Systemic 2[C]

Chapter 19: REGULATION OF THE INTERNAL ENVIRONMENT

Learning Objectives: Upon completion of this chapter, students should be able to:

- Define homeostasis and explain its importance.
- Describe the structure and functions of the kidneys.
- Discuss common diseases affecting the kidneys.
- Explain the structure and functions of the liver.
- Discuss common diseases affecting the liver.
- Describe the structure and functions of the skin.
- Outline the functions of hormones in internal regulation.
- Identify important endocrine glands and the hormones they produce.
- Discuss the roles of specific hormones in maintaining homeostasis.

19.1 Homeostasis

- **Definition:** Homeostasis is the maintenance of a relatively constant internal environment in living organisms, despite changes in the external environment. This stable internal state is crucial for optimal enzyme activity and overall bodily function.
- **Importance:**
    - Enzymes, which control most metabolic reactions, are highly sensitive to changes in temperature and pH. Maintaining stable conditions ensures they function optimally.
    - Cells require a constant supply of nutrients and oxygen, and efficient removal of waste products, which is facilitated by a stable internal environment.
    - Prevents damage to cells and tissues from extreme conditions.

19.2 Kidneys: Functions and Diseases

The kidneys are vital organs for regulating the internal environment.

- **Functions (as part of the Excretory System - covered in more detail in Chapter 16):**
    - **Excretion of Metabolic Wastes:** Filter blood to remove nitrogenous wastes (primarily urea), creatinine, and uric acid.
    - **Osmoregulation:** Regulate water potential (water balance) and electrolyte (salt) balance in the blood.
    - **pH Regulation:** Maintain the acid-base balance of the blood.
    - **Blood Pressure Regulation:** Produce hormones (e.g., renin) that help control blood pressure.

    - **Red Blood Cell Production:** Produce erythropoietin, a hormone that stimulates red blood cell production.
- **Structure (briefly, as covered in Chapter 16):** Consists of cortex, medulla, pelvis, and millions of nephrons (functional units).
- **Common Kidney Diseases:**
    - **Kidney Stones (Renal Calculi):** Hard deposits of minerals and salts that form inside the kidneys, causing severe pain and blockages.
    - **Kidney Failure (Renal Failure):** A condition where the kidneys lose their ability to filter waste from the blood. Can be acute or chronic.
        - *Treatment:* Dialysis (artificial kidney machine) or kidney transplant.
    - **Urinary Tract Infections (UTIs):** Bacterial infections affecting any part of the urinary system (kidneys, bladder, urethra).
    - **Glomerulonephritis:** Inflammation of the glomeruli (filtering units) in the kidneys, impairing their ability to filter blood.

19.3 Liver: Functions and Diseases

The liver is the largest internal organ and performs a vast array of metabolic and regulatory functions.

- **Functions (relevant to internal regulation):**
    - **Detoxification:** Converts harmful substances (e.g., alcohol, drugs, toxins) into less toxic forms that can be excreted.
    - **Deamination:** Removes the amino group from excess amino acids, forming ammonia, which is then converted into less toxic urea for excretion by the kidneys.
    - **Metabolism of Carbohydrates:**
        - Converts excess glucose into glycogen for storage (glycogenesis) and releases glucose from glycogen when blood sugar is low (glycogenolysis).
        - Converts other non-carbohydrate sources (e.g., amino acids, glycerol) into glucose (gluconeogenesis).
    - **Metabolism of Fats:** Synthesizes cholesterol and lipoproteins; converts excess carbohydrates and proteins into fatty acids and triglycerides.
    - **Protein Synthesis:** Produces many plasma proteins, including albumin (maintains osmotic pressure), clotting factors (e.g., fibrinogen, prothrombin), and immune proteins.
    - **Storage:** Stores glycogen, vitamins (A, D, B12), iron, and copper.
    - **Production of Bile:** Produces bile, which aids in fat digestion and absorption in the small intestine. Also excretes bilirubin (from broken-down red blood cells) in bile.
    - **Heat Production:** Many metabolic reactions in the liver generate heat, contributing to body temperature maintenance.
- **Common Liver Diseases:**
    - **Hepatitis:** Inflammation of the liver, often caused by viral infections (Hepatitis A, B, C) but can also be due to alcohol or autoimmune conditions.
    - **Cirrhosis:** Irreversible scarring of the liver, often caused by chronic hepatitis or long-term alcohol abuse. Impairs liver function.
    - **Fatty Liver Disease:** Accumulation of fat in liver cells, often associated with obesity, diabetes, or alcohol abuse.
    - **Liver Cancer:** Can be primary (originating in the liver) or secondary (spread from other parts of the body).

