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A Textbook of Biology
for Grade 10

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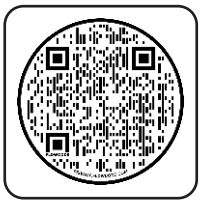

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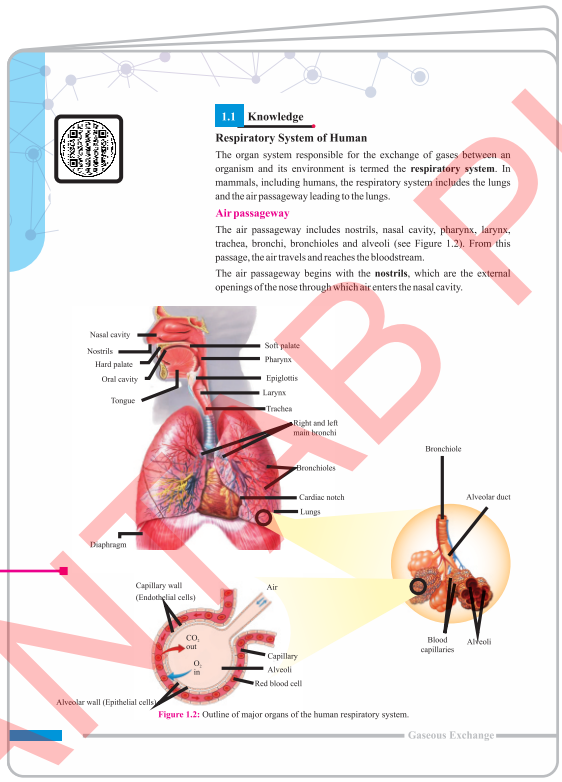
Preface

Biology textbook is designed for Grade 10 students and is aligned with the 2022 – 2023 National Curriculum. The book has been created to provide an enhanced learning experience to students, through the use of high-quality pictorial representations, real-life applications, and experimental skills. It also includes high-order thinking exercises, skill sheets for testing understanding, group activities, and recorded video lectures with animations and simulations. The book has been structured to assist teachers in creating assessment questions based on Bloom's Taxonomy. Additionally, there is a comprehensive glossary located at the end of the book, which provides quick-term references. The ultimate goal of this educational tool is to enrich students' knowledge and appreciation of biology.

How to use this book

The QR codes in the biology textbook provide easy access to video lectures for gaining knowledge and skill sheets for practical application. They make learning more interactive, letting students watch lectures and practice skills right when they need them, making studying biology more engaging and effective.



1.1 Knowledge

Respiratory System of Human

The organ system responsible for the exchange of gases between an organism and its environment is termed the **respiratory system**. In mammals, including humans, the respiratory system includes the lungs and the air passageway leading to the lungs.

Air passageway

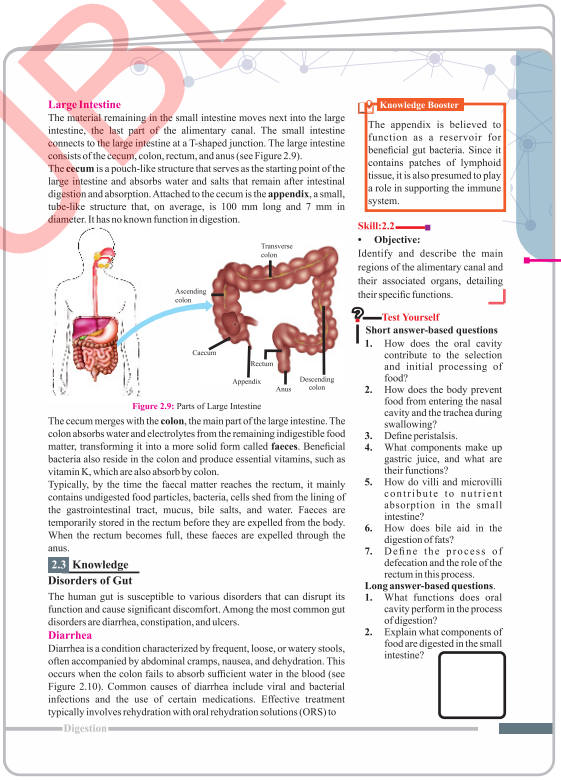
The air passageway includes nostrils, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles and alveoli (see Figure 1.2). From this passage, the air travels and reaches the bloodstream.

The air passageway begins with the **nostrils**, which are the external openings of the nose through which air enters the nasal cavity.

Figure 1.2: Outline of major organs of the human respiratory system.

Gaseous Exchange

Pictures in a biology textbook create strong mental images that stick with students, making it easier to remember and understand complex information quickly. These visuals serve as powerful memory aids, reinforcing concepts in a way that stays in students' minds for a long time.



Large Intestine

The material remaining in the small intestine moves next into the large intestine, the last part of the alimentary canal. The small intestine connects to the large intestine at a T-shaped junction. The large intestine consists of the cecum, colon, rectum, and anus (see Figure 2.9).

The **cecum** is a pouch-like structure that serves as the starting point of the large intestine and absorbs water and salts that remain after intestinal digestion and absorption. Attached to the cecum is the **appendix**, a small, tube-like structure that, on average, is 100 mm long and 7 mm in diameter. It has no known function in digestion.

Figure 2.9: Parts of Large Intestine

The cecum merges with the **colon**, the main part of the large intestine. The colon absorbs water and electrolytes from the remaining indigestible food matter, transforming it into a more solid form called **faeces**. Beneficial bacteria also reside in the colon and produce essential vitamins, such as vitamin K, which are also absorb by colon.

Typically, by the time the faecal matter reaches the rectum, it mainly contains undigested food particles, bacteria, cells shed from the lining of the gastrointestinal tract, mucus, bile salts, and water. Faeces are temporarily stored in the rectum before they are expelled from the body. When the rectum becomes full, these faeces are expelled through the anus.

2.3 Knowledge

Disorders of Gut

The human gut is susceptible to various disorders that can disrupt its function and cause significant discomfort. Among the most common gut disorders are diarrhea, constipation, and ulcers.

Diarrhea

Diarrhea is a condition characterized by frequent, loose, or watery stools, often accompanied by abdominal cramps, nausea, and dehydration. This occurs when the colon fails to absorb sufficient water in the blood (see Figure 2.10). Common causes of diarrhea include viral and bacterial infections and the use of certain medications. Effective treatment typically involves rehydration with oral rehydration solutions (ORS) to

Digestion

Knowledge Booster

The appendix is believed to function as a reservoir for beneficial gut bacteria. Since it contains patches of lymphoid tissue, it is also presumed to play a role in supporting the immune system.

Skill:2.2

- **Objective:**

Identify and describe the main regions of the alimentary canal and their associated organs, detailing their specific functions.

Test Yourself

Short answer-based questions

1. How does the oral cavity contribute to the selection and initial processing of food?
2. How does the body prevent food from entering the nasal cavity and the trachea during swallowing?
3. Define peristalsis.
4. What components make up gastric juice, and what are their functions?
5. How do villi and microvilli contribute to nutrient absorption in the small intestine?
6. How does bile aid in the digestion of fats?
7. Define the process of defecation and the role of the rectum in this process.

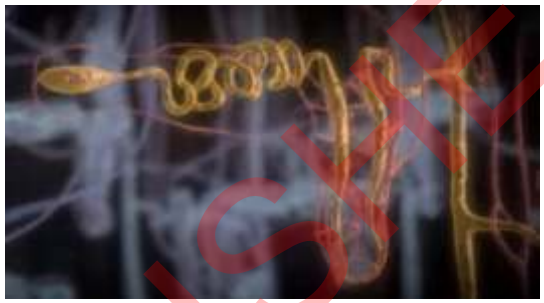
Long answer-based questions.

1. What functions does oral cavity perform in the process of digestion?
2. Explain what components of food are digested in the small intestine?

Skill sheets in textbooks are essential tools that guide students through developing necessary competencies and skills. They help educators identify where students need additional support for more effective teaching strategies.

SLO based Model Video lecture

Animation



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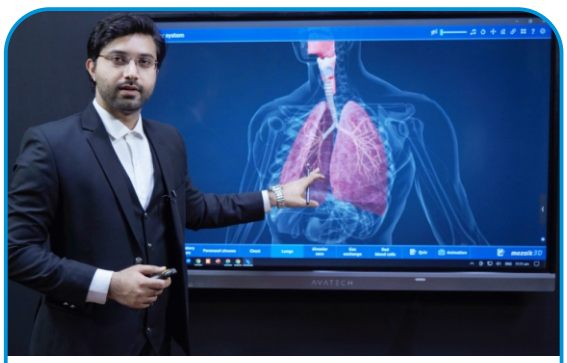

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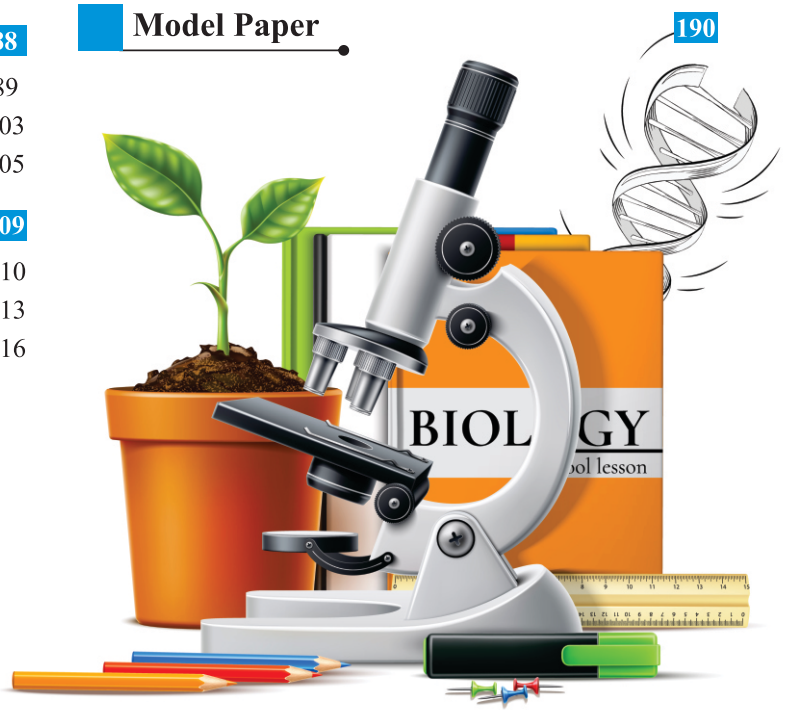

CHAPTER 1

Gaseous Exchange

"Let us embark on an exciting journey through the Student Learning Outcomes (SLOs) outlined in the curriculum. These SLOs serve as your roadmap to mastering essential knowledge and honing core skills. To make your learning experience seamless and interactive, you will find QR codes embedded within the main text. These codes provide instant access to test skills, skill sheets, and worksheets, all thoughtfully designed to help you apply what you have learned effectively."

1.1 Knowledge

Respiratory System of Human

Student Learning Outcomes

Describe the roles of the parts of the air passageway and lungs.

1.2 Knowledge

Mechanism of Breathing

Student Learning Outcomes

Describe the mechanism of breathing in terms of movements of ribs and diaphragm.
Differentiate between the composition of inspired and expired air.

1.3 Knowledge

Respiratory Disorders

Student Learning Outcomes

Discuss briefly diseases related to respiratory system like bronchitis, emphysema, pneumonia, asthma, and lung cancer.

Introduction

In grade 9, students studied cellular respiration, an energy-releasing process at the cellular level. During cellular respiration, cells break down organic molecules (primarily glucose) to release energy in the form of ATP (adenosine triphosphate), the energy currency of the cell. For aerobic respiration (a type of cellular respiration), oxygen (O_2) is required for the complete oxidation of food molecules, while carbon dioxide (CO_2) is released as a byproduct. The carbon dioxide produced must be removed from the cell to maintain cellular health and function. This means that organisms need to take in O_2 from the environment (air or water) for aerobic respiration and remove CO_2 into the environment.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$$

Glucose Oxygen Carbon Dioxide Water Energy

This unit will focus on **respiration,** the physiological process that collectively supply body cells with oxygen from the environment and deliver waste carbon dioxide to the environment. This process involves the **exchange of gases** at both the organismic and cellular levels (see Figure 1.1).

Gaseous exchange at the organismic level is the process of exchanging oxygen and carbon dioxide between an organism and its external environment. This exchange occurs through specialized respiratory structures, such as the lungs in terrestrial mammals. For instance, in humans, oxygen is inhaled into the lungs and diffuses into the bloodstream. Simultaneously, carbon dioxide diffuses from the blood into the lungs to be exhaled.

At the cellular level, gaseous exchange involves the movement of oxygen from the blood into the cells and the removal of carbon dioxide from the cells into the blood. This exchange occurs via diffusion across cell membranes.

Knowledge Booster

Breathing is the physical process of moving air into and out of the lungs.

