Chapter 5: Peripheral Nervous System (Autonomic Nervous System)

Autonomic Nervous System (ANS)

- **Innervates organs not under voluntary control**.
- **Effectors**:
  - Cardiac muscle
  - Smooth muscle of visceral organs and blood vessels
  - Glands
- Part of the **PNS**.
- Primarily motor neurons, but includes sensory neurons from viscera for control.

Differences between Somatic and Autonomic Motor Neurons

Somatic Motor Neurons

- Cell bodies in the **CNS** (brainstem and spinal cord).
- Single neuron from CNS to effector (**skeletal muscles**).
- Release only **acetylcholine (ACh)**, always excitatory.

Autonomic Motor Neurons

- Two sets of neurons in the **PNS**.
- **Preganglionic neuron**:
  - Cell bodies in brainstem or spinal cord.
  - Synapses in an **autonomic ganglion**.
  - Originate in brainstem (midbrain or hindbrain) or thoracic, lumbar, or sacral spinal cord.
- **Postganglionic neuron**:
  - Cell bodies in the ganglion.
  - Synapses on the effector (smooth muscle, cardiac muscle, glands).
  - Originate in ganglion.
- **Autonomic ganglia** located in head, neck, abdomen, and in chains along the spinal cord.
- Release mainly **acetylcholine** and **norepinephrine**, can be excitatory or inhibitory.

Divisions of the Autonomic Nervous System

1. Sympathetic Division

- Also called the **thoracolumbar division**.
- Preganglionic neurons from thoracic and lumbar regions of spinal cord.
- Synapse in sympathetic ganglia parallel to the spinal cord.

- **Functions** ("fight or flight"):
  - Increases heart rate.
  - Decreases digestive activities.
  - Pupil **dilation**.
  - Increases blood glucose levels.
  - Diverts blood to skeletal muscles.

2. Parasympathetic Division

- Also called the **craniosacral division**.
- Preganglionic neurons from brain or sacral region of spinal cord.
- Synapse on **terminal ganglia** located near or in effector organs.
- Terminal ganglia supply short postganglionic neurons to effectors.
- **Functions** ("rest and digest"):
  - Decreases heart rate.
  - Increases digestive activities.
  - Pupil **constriction**.
  - Achieved via **ACh** release from postganglionic neurons.

Combined Effects

- **Complementary Effects**: Both divisions produce similar effects on the same target (e.g., salivary gland secretion - watery by parasympathetic, thicker by sympathetic due to vasoconstriction).
- **Cooperative Effects**: Both divisions produce different effects that work together for a single action (e.g., male and female reproductive systems).

Chapter 6: Sensory Physiology

Categories of Sensory Receptors (Functional)

1. **Chemoreceptors**: Sense chemicals (taste, smell, blood chemicals).
2. **Photoreceptors**: Sense light.
3. **Thermoreceptors**: Respond to cold or heat.
4. **Mechanoreceptors**: Stimulated by mechanical deformation (touch, hearing).
5. **Nociceptors**: Pain receptors; depolarize from tissue damage (heat, cold, pressure, chemicals).

The Ear

Outer Ear

- **Pinna (auricle)** funnels sound waves.
- **External auditory meatus** channels sound to **tympanic membrane (eardrum)**.

Middle Ear

- Air-filled cavity between tympanic membrane and cochlea.
- Contains three **ossicles**:
  - **Malleus, incus, stapes.**
  - Transmit and amplify vibrations.
  - **Stapes** attached to **oval window**, transfers vibrations to cochlea (inner ear).

The Eyes and Vision

- Vision is light energy transduced into nerve impulses.
- Only a limited part of the electromagnetic spectrum excites photoreceptors.

General Pathway of Light Through the Eye

1.Light passes through **cornea**.
2.Enters **anterior chamber**.
3.Passes through **pupil** (regulated by pigmented **iris muscle**).
4.Through the **lens** (changes shape to focus image).
5.Through **posterior chamber** and **vitreous body**.
6.Hits the **retina** (where photoreceptors are).
7.Absorbed by pigmented **choroid layer**.

Rods and Cones

- **Rods**: Black-and-white vision in low light.
- **Cones**: Less light-sensitive, but allow **color vision** and **greater visual acuity**.

