Biology

For Distance Learner

Module 2

Grade 10

Biology

Grade 10

Module 2

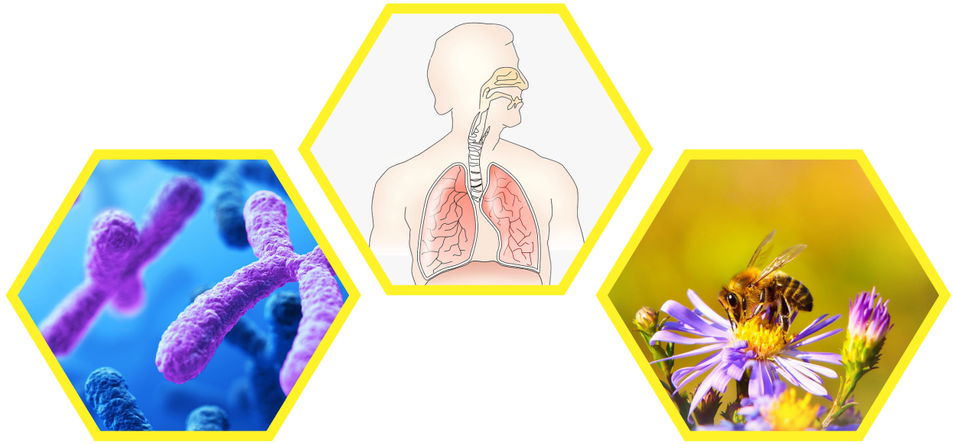
Federal Democratic Republic of Ethiopia
Ministry of Education

Biology

For Distance Learner

Module 2

CELL REPRODUCTION, HUMAN BIOLOGY AND ECOLOGICAL INTERACTIONS



Grade 10

Federal Democratic Republic of Ethiopia
Ministry of Education

Biology

For Distance Learner

Grade 10

Module 2

CELL REPRODUCTION, HUMAN BIOLOGY AND ECOLOGICAL INTERACTIONS

Writers:

Beyene Dobo, PhD

Girma Tilahun, PhD

Editors:

Girma Moti, PhD (**Curriculum Editor)**

Temesgen Daniel, PhD (**Language Editor**)

Designer:

Tesfamichael Getu, PhD

Evaluators:

Berhanu Tesfaye, MA, MEd

Gebrehhana Zeleke, MSc

FDRE Ministry of Education

Hawassa University

First Published xxxxx 2023 by the Federal Democratic Republic of Ethiopia, Ministry of Education, under the General Education Quality Improvement Program for Equity (GEQIP-E) supported by the World Bank, UK's Department for International Development/DFID-now merged with the Foreign, Common wealth and Development Office/FCDO, Finland Ministry for Foreign Affairs, the Royal Norwegian Embassy, United Nations Children's Fund/UNICEF), the Global Partnership for Education (GPE), and Danish Ministry of Foreign Affairs, through a Multi Donor Trust Fund.

The Ministry of Education wishes to thank the many individuals, groups and other bodies involved – directly or indirectly – in publishing this Textbook. Special thanks are due to Hawassa University for their huge contribution in the development of this textbook in collaboration with Addis Ababa University, Bahir Dar University, Jimma University and Semera University.

Printed by:

xxxxxxxx PRINTING
P.O.Box xxxxxx
xxxxxxx, ETHIOPIA
Under Ministry of Education Contract no. xxxxxxxxxxx

ISBN: XXXXXXXXXXXX

Contents

MODULE INTRODUCTION

According to the national inclusive educational policy and the living and working conditions in various settings, including population engaged in agriculture, trade, regular office work, housewives, etc., Ethiopian ministry of education prepared distance learning modules for all high school subjects. This module is for grade 10 biology students learning at a distance. The module will be covered during the second semester of the academic year. It is divided into three units: cell reproduction, human biology &ecological interactions. Each unit is divided into sections and sub-sections, and for each section and sub-subsection, there is introduction, a section's content, a self-test exercise with an answer key, and a checklist to ensure that you comprehended the section in question. Within each unit of this module, there are activities as well; some of these activities must be completed on one's own or with the assistance of a tutor assigned.