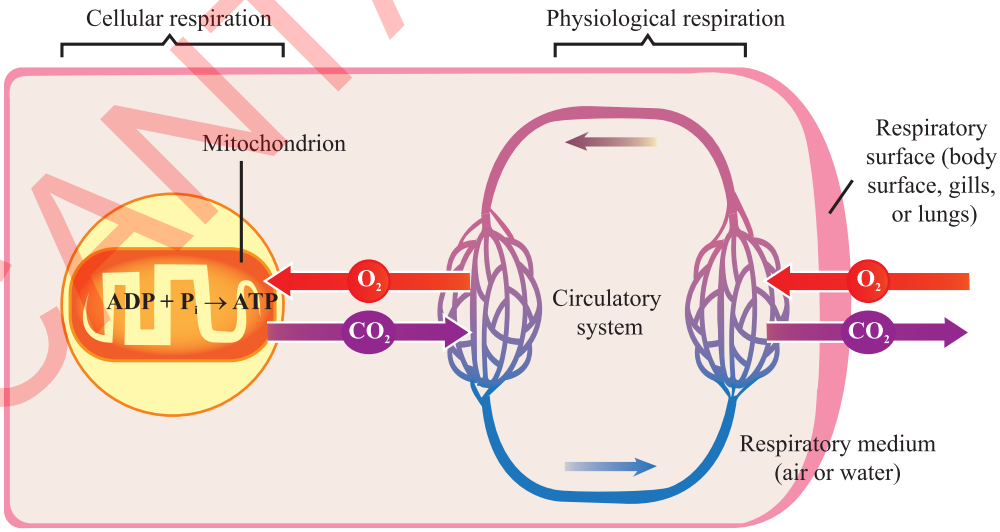

Figure 1.1: The relationship between cellular respiration and physiological respiration.

1.1 Knowledge

Respiratory System of Human

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Air passageway

The air passageway includes nostrils, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles and alveoli (see Figure 1.2). From this passage, the air travels and reaches the bloodstream.

The air passageway begins with the **nostrils**, which are the external openings of the nose through which air enters the nasal cavity.

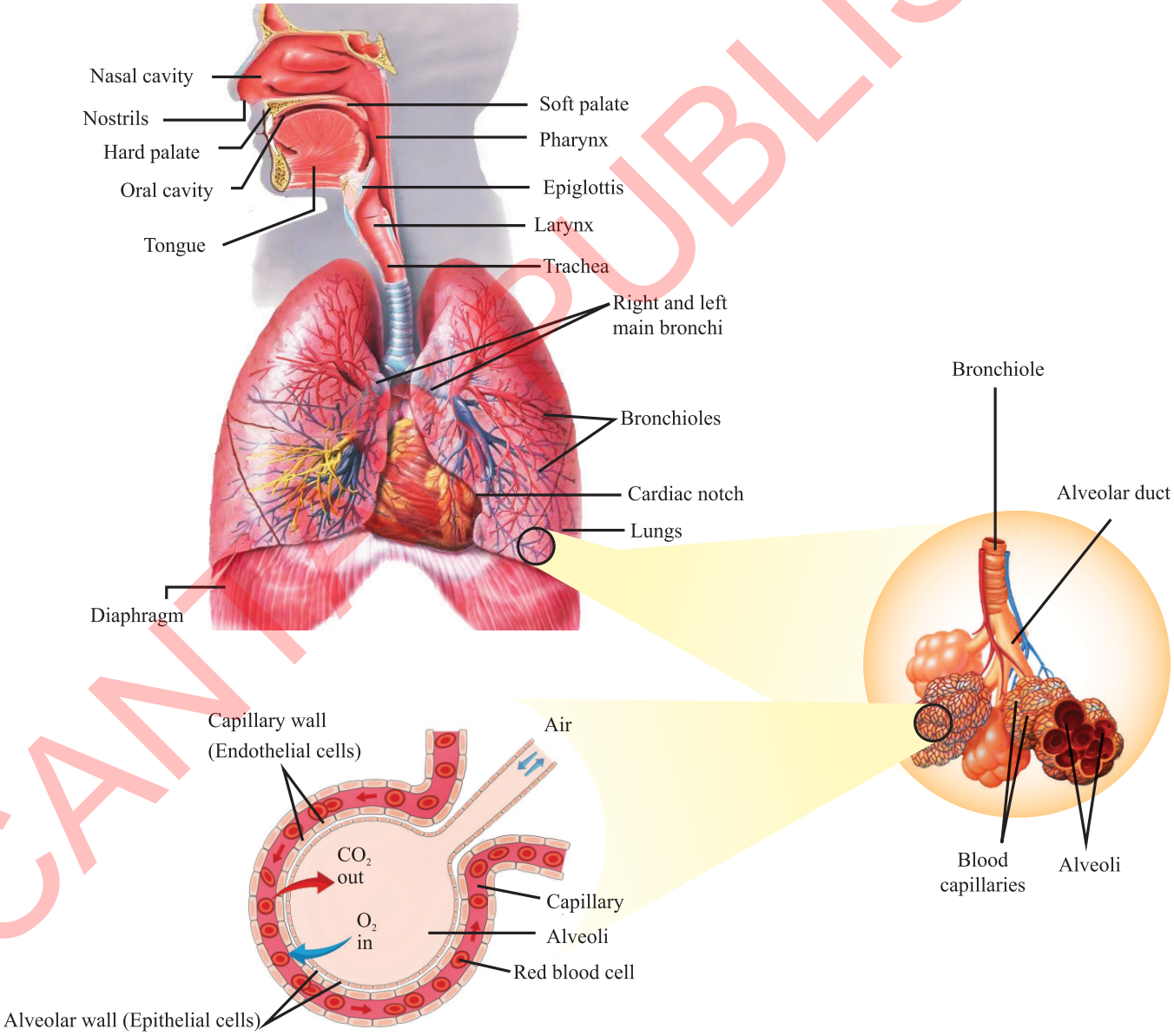


Figure 1.2: Outline of major organs of the human respiratory system.

The **nasal cavity** is the internal space behind the nostrils within the nose and is divided by the nasal septum (composed of bone and cartilage) into two chambers. The nasal cavity is lined with tiny hairs, cilia and a mucous membrane, which trap dust, pollen and pathogens. The mucous membrane also moistens the air. The blood vessels lining the nasal cavity release heat, warming the incoming air. This filtered, humidified, and warmed air then continues down the respiratory tract.

Air continues to the back of the nasal cavity and passes through the internal openings (known as the internal nostrils) into the pharynx, which is also lined with a mucus membrane. The **pharynx** is a muscular passageway common for both air from the nasal cavity to the larynx and food from the mouth to the esophagus. From the pharynx, air moves into the **larynx**, which is commonly known as the voice box because of its role in sound production. The space inside the larynx is called glottis, across which the two vocal cords (or vocal folds) are stretched. These vocal cords are two flexible bands of muscle and connective tissue covered by a mucus membrane. As air passes through the **glottis**, these vocal cords vibrate, producing sound. A cartilage flap in the upper part of the larynx is called **epiglottis**. During swallowing, the epiglottis covers the glottis to prevent food from entering the windpipe. However, when you breathe in, the glottis stays uncovered to allow air into the trachea.

Knowledge Booster

Talking or laughing while swallowing can leave the glottis open, allowing food or liquid to enter the trachea instead of the esophagus. This can lead to choking or trigger a strong cough to expel the food or liquid.

From the larynx, air travels down the **trachea** (windpipe), a 10–12 cm long tube. The trachea contains C-shaped cartilaginous rings, which keep it open and prevent it from collapsing. The trachea then divides into two **bronchi**, which enter the left and right lungs, directing air into the lungs. These bronchi have irregularly shaped plates of cartilage, which help keep them open. These bronchi continue to branch and become progressively smaller in diameter. When the bronchi reach a diameter of 1millimeter or less than 1mm, they are called **bronchioles**. Unlike the bronchi, bronchioles do not contain cartilage. Each bronchiole further branches into **alveolar ducts**, which open into alveolar sacs. These sacs contain multiple cup-shaped structures called **alveoli**, where gas exchange occurs.

Do You Know ?

The trachea and bronchi have tiny hair-like structures called cilia and a mucous membrane that help keep the lungs clean. The mucus traps dust and other particles, while the cilia push the mucus upward toward the throat. This process, like an elevator, moves unwanted particles away from the lungs, where they are swallowed and removed from the body.

Lungs

A pair of lungs is located on either side of the heart within the thoracic cavity (chest cavity). The right lung is divided into three lobes, while the left lung is slightly smaller, divided into two lobes, and includes the **cardiac notch**, an indentation to accommodate the heart. The lungs are covered by a double layer of epithelial tissue called the **pleura**. The inner pleural membrane (visceral pleura) directly covers the surface of the lungs, while the outer pleural membrane (parietal pleura) lines the internal surface of the thoracic cavity. The space between these layers

is called the **pleural cavity**, which contains pleural fluid and reduces friction during breathing movements (see Figure 1.3). The lungs are protected by the ribcage, which is composed of 12 pairs of ribs. The ribs are connected to the vertebrae at the back and, mostly, to the sternum at the front through costal cartilage.

Skill:1.1

Objective:

Critically analyze and interpret the structural and functional aspects of the air passageway and lungs to gain a comprehensive understanding of their roles.

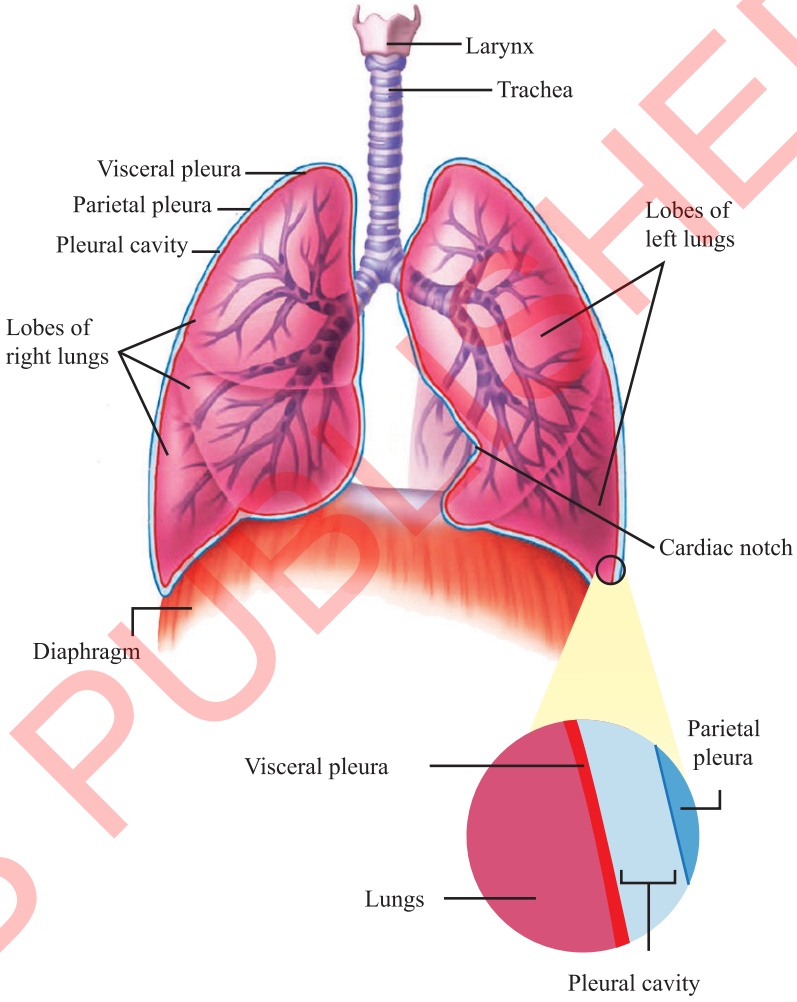


Figure 1.3: The pleura of the lungs

Test Yourself

Short answer-based questions

1. What is the function of the trachea in the respiratory system?
2. How do the alveoli contribute to the process of gaseous exchange in the lungs?
3. What are the features of lungs?

The lungs have a light, spongy structure due to the millions of alveoli they contain. This extensive network of alveoli provides a greater surface area, ensuring that a large amount of oxygen and carbon dioxide can be exchanged simultaneously. The alveoli have very thin walls, just one cell thick, made of epithelial cells. Each alveolus is surrounded by a dense network of capillaries, which are also one cell thick and made of endothelial cells. Oxygen from the alveoli diffuses across the alveolar wall and thin capillary wall into the bloodstream. On the other hand, carbon dioxide, carried by the blood from the body's tissues, diffuses from the capillary wall and alveolar wall into the alveolar space (see Figure 1.2). From there, it is removed from the body. The thin walls of both the alveoli and capillaries ensure efficient gas exchange.

1.2 Knowledge

Mechanism of Breathing

Breathing is the mechanical process of moving air into and out of the lungs. The lungs themselves do not draw air in or push air out. Instead, **intercostal muscles** and the **diaphragm** facilitate the expansion and compression of the lungs. Intercostal muscles are located between the ribs, while the diaphragm is a large, dome-shaped muscle located at the base of thoracic cavity. Inhaling air is called **inhalation** (inspiration), while exhaling air is called **exhalation** (expiration).

Inhalation

During inhalation, the dome-shaped diaphragm contracts to move downward and becomes less dome-like. This movement increases the vertical dimension of the thoracic cavity, increasing its overall volume. At the same time, intercostal muscles contract and pull the ribs upward and outward. This action increases the dimensions of the thoracic cavity in both front-to-back and side-to-side (lateral) directions, further increasing its volume. The combined actions of the diaphragm moving downward and the ribs moving upward and outward significantly increase the volume of the thoracic cavity (see Figure 1.4). As a result, the lungs expand and the air pressure in the lungs falls below the air pressure outside the body. This difference in pressure causes the air to flow into the lungs from the outside to equalize the pressure.