19.4 Skin: Structure and Functions

The skin is the body's largest organ and plays several roles in homeostasis.

- **Structure:**
    - **Epidermis:** Outer protective layer, constantly shedding dead cells. Contains keratinocytes (produce keratin for waterproofing) and melanocytes (produce melanin for UV protection and skin color).
    - **Dermis:** Middle layer, contains connective tissue, blood vessels, nerve endings, hair follicles, sweat glands, and sebaceous (oil) glands.
    - **Subcutaneous Tissue (Hypodermis):** Innermost layer (not strictly part of the skin), composed of loose connective tissue and adipose (fat) tissue. Provides insulation and energy storage.
- **Functions (relevant to internal regulation):**
    - **Protection:** Acts as a physical barrier against pathogens, UV radiation, mechanical injury, and dehydration.
    - **Thermoregulation (Temperature Control):**
        - **Sweat Glands:** Secrete sweat, which evaporates and cools the body.
        - **Blood Vessels:** Vasodilation (widening) of blood vessels in the dermis increases blood flow to the surface, facilitating heat loss; Vasoconstriction (narrowing) reduces blood flow, conserving heat.
        - **Hair and Adipose Tissue:** Provide insulation, trapping a layer of air or fat to reduce heat loss.
    - **Sensory Reception:** Contains nerve endings for touch, pressure, pain, and temperature.
    - **Excretion:** Excretes small amounts of water, salts, and urea via sweat.
    - **Vitamin D Synthesis:** Produces Vitamin D when exposed to UV light.

19.5 Hormones: Endocrine Glands and Their Functions

Hormones are chemical messengers produced by endocrine glands that regulate various physiological processes to maintain homeostasis.

- **Endocrine Glands:** Ductless glands that secrete hormones directly into the bloodstream.
- **Important Hormones and Their Functions in Homeostasis:**
    1. **Pancreas:**
        - **Insulin:** Lowers blood glucose levels by promoting glucose uptake by cells and conversion to glycogen in the liver and muscles.
        - **Glucagon:** Raises blood glucose levels by stimulating the breakdown of glycogen to glucose in the liver (glycogenolysis) and the synthesis of glucose from non-carbohydrate sources (gluconeogenesis).
        - *Regulation:* Both insulin and glucagon work antagonistically to maintain blood glucose homeostasis.
    2. **Adrenal Glands (located on top of kidneys):**
        - **Adrenaline (Epinephrine):** "Fight-or-flight" hormone. Increases heart rate, blood pressure, dilates airways, and increases blood glucose by converting glycogen to glucose. Prepares the body for immediate action.
        - **Aldosterone:** Regulates salt and water balance by promoting sodium reabsorption and potassium excretion in the kidneys. Influences BP.

3. **Thyroid Gland (in the neck):**
    - **Thyroxine:** Regulates metabolic rate, growth, and development.
    - *Regulation:* Negative feedback loop involving the hypothalamus and pituitary gland.
4. **Pituitary Gland (Master Gland, at base of brain):**
    - **Antidiuretic Hormone (ADH) / Vasopressin:** Regulates water reabsorption by the kidneys, controlling urine volume and blood water potential.
    - **Thyroid-Stimulating Hormone (TSH):** Stimulates the thyroid gland to produce thyroxine.
    - **Growth Hormone (GH):** Stimulates growth and cell reproduction.
    - **Follicle-Stimulating Hormone (FSH) & Luteinizing Hormone (LH):** Regulate reproductive functions in gonads.
5. **Ovaries (Female Gonads):**
    - **Estrogen:** Responsible for development of female secondary sexual characteristics and regulates the menstrual cycle.
    - **Progesterone:** Prepares the uterus for pregnancy and maintains pregnancy.
6. **Testes (Male Gonads):**
    - **Testosterone:** Responsible for development of male secondary sexual characteristics and sperm production.