

Chapter 5

TISSUES, ORGANS, AND ORGAN SYSTEMS

After studying this chapter, students will be able to:

- Distinguish between tissues, organs and organ systems with examples from animals and plants.
- Enlist the different types of tissue that come together to form the stomach organ in the human body.
- Discuss the organ systems that come together to form the human body.
- Describe the advantages of homeostasis.
- Discuss how various organs and organ systems of the human body work to maintain homeostasis.
- Discuss the different types of tissue that come together to form the leaf.
- Explain plant physiology in terms of structures and roles of various plant organs.

Living organisms exhibit a complex organization of structures in which each level of structure is built upon the previous one. This chapter will explore the fundamental levels of biological organization: cells, tissues, organs, and organ systems. We will study the characteristics and examples of each level, understanding how they perform the functions of life.

5.1- LEVELS OF ORGANIZATION

Organisms are built on a pattern of increasing complexity. There are different levels of organization where lower levels are simpler and higher levels are increasingly complex. The levels of organization in multicellular organisms begin with the simplest and smallest level i.e., the atom, and progresses to the largest and most complex level i.e., the organism.

- 1- **Atom:** Atoms are the smallest unit of matter that maintain the property of an element. For example; carbon, hydrogen, oxygen.
- 2- **Molecule:** Atoms combine to form molecules which can have entirely different properties than the atoms they contain. For example; water, protein, nucleic acid.
- 3- **Organelle:** Molecules combine in specific ways and make the subcellular level i.e., organelle. Each organelle is specialized to do a particular function. For example; **mitochondria** are responsible for cellular respiration and **ribosomes** are specialized for protein synthesis.
- 4- **Cell:** When organelles assemble and interact with each other, they make cell – the smallest unit with characteristics of life. They can carry out life activities and can also reproduce. Unicellular organisms are made of only one cell while multicellular organisms are made of many cells.
- 5- **Tissue:** In multicellular organisms, cells make tissues. A tissue is a group of similar cells that work together to perform one or more specific functions. Examples of tissues include:
 - In animals,
 - **Epithelial tissue** – covers body surfaces and lines cavities (e.g., skin)
 - **Muscle tissue** – enables movement (e.g., cardiac muscle in the heart).
 - In plants;
 - **Epidermal tissue** – protects the underlying parts (e.g., epidermis of leaf)
 - **Vascular tissue** – transports water and nutrients (e.g., xylem and phloem).
- 6- **Organ:** An organ is a structure made up of related tissues working together to perform specific functions. Examples of organs include:
 - In animals; Heart (pumps blood through the circulatory system), and lungs (facilitate gas exchange)
 - In plants; Leaves (conduct photosynthesis), and roots (absorb water and nutrients from soil).

7- **Organ System:** An organ system consists of multiple organs that work together to perform related functions. Examples of organ system include:

- In animals - circulatory system (transports nutrients and oxygen throughout the body) and digestive system (breaks down food and absorbs nutrients).
- In plants - root system (anchors the plant and absorbs water and nutrients) and shoot system (supports the plant and conducts photosynthesis).

8- **Organism:** An organism is a living entity that can function independently on behalf of proper functioning of its organ systems. Examples include humans and trees.