Knowledge Booster

Inhalation is an active process requiring muscle contraction to expand the thoracic cavity, allowing air to enter the lungs. In contrast, exhalation is usually passive at rest; the muscles relax, reducing the thoracic cavity's volume and pushing air out.

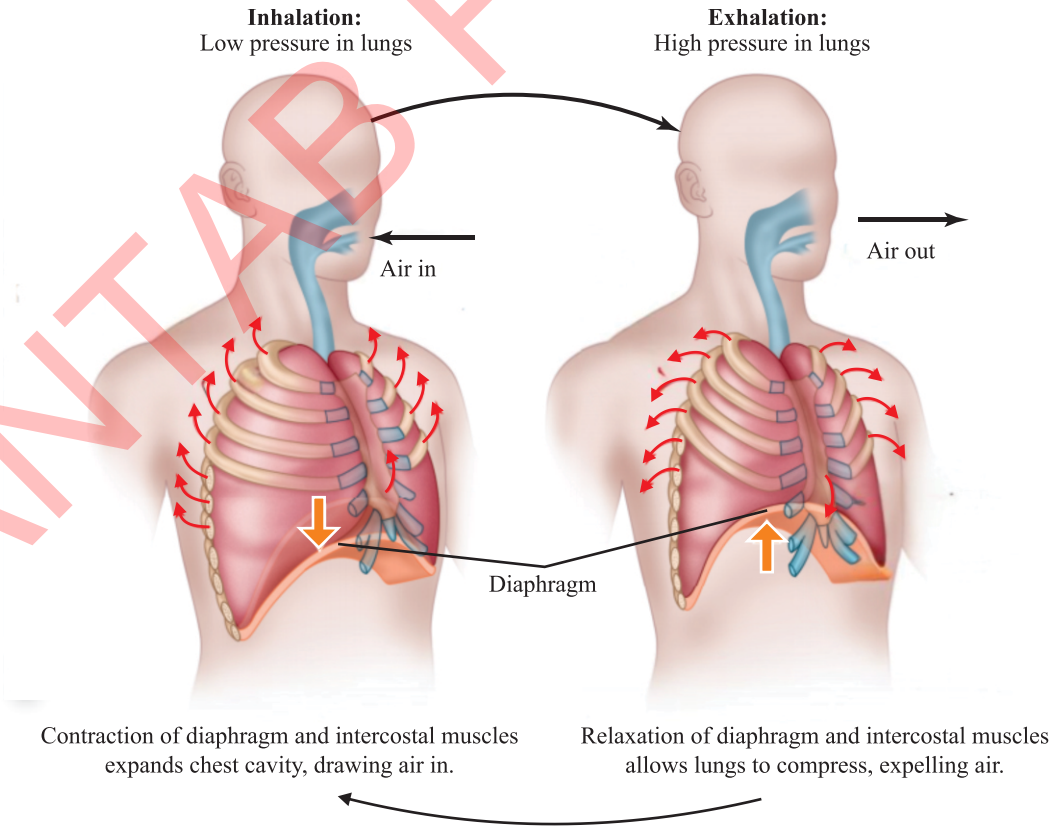


Figure 1.4: Mechanism of breathing in humans.

Exhalation

During exhalation, the diaphragm relaxes and moves upward, returning to its dome-shaped position. The intercostal muscles relax, bringing the ribs back to their inward and downward position. These movements reduce the volume of the thoracic cavity. As a result, the lungs are compressed, and the air pressure inside the lungs increases compared to the one outside of the body. Thus, air flows out of the lungs to the outside environment through the air passageway to equalize the pressure.

Rate of Breathing at Rest and after Exercise

The average breathing rate at rest for adults is about 12-20 breaths per minute. During exercise, this rate increases significantly, sometimes reaching 40-60 breaths per minute, depending on the intensity of the exercise. This increase occurs because, during exercise, muscle cells increase the rate of aerobic respiration, leading to a higher production of carbon dioxide. The respiratory center in the brain (medulla oblongata) detects elevated levels of carbon dioxide in blood and sends signals to the diaphragm and intercostal muscles to contract more frequently, causing increased breathing. These adjustments ensure that carbon dioxide is effectively removed from the body.

Do You Know ?

Stress or excitement can increase breathing rate, while relaxation and meditation slow it down. This is why deep breathing helps reduce anxiety.

Difference between Inspired and Expired Air

The air we breathe in is called **inspired air**, and the air we breathe out is known as **expired air**. The composition of inspired (inhaled) and expired (exhaled) air differs significantly due to the processes of gas exchange that occur in the alveoli in the lungs. The table below illustrates the differences in the composition of inspired and expired air:

Table 1.1: Composition of Inspired and Expired Air

Component	Inspired Air (%)	Expired Air (%)	Change
Oxygen (O_2)	21	16	Decreases (used in respiration)
Carbon Dioxide (CO_2)	0.04	4	Increases (produced in respiration)
Nitrogen (N_2)	79	79	Remains largely unchanged
Water Vapour (H_2O)	Variable	Saturated	Increases (humidified by respiratory tract)

This table illustrates that the primary differences between inspired and expired air are the differences in the levels of oxygen and carbon dioxide.

Skill:1.2

Objective:

Apply anatomical and physiological knowledge to explain the mechanics of breathing and analyze the changes in gas composition during the respiratory process.

Test Yourself

Short answer-based questions

1. What is the role of the diaphragm in breathing?
2. Compare the inspired or expired air during breathing.

Long answer-based questions

3. Explain the mechanism of breathing in human.

1.3 Knowledge

Respiratory Disorders

The respiratory system plays a vital role in providing oxygen to the body and removing carbon dioxide. However, it can be affected by various

diseases that impair its function, leading to difficulties in breathing and reduced oxygen supply to the body. These respiratory diseases can affect any part of the respiratory system. These diseases can be acute (short-term) or chronic (long-term) and may result from infections, environmental factors, genetic conditions, or other underlying health issues. Common respiratory diseases include the following diseases.

Bronchitis

Bronchitis is the inflammation of bronchial tubes, leading to excessive mucus secretion in the tubes (see Figure 1.5). This excess mucus can clog the airways, making it difficult to breathe and resulting in a cough. It is caused by viruses, bacteria, or irritants like tobacco smoke, dust, and toxic gases. Symptoms of bronchitis include a persistent cough, chest discomfort, difficulty in breathing or shortness of breath, fever, and fatigue. Based on the duration and severity of symptoms, bronchitis is classified into two types: acute bronchitis and chronic bronchitis.

Acute bronchitis is a short-term inflammation of the bronchial tubes that typically lasts from a few days to a few weeks. Viruses are the most common cause of acute bronchitis. Treatment focuses on relieving symptoms, which includes rest, pain relievers, and cough medicines. Most patients recover completely, and the bronchial tubes return to normal function within a couple of weeks without complications.

Chronic bronchitis, on the other hand, is a long-term condition characterized by persistent inflammation of the bronchial tubes, often due to prolonged exposure to irritants such as tobacco smoke. Symptoms last for at least three months to two consecutive years. There is no cure for chronic bronchitis, and the damage to the airways is often permanent.

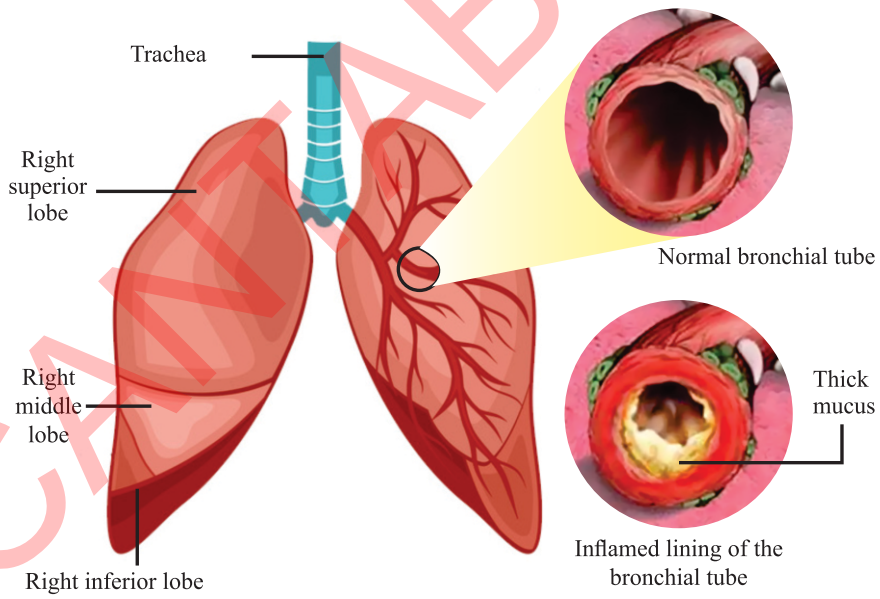


Figure 1.5: Diagram illustrating bronchitis, showing the normal bronchial tube compared to an inflamed bronchial tube with thick mucus.

Emphysema

Emphysema is characterized by the destruction of the walls of alveoli in the lungs. The most significant risk factor for emphysema is smoking. Long-term exposure to air pollutants such as dust and fumes can also contribute to the development of emphysema.

Irritants such as tobacco smoke cause the elastic fibers in the alveolar walls to be destroyed. The destruction of alveolar walls creates larger air spaces, replacing the many smaller ones, which reduces the available surface area for gas exchange (see Figure 1.6). The lungs lose their ability to return to their normal size. It causes air to become trapped in the lungs. This trapped air leads to overinflation of the lungs, making it difficult to expel air during exhalation.

Knowledge Booster

Rarely, emphysema is caused by an inherited deficiency of a protein that protects the elastic structures in the lungs. It is called **alpha-1-antitrypsin deficiency emphysema.**

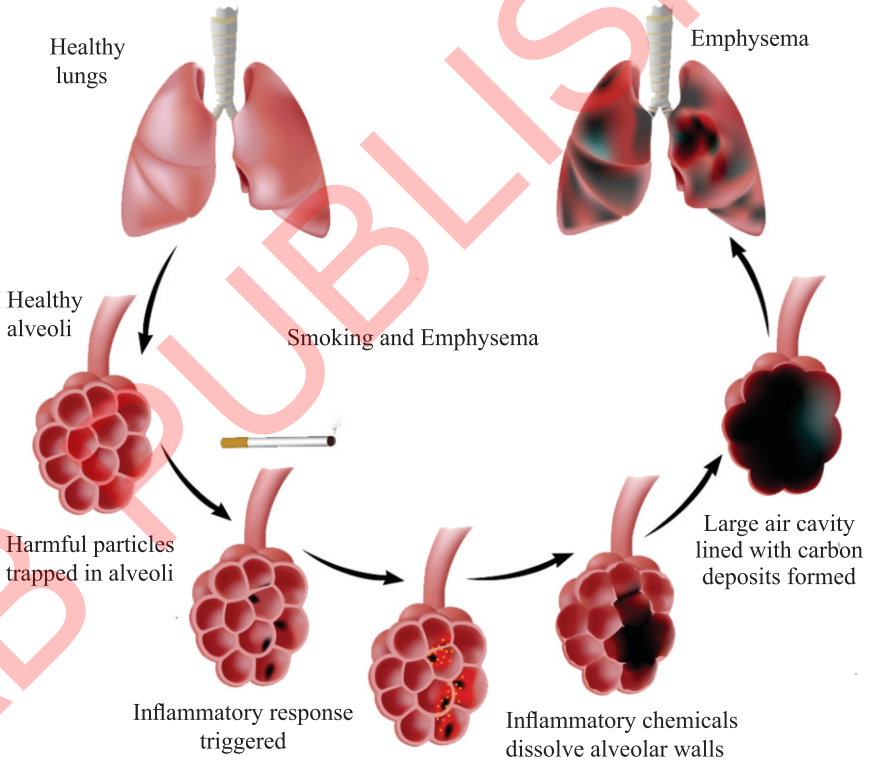


Figure 1.6: The progression from healthy lungs to emphysema caused by smoking.

Symptoms of emphysema include shortness of breath, especially during physical activities but can progress to constant breathlessness even at rest, persistent cough, wheezing (whistling sounds during breathing), fatigue and weight loss.

While there is no cure for emphysema, quitting smoking and avoiding irritants can slow the progression of the disease. Oxygen therapy is needed for patients with severe emphysema and low blood oxygen levels.

Pneumonia

Pneumonia is an infection that inflames the alveoli in one or both lungs. It can be caused by various organisms, including bacteria, viruses, and fungi. The most common bacterial cause is *Streptococcus pneumoniae*.

Pathogens are introduced into the alveoli through inhalation of airborne droplets. These droplets, which contain infectious agents, are expelled into the air when an infected person coughs or sneezes. Once inhaled, these microorganisms settle in the alveoli, multiply and cause inflammation. As a result, the alveoli fill with pus, which hinders the exchange of oxygen and carbon dioxide (see Figure 1.7). Symptoms of pneumonia include a cough with thick mucus, which may be green, yellow, or rust-coloured and sometimes has an unpleasant smell. Additional symptoms are fever, chills, difficulty in breathing, and chest pain that can make breathing and coughing painful. Severe pneumonia can cause significant drops in oxygen levels, resulting in a bluish discolouration of the skin, particularly on the lips, fingertips, and toes.