Chapter 7: Endocrine Glands and Hormones

Endocrine Glands & Hormones

- **Ductless glands**.
- Secrete hormones directly into the **blood**.
- Hormones travel to **target cells** with specific receptors.
- **Neurohormones** secreted by specialized hypothalamic cells.
- Regulate body **metabolism, growth, and reproduction**.

Chemical Classification of Hormones

1.**Amines**: Derived from tyrosine and tryptophan (e.g., adrenal medulla, thyroid, pineal glands hormones).
2.**Polypeptides and Proteins**: Chains of amino acids (e.g., antidiuretic hormone, insulin, growth hormone).
3.**Glycoproteins**: Long polypeptides bound to carbohydrates (e.g., FSH, LH, TSH).
4.**Steroids**: Lipids derived from cholesterol (e.g., testosterone, estradiol, progesterone, cortisol); secreted by adrenal cortex and gonads.

Hormone Classifications by Action

1.**Polar hormones**: Water-soluble.
   - Cannot pass through plasma membranes.
   - Includes polypeptides, glycoproteins, catecholamines (norepinephrine, epinephrine).
   - Receptors on outer surface of plasma membrane.

2.**Nonpolar hormones**: Insoluble in water (**lipophilic**).
   - Can enter target cells directly.
   - Includes steroids, thyroid hormone, melatonin.
   - Receptors in cytoplasm or nucleus.

Mechanisms of Hormone Action

- Hormones bind to highly specific receptors with high affinity and low capacity (saturable).

Pituitary Gland

- Attached to **hypothalamus** by the **infundibulum**.
- Divided into **anterior lobe (adenohypophysis)** and **posterior lobe (neurohypophysis)**.
   - Anterior pituitary: Glandular epithelium.
   - Posterior pituitary: Nervous tissue.

Posterior Pituitary Hormones

- Stores and releases two hormones made in the hypothalamus:

1.**Antidiuretic hormone (ADH)** / **arginine vasopressin (AVP)**: Promotes water retention in kidneys.

2.**Oxytocin**: Stimulates childbirth contractions and milk let-down.

- **Hypothalamic Control**:
  - ADH produced by supraoptic nuclei, oxytocin by paraventricular nuclei of hypothalamus.
  - Transported along axons of **hypothalamo-hypophyseal tract** to posterior pituitary for storage.

Anterior Pituitary Hormones

- Secreted by the anterior lobe.
- **Trophic hormones**: Stimulate hormone secretion in other glands.
  - **Growth hormone (GH)** / somatotropin.
  - **Thyroid-stimulating hormone (TSH)** / thyrotropin.
  - **Adrenocorticotropic hormone (ACTH)** / corticotropin.
  - **Follicle-stimulating hormone (FSH)** / folliculotropin.
  - **Luteinizing hormone (LH)** / luteotropin (interstitial cell stimulating hormone (ICSH) in males).
  - **Prolactin (PRL)**.

Adrenal Glands

- Found atop the kidneys.
- Consist of:
  - **Outer adrenal cortex**.
  - **Inner adrenal medulla**.

Adrenal Medulla

- **Neural tissue**.
- Secretes **epinephrine** and **norepinephrine** in response to sympathetic neural stimulation.

Adrenal Cortex

- **Glandular epithelium**.
- Secretes **steroid hormones** in response to ACTH.
- Three layers:
  - 1. **Zona glomerulosa**: Secretes **mineralocorticoids** (e.g., **aldosterone**) – regulate Na+ and K+ balance.
  - 2. **Zona fasciculata**: Secretes **glucocorticoids** (e.g., **cortisol**) – regulate glucose metabolism.
  - 3. **Zona reticularis**: Secretes **adrenal androgens** (e.g., **DHEA**) – weak sex hormones.

Thyroid Gland

- Located just below the larynx, two lobes connected by isthmus.
- **Thyroid follicles**: Hollow spaces composed of follicular cells producing **thyroxine (T4)** and **triiodothyronine (T3)**.
- Follicles filled with **colloid**.
- **Parafollicular cells** (outside follicles) secrete **calcitonin**.

Production & Action of Thyroid Hormone

- T4 and T3 secreted when stimulated by TSH.
- **Actions**:
  - Stimulates protein synthesis.
  - Promotes maturation of nervous system.
  - Increases rates of cellular respiration.
  - Elevates basal metabolic rate.

