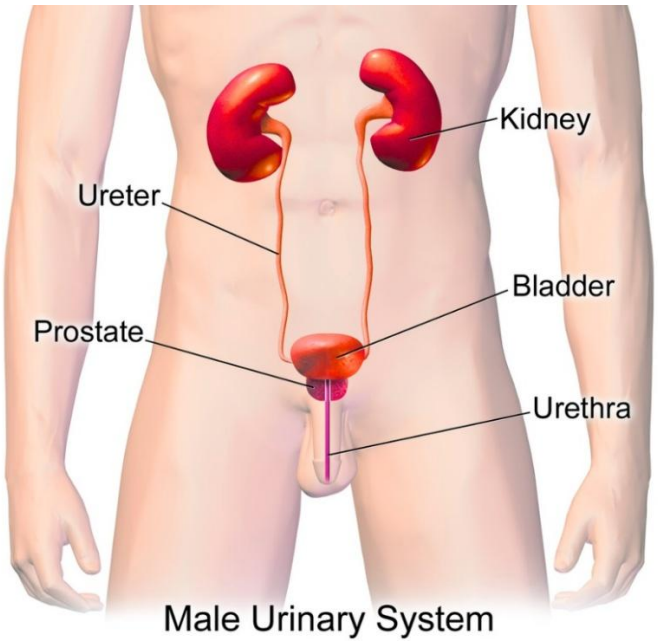
Anatomy of Urinary System

Overview

- The **urinary system** (also called the **renal system**) is responsible for:
  - **Filtering blood**
  - **Removing waste products**
  - **Regulating fluid, electrolyte, and acid-base balance**
  - **Maintaining blood pressure and red blood cell production**

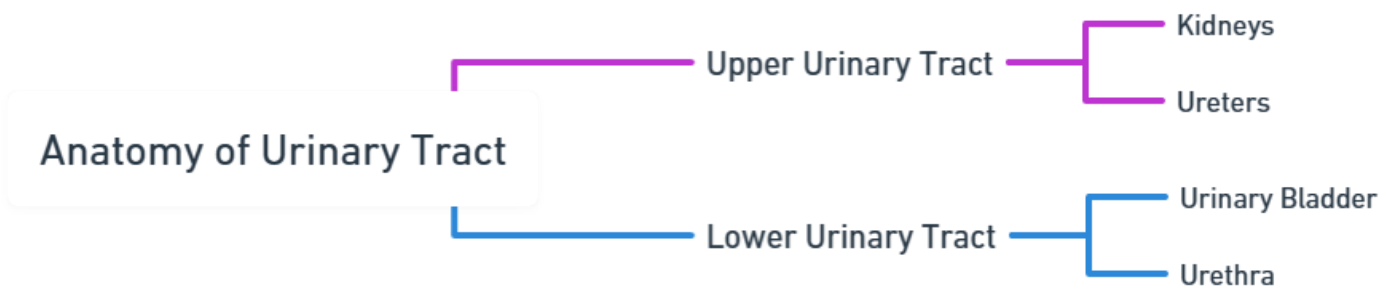
Main Components

- The urinary system consists of the following structures:
  1. **Kidneys** (2) – Filter blood, form urine
  2. **Ureters** (2) – Transport urine from kidneys to bladder
  3. **Urinary bladder** – Stores urine
  4. **Urethra** – Discharges urine from the body



Male Urinary System

The anatomy of the urinary tract divided into upper and lower parts



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Upper urinary tract:

1. Kidneys

- **Function**: Filter blood and produce urine.
- **Structure**: A pair of **bean-shaped organs** located on either side of the spine, below the ribcage.
- **Nephrons**: Each kidney contains about 1 million nephrons, which perform filtration, reabsorption, secretion, and excretion.

2. Ureters

- **Function**: Transport urine from the kidneys to the bladder.
- **Structure**: Two muscular tubes, each about **10-12 inches (25-30 cm)** long.
- **Mechanism**: Use **peristalsis** (involuntary muscular contractions) to move urine along their length.