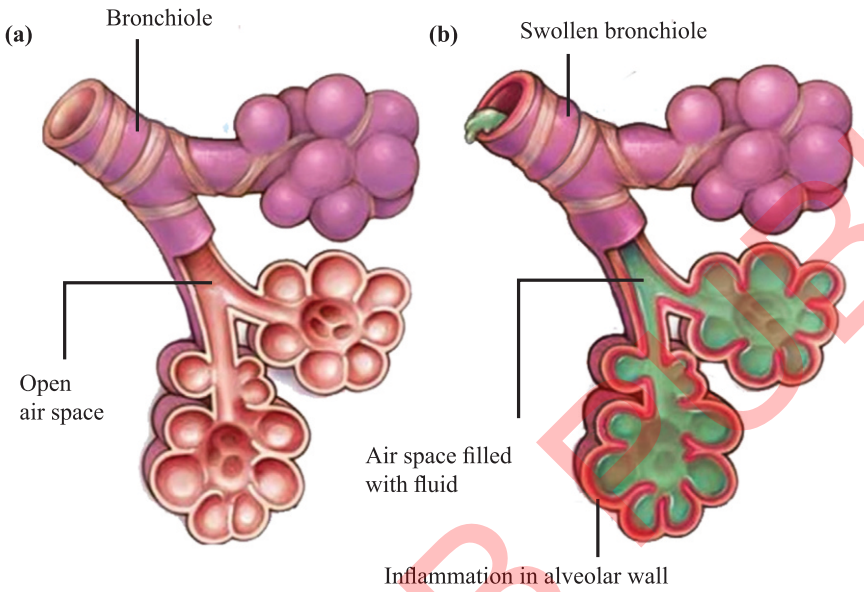


Figure 1.7: (a) Healthy alveoli with open-air spaces. (b) Inflamed alveoli with swollen bronchioles and fluid-filled air spaces, typical of pneumonia.

The primary treatment for pneumonia is antibiotics based on the type of causative bacteria. Preventive measures include vaccines such as *pneumococcal* vaccine, which protects against *Streptococcus pneumoniae* and helps prevent pneumonia.

Asthma

Asthma is a chronic respiratory condition characterized by inflammation and constriction of the airways (primarily bronchi), leading to difficulty breathing. It can be triggered by allergens (allergy-causing agents) such as pollen, dust, and mold spores, as well as irritants like tobacco smoke, air pollution, and chemical fumes. Some people may experience worse symptoms when they have a cold or during changes in the weather.

With asthma, an inhaled allergen or irritant triggers inflammation and tightening of the smooth muscles around the bronchi, causing **bronchoconstriction**. The inflammation also causes excessive mucus production, which can form plugs and block the smaller airways, further

Interesting information

The **hygiene hypothesis** suggests that a lack of early childhood exposure to microbes due to overly clean environments may lead to an increased risk of developing allergic diseases and autoimmune conditions later in life. This exposure helps "train" the immune system to differentiate between harmful and harmless substances. In sanitized environments, this training is weaker, potentially leading to more conditions like asthma and allergies.

obstructing airflow. Symptoms of asthma include shortness of breath, wheezing, coughing (often worse at night or early morning), and chest tightness.

Bronchodilators are medications that relax the muscles around the airways and dilate the airways, making it easier to breathe. They are commonly used in the form of inhalers, which deliver the medication directly into the lungs for rapid effect.

Lung Cancer

Lung cancer is a type of malignancy that primarily originates in the cells lining the air passages (bronchi, bronchioles, and alveoli). It is characterized by the uncontrolled growth of abnormal cells, forming tumors that can block airflow (see Figure 1.8). These tumors can invade nearby tissues such as the pleura and diaphragm and may spread to other body parts (metastasize).

Skill:1.3

Objective:

Effectively analyze, and articulate the causes, symptoms, effects, and treatment options for respiratory diseases.

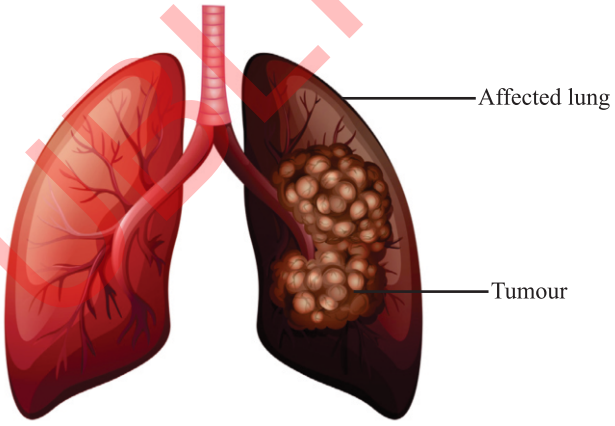


Figure 1.8: Illustration of Healthy Lung vs. Diseased Lung.

Test Yourself

Short answer-based questions

1. What are the primary effects of emphysema on lung respiratory function?
2. Identify the main symptoms and causes of pneumonia.
3. What are the risk factors associated with the development of lung cancer?

Symptoms of lung cancer include persistent cough, chest pain, shortness of breath, wheezing, coughing up blood, weight loss, and fatigue. Smoking is the leading cause of lung cancer, responsible for about 85% of cases. Cigarette smoke contains a complex mixture of over 9500 chemical compounds, including 83 carcinogens (cancer-causing agents) identified by the International Agency for Research on Cancer (IARC). These harmful chemicals cause mutations (changes in DNA) in lung cells, leading to uncontrolled cell growth. Inhaling smoke from other people's cigarettes (passive smoking) also increases the risk of lung cancer. Ionizing radiation, such as frequent X-ray exposure, can also cause mutations in lung cells, increasing the risk of developing lung cancer. Avoiding and quitting smoking is the most effective way to prevent lung cancer. Ensuring smoke-free environments at home, work, and public places is also crucial. The most common treatment for lung cancer is surgery, which includes **segmentectomy** (removal of a small part of the lung), **lobectomy** (removal of a lung lobe) or **pneumonectomy** (removal of an entire lung).

Key Points

- The human respiratory system is responsible for gas exchange between the body and the environment and consists of air passageways and lungs.
- The air passageway includes the nostrils, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, and alveoli, through which air travels to reach the bloodstream.
- The nasal cavity filters, warms, and humidifies incoming air through the action of cilia, mucous membranes, and blood vessels, ensuring the air is clean and suitable for the lungs.
- The larynx, or voice box, contains the vocal cords, which vibrate to produce sound as air passes through the glottis.
- The trachea is supported by C-shaped cartilaginous rings to prevent collapse and divides into bronchi, which further branch into bronchioles and lead to alveolar ducts and alveoli for gas exchange.
- Alveoli have thin walls, surrounded by capillaries, where oxygen diffuses into the blood, and carbon dioxide diffuses out of the blood for exhalation.
- The lungs are spongy organs divided into lobes, covered by pleural membranes with a pleural cavity containing fluid to reduce friction during breathing.
- Breathing involves inhalation (expansion of the thoracic cavity by diaphragm contraction and rib elevation) and exhalation (contraction of the thoracic cavity by diaphragm relaxation and rib lowering).
- Common respiratory diseases include bronchitis, emphysema, pneumonia, asthma, and lung cancer, each affecting different parts of the respiratory system and impairing breathing.

Exercise

Scan QR code for the answers

SLO: ***Describe the roles of the parts of the air passageway and lungs.***

Multiple-Choice Questions (MCQs)

1. The part of respiratory system where gaseous exchange occurs is:
a) Trachea **b)** Bronchi **c)** Bronchioles **d)** Alveoli

2. Exchange of oxygen and carbon dioxide between the body and environments is called:
a) Nutrition **b)** Transportation **c)** Respiration **d)** Excretion

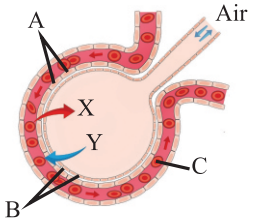
3. The structure which closes off the larynx when food is being swallowed is
a) Glottis **b)** epiglottis **c)** Internal nares **d)** vocal cords

4. Gaseous exchange in the lungs happens by the process of:
a) Osmosis **b)** diffusion **c)** Exocytosis **d)** Active transport

5. Which sequence of organs is correct in air passageway of man?
a) Nasal cavities → larynx → pharynx → trachea → bronchi
b) Nasal cavities → pharynx → trachea → larynx → bronchi
c) Nasal cavities → pharynx → larynx → bronchi → trachea
d) Nasal cavities → pharynx → larynx → trachea → bronchi

Short Response Questions (SRQs)

1. Below is a diagram of an alveolus and the surrounding structures.
a) Label the cells A, B and C. b) Identify the gases X and Y.
c) Why is the structure of alveoli suited for gas exchange?

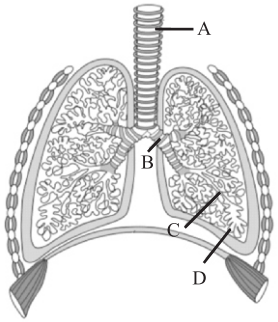


2. What is the role of nasal cavity in respiratory system?

3. How do the alveoli facilitate gas exchange in the lungs?

4. What is the role of the pleural membranes and pleural fluid in the respiratory system?

5. Below is a part of the respiratory system in humans.
a) Identify the parts labelled A, B, C and D in the diagram.
b) State the name of the tissue that forms C-shaped structures in the wall of the structure labelled A and state its function.



Extended Response Questions

1. Describe the pathway of air from the nostrils to the alveoli.
2. Explain how the structure of the lungs facilitate efficient breathing and gas exchange.

SLO: *Describe the mechanism of breathing in terms of movements of ribs and diaphragm.*

Multiple-Choice Questions (MCQs)

1. During inspiration, the chest cavity:
   a) contracts **b)** expands **c)** not affected at all **d)** both 1 & 2
2. What does not happen during inspiration in man?
   a) The intercostal muscles contract **b)** Ribs are elevated
   c) Diaphragm becomes dome-shaped **d)** Ribs move forward
3. Which of the following changes occur in the thoracic cavity during inhalation?

Option	Volume of Thoracic Cavity	Pressure in Thoracic Cavity
(a)	Decreases	Increases
(b)	Increases	Decreases
(c)	No Change	No Change
(d)	Increases	No Change

4. What happens to the air pressure inside the lungs during exhalation?
   a) It decreases below atmospheric pressure **b)** It remains the same as outside pressure
   c) It increases above atmospheric pressure **d)** It becomes zero
5. How does the ribs and diaphragm behave during exhalation?

Option	Ribs	Diaphragm
(a)	Moves downward	Less dome like
(b)	Moves upward	More Dome-shaped
(c)	Stays the same	Remains flat
(d)	Expands	Contracts

Short Response Questions (SRQs)

1. Define inhalation and exhalation in terms of the movement of air in the lungs.
2. What happens to the diaphragm during breathing, and how does it affect the thoracic cavity?
3. Give the role of intercostal muscles in the breathing process.
4. Describe the pressure changes inside the lungs during inhalation and exhalation.

Extended Response Questions (ERQs)

1. Explain the mechanism of breathing in detail.

SLO: *Differentiate between the composition of inspired and expired air.*

Multiple-Choice Questions (MCQs)

1. Which component remains almost the same in inspired and expired air?
   a) Oxygen **b)** Carbon dioxide **c)** Nitrogen **d)** Water vapour
2. When we breathe in, we inhale many gases, including oxygen. What happens to the gases that the body can't use?
   a) They are exhaled. **b)** They are changed into oxygen by the lungs.
   c) They circulate through the body and are disposed of later.
   d) They are absorbed into the digestive system and used to create energy

3. Which gas shows the greatest percentage decrease in expired air?
   a) Oxygen **b)** Carbon dioxide **c)** Nitrogen **d)** Water vapour
4. What is the approximate percentage of oxygen in inspired air?
   a) 16% **b)** 21% **c)** 79% **d)** 4%

Short Response Questions (SRQs)

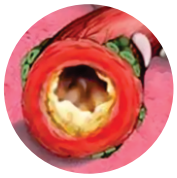
1. Define inspired air and expired air.
2. What changes occur in the composition of inspired and expired air?
3. Why is there a difference in the concentration of carbon dioxide between inspired and expired air?
4. Complete the table.

Gas	Inspired air	Expired air
	21%	
CO_2		
		79%

SLO: ***Discuss briefly diseases related to respiratory system like bronchitis, emphysema, pneumonia, asthma, and lung cancer.***

Multiple-Choice Questions (MCQs)

1. Smoking has been shown to cause:
   a) Bronchitis **b)** Emphysema **c)** Lung cancer **d)** All of these
2. Which respiratory disease is primarily treated with bronchodilators?
   a) Lung cancer **b)** Asthma **c)** Pneumonia **d)** Emphysema
3. Which respiratory disorder is most commonly triggered by allergens and leads to airway constriction?
   a) Pneumonia **b)** Emphysema **c)** Asthma **d)** Lung cancer
4. What respiratory condition is depicted in the following diagram?
   a) Emphysema **b)** Pneumonia
   c) Bronchitis **d)** Lung Cancer



Short Response Questions (SRQs)

1. Enlist causes, symptoms and treatment of pneumonia.
2. Differentiate between acute and chronic bronchitis.
3. How does emphysema affect lung function and what are its primary causes?
4. What are the causes of lung cancer?
5. Complete the table with respect to respiratory disorders.

Disease	Causes	Treatment
	Allergens	
Emphysema		
		Pneumonectomy

Extended Response Questions (ERQs)

1. What are the causes, symptoms and types of bronchitis?
2. Describe the causes, symptoms, and effects of pneumonia on lung function.