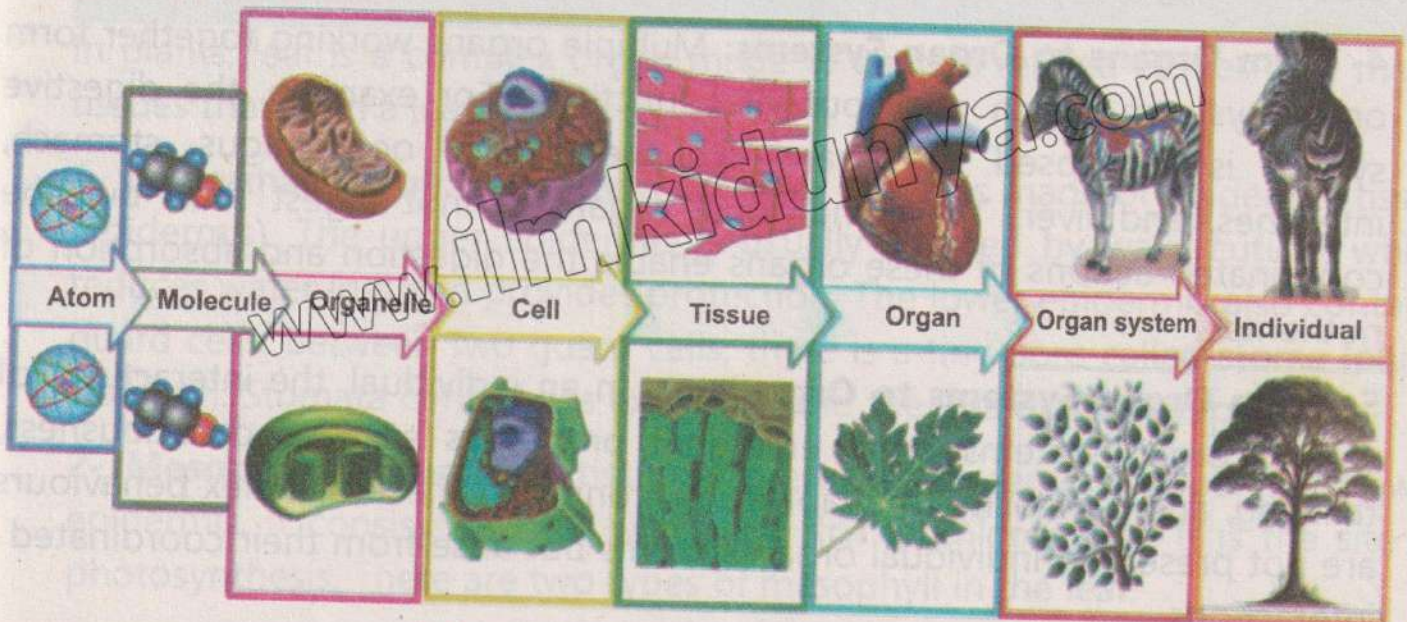


FIGURE 5.1: Levels of organization

Emergent Properties

In organisms, the components at each level do not work solely. Instead, they interact. Due to their interactions, they create new functions called **emergent properties**.

These include the abilities that are present in higher level of organization but are not possible from the individual components. Following are the examples of emergent properties when lower levels make higher levels:

The Greek philosopher Aristotle said; "The whole is greater than the sum of its parts."

1- From Organelles to Cells: Individual organelles have specific functions. However, when these organelles interact within a cell, they create a complex system capable of carrying out various cellular processes, such as cell division, protein synthesis, and energy production.

2- From Cells to Tissues: Individual cells do not have properties that are present in the tissue which they make. For example, muscle cells combine to form muscle tissue, which can contract and generate force.

3- From Tissues to Organs: An organ performs complex functions that its individual tissues cannot perform. For example, the heart is composed of various tissues, including muscle tissue, connective tissue, and epithelial tissue. The coordinated interaction of these tissues allows the heart to pump blood throughout the body.

4- From Organs to Organ Systems: Multiple organs working together form organ systems, which carry out vital functions. For example, the digestive system is composed of organs like the mouth, oesophagus, stomach, intestines, and liver. These individual organs cannot digest food but the coordinated actions of these organs enable the digestion and absorption of nutrients.

5- From Organ Systems to Organisms: In an individual, the interactions of various organ systems bring emergent properties such as consciousness, thinking, and the ability to adapt to environment. These complex behaviours are not present in individual organ systems but arise from their coordinated interactions.

5.2- ORGANS AND ORGAN SYSTEMS IN PLANTS

You know that organs are made of two or more types of tissues organized to serve a particular function. Organs which perform related functions work together and make an organ system. The following are examples of organs and organ systems in plants.

Organs in Plants

Roots: Roots are usually found underground anchor the plant in the soil and absorb water and essential minerals from the soil. Roots also store nutrients that the plant uses for their growth.

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Stems: Stems support leaves, flowers, and fruits. Stems contain vascular tissues (xylem and phloem) that facilitate the movement of water, minerals, and nutrients between roots and leaves.

Leaves: Leaves are the primary sites of photosynthesis and transpiration. Transpiration in leaves is the loss of water vapour through small pores called stomata.