The module uses a variety of teaching techniques that are thought to benefit distant learners. The following learning techniques can be used to ensure that your distance learning process is successful wherever they are pertinent to the main topics or subtopics of your lesson. These include summarizing (outlining and creating flow chart summaries), mind mapping, short visits/onsite observation, comparing and contrasting, drawing and photographing actual living things, creating analogies, paraphrasing, taking brief notes, and underlining or highlighting important points.

The module also provided time for you to study each sections and complete your activities in line with the learning strategies. As soon as each unit is finished, you must complete your assessment for submission, which will be made available in the tutorial centres. Final exams will be organized at each tutorial centre according to the ministry of education schedules for each academic year.

In this module, you will find the following icons or graphic symbols with the description they represent throughout the module.

 This tells you there is an overview of the unit and what the unit is about.

 This tells you there is an in-text question to answer or think about in the text.

 This tells you to take notes or to remember an important point.

 This tells you there is a self- test for you to do.

 This tells you there is an activity for you to do.

√ This tells you there is a checklist.

 This tells you there is a written assignment.

 This tells you that this is the key to the answers for the self- tests.

OBJECTIVES OF THE MODULE

After going through the three units and different sections of module 2, the distance learner will be able to:

- Outline the major stages or phases of cell cycle and cell division,
- distinguish the difference between mitosis and meiosis,
- identify the structure of the different systems (digestive, breathing, circulatory, lymphatic systems) of the human body,
- describe processes or functions performed by the different systems of the human body,
- explain some disorders or diseases associated with different systems of the human body, and
- explain energy flow and cycling of materials (nutrients) in and ecosystem.

ASSESSMENT TECHNIQUES

Besides the assignment for submission and the final examination to be arranged at the tutorial centre, the distance learner can perform continuous assessment by doing the self-test exercises and checklists at the end of each section of the three units and self – assessment questions at the end of each unit. By so doing, the distance learner can have his/her own record to know the progress and adjust the method of learning to get best result from self-learning and support from the tutorial sessions.

UNIT ONE: CELL REPRODUCTION

INTRODUCTION

 Dear learner! Welcome to unit one of module 2 which deals with cell reproduction. Do you know that multicellular living body, including human beings started their life from a single cell? You may wonder how a single cell goes on increasing its number to form multicellular organism. All cells reproduce by dividing themselves into two with each parental or maternal cell-giving rise to two daughter cells each time it divides. These newly formed daughter cells grow and divide repeatedly giving rise to multicellular body. It is such cycles of growth and division that allows a living body to for million or trillion cells.

Dear learner! in this unit you will learn about cell cycle and cell division. Particularly, you will study why and how a cell divides with regular pattern under normal conditions.

LEARNING OUTCOMES

Upon successful completion of this unit, you will be able to:

- outline the series of events taking place in the cell cycle,
- identify the two types of cell division,
- compare and contrast mitosis and meiosis,
- explain the importance of cell division, and
- recognize the occurrence of cancer cells due to failure to control the cell cycle.

UNIT CONTENTS

This unit includes the following two major contents organized in sections:

1.1 Cell cycle

1.2 Cell division

REQUIRED STUDY TIME

You are expected to spend 13 Learning hours (4 days) of the semester to learn this unit. You should use the allocated study time properly and efficiently to cover the lessons included in this unit.

LEARNING STRATEGIES

For your successful distance learning, you can use the following learning strategies wherever they are appropriate to the topics/ subtopics of your lesson. These are mentally rehearsing, short visits/onsite observation, comparing and contrasting, drawing and taking pictures of real plants, creating analogies, paraphrasing, summarizing (outlining and preparing flow chart summaries), taking short notes, underlining or highlighting key points and self – reflection.

SECTION 1.1 CELL CYCLE

INTRODUCTION

 Dear learner! Do you know that it was a single fertilized egg cell of your mother upon fertilization by your father's sperm cell that underwent a series of divisions and resulted in huge number of your body cells estimated in several trillions? It was cell division that increased the size and complexity of your body until eventually you reached your current body size. It is in this way that multicellular organisms grow in size and maintain the cell of their body by a sequence of events called cell cycle. In this section, you will study how an initial single cell (parent/mother cell) will undergo in distinct and continuous stages of a cell cycle.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, you will be able to:

- define cell cycle,
- outline the different stages of cell cycle, and
- collect information on cancer.

Which cell structure is mainly involved in cell reproduction?