CHAPTER 2

Digestion

"Let us embark on an exciting journey through the Student Learning Outcomes (SLOs) outlined in the curriculum. These SLOs serve as your roadmap to mastering essential knowledge and honing core skills. To make your learning experience seamless and interactive, you will find QR codes embedded within the main text. These codes provide instant access to test skills, skill sheets, and worksheets, all thoughtfully designed to help you apply what you have learned effectively."

2.1 Knowledge

Digestive Processes

Student Learning Outcomes

- *Describe the needs of ingestion, digestion, absorption, assimilation and egestion.*

2.2 Knowledge

Human Digestive System

Student Learning Outcomes

- *Identify and describe the structures of the main regions of the alimentary canal and the associated organs.*
- *Describe Swallowing and Peristalsis*
- *Describe the structure of a villus, including the roles of capillaries and lacteals.*
- *State the role of the liver.*
- *Sort out the action of enzymes in specific regions of alimentary canal, with respect to their substrates and products.*

2.3 Knowledge

Disorders of Gut

Student Learning Outcomes

- *State the signs and symptoms, causes, treatments and preventions of the disorders of gut i.e. diarrhea, constipation, and ulcer.*

Introduction

Digesting food is a vital process that involves several steps to turn what we eat into energy and nutrients our body can use. In this chapter, we will explore how food is taken in, broken down, absorbed, utilized, and eventually eliminated. We will examine the main parts of the digestive system, including how they work together to process food. Additionally, we will look at how enzymes help with digestion and discuss common digestive issues like diarrhea, constipation, and ulcers. This chapter will provide a comprehensive overview of how the digestive system functions and why it is crucial for maintaining good health.

2.1 Knowledge

Digestive Processes

Every living organism requires energy to survive, grow, and function efficiently. In humans, this energy is derived from the food we consume. The major components of our food are water, minerals, vitamins, carbohydrates, proteins, and fats. However, except for water, minerals and vitamins, our body cannot directly absorb and utilize the complex organic molecules in their original form. The processing of food is needed to convert these large and complex molecules into simpler substances such as amino acids, simple sugars, and fatty acids that can easily be absorbed and utilized by the body cells. The human digestive system completes this process in five stages: ingestion, digestion, absorption, assimilation, and egestion. Each stage is essential in ensuring that the body efficiently processes and utilizes nutrients while eliminating waste products.

Ingestion: The first step in processing food is ingestion, which involves the intake of food by mouth. Ingestion allows the body to take in nutrients, including carbohydrates, proteins, fats, vitamins, and minerals. Nutrients like carbohydrates, proteins, and fats can then be processed further in subsequent stages.

Digestion: The breakdown of large ingested food molecules into simple, absorbable form is called digestion. Digestion ensures that nutrients are in a form that can be utilized by the body's cells. Digestion can be mechanical (physical breakdown of food through chewing, grinding, or churning) and chemical (enzymatic breakdown of complex molecules into simpler forms).

Absorption: Absorption is the process by which nutrients are taken up from the digestive tract into the bloodstream. This is essential for distributing nutrients to all body cells. Absorption occurs primarily in the small intestine, where specialized structures, such as villi, facilitate it (for detail, see Knowledge 2.2).

Assimilation: Assimilation is the process by which absorbed nutrients are incorporated into the body's cells and tissues. It involves the utilization of absorbed nutrients by cells for various metabolic processes. For example, glucose is used to generate energy, amino acids to build proteins, and fatty acids to construct cell membranes. Assimilation is crucial for repairing damaged tissues and supporting the growth and

Skill:2.1

Objective:

Ability to understand the steps involved in the process of digestion.

Test Yourself

Short answer-based questions

1. Why is ingestion a crucial first step in the processing of food?
2. How does egestion contribute to maintain digestive health?
3. Define the term digestion and give its importance.

Long answer-based questions

1. Describe the steps involved in the processing of food.

development of the body.

Egestion: Egestion is the process of eliminating undigested and unabsorbed food material from the body. This helps prevent the buildup of waste products in the digestive tract, maintain a healthy internal environment, and prevent the accumulation of harmful substances.

In summary, these stages work together to ensure that the body receives and utilizes essential nutrients while effectively eliminating waste. Each stage is crucial for maintaining overall health and supporting the body's functions.

2.2 Knowledge

Human Digestive System

The human digestive system is a complex series of organs and glands that work together to process food. It is made up of a long tube known as the **alimentary canal** (also referred to as the digestive tract, gastrointestinal tract (GIT), or gut), which extends from the mouth to the anus. The primary components of this canal include the mouth, pharynx (throat), esophagus (food pipe), stomach, small intestine, and large intestine (see Figure 2.1). The alimentary canal is responsible for ingestion, digestion, absorption and egestion of indigestible waste. Additionally, several glands associated with the alimentary canal play a vital role in digestion. These include the three pairs of salivary glands, the pancreas, and the liver. These glands secrete various enzymes and substances that assist in the breakdown of food. In this knowledge, we will study the structure and function of the digestive system.

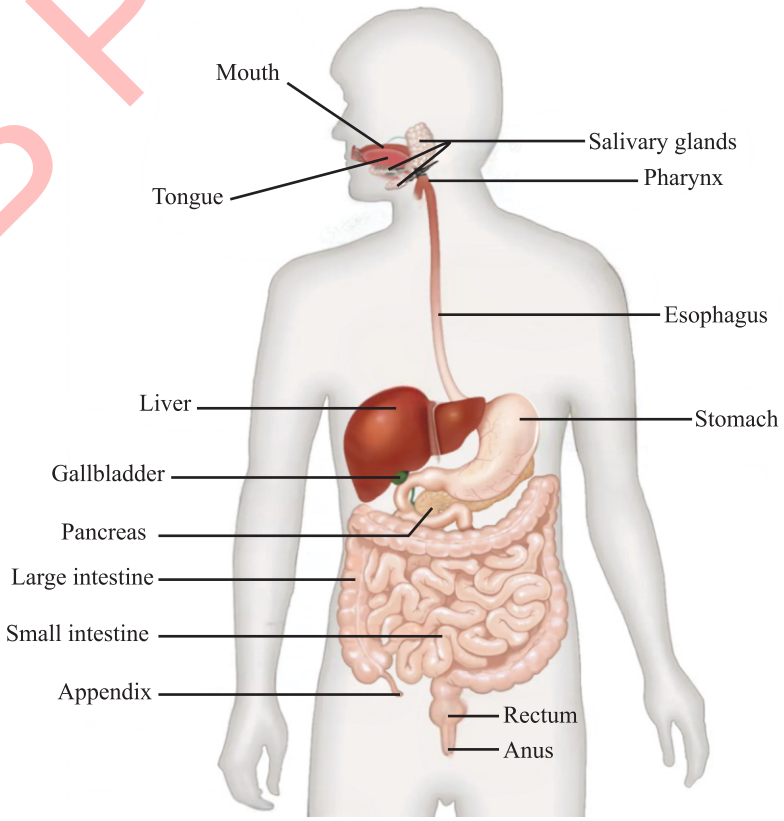


Figure 2.1: Human digestive system

Oral cavity

The alimentary canal begins with the mouth, which serves as the entry point for food. The space inside the mouth is called the **oral cavity**, which is bounded by the lips, cheeks, hard and soft palates, and the muscular floor of the mouth. The oral cavity houses the teeth, gums, tongue and salivary glands, all of which work together to carry out the initial stages of digestion.

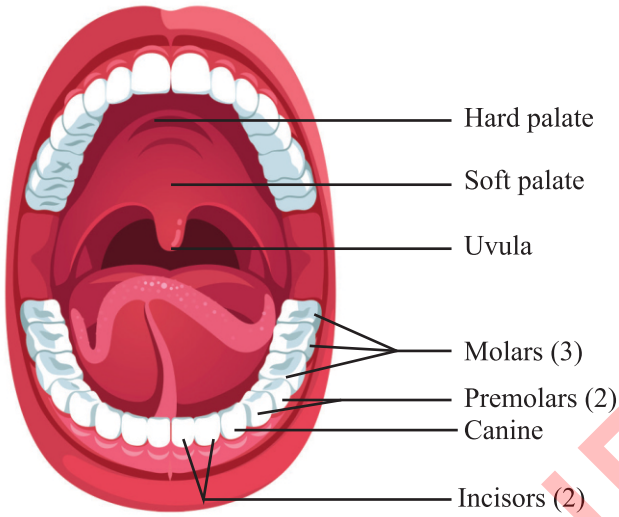


Figure 2.2: Mechanical digestion begins with the teeth. Incisors and canines grasp and cut food, while premolars and molars crush and grind it into smaller pieces for swallowing.

The oral cavity plays an important role in **food selection**. As soon as a bite of food is ingested in the oral cavity, it is tasted and felt. The taste buds present on the tongue help to detect the flavour of food. Other sensory cells on the tongue and the lining of the mouth detect whether food is hard, soft, hot, or cold, helping the oral cavity to choose food that is easy and safe to eat. Additionally, the senses of smell and vision aid in determining the flavour and freshness of food, ensuring that harmful or spoiled items are avoided.

Next, the selected bite undergoes **mastication** (chewing), which is the mechanical process of breaking down food into smaller pieces. The teeth cut, tear, and grind the food, while the tongue and cheeks help in positioning the food between the teeth. This mechanical breakdown increases the surface area of the food, making it easier for digestive enzymes to digest it.

The chewing process stimulates the secretion of saliva from the three pairs of salivary glands. These are the **parotid glands**, located in front of the ears; the **submandibular glands**, beneath the lower jaw; and the **sublingual glands**, under the tongue. Each gland is made up of **acini**, which are clusters of cells that produce saliva. These acini pour their secretions into a salivary duct that transports saliva to the mouth (see Figure 2.3). Saliva contains enzymes, mainly **salivary amylase**, which breaks down starch (polysaccharide) into maltose (simple sugar). It also contains **mucus**, which helps lubricate food. Additionally, saliva contains **bicarbonate ions (HCO_3^-)**, which help neutralize acids in food

Interesting information

Salivary glands are constantly at work, producing about 0.5 mL of saliva per minute even when your mouth is empty, keeping it moist. When food enters the mouth, the brain signals the glands to increase saliva production, helping with digestion. Interestingly, acidic foods such as lemon juice can boost saliva flow up to eight times.

Knowledge Booster

Saliva also contains the enzyme lysozyme, which helps kill bacteria that enter the mouth with food.

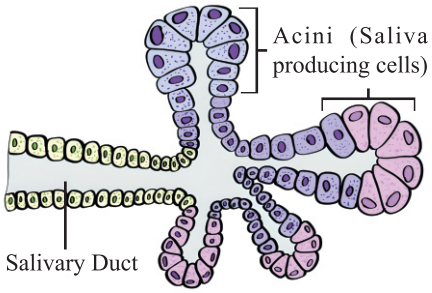


Figure 2.3: Structure of a Salivary Gland

and keep the pH of the mouth between 6.5 and 7.5, which is the optimal range for salivary amylase to function.

As the food is chewed, lubricated, and partially digested, the tongue rolls the pieces of food into a round, smooth, slippery mass called a **bolus**, which is ready to be swallowed. This well-lubricated bolus ensures smooth passage down the esophagus, facilitating the next stages of digestion.

Esophagus

After the formation of the bolus in the oral cavity, the process of swallowing begins. Swallowing, also known as **deglutition**, is the process of moving food from the mouth to stomach through the pharynx and esophagus. It involves three phases: the oral phase, the pharyngeal phase, and the esophageal phase.

Oral Phase: During the oral phase of swallowing, the tongue pushes the bolus to the back of the mouth towards the pharynx, a muscular tube common to both food and air. This phase is under voluntary control.

Pharyngeal Phase: The pharyngeal phase is involuntary. During this phase, the soft palate rises to close off the nasal passages, preventing food from entering the nasal cavity. Simultaneously, the larynx moves upward, and the epiglottis folds down to cover the glottis. This action prevents food and liquid from entering the trachea (windpipe) and directs them towards the esophagus. The upper esophageal sphincter (a ring-like valve of muscle) relaxes, allowing the bolus to enter the esophagus (see Figure 2.4).

Knowledge Booster

The involuntary phases of swallowing are controlled by the swallowing center located in the medulla oblongata and lower pons.