Flower: Flower is reproductive part of a plant. It plays a crucial role in plant's sexual reproduction.

Leaf as an Organ

In plants, leaf is a complex organ made of various related tissues. The major tissues that form a leaf are:

1- Epidermal Tissue: The outermost layer of leaf is made of epidermal tissue (epidermis). The upper epidermis is usually covered by waxy cuticle, which reduces water loss and provides protection. The lower epidermis also contains guard cells. Between two guard cells, there is a tiny pore called stoma (plural *stomata*). Stomata control gas exchange and the loss of water vapours.

2- Mesophyll Tissue: This tissue is present between the upper and lower epidermis. It consists of cells which are rich in chloroplasts. It is the site of photosynthesis. There are two types of mesophyll in the leaf.

- **Palisade mesophyll:** It is located just beneath the upper epidermis. It consists of tightly packed elongated cells.
- **Spongy Mesophyll:** It is present below the palisade mesophyll. It is composed of loosely arranged cells with air spaces between them. These air spaces facilitate the diffusion of gases throughout the leaf.

3- Vascular Tissue: This tissue is located in the midrib and veins of leaf. It is called a complex tissue because it consists of two tissues i.e., xylem tissue and phloem tissue. The xylem tissue of leaf conducts water and minerals from the xylem of stem to leaf cells. Phloem tissue transports the products of photosynthesis (sugars) from leaf cells to the phloem of stem.