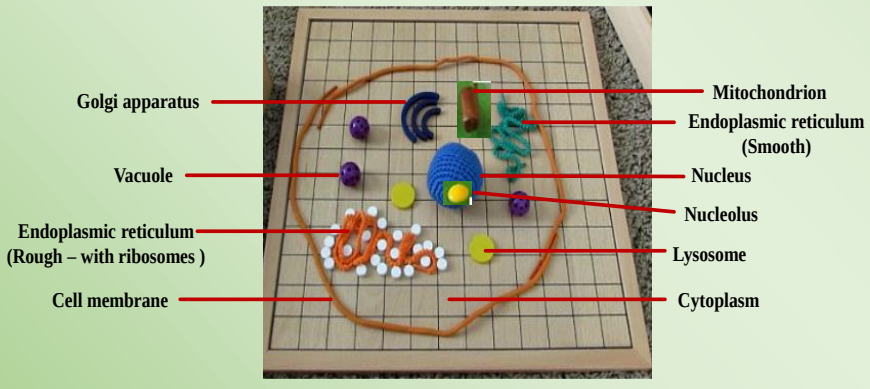
Dear learner! Before dealing with cell cycle, you need to refresh your memory about cell structure and function, particularly the nucleus where key processes of cell reproduction take place. The next activity (Activity 1. 1) gives you opportunity to construct at least two-dimensional (2D) cell model using a cardboard or stiff paper to show an animal cell and the arrangement of cell organelles.

Activity 1.1

Dear learner! We have an exciting activity for you to try out. It is a hands-on activity to learn about cells and their organelles. What you all need is the following simple materials that can be easily found in your local area: A cardboard or stiff paper, glue, threads of different colors, a puncher, colored paper, tiny beads, or small seeds such as peas, chickpeas, or lentils, scissors, and wool or cotton.

After collecting the required materials, you can start the activity. Follow the steps below to create your cell model:

1. Take the colored thread and form it into a round boundary. This will represent the shape and membrane of the cell.
2. Next, glue a piece of rolled wool or cotton and a colored bead at the center of the boundary. This will show the position of the nucleus and nucleolus.
3. To represent the different organelles, use small colored paper that has been punched out, beads or seeds of similar size or shape, and thin colored threads. Attach these items to the cell model using glue. Refer to the figure below to help you visualize the process.
4. Finally, draw the diagram on a separate paper and label the parts without looking at the cell model below



Refer to Biology books and point out why nucleus is important to the cell. Write the difference between nucleus and nucleolus. Keep your note for reflection or discussion during the tutorial session.

You can follow the same procedure to prepare a model of plant cell, where chloroplasts and cell wall are included as additional structures. The presence of cell wall in your model creates difference in the cellular cytoplasmic division of a plant cell as opposed toan animal cell.

What are the main phases of a cell cycle?

Dear learner! You will learn about series of events that take place in a cell this is cell cycle, which is a sequence of events that take place in the parent cell as a means of distributing genetic materials between daughter cells (Figure 1. 1). The cell cycle is divided into two major phases: Interphase and cell division phase. It should be well noted that the cycle is a continuous process and does not pause after each phase. The Interphase is divided into three sub-phases called G_1, S, and G_2.

Dear learner! we can proceed and look to what happens at the following distinct stages of interphase.

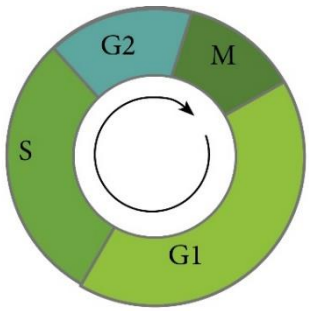
G_1 Phase (First Gap): is the first stage of interphase. During this stage, cells are quite active metabolically. They accumulate the building blocks of chromosomal DNA and the associated proteins as well as store sufficient energy reserves to complete the task of replicating each chromosome in the nucleus.

S Phase (Synthesis of DNA): is the stage of DNA replication (synthesis).

G_2 Phase (Second gap): is the stage where the cell replenishes its energy stores and synthesizes proteins necessary for chromosome manipulation and movement. Some cell organelles are duplicated during this stage. Cells may continue growing during the G_2 phase in which they make the final preparations before entering into the mitotic phase.

Dear learner! Following the G_2 phase of the interphase, the cell division will continue. The cell division in turn includes **nuclear division or Karyokinesis** (mitosis, or, M - stage) followed by **cytoplasmic division** (Cytokinesis). The cell

division ultimately results in two identical daughter cells and each daughter cell grows and starts the cycle as mother cell again.