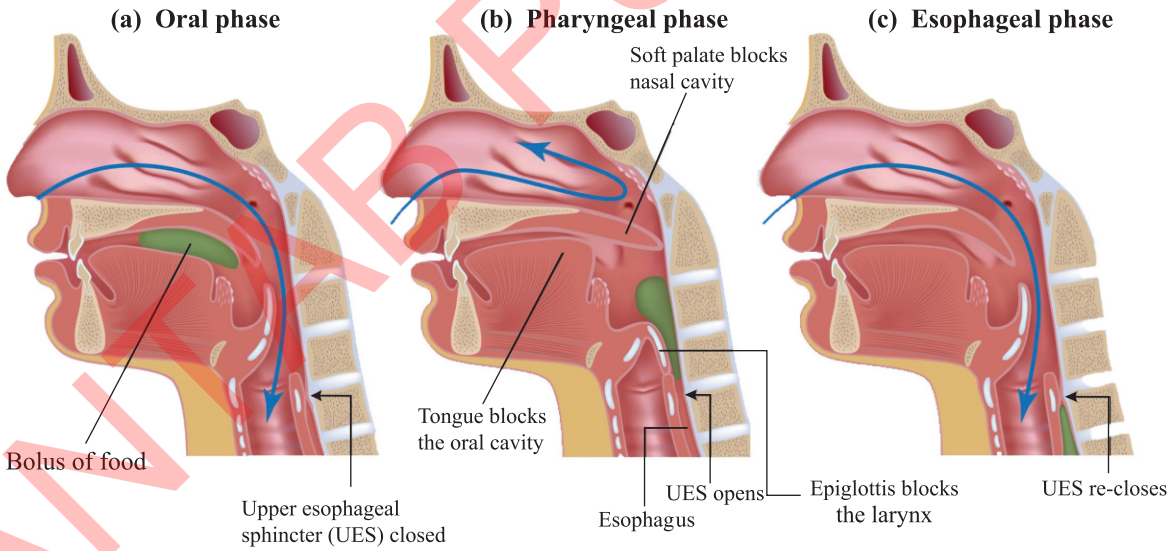


Figure 2.4: Phases of swallowing: **(a)** The bolus of food pushed back by the tongue. **(b)** The soft palate blocks the nasal cavity, the epiglottis blocks the trachea, and the UES opens. **(c)** Bolus enters the esophagus, and UES re-closes.

Esophageal Phase: The esophageal phase is also involuntary. The bolus is moved down the esophagus through peristalsis. **Peristalsis** is the involuntary, rhythmic contraction of muscles that moves the bolus from the esophagus to the stomach and through the rest of the alimentary canal. During peristalsis, the circular muscles of the esophagus contract behind the bolus, narrowing the esophagus and pushing the bolus forward. At the same time, the longitudinal muscles ahead of the bolus contract,

widening and shortening the esophageal segment to make the forward passage of the bolus easier (see Figure 2.5). A series of alternating contractions and relaxations of the circular and longitudinal muscles produce peristaltic waves that propel the bolus downward to the stomach. The lower esophageal sphincter (LES) or cardiac sphincter relaxes to allow the bolus to enter the stomach.

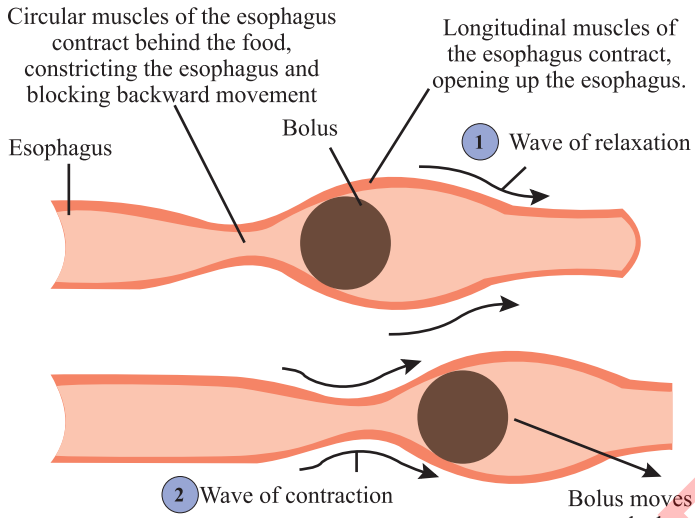


Figure 2.5: Peristalsis

The pharynx and esophagus contribute nothing to digestion but provide the pathway by which ingested materials reach the stomach. Swallowing and peristalsis work together to ensure food is efficiently moved from the mouth to the stomach, where digestion continues.

Stomach

The stomach is a J-shaped, muscular organ located on the left side of the upper abdomen, just below the diaphragm. It connects the esophagus to the small intestine and has two main sphincters: the cardiac sphincter and the pyloric sphincter (see Figure 2.6).

- The cardiac (lower esophageal) sphincter is located at the junction between the esophagus and the stomach. Food enters the stomach from the esophagus through the cardiac sphincter.
- The pyloric sphincter is located at the junction between the stomach and the small intestine (duodenum). It controls the passage of partially digested food from the stomach to the small intestine.

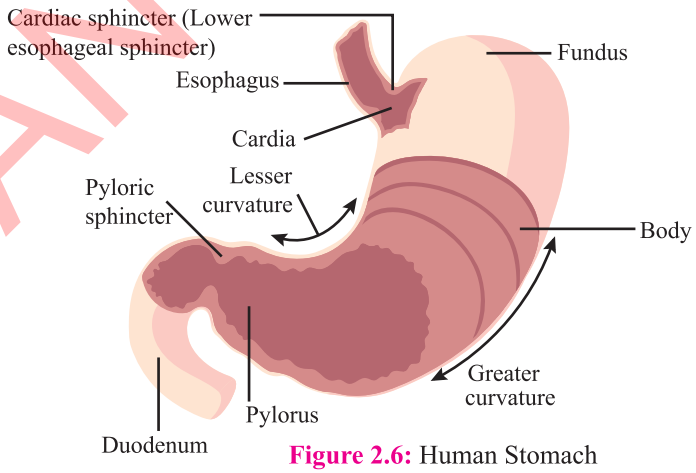


Figure 2.6: Human Stomach

Knowledge Booster

Sometimes the normal peristaltic waves are reversed, called **antiperistalsis**, where the contents move backwards through the digestive tract. This reversal of movement is responsible for vomiting, as it causes stomach contents to be pushed up into the esophagus and out of the mouth.

Do You Know ?

When the stomach has been empty for several hours, it experiences rhythmic muscle contractions known as **hunger contractions**. These contractions can become quite strong, leading to **hunger pangs**, which are mild pains in the stomach. Hunger pangs typically begin 12 to 24 hours after eating.

The stomach consists of several distinct regions: the cardia, fundus, body, and pylorus. The **cardia** is the uppermost part where food first enters the stomach. Above the cardia is the dome-shaped **fundus**, which serves as a temporary holding area for food. The **body** is the central region of the stomach and is the primary site for digestion. The lower part of the stomach, the **pylorus**, connects to the small intestine (see Figure 2.6).

Upon entering the stomach, food stimulates the **gastric glands** located in the lining of the stomach. These glands secrete **gastric juice**, a mixture of hydrochloric acid (HCl), pepsinogen, and mucus. Hydrochloric acid creates an acidic environment in the stomach that activates pepsinogen, an inactive enzyme, into pepsin, its active form. Pepsin then begins the breakdown of proteins into smaller peptides. The acidic environment also helps kill harmful microorganisms ingested with food. Mucus, another component of gastric juice, coats the stomach lining, protecting it from the corrosive effects of HCl and digestive enzymes. The muscular walls of the stomach contract rhythmically, mixing the food with gastric juices in a process known as **churning**. This process breaks down the food into a semi-liquid substance called **chyme**, which is gradually released into the small intestine through the pyloric sphincter.

Knowledge Booster

Most digestion and nutrient absorption occur in the small intestine. No absorption takes place in the mouth, pharynx, or esophagus. However, the stomach absorbs a few substances, such as alcohol, aspirin, caffeine, and water, before food moves into the intestines for further processing.

Small Intestine

The small intestine plays a crucial role in the digestion and absorption of nutrients. Despite its name, the small intestine is quite long, measuring approximately 6 meters (20 feet) in adults. However, it is called "small" because of its relatively narrow diameter compared to the large intestine. It is divided into three main parts: the duodenum, jejunum, and ileum. The duodenum is the first segment of the small intestine, measuring about 25-30 centimeters (10-12 inches) in length. It receives partially digested food (chyme) from the stomach and is the primary site for digestion. The chyme in the duodenum stimulates the release of secretions from the liver, pancreas, and intestinal glands.

Liver: The liver is the largest internal organ in the human body, weighing approximately 1.2 to 1.5 kilograms in adults. It is reddish-brown in colour and has a soft, smooth texture. The liver is located in the upper right part of the abdomen, just below the diaphragm.

Structurally, the liver is divided into two main lobes: the larger right lobe and the smaller left lobe. These lobes are further subdivided into smaller **lobules**, which are the functional units of the liver. Each lobule consists of mainly **hepatocytes** (liver cells), which perform various metabolic functions. Beneath the liver is a small, pear-shaped organ known as the **gallbladder**.

The liver produces bile, which is stored in the gallbladder and released into the duodenum through the common bile duct (see Figure 2.7). **Bile** is a yellowish-green fluid composed of water, bile salts, bile pigments, cholesterol, and lecithin (a phospholipid). Although bile contains no digestive enzymes, it helps in the **emulsification** of fats. Emulsification is the process of breaking down large fat droplets into smaller ones, making it easier for enzymes (lipase) to digest fats.

In addition to bile production, the liver has several other crucial roles:

1. The liver detoxifies toxins and other substances, such as drugs and alcohol, converting them into less harmful compounds.
2. Stores glucose in the form of glycogen and releases it when needed to maintain blood glucose levels.
3. Removes the amino group (NH_2) from amino acids through a process called **deamination.**
4. Converts ammonia into urea via the urea cycle, which is then excreted by the kidneys.
5. Destroys old red blood cells and recycles their components.
6. Produces plasma proteins such as **fibrinogen** for blood clotting and **albumin** for maintaining the body's fluid balance.

7. Stores iron and fat-soluble vitamins A, D, E and K.

Pancreas: The pancreas is an elongated gland located in the upper abdomen, behind the stomach. It has both endocrine and exocrine functions. The endocrine portion consists of small clusters of cells called the **Islets of Langerhans**. These islets release hormones such as insulin and glucagon into the bloodstream to regulate blood sugar levels.

The exocrine portion of the pancreas is composed of clusters of specialized cells called **pancreatic acini** (acinar cells) and a network of **ducts** formed by **ductal cells**, which together produce pancreatic juice (see Figure 2.7). The acini produce digestive enzymes such as pancreatic amylase, pancreatic lipase, and trypsin, while the ductal cells secrete bicarbonate ions (HCO_3^-). A large **pancreatic duct** collects this enzyme-rich pancreatic juice and carries it to the duodenum, where it aids in digestion:

- Bicarbonate ions (HCO_3^-) neutralize acidic chyme from the stomach.
- Pancreatic amylase converts starch into maltose.
- Pancreatic lipase breaks down fat droplets into glycerol and fatty acids.
- Trypsin digests proteins into peptides.

Like pepsin, trypsin is secreted in its inactive form (trypsinogen) and is activated in the duodenum.

Do You Know ?

Peyer's patches are small lymphoid tissue clusters found abundantly in the ileum of the small intestine. They play a crucial role in the immune system by detecting and defending against harmful bacteria and pathogens in the digestive tract. These patches help prevent infections and maintain gut health by fighting off harmful microorganisms.

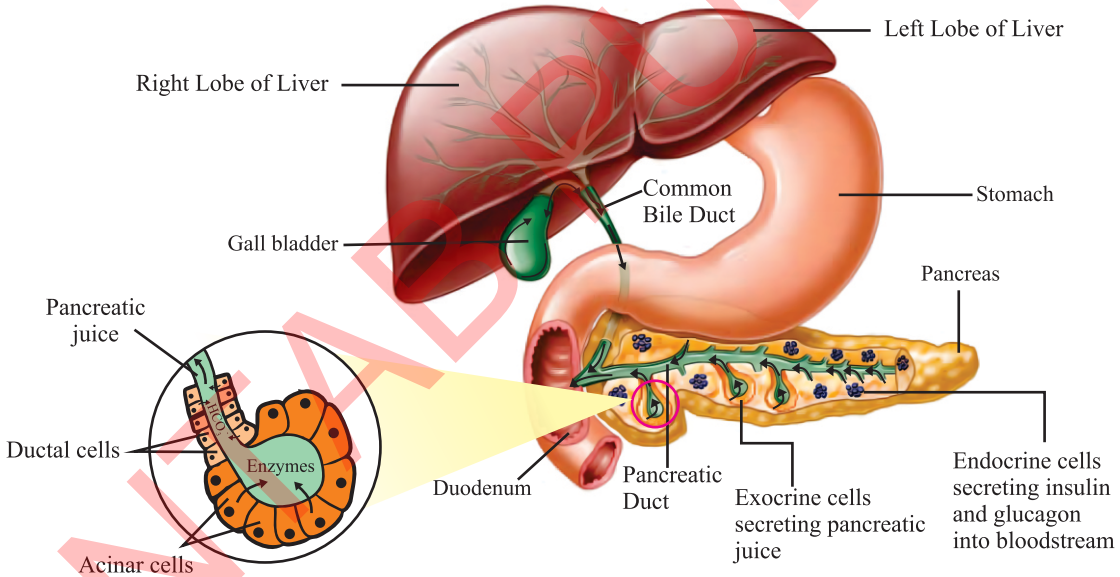


Figure 2.7: Structure of liver and pancreas with associated ducts.

Intestinal glands: These glands are located in the lining of the small intestine and produce intestinal juice.

Following the duodenum is the **jejunum**, which measures about 2.5 meters in length. It continues the digestive process with the help of intestinal enzymes. The intestinal enzymes present in this region include **disaccharidases** (maltase, sucrase, and lactase) that break down disaccharides into monosaccharides, **peptidases** that break down peptides into amino acids, and **enterokinase**, which activates pancreatic trypsinogen into trypsin. Jejunum also plays a significant role in nutrient absorption.