Calcitonin (Thyrocalcitonin)

- Made by parafollicular cells.
- Inhibits calcium dissolution from bone.
- Stimulates calcium excretion in kidneys to lower blood calcium levels.

Parathyroid Glands

- Generally 4 glands embedded in the back of the thyroid gland.
- Secrete **parathyroid hormone (PTH)**.
- PTH promotes a rise in blood calcium by acting on bones, kidneys, and intestine.

Chapter 8: Cardiovascular System (Blood, Heart, and Circulation)

Functions of the Circulatory System

1.**Transportation**: Carries substances essential for cellular metabolism.
2.**Regulation**: Contributes to hormonal and temperature regulation.
3.**Protection**:
- **Clotting**: Against blood loss from injury.
- **Immune**: Leukocytes (white blood cells) protect against pathogens.

Components of the CVS

1.**Heart**: Four chambers (2 atria, 2 ventricles) acts as a pump.

2.**Blood Vessels**:
- **Arteries and arterioles**: Carry blood *from* the heart.
- **Venules and veins**: Carry blood *back to* the heart.
- **Blood capillaries**: Networks connecting arterioles and venules.

- **Arterial blood**: Bright red, high oxyhemoglobin (leaving heart).
- **Venous blood**: Darker red, lower oxygen (returning to heart).

Composition of the Blood

- Total blood volume: ~**5 liters** (adult).
- Separated by centrifugation into:
  1. **Plasma** (fluid portion, **55%**).
  2. **Formed or Cellular elements** (**45%**): erythrocytes, leukocytes, platelets.

Clotting Factors

- **Thrombin** converts soluble **fibrinogen** into **fibrin** monomers.

Structure of the Heart

- **4 chambers**:
  - Two **atria**: Receive venous blood.
  - Two **ventricles**: Eject blood into arteries.
- **Right ventricle**: Pumps blood to the lungs for oxygenation.
- **Left ventricle**: Pumps oxygenated blood to the entire body.

Pulmonary Circulation

1.Low oxygen, high CO_2 blood.
2.Returns to **right atrium**.
3.To **right ventricle**.
4.To lungs via **pulmonary trunk** and **pulmonary arteries**.
5.Gas exchange in **lung capillaries** and **alveoli**.
6.Oxygen-enriched, CO_2-depleted blood returns to **left atrium** via **pulmonary veins**.

Systemic Circulation

1.Oxygenated blood leaves **left atrium** to **left ventricle**.
2.Pumped through the **aorta** to all organ systems.
3.Arterial branches from aorta supply oxygen-rich blood.
4.Material exchange occurs.
5.Low oxygenated blood returns to **right atrium** via **superior and inferior venae cavae**.

The Heart Valves

- **Atrioventricular (AV) valves**:

1.**Tricuspid valve**: Between right atrium and right ventricle (3 flaps).
2.**Bicuspid valve / mitral valve**: Between left atrium and left ventricle (2 flaps).

- **Semilunar valves**: At the origin of the pulmonary artery and aorta.

The Heart Sounds

- Two normal sounds, "lub-dub," from valve closing.
  - **First sound (S1, lub)**: Closing of AV valves during ventricular isovolumetric contraction (ventricular systole).
  - **Second sound (S2, dub)**: Closing of semilunar valves when ventricular pressure falls below arterial pressure (ventricular diastole).
- **Heart Murmurs**: Abnormal sounds from defective heart valves causing abnormal blood flow patterns.

The Electrocardiogram (ECG)

- Each cardiac cycle produces three distinct ECG waves:

1.**P wave**: Atrial depolarization (corresponds to atrial contraction).
2.**QRS complex**: Ventricular depolarization (corresponds to ventricular contraction); atrial repolarization is masked.
3.**T wave**: Ventricular repolarization (corresponds to ventricular relaxation).

Chapter 9: Respiratory Physiology

Respiratory System Divisions

1.**Respiratory zone**: Site of gas exchange (air and blood).

2.**Conducting zone**.

Functions of Respiration (Three Related Functions)

1.**Ventilation (breathing)**.

2.**Gas exchange**: Between air/blood in lungs, and blood/tissues in body.