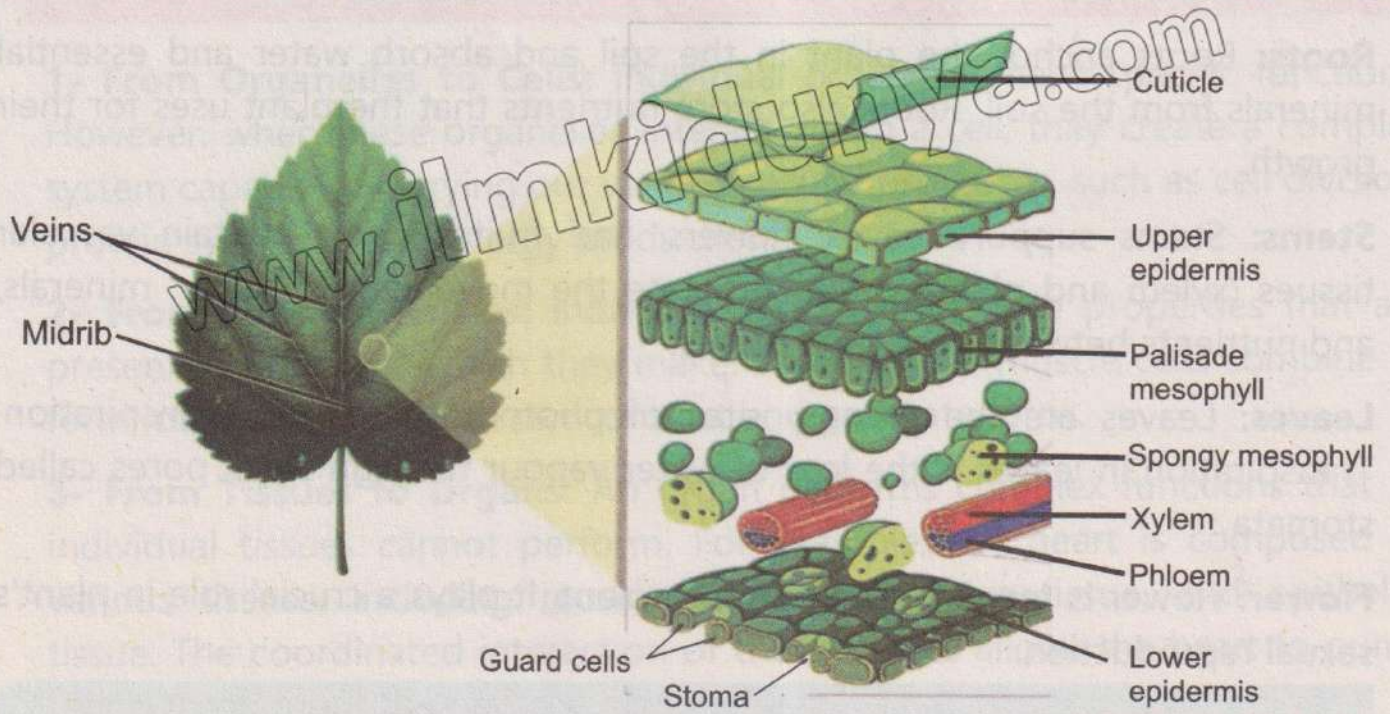


FIGURE 5.2: Tissues which make the leaf organ

Organ Systems in Plants

An organ system consists of organs that work together to perform essential functions. Unlike animals, plants are stationary organisms, so their organ systems are less complex. Plants have two main organ systems i.e., the root system and the shoot system. The **root system** consists of roots which anchor the plant in the soil. Roots also absorb water and salts needed from soil, and, in some cases, store food. The **shoot system** includes stems, branches, leaves, and flowers (and fruits formed from flowers). These organs work to enable processes like photosynthesis and reproduction.

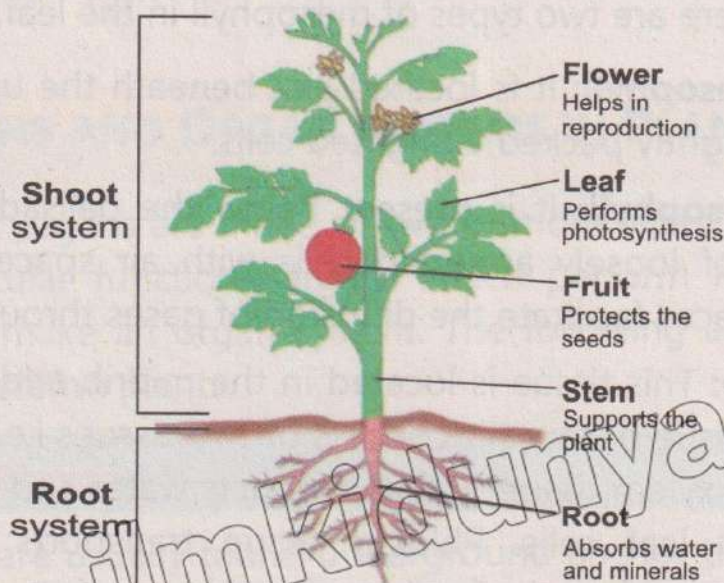


FIGURE 5.3: Organs and organ systems in Plants

5.3- ORGANS AND ORGAN SYSTEMS IN HUMANS

Organs in Human Body

Various organs are present in human body, each with specific functions. Here are a few of the most important organs:

Heart: The heart is a muscular organ that pumps blood throughout the body. It is essential for delivering oxygen and nutrients to cells and removing waste products.

Lungs: The lungs are responsible for breathing. It facilitates the exchange of oxygen and carbon dioxide between the body and environment.

Brain: The brain is the control center of the body. It is responsible for coordination among other organs, thinking, and decision-making.

Liver: The liver performs many vital functions, including filtering blood, producing bile, and storing glucose.

Kidneys: The kidneys are responsible for filtering waste products from the blood and producing urine.

Stomach: The stomach is a muscular organ that breaks down food using digestive enzymes.

Intestines: The intestines are long, tubular organs that digest food and absorb nutrients from the digested food.

Pancreas: The pancreas produces digestive enzymes. It also produces hormones such as insulin and glucagon.

Stomach as an Organ

Stomach is an important organ of the digestive system. It is responsible for the partial digestion of proteins. It also stores food. It is composed of the following tissues:

1- Epithelial Tissue: The inner wall is made up of epithelial tissue. It is glandular in nature and secretes mucus. The mucus lines the inner wall and protects it from acid. This tissue also secretes gastric juice that contains enzyme pepsinogen for protein digestion and hydrochloric acid for activating pepsinogen to pepsin enzyme.

2- **Connective Tissue:** It lies beneath epithelial tissue. It provides structural support and contains blood vessels, nerves, and lymphatics.

3- **Muscle Tissue:** There are three layers of smooth muscles: the outer longitudinal layer, the middle circular layer, and the inner oblique layer. These muscle contract and relax to mix food with the gastric juice.