Following the jejunum is the **ileum**, which measures about 3 meters in length. The ileum plays a minimal role in digestion. However, its primary function is the absorption of nutrients, including vitamin B_{12} and bile salts. Table 2.1 provides a summary of digestion and sorts out the action of enzymes in specific regions of the alimentary canal with respect to their substrates and products:

Table 2.1: A summary of digestion.

	Carbohydrates	Proteins	Lipids
Mouth	Polysaccharides ↓ Salivary amylase Maltose	Nill	Nill
Stomach	Nill	Protein ↓ Pepsin Short polypeptides	Nill
Small intestine	Undigested polysaccharides ↓ Pancreatic amylase Maltose ↓ Disaccharidase Monosaccharides (Glucose)	Polypeptides ↓ Trypsin Short peptides ↓ Peptidases Amino acids	Globule of fat ↓ Bile salts Emulsified fat droplets ↓ Lipase Fatty acids and glycerol

Absorption in the Small Intestine

The inner lining of the small intestine is covered with finger-like projections called **villi**, which increase the surface area for the absorption of nutrients. Each villus is covered with epithelial cells and contains a rich supply of blood vessels and a lymphatic vessel called lacteal (see Figure 2.8). The structure and function of a villus is described as follows:

- Each villus is composed of simple **columnar epithelial cells** equipped with **microvilli**, forming a brush border that further increases the surface area for absorption. **Goblet cells** are scattered among the epithelial cells which secrete mucus to lubricate the intestinal lining and protect it from digestive enzymes.
- Each villus contains a network of **capillaries** that originate from small arterioles and drain into small venules. These capillaries are crucial for the absorption and transport of water-soluble nutrients, including amino acids and monosaccharides (simple sugars). These nutrients pass through the epithelial cells and enter the capillaries, where the blood carries them to the liver via the hepatic portal vein for filtering. From the liver, nutrients travel to the heart. The bloodstream then carries these nutrients to the body tissues and cells, where they are assimilated for various metabolic activities.
- The **lacteal** is a central lymphatic vessel within each villus that absorbs fatty acids and glycerol. These molecules are transported through the lymphatic system, eventually reaching the bloodstream and delivered to various tissues.

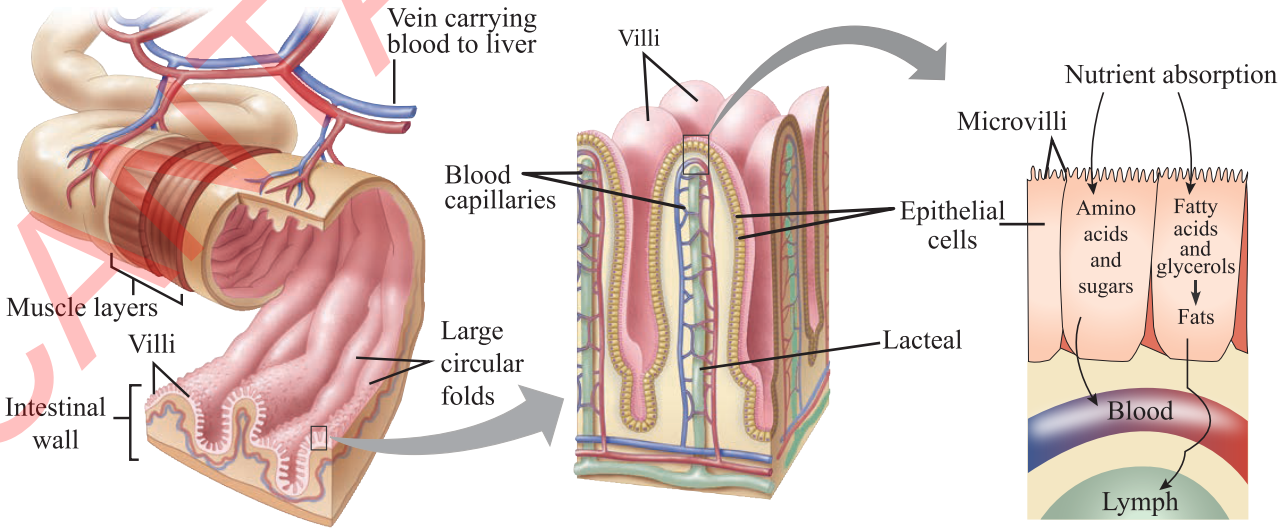


Figure 2.8: Nutrient absorption in the small intestine.

Large Intestine

The material remaining in the small intestine moves next into the large intestine, the last part of the alimentary canal. The small intestine connects to the large intestine at a T-shaped junction. The large intestine consists of the cecum, colon, rectum, and anus (see Figure 2.9).

The **cecum** is a pouch-like structure that serves as the starting point of the large intestine and absorbs water and salts that remain after intestinal digestion and absorption. Attached to the cecum is the **appendix**, a small, tube-like structure that, on average, is 100 mm long and 7 mm in diameter. It has no known function in digestion.

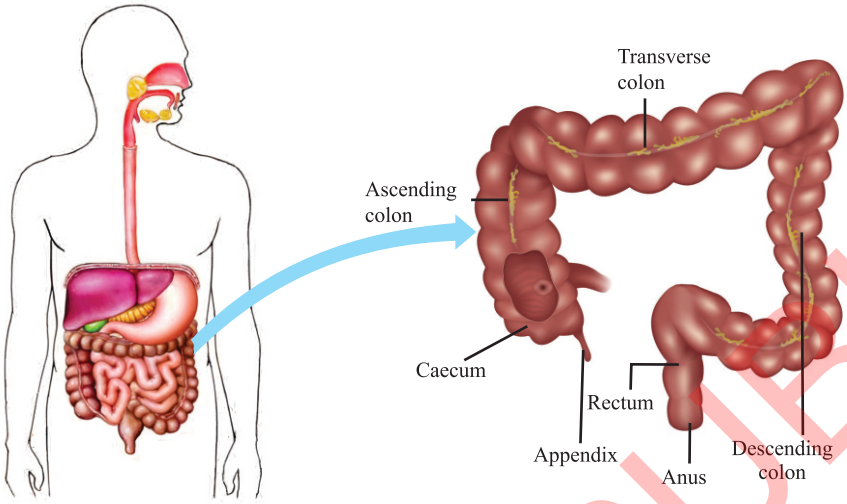


Figure 2.9: Parts of Large Intestine

The cecum merges with the **colon**, the main part of the large intestine. The colon absorbs water and electrolytes from the remaining indigestible food matter, transforming it into a more solid form called **faeces**. Beneficial bacteria also reside in the colon and produce essential vitamins, such as vitamin K, which are also absorb by colon.

Typically, by the time the faecal matter reaches the rectum, it mainly contains undigested food particles, bacteria, cells shed from the lining of the gastrointestinal tract, mucus, bile salts, and water. Faeces are temporarily stored in the rectum before they are expelled from the body. When the rectum becomes full, these faeces are expelled through the anus.

2.3 Knowledge

Disorders of Gut

The human gut is susceptible to various disorders that can disrupt its function and cause significant discomfort. Among the most common gut disorders are diarrhea, constipation, and ulcers.

Diarrhea

Diarrhea is a condition characterized by frequent, loose, or watery stools, often accompanied by abdominal cramps, nausea, and dehydration. This occurs when the colon fails to absorb sufficient water in the blood (see Figure 2.10). Common causes of diarrhea include viral and bacterial infections and the use of certain medications. Effective treatment typically involves rehydration with oral rehydration solutions (ORS) to

Knowledge Booster

The appendix is believed to function as a reservoir for beneficial gut bacteria. Since it contains patches of lymphoid tissue, it is also presumed to play a role in supporting the immune system.

Skill:2.2

Objective:

Identify and describe the main regions of the alimentary canal and their associated organs, detailing their specific functions.

Test Yourself

Short answer-based questions

1. How does the body prevent food from entering the nasal cavity and the trachea during swallowing?
2. Define peristalsis.
3. What components make up gastric juice, and what are their functions?
4. How do villi and microvilli contribute to nutrient absorption in the small intestine?
5. How does bile aid in the digestion of fats?
6. Define the process of defecation and the role of the rectum in this process.

Long answer-based questions

1. What functions does oral cavity perform in the process of digestion?
2. Explain what components of food are digested in the small intestine?

replenish lost fluids and electrolytes. In some cases, antibiotics may be necessary to address underlying infections. Dietary adjustments, such as following the BRAT diet (bananas, rice, apple sauce, toast), can also help manage symptoms. Preventing diarrhea involves practicing good hygiene, consuming clean water and avoiding known food triggers.

Knowledge Booster

Psychogenic diarrhea is stress-induced diarrhea that occurs during anxiety, like before exams or important events. It happens because stress speeds up intestinal movement, causing loose stools. This type of diarrhea is temporary and stops once the stress is reduced.

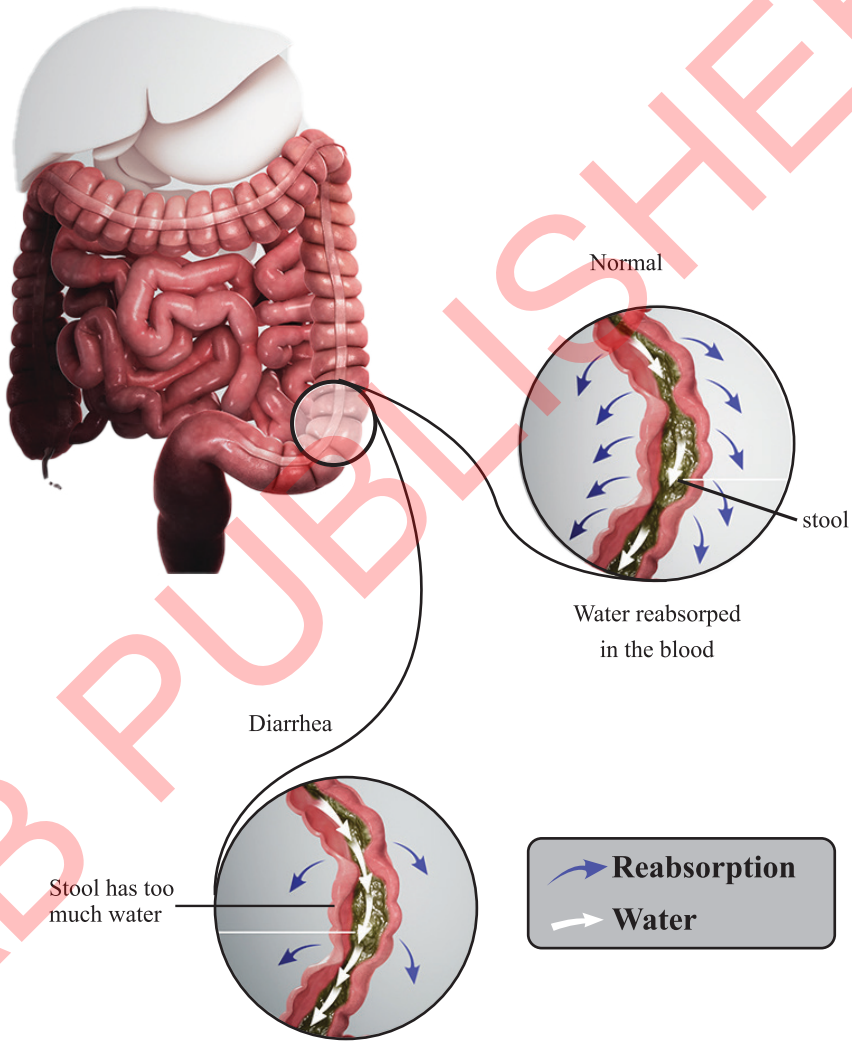


Figure 2.10: Difference between normal stool formation and diarrhea, highlighting water reabsorption in the colon.

Constipation

Constipation results from slow movement of faeces through the large intestine, causing the colon too absorb to much water from it. It is characterized by difficulty in passing stools, which are often hard, dry, or lumpy. This condition is usually accompanied by abdominal pain, bloating, and a feeling of incomplete evacuation. A low-fiber diet and insufficient water intake can cause stools to become hard and difficult to pass. Certain medications, especially those containing calcium or aluminium, can also contribute to constipation. Treating constipation typically involves increasing fiber intake by consuming more fruits and vegetables and drinking plenty of water throughout the day. Laxatives

Skill:2.3

Objective:

Analyze the signs and symptoms, causes, treatments, and prevention methods for each of the gastrointestinal disorders.

may be used to stimulate bowel movements if needed. Preventing constipation involves maintaining a balanced diet, staying hydrated, and regular exercise.

Ulcer

An ulcer is a sore that develops on the inner wall of the esophagus, stomach or small intestine. (see Figure 2.11). This condition is commonly referred to as a **peptic ulcer** when it occurs in the stomach (gastric ulcer) or the upper part of the small intestine (duodenal ulcer). Ulcers are painful and can lead to serious complications if not treated properly. The most common symptom of an ulcer is burning stomach pain, which typically occurs between meals or at night. The bacteria *Helicobacter pylori* is a major cause of ulcers. Additionally, excessive acid production in the stomach and long-term use of medicines, such as aspirin and ibuprofen, can lead to the development of ulcers. Lifestyle factors such as smoking and excessive alcohol consumption also contribute to ulcer formation. Ulcers are treated with antibiotics to eradicate *H. pylori* and antacids to neutralize stomach acid. Preventive measures include avoiding spicy and acidic foods, refraining from smoking, and limiting the consumption of colas.