3.**Oxygen utilization**: By tissues in cell respiration.
- **External respiration**: Ventilation and gas exchange between air and blood.
- **Internal respiration**: Gas exchange between blood and tissues, and O2 utilization by tissues.

Lung Volumes and Capacities (Spirometry)

- **Tidal volume**: Air expired in each breath.
- **Vital capacity**: Max air forcefully exhaled after max inhalation.
- **Residual volume**: Air that cannot be expired, even after max forced expiration.
- **Expiratory reserve volume**: Additional air in lungs after unforced expiration.
- **Functional residual capacity**: Sum of residual volume and expiratory reserve volume.
- Total minute volume: ~**6 L per minute** (tidal volume at rest x breaths/min).
- Vital capacity and functional residual capacity are clinically important.

Hemoglobin and Oxygen Transport

- **Deoxyhemoglobin** loads with oxygen to form **oxyhemoglobin** in pulmonary capillaries.
- Total oxygen content depends on PO2 and hemoglobin concentration.
- Each **Hb** (hemoglobin) has **4 globin polypeptide chains** and **4 heme groups** that bind O2.
- Each heme has a **ferrous ion** that binds **1 O2**.
- Therefore, each Hb can carry **4 O2 molecules**.

Chapter 10: Physiology of the Kidneys

Functions of Kidney

- Remove **waste products** from blood.
- Control **acid-base balance** (HCO3- & H+).
- **Electrolyte homeostasis** (K+, Na+, Ca++).
- Secrete hormones and enzymes: **erythropoietin** and **renin** (Chronic Renal Failure can lead to anemia due to reduced erythropoietin).
- Activates **Vitamin D**.
- Regulate **body fluids** and **arterial blood pressure**.

Gross Anatomy of the Urinary System

- Urine made in kidney drains into **renal pelvis**, then down **ureter** to **urinary bladder**.
- Passes from bladder through **urethra** to exit body.

Kidney Anatomy

- Two distinct regions:

1.**Renal cortex**.
2.**Renal medulla** (made of renal pyramids).

- Each pyramid drains into a **minor calyx** → **major calyx** → **renal pelvis**.

Anatomy of the Nephron

- **Nephron**: Functional unit of the kidney (~1 million/kidney).
- Consists of small tubules and associated blood vessels.
- Blood filtered → fluid enters tubules → modified → leaves as urine.
- **Glomerular (Bowman's) capsule** surrounds the **glomerulus**; together they form the **renal corpuscle**.
- Filtrate passes into **proximal convoluted tubule**.
- Fluid passes into descending and ascending limbs of **loop of Henle**.
- After loop of Henle, fluid passes into **distal convoluted tubule**.

Urine Formation Process (Four Key Steps)

1.**Filtration**: Blood plasma filtered through glomerulus; water, solutes, small molecules enter nephron as filtrate.
2.**Reabsorption**: Essential nutrients, solutes, water reabsorbed from filtrate in renal tubules back into bloodstream (peritubular capillaries).
3.**Secretions**: Certain substances actively secreted from blood into filtrate in renal tubules (ions, wastes).
4.**Excretion**: Refined filtrate (urine) passes through collecting ducts to renal pelvis, down to bladder, out via urethra.

Salt and Water Reabsorption

- Occurs in the proximal tubule.
- Involves the **countercurrent multiplier system**.

Chapter 12: The Digestive System

Parts of the Digestive System

1. **Gastrointestinal (GI) canal/tract**: Continuous coiled hollow tube.
    - Oral cavity (mouth), Pharynx, Esophagus, Stomach, Small intestine, Large intestine.

2. **Accessory/Associated digestive organs**:
    - Teeth, Salivary Glands, Pancreas, Liver, Gallbladder.

- **Digestion**: Breakdown of food molecules into smaller subunits.
- **Absorption**: Passage of digested end products into blood or lymph.

Functions of the Stomach

1. **Stores food** (via rugae).
2. **Churns food** to mix with gastric secretions.
3. Begins **protein digestion** (pepsin).
4. **Acid**: Kills bacteria, denatures proteins, activates pepsinogen to pepsin.
5. **Intrinsic factor secretion**: From stomach lining, aids vitamin B12 reabsorption in intestine.
6. Moves food (as **chyme**) into small intestine.