4- **Outer Connective Tissue:** It is the outermost layer that encircles the stomach and supports it.

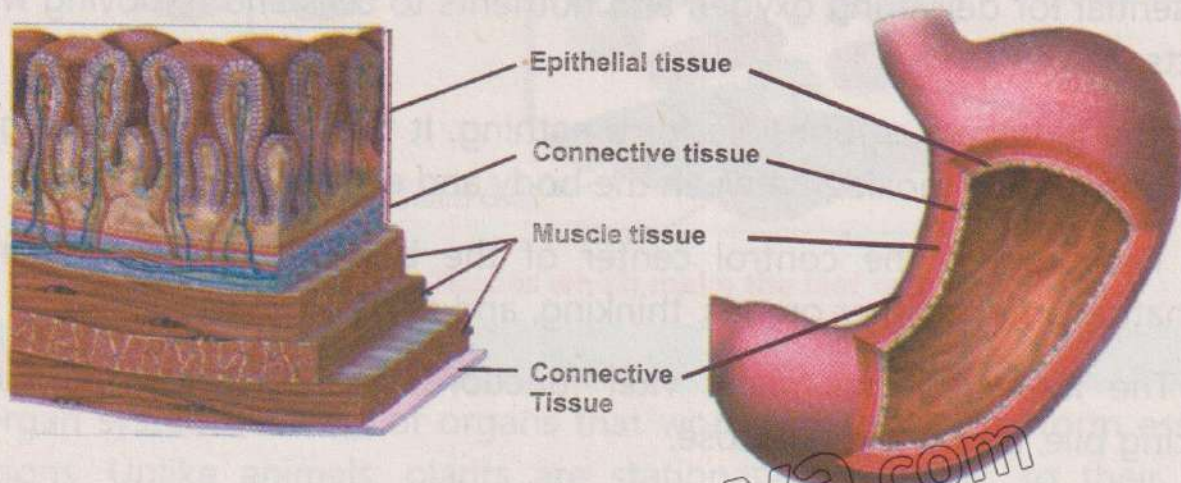


FIGURE 5.4: Tissues which make the stomach organ

Organ Systems in Human Body

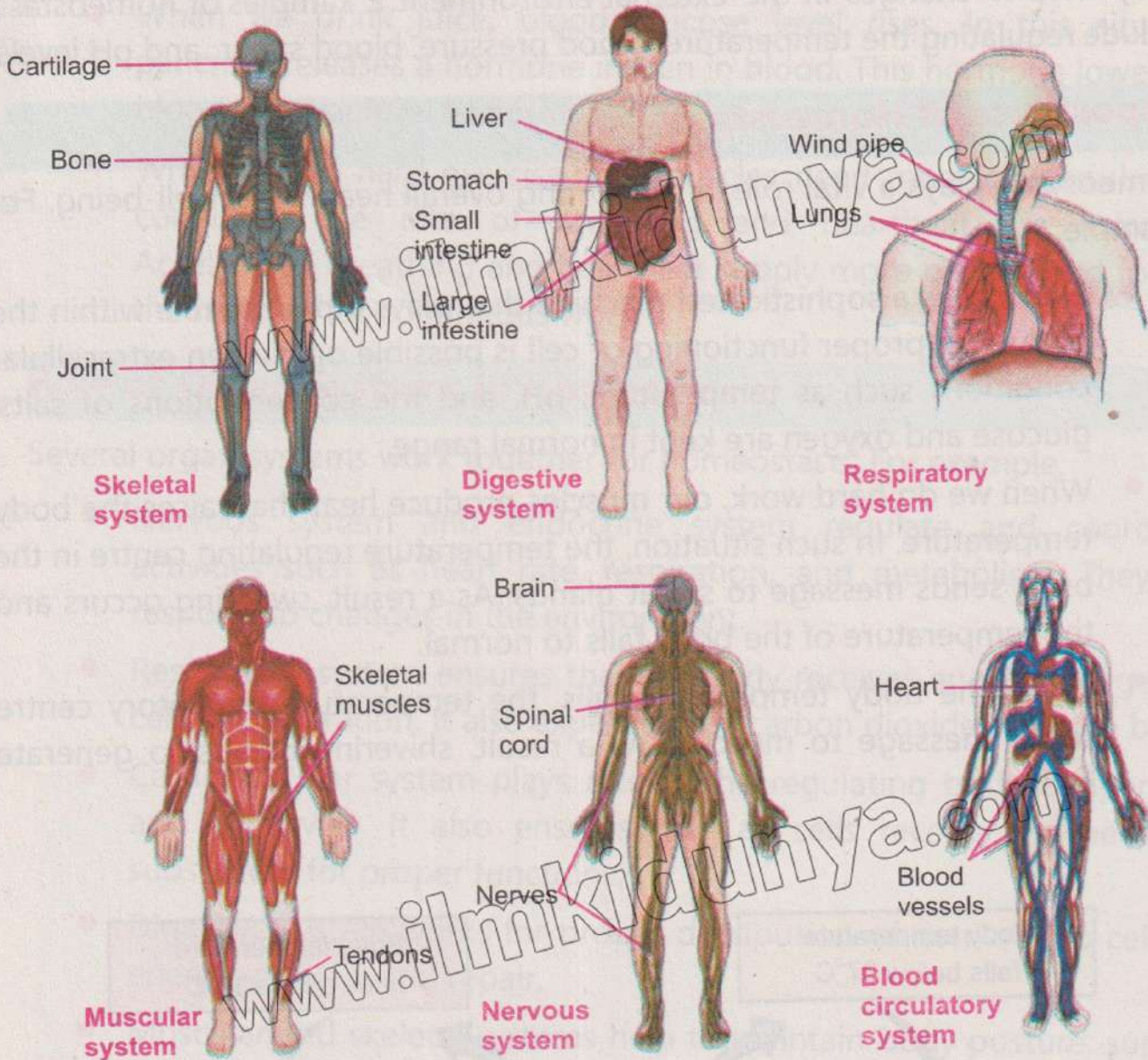
Here are a few examples of organ systems which form the human body.