Lower Urinary Tract

1. Urinary Bladder

Anatomy:

- Hollow, muscular organ located in the **pelvic cavity**
- **Detrusor muscle**: Smooth muscle that contracts during urination
- Lined with **transitional epithelium**
- **Trigone**: Triangular area between openings of ureters and urethra (common site for infection)
- In males: anterior to rectum; in females: anterior to vagina and uterus

Physiology:

- Temporary **storage of urine** (capacity: ~400–600 mL)
- As the bladder fills, stretch receptors send signals to initiate the **micturition reflex**
- Urination involves:
  - Relaxation of internal and external urethral sphincters
  - Contraction of detrusor muscle

2. Urethra

Anatomy:

- Tube that carries urine from the bladder to the outside
- **Internal urethral sphincter**: Involuntary (smooth muscle)
- **External urethral sphincter**: Voluntary (skeletal muscle)
- **Length**:

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- Female: ~4 cm (shorter)
- Male: ~20 cm (passes through prostate and penis)

Physiology:

- Conveys urine during **micturition**
- In males, also transports **semen** (shared with reproductive system)

- In males, the urethra is about 8 inches (20 cm) long and passes through the prostate gland, the urogenital diaphragm, and the penis.
- The male urethra has three sections: the prostatic urethra, the membranous urethra, and the spongy (penile) urethra.
- In females, the urethra is much shorter, approximately 1.5 inches (4 cm) long, and extends from the bladder to the vaginal vestibule.
- The female urethra has a single section called the urethral meatus.

Kidney Anatomy

- The anatomy of the kidney is intricate, designed to efficiently filter blood, remove waste, maintain electrolyte balance, and regulate blood pressure.
- Each kidney is a bean-shaped organ, approximately the size of a fist, located on either side of the spine, just below the rib cage.
- The kidneys are part of the upper urinary tract and play a crucial role in the body's urinary system.

External Anatomy

1. Location

- The kidneys are **retroperitoneal organs**, meaning they are located behind the peritoneum (the lining of the abdominal cavity).
- They lie on either side of the vertebral column, with the **right kidney** positioned slightly lower than the left due to the presence of the liver.

2. Size and Shape

- Each kidney is approximately **12 cm** (4.5 inches) long, **6 cm** (2.5 inches) wide, and **3 cm** (1.2 inches) thick, resembling a large bean.

3. Renal Capsule

- A **tough, fibrous membrane** surrounding each kidney, protecting it from trauma and infection.

4. Renal Hilum

- The **medial indentation** where the **renal artery** enters, and the **renal vein** and **ureter** exit the kidney. It acts as a gateway for blood vessels and nerves.