Digestion and Absorption in the Stomach

- **Protein digestion** starts.
- **Starch digestion** (from salivary amylase) stops at pH ≤ 2.
- Only common substances absorbed: **alcohol** and **NSAIDs (aspirin)**.

Small Intestine Structure

- Divided into three sections:
    - **Duodenum** (first ~25 cm): Most digestion.
    - **Jejunum** (middle 2/5): Most absorption.
    - **Ileum** (last 3/5): Important absorption (bile salts, vitamin B12, water, electrolytes).
- Mucosa and submucosa folded into **plicae circulares**.
- Mucosa further folded into **villi**.
- Epithelial plasma membranes folded into **microvilli**.
- Greatly increase surface area for absorption and digestion.

Function of the Small Intestine

- Complete digestion of carbohydrates, proteins, and fats.
- Rapid absorption of nutrients due to villi and microvilli.

Large Intestine Structure

- Parts: Cecum, Ascending colon, Descending colon, Transverse colon, Sigmoid colon, Rectum, Anal canal, Anus.

Large Intestine Function

1. Absorption of **water, electrolytes, vitamin K, and some B vitamins**.
2. Production of **vitamin K and B vitamins** by microbial organisms (microbiota).
3. **Storage of feces**.

Accessory Digestive Organs

1. Salivary Glands

- Produce saliva.
- **Parotid glands, Submandibular glands, Sublingual glands**.

2. Teeth

- Role is to **masticate (chew)** food.

3. Pancreas

- Produces wide spectrum of **digestive enzymes** (break down all food categories).
- **Endocrine products**: Insulin, Glucagon.

4. Liver

- Produces **bile**.
- Bile composition: Bile salts, Bile pigment (bilirubin), Cholesterol, Phospholipids, Electrolytes.

5. Gallbladder

- Sac in hollow fossa of liver.
- **Stores bile** from the liver via the cystic duct.

Chapter 11: The Reproductive System

The Male Reproductive System

- Main structures: Testes, Epididymis, Vas deferens, Urethra, Penis.
- Work together to produce and deliver sperm.

1. **Testes**: Make and store sperm. Descend into **scrotum** (1-2°C below body temp).
2. **Scrotum**: Sac-like pouch housing testes.
3. **Seminiferous tubules**: Within each testis, produce sperm.
4. **Epididymis**: Temporary storage organ for sperm at beginning of vas deferens until fully mature.
5. **Vas Deferens**: Tube carrying sperm past lubricating glands.
6. **Lubricating glands**:
    - **Cowper's gland, Seminal vesicle, Prostate gland**.
    - **Prostate** produces alkaline fluid to neutralize urine in urethra.
7. **Urethra**: Opening through the penis.
8. **Penis**: Releases **semen** (liquid loaded with sperm).

- **Ejaculation**: Sperm ejected by contractions of smooth muscles lining glands in reproductive tract.

Female Reproductive System

- Main structures: Ovaries, Fallopian tubes, Uterus, Vagina.
- Produces eggs and prepares body to nourish a developing embryo.

1. **Primary oocyte**: 46 chromosomes.
2. **Secondary oocyte**: 23 chromosomes.

Fertilization, Pregnancy, and Parturition

1. **Site for fertilization**: **Fallopian tubes (oviduct)**.
    - Egg released from follicle during **ovulation**, swept into fallopian tube.
2. Eggs are **not motile**, pushed by cilia along fallopian tube.
3. **Uterus (womb)**: Site where fertilized egg implants.
    - Lining prepared to receive fertilized egg.
    - Outer end of uterus: **cervix**.
4. **Vagina**: Birth canal.

Human Menstrual Cycle

- Mature egg develops and is released approx. every **28 days**.
- **4 stages**:

1. **Follicle Stage**: FSH (follicle stimulating hormone) dominance (**10-14 days**).
2. **Ovulation**: FSH decreases, LH (luteinizing hormone) surge (**Day 14**).
3. **Corpus Luteum Stage** (yellow body stage).
4. **Menstruation**: If fertilization doesn't occur, LH decreases, corpus luteum breaks down (**3-5 days**).

- **Menopause**: Permanent cessation of menstrual cycle, approx. **45-50 years of age**.

Done by: Raeda Khaleel