Skeletal system: It consists of bones, cartilages and tendons. It provides structure, support, and protection to the body. It serves as a framework for muscles to attach, allowing movements. It also stores minerals and produces blood cells.

Digestive System: It consists of organs such as mouth, oesophagus, stomach, small intestine, and large intestine. This system is responsible for the digestion of food and the absorption of digested food.

Respiratory System: It includes the lungs, trachea (windpipe), and bronchi. This system is involved in the exchange of gases (oxygen and carbon dioxide) between the body and the environment.

Muscular System: It includes skeletal muscles, which attach to bones. These muscles contract to move bones. It allows movements and locomotion in the body.



Nervous System: It includes brain, spinal cord, and nerves. The nervous system coordinates and controls body functions through nerve impulses.

Blood Circulatory System: It includes heart, blood vessels (arteries, veins, and capillaries), and blood. This system transports oxygen, nutrients, hormones, and waste products throughout the body.

5.4- HOMEOSTASIS

The organs and organ systems of the body work in coordination to maintain a stable internal environment. It is called homeostasis. **Homeostasis** is defined as the ability of an organism to maintain a stable internal environment of the

body despite changes in the external environment. Examples of homeostasis include regulating the temperature, blood pressure, blood sugar, and pH levels.

Importance of Homeostasis

Homeostasis plays a vital role in supporting overall health and well-being. For example;

- Each cell is a sophisticated machine that plays a precise role within the body. The proper functioning of cell is possible only when extracellular conditions such as temperature, pH, and the concentrations of salts, glucose and oxygen are kept in normal range.
- When we do hard work, our muscles produce heat that raises the body temperature. In such situation, the temperature regulating centre in the brain sends message to sweat glands. As a result, sweating occurs and the temperature of the body falls to normal.
- When the body temperature falls, the temperature regulatory centre sends message to muscles. As a result, shivering occurs to generate heat.