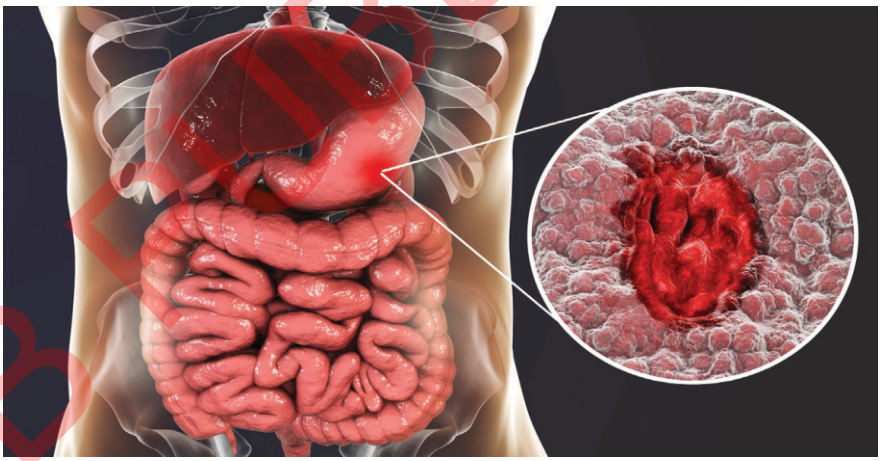


Figure 2.11: Illustration of a peptic ulcer developing on the inner wall of the stomach.

Test Yourself

Short answer-based questions

1. How constipation occurs and what lifestyle changes can help prevent it?
2. What are the primary causes of diarrhea?
3. How peptic ulcers can be prevented?

Key Points

- The stages of food processing include ingestion (food intake), digestion (breaking down food), absorption (nutrient uptake), assimilation (utilizing nutrients), and egestion (waste elimination).
- The digestive system includes the alimentary canal (mouth, pharynx, esophagus, stomach, small intestine, large intestine) and associated organs (salivary glands, pancreas, liver).
- The oral cavity includes structures such as tongue, teeth, and salivary glands, which facilitate the initial stages of digestion by mechanically breaking down food and mixing it with saliva to form a bolus.
- Swallowing involves the oral phase (tongue pushes bolus to pharynx), pharyngeal phase (soft palate and epiglottis prevent food from entering nasal cavity and trachea), and esophageal phase (peristalsis moves bolus to stomach).
- The stomach secretes gastric juice containing hydrochloric acid, pepsinogen, and mucus, churns food into chyme, and releases it gradually into the small intestine.
- The small intestine, including the duodenum, jejunum, and ileum, is the primary site for digestion and absorption, receiving bile from the liver and digestive enzymes from the pancreas.
- The liver produces bile, stored in the gallbladder and released into the duodenum to emulsify fats, aiding their digestion and absorption.
- The large intestine absorbs water and electrolytes from indigestible food matter, forming faeces, with egestion eliminating waste from the body.

- Diarrhea involves frequent, loose, or watery stools caused by infections or certain medications.
- Constipation is characterized by infrequent, hard, dry, or lumpy stools caused by low-fiber diets, insufficient water intake, and certain medications.
- Peptic ulcers are sores on the inner wall of the stomach or small intestine caused by *Helicobacter pylori*, excessive stomach acid, or long-term use of certain medications.

Exercise

Scan QR code for the answers

SLO: ***Describe the needs of ingestion, digestion, absorption, assimilation and egestion.***

Multiple-Choice Questions (MCQs)

1. Which of the following processes involves the movement of digested nutrients into the bloodstream?
   a) Ingestion **b)** Digestion **c)** Absorption **d)** Egestion
2. Which of the following nutrients do not require digestion before absorption?
   a) Carbohydrates and proteins **b)** Fats and vitamins
   c) Water, minerals, and vitamins **d)** Proteins, vitamins, and minerals
3. Which of the following is NOT a part of food processing?
   a) Breaking down food molecules **b)** Absorbing nutrients into the bloodstream
   c) Removing metabolic waste through urine **d)** Eliminating undigested food as faeces

Short Response Questions (SRQs)

1. Differentiate between digestion and absorption in terms of their function in the digestive system.
2. Name the five stages of food processing in the human digestive system.
3. Why do fats, proteins, and carbohydrates need to be broken down into smaller molecules in the body?

Extended Response Questions (ERQs)

1. Describe the five stages of food processing in the human digestive system and explain why each stage is essential.

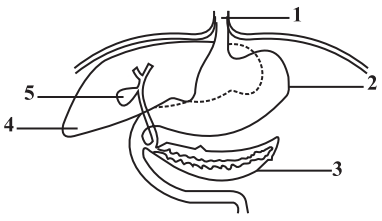
SLO: ***Identify and describe the structures of the main regions of the alimentary canal and the associated organs.***

Multiple-Choice Questions (MCQs)

1. If you put the following events in the order they occur in the human digestive system, the third event in the series would be:
   a) Gastric glands secrete gastric juice **b)** Protein digestion in stomach
   c) HCl activates pepsinogen. **d)** Partially digested food enters the small intestine.
2. Which of the following organs is incorrectly paired with its function?

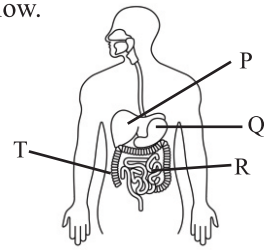
Option	Organ	Function
(a)	Stomach	Protein digestion
(b)	Large intestine	Bile production
(c)	Small intestine	Nutrient absorption
(d)	Pancreas	Enzyme secretion

3. The diagram shows part of the human alimentary canal.
   Which two structures produce substances involved in the digestion of fat?
   a) 1 and 4 **b)** 2 and 3
   c) 3 and 5 **d)** 4 and 5



4. After surgical removal of the gallbladder, a person might need to limit his or her dietary intake of
   a) starch **b)** protein **c)** sugar **d)** fat

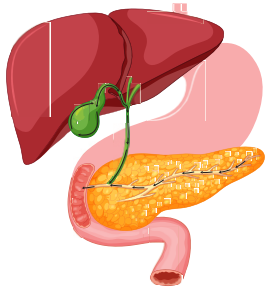
Questions 5 and 6 are based on the figure below.



5. The diagram above shows the human alimentary canal. Which of the parts is involved in the absorption of food?
   a) P **b)** Q **c)** R **d)** S
6. Which of the following processes occurs in T?
   a) Reabsorption of water **b)** Digestion of protein
   c) Digestion of starch **d)** Production of vitamin A
7. What does the term "chyme" refer to?
   a) Partially digested food in the stomach **b)** Feces in the rectum
   c) Partially digested food in the mouth **d)** Bile stored in the gallbladder
8. Which of the following is NOT a component of gastric juice?
   a) Hydrochloric acid **b)** Pepsinogen **c)** Mucus **d)** Bile

Short Response Questions (SRQs)

1. What is the role of saliva in the digestion process?
2. What is the composition of saliva?
3. Name the main regions of the stomach?
4. Give the role of the cardiac and pyloric sphincters in the digestive process.
5. Describe the process of churning in the stomach and its significance in digestion.
6. Enlist the main functions of the duodenum in the digestive process?
7. How do the functions of the pancreas contribute to digestion in the small intestine?
8. What role does the large intestine play in the digestive system?
9. What are the functions of the tan-coloured organ and the green-coloured organ shown here?



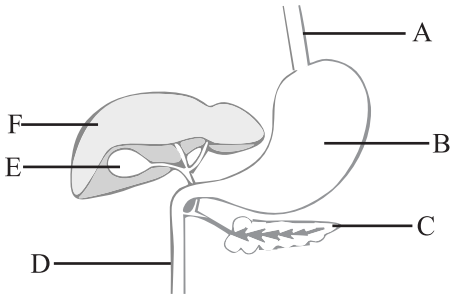
Extended Response Questions (ERQs)

1. Describe the process of protein digestion in the stomach.
2. Explain the structure of pancreas and its role in digestion of food.
3. Outline the digestive enzymes involve in the breakdown of food.

SLO: *Describe Swallowing and Peristalsis*

Multiple-Choice Questions (MCQs)

1. The swallowing process is divided into three phases. Which of the following lists the phases in the correct sequence regarding the passage of food from the mouth to the stomach?
   a) Oral, pharyngeal, esophageal **b)** Pharyngeal, oral, esophageal
   c) Oral, esophageal, pharyngeal **d)** Esophageal, oral, pharyngeal
2. Peristalsis occurs in structures



   a) A and D **b)** B and C **c)** C and E **d)** E and F

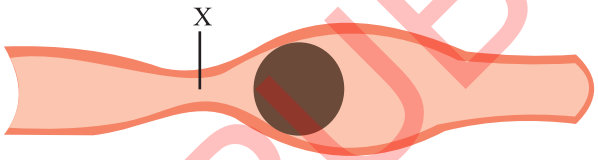
3. Which of the following correctly pairs the phases of swallowing with their voluntary or involuntary nature?

Option	Oral Phase	Pharyngeal Phase	Esophageal Phase
(a)	Voluntary	Involuntary	Involuntary
(b)	Involuntary	Voluntary	Involuntary
(c)	Voluntary	Voluntary	Involuntary
(d)	Involuntary	Involuntary	Voluntary

4. Peristalsis is an example of which type of muscle movement?
   a) Voluntary contraction **b)** Involuntary wave-like contractions
   c) Rapid jerking movements **d)** Sudden relaxation
5. Which of the following structures open to allow food into the stomach?
   a) Epiglottis **b)** Pharyngeal sphincter
   c) Lower esophageal sphincter **d)** Upper esophageal sphincter

Short Response Questions (SRQs)

1. Give the role of the soft palate and epiglottis in swallowing.
2. Why is swallowing considered both a voluntary and involuntary action?
3. Define peristalsis and why it is important in the digestive system?
4. The diagram shows some food moving along the alimentary canal by peristalsis



What are the muscles in the wall of the alimentary canal doing at point X?

Extended Response Questions (ERQs)

1. Describe the three phases of swallowing.

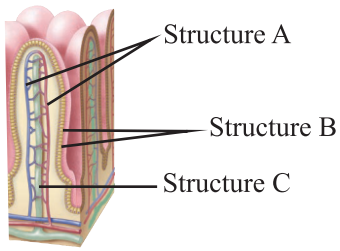
SLO: ***Describe the structure of a villus, including the roles of capillaries and lacteals.***

Multiple-Choice Questions (MCQs)

1. Which vessel within a villus is responsible for the absorption of fatty acids and glycerol?
   a) Capillaries **b)** Arterioles **c)** Venules **d)** Lacteal
2. Villi are present in
   a) Stomach **b)** Intestine **c)** Oesophagus **d)** Both A and B
3. After absorption from the capillaries of the villi, water-soluble nutrients are transported to the liver via the:
   a) Hepatic artery **b)** Hepatic portal vein **c)** Lymphatic system **d)** Aorta

Short Response Questions (SRQs)

1. Below is a diagram of a villus.
   a) Identify the structure A, B and C in the diagram.
   b) Name the type of chemical that would be absorbed in Structure A and Structure C.



2. How does the absorption of fat-soluble nutrients via the lacteal differ from that of water-soluble nutrients?
3. What types of nutrients are absorbed by the blood vessels in the villi, and how are they transported to the rest of the body?

Extended Response Questions (ERQs)

1. Explain the role of villi in the small intestine for efficient nutrient absorption and explain how their structure supports this function.

SLO: ***Sort out the action of enzymes in specific regions of alimentary canal, with respect to their substrates and products.***

Multiple-Choice Questions (MCQs)

1. Which of the following correctly matches the nutrient with its breakdown product?

Option	Nutrient	End Product
(a)	Carbohydrates	Amino acids
(b)	Proteins	Fatty acids and glycerol
(c)	Fats	Simple sugars
(d)	Proteins	Amino acids

2. Which enzyme initiates carbohydrate digestion in the mouth?
   a) Salivary amylase **b)** Pancreatic amylase
   c) Maltase **d)** Pepsin
3. Which group of brush border enzymes converts disaccharides into monosaccharides?
   a) Maltase, sucrase, lactase **b)** Trypsin and chymotrypsin
   c) Pepsin and carboxypeptidase **d)** Pancreatic lipase and bile salts

Short Response Questions (SRQs)

1. Identify the pancreatic enzymes that digest proteins in the small intestine and state their primary products.
2. List the enzymes present in the small intestine that are involved in carbohydrate digestion.

Extended Response Questions (ERQs)

1. Outline the key enzymes involved in the digestion of proteins including their specific substrates and the final products formed.

SLO: ***State the signs and symptoms, causes, treatments and preventions of the disorders of gut i.e. diarrhea, constipation, and ulcer.***

Multiple-Choice Questions (MCQs)

1. Which diet is recommended for managing diarrhea?
   a) Keto diet **b)** Mediterranean diet **c)** BRAT diet **d)** Vegan diet
2. Which bacteria is a major cause of peptic ulcers?
   a) *Escherichia coli* **b)** *Streptococcus* **c)** *Helicobacter pylori* **d)** *Staphylococcus*
3. Which lifestyle factor is most commonly associated with constipation?
   a) High fluid intake **b)** Regular exercise
   c) Low dietary fiber intake **d)** Frequent consumption of vegetables

Short Response Questions (SRQs)

1. What are the symptoms of diarrhea.
2. Describe the symptoms and main causes of peptic ulcers.

Extended Response Questions (ERQs)

1. What are the typical symptoms of constipation, and how can it be treated?