Chapter 27: Urinary System

1. General Structure and Functions of the Urinary System

Components of the Urinary System

1. **Kidneys**: Filter blood and produce urine.
2. **Ureters**: Transport urine from the kidneys to the bladder.
3. **Urinary Bladder**: Stores urine.
4. **Urethra**: Expels urine from the body.

Functions of the Urinary System

1. **Storage of Urine**: In the urinary bladder.
2. **Expulsion of Urine**: Through the urethra (micturition).
3. **Regulation of Blood Volume**: Influenced by hormones (e.g., ADH, aldosterone).
4. **Regulation of Erythrocyte Production**: Via the hormone **erythropoietin (EPO)**.
5. **Regulation of Ion Levels**: Sodium, potassium, calcium, phosphate.
6. **Regulation of Acid-Base Balance**: By adjusting hydrogen (H^+) and bicarbonate (HCO_3^-) levels.

2. Kidneys

Location and Structure

- **Position**: Retroperitoneal, against the posterior abdominal wall.
- **Left Kidney**: Superior pole at **T12**.
- **Right Kidney**: Superior pole is 2 cm lower (due to the liver).
- **Inferior Pole**: At **L3** vertebra.
- **Hilum**: Medial concave area where blood vessels, nerves, and ureters connect.
- **Renal Sinus**: Internal space continuous with the hilum.

Protective Layers (Innermost to Outermost)

1. **Fibrous Capsule**: Dense irregular connective tissue.
2. **Perinephric Fat**: Adipose tissue providing cushioning.
3. **Renal Fascia**: Anchors kidney to the abdominal wall.
4. **Paranephric Fat**: Between renal fascia and peritoneum.

Internal Anatomy

- **Renal Cortex**: Outer region.
- **Renal Medulla**: Inner region, containing:
    - **Renal Pyramids**: 8-15 cone-shaped structures.
    - **Renal Papilla**: Tip of the pyramid.
- **Renal Columns**: Extensions of the cortex between pyramids.
- **Minor Calyx**: Funnels urine from the renal papilla.
- **Major Calyx**: Formed by merging minor calyces.
- **Renal Pelvis**: Collects urine and funnels it into the ureter.

3. Blood Supply to the Kidneys

Arterial Supply Pathway

1. **Renal Artery**
2. **Segmental Arteries**
3. **Interlobar Arteries** (run through renal columns)
4. **Arcuate Arteries** (arch along corticomedullary junction)
5. **Interlobular Arteries** (radiate into cortex)
6. **Afferent Arterioles → Glomerulus → Efferent Arterioles**

Capillary Networks

- **Peritubular Capillaries**: Surround convoluted tubules in the cortex.
- **Vasa Recta**: Surround nephron loops in the medulla.

Venous Drainage Pathway

1. **Interlobular Veins**
2. **Arcuate Veins**

3. **Interlobar Veins**
4. **Renal Vein**

4. Nephrons

Structure of a Nephron

- **Renal Corpuscle**:
  - **Glomerulus**: Capillary tuft for filtration.
  - **Glomerular Capsule**: Surrounds glomerulus; collects filtrate.
- **Renal Tubule**:
  - **Proximal Convoluted Tubule (PCT)**: Reabsorbs nutrients and water.
  - **Nephron Loop (Loop of Henle)**:
    - **Descending Limb**: Water reabsorption.
    - **Ascending Limb**: Solute (Na^+, Cl^-) reabsorption.
  - **Distal Convoluted Tubule (DCT)**: Secretes K^+ and H^+; responds to **ADH** and **aldosterone**.

Types of Nephrons

1. **Cortical Nephrons**: 85%; mainly in the cortex.
2. **Juxtamedullary Nephrons**: 15%; nephron loops extend deep into the medulla.

Urine Formation Processes

1. **Filtration**: Plasma filtered in the glomerulus.
2. **Tubular Reabsorption**: Water and solutes return to the blood.
3. **Tubular Secretion**: Unwanted solutes actively transported into tubular fluid.

5. Urinary Tract

Ureters

- **Structure**:
  - **Mucosa**: Transitional epithelium.
  - **Muscularis**: Smooth muscle (inner longitudinal, outer circular).

    - **Adventitia**: Areolar connective tissue.
- **Function**: Conduct urine from the kidneys to the bladder.

Urinary Bladder

- **Location**:
    - **Female**: Anteroinferior to uterus.
    - **Male**: Anterior to rectum, above the prostate.
- **Structure**:
    - **Mucosa**: Transitional epithelium; has **rugae** for expansion.
    - **Muscularis**: **Detrusor Muscle** (smooth muscle).
    - **Trigone**: Triangular area between ureteral openings and urethra.

Urethra

- **Female Urethra**: Transports urine only.
- **Male Urethra**: Transports urine and semen; divided into:
    - **Prostatic Urethra**
    - **Membranous Urethra**
    - **Spongy Urethra**

Micturition (Urination)

- Controlled by the **micturition reflex**:
    - Stretch receptors in the bladder signal the spinal cord.
    - **Parasympathetic Signals**: Relax internal urethral sphincter, contract detrusor muscle.
    - **Voluntary Control**: Relaxation of the external urethral sphincter.

Quick Study

Functions of the Urinary System

Function	Description
Storage of Urine	Bladder stores urine until micturition.
Expulsion of Urine	Urethra expels urine from the body.

Blood Volume Regulation	Via hormones (e.g., ADH, aldosterone).
Erythropoiesis Regulation	EPO stimulates red blood cell production.
Ion Regulation	Sodium, potassium, calcium, phosphate balance.
Acid-Base Balance	Adjusts H^+ and HCO_3^- levels.

Nephron Mnemonic

Mnemonic:

“Really Pretty Nephrons Do Cool Jobs”

- **R**: Renal Corpuscle
- **P**: Proximal Convoluted Tubule
- **N**: Nephron Loop
- **D**: Distal Convoluted Tubule
- **C**: Collecting Tubule
- **J**: Juxtaglomerular Apparatus

Urine Formation Steps

Mnemonic:

“Fancy Rabbits Secretly Pee”

1. **F**: Filtration (in glomerulus)
2. **R**: Reabsorption (PCT, nephron loop, DCT)
3. **S**: Secretion (DCT)
4. **P**: Pee (final urine formation)