G1 - growth

S - DNA synthesis

G2 - Growth and preparation for mitosis

M - Mitosis

Figure 1.1 Phases of the cell cycle

KEY TERMS

- **Cell cycle**: is the sequence of stages through which a cell passes from one cell division to the next.
- **Mitosis**: isacell division in which a daughter cell receives the same number of chromosomes as the parent cell.
- **Cytokinesis**: is the division of cytoplasm.
- **Interphase**: is the time interval between nuclear divisions when a cell increases in mass , roughly doubles the cytoplasmic components, and duplicates the chromosomes.

Dear learner! In the next activity, you will have an opportunity to combine skills in computation with geometry to estimate the time spent or to determine the proportion (percentage) of each stage or phase of cell cycle using Figure 1.1. This can help you to create paper time clock taking one round cell cycle as 360 degree and assuming the whole cell cycle is completed within 24 hrs.

Activity 1.2

Dear learner! Welcome to this activity. We will be using Figure 1.1 to help us understand the cell cycle better. To efficiently complete your task follow the steps below:

- Divide the circle that represents the cell cycle into four parts. We do this by using a ruler to split the circle into two halves vertically and then horizontally. This gives us four quarters, each representing 900 degrees. This makes it easier for us to measure the degree bounding each cell cycle stage
- Measure the degree of angles for each stage with the corresponding time interval using the 24-hour clock (Hint: 150 = 1 hour). You can easily estimate how much time is spent in each phase of the cell cycle. It will also allow you to measure the degree bounding each cell cycle stage
- Then calculate the exact time spent in each stage/phase, using the following formula: (Degree measured / 3600) X 24 hr. This formula helps us to convert the time in degrees to actual hours.
- Finally, you can summarize your results in the table provided, which will help you to understand the cell cycle better and determine the proportion of time spent by each stage of the cell cycle .

Variable	Interphase			Cell division (mitosis + cytokinesis	Total
	G_1	S	G_2		
Measured degree					360^0
Time spent (hr)					24hr
Percentage					100%

Questions

- What is the proportion of time spent in interphase as compared to cell division (mitosis & cytokinesis)
- Why does a cell spend most of its time in the interphase?
- Each stage of cell cycle is not static. What does this mean?

Remark: Dear learner! If you encounter a problem while doing this activity, sort out your difficulties to bring them forward in class during the tutorial session.

What will happen if cell cycle is not controlled?

Dear learner! For sure, you will be interested to know if there is an internal controlling system that enables a cell to follow regular pattern during the cell cycle in general and cell division in particular. Imagine what will happen in the human body if it does not have such controlling system and such regulatory system fails to work properly. The danger is that the cells excessively divide, which may be called **"cell madness".** This is how cancer occurs as a result of failure of controlling cell division. Cancer cells do not respond normally to the cell cycle controlling system; they divide in unregulated manner and may invade other tissues of the body.

REMARK

- Cancer can start when the controlling factors over cell division and cell growth fail. It occurs in the absence of growth factors allowing a cell to divide continuously at very high density at the expense of other normal cells.

- Cancer cells can have a number of problems:
  - ✓ They might not be able to communicate with healthy cells.
  - ✓ They may not be able to carry out normal cell functions.
  - ✓ They may not securely anchor themselves like other cells do, which can make them more likely to travel somewhere and spread to other parts of the body.

.

Activity 1. 3

Dear learner!

It will be very interesting and useful that you take some time to visit the health center located near your school or home. Your purpose for this visit will be to conduct an interview with the health workers there and gather relevant information about cancer. Your interview should focus on the following key questions that will give you a deeper understanding of cancer.

- What is cancer, and what are the most common types of cancer that can affect the human body?
- What are the causes of cancer, and how does cancer affect an individual? What can be done to prevent cancer?
- How can patients with cancer be treated, and what are the most effective treatment options available?

Remark : Once you have completed the interview, take some time to prepare a brief report summarizing your findings. You may use this report as a point of reference during reflection and

✓Self-evaluation checklist

Put a tick (√) mark against each of the following tasks, which you can perform. If you cannot perform any of these tasks, go back and read the lesson for that particular task.

I can:

- define cell cycle_____ ☐
- describe the different phases of cell cycle_____ ☐
- discuss how cancer cells are formed