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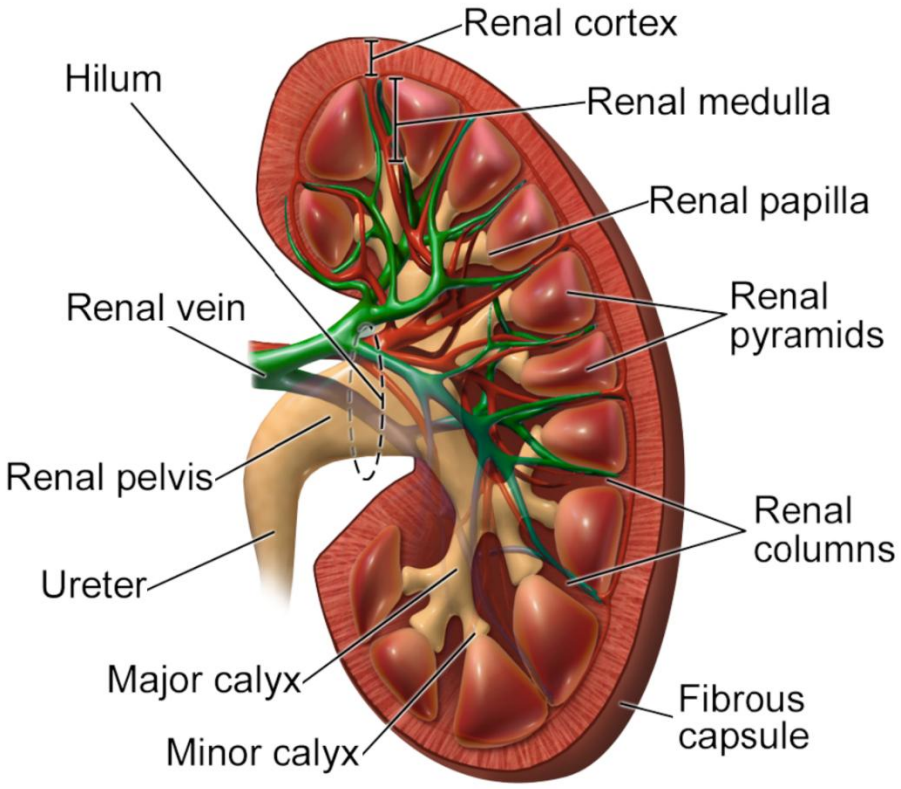
Internal Anatomy:



1. Renal Cortex

- The **outer layer** of the kidney, granular in appearance, containing glomeruli, proximal and distal convoluted tubules, and blood vessels.

2. Renal Medulla

- The **inner layer**, consisting of 10 to 18 **renal pyramids**.
- These cone-shaped tissues house the **loops of Henle** and **collecting ducts**.
- The apex of each pyramid, called the **renal papilla**, points towards the **renal pelvis**.

3. Renal Columns

- **Inward extensions** of cortical tissue separating the renal pyramids.
- These columns provide a path for **blood vessels** to enter and exit the cortex.

4. Renal Pelvis

- A **funnel-shaped space** in the center of the kidney that collects urine from the major calyces and channels it into the **ureter**.

5. Calyces

- The **renal pelvis** is divided into **major calyces**, which further divide into **minor calyces**.
- These cup-shaped structures enclose the tips of the renal pyramids, collecting urine and draining it into the renal pelvis.

Blood Supply:

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1. Renal Arteries

- Branches of the **abdominal aorta** that deliver oxygenated, nutrient-rich blood to the kidneys.

2. Renal Veins

- Carry deoxygenated, filtered blood from the kidneys back to the **inferior vena cava**.

The kidneys receive a significant amount of blood flow, essential for their **filtration** and **excretion** functions.

Microscopic Structure:

Nephrons

- The **functional units** of the kidney, with approximately **1 to 1.5 million** nephrons per kidney.
- Each nephron contains a **glomerulus** (a capillary bed that filters blood) and a **renal tubule**, where the filtrate is processed and converted into urine.

Physiology (Functions of the Kidneys)

1. Filtration:

- Occurs in the **glomerulus**
- Blood pressure forces plasma (minus proteins) into Bowman's capsule → forms **filtrate**

2. Reabsorption:

- Occurs mainly in the **PCT**
- Water, glucose, amino acids, and electrolytes are reabsorbed into the bloodstream

3. Secretion:

- Occurs in the **DCT and collecting duct**
- Ions, hydrogen ions, drugs, and toxins are secreted into the tubule

4. Urine Formation:

- Final urine: Mostly water, urea, creatinine, uric acid, and electrolytes
- ~1.5 liters/day produced from ~180 liters/day of filtrate

5. Homeostatic Functions:

- **Regulates blood pressure** via renin-angiotensin-aldosterone system (RAAS)
- **Erythropoietin**: Stimulates red blood cell production
- **Activates vitamin D** to regulate calcium absorption
- Maintains **acid-base balance** by excreting H^+ and reabsorbing HCO_3^-

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