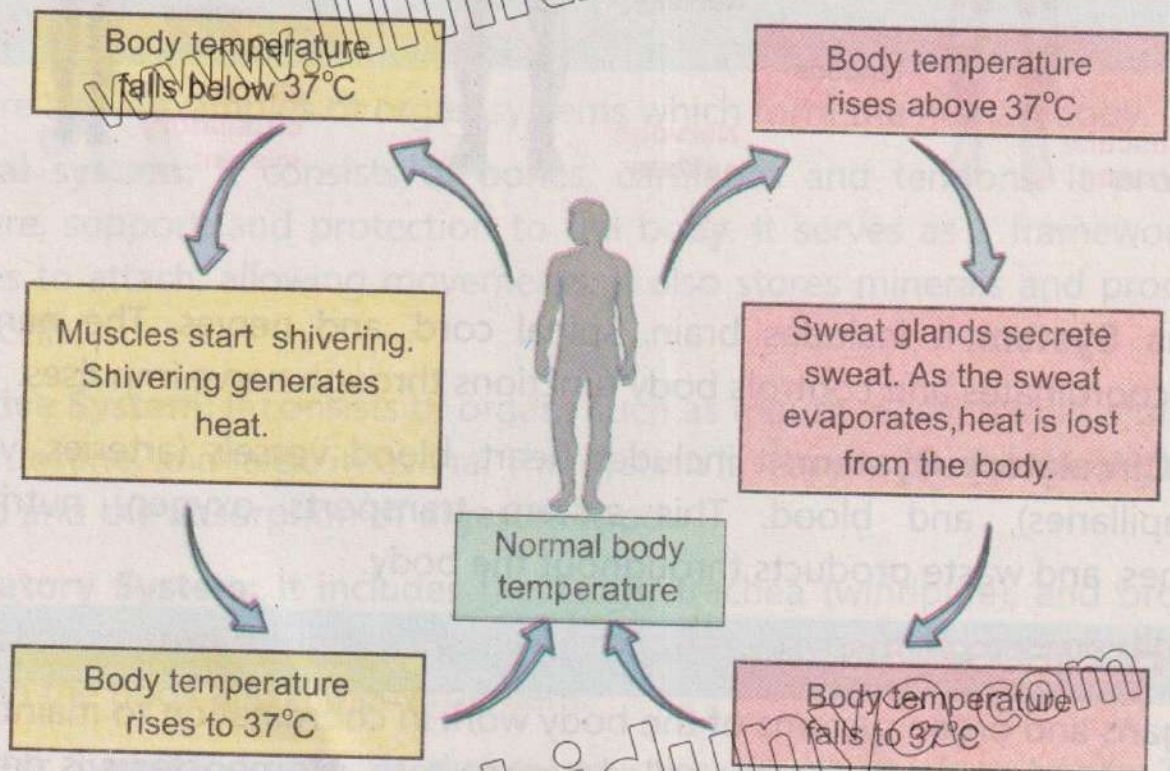


FIGURE 5.6: Homeostasis of body temperature

- When we drink juice, blood glucose level rises. In this situation, pancreas releases a hormone insulin in blood. This hormone lowers the blood glucose level to normal.
- When we do hard exercise, our muscles need more oxygen. In such condition, the rate of breathing and heartbeat are increased. Accelerated breathing and heartbeat supply more oxygen and food to the muscles for continuous work.

Role of Organ Systems in Homeostasis

Several organ systems work together for homeostasis. For example;

- Nervous system and endocrine system regulate and coordinate activities such as heart rate, respiration, and metabolism. They also respond to changes in the environment.
- Respiratory system ensures that the body receives enough oxygen for cellular respiration. It also expels excess carbon dioxide from the body.
- Cardiovascular system plays role in the regulating body temperature and pH levels. It also ensures that all cells receive the necessary substances for proper functions.
- Digestive system works for proper distribution of nutrients to cells for energy, growth, and repair.
- Muscular and skeletal systems help to maintain body posture, support and movement.
- Urinary system eliminates waste materials from the body. It also regulates water and salt balance in body tissues. In this way, it maintains blood volume, blood pressure, and pH levels.
- Integumentary system acts as a barrier to protect the body from external factors. It also helps to regulate temperature through sweating.

KEY POINTS

- Organelles are the subunits of a cell that perform distinct functions.
- A tissue is a group of similar cells that work together to perform a specific function.
- Organs are structures made up of more than one type of tissues having related function that work together.
- An organ system is a collection of different organs that work together to perform a related function.
- The epithelial tissue of the stomach secretes gastric juice, which contains mucus, HCl and pepsinogen. Mucus protects the stomach lining.
- The smooth muscles of stomach help in the breakdown of food.
- Mesophyll tissue is present in leaf. Its cells contain chloroplasts. It is the site of photosynthesis.
- Xylem and Phloem are the vascular tissues responsible for transporting water and nutrients.
- Homeostasis is defined as the body's ability to maintain a relatively stable internal environment despite the changes in the external environment.
- Organ systems work together for homeostasis.

EXERCISE

A. Select the correct answers for the following questions.

1. A higher level of organization exhibits emergent properties when:
 - a) Its parts function independently.
 - b) The sum of its parts is greater than the whole.
 - c) The individual parts are more important than the whole.
 - d) Its parts interact to perform more functions.
2. Which of the following demonstrates the levels of organization of the body, from simplest to most complex?
 - a) Cell → Organ → Tissue → Organelle → Organ system
 - b) Organelle → Cell → Tissue → Organ → Organ system

- c) Tissue → Cell → Organelle → Organ → Organ system
 d) Organ system → Tissue → Cell → Organelle → Organ
3. At which level of organization gas exchange occurs between body and environment?
 a) Organelle level in mitochondria
 b) Cellular level in alveolar cells
 c) Tissue level in epithelial tissues
 d) Organ system level in the respiratory system
4. The epithelial tissue in the stomach wall is responsible for producing:
 a) Mucus
 b) Pepsinogen
 c) Hydrochloric acid
 d) All of these
5. In the wall of stomach, which tissue also contains blood vessels and nerves?
 a) Epithelial
 b) Muscle
 c) Inner connective
 d) Outer connective
6. In a leaf, which tissue is responsible for photosynthesis?
 a) Xylem
 b) Mesophyll
 c) Epidermis
 d) Phloem
7. What is the primary function of the xylem tissue in a leaf?
 a) To transport sugars to other parts
 b) To transport water to parts of leaf
 c) To synthesize chlorophyll
 d) To control the opening and closing of stomata
8. Which of these is a function of the human skeletal system?
 a) Storing minerals and producing blood cells
 b) Removing carbon dioxide from blood
 c) Filtering blood to remove waste products
 d) Breaking down food for energy
9. Which structures are responsible for the transport of food in plant body?
 a) Xylem tissue
 b) Palisade mesophyll
 c) Phloem tissue
 d) Spongy mesophyll
10. In a plant, which of the following is the primary function of the flower?
 a) Transporting water and minerals
 b) Supporting leaf growth
 c) Facilitating reproduction through pollination
 d) Regulating gas exchange

B. Write short answers.

1. Enlist the levels of organization from cells to organ systems.
2. What are the major roles of the epithelial tissue present in the stomach?
3. How do the smooth muscles contribute to the stomach's function?
4. What is the function of the palisade mesophyll in the leaf?
5. What is the role of the shoot system in plants?
6. What is homeostasis, and why is it important for organisms?
7. How does the human body maintain a stable internal temperature?
8. Differentiate between the following:
 - i. Tissue and organ
 - ii. Root system and shoot system
 - iii. Epidermal and mesophyll tissue
 - iv. Palisade and spongy mesophyll

C. Write answers in detail.

1. Explain the levels of organization in multicellular organism. How does each level contribute to the overall functioning of an organism?
2. What is a tissue level? Explain plant and animal tissues.
3. Describe the tissue composition of the stomach. How does each tissue contribute to the digestive function of the stomach?
4. Describe the tissue composition of the leaf. How does each tissue contribute to the functions of the leaf?
5. How do the organ systems come together to form the human body?
6. Describe the roles of the digestive system and the excretory system in homeostasis.
7. Explain the functions of various plant organs.
8. Describe the structure and function of the plant root system.
9. Define homeostasis and explain its importance. Discuss how different organ systems work together to maintain homeostasis.
10. Describe how the respiratory and circulatory systems work together to maintain homeostasis of oxygen and carbon dioxide levels in the body.

D. Inquisitive questions.

1. How does the structure of epithelial tissue relate to its function in different parts of the body?
2. Evaluate the importance of organ systems working in harmony and predict the consequences of a failure in one system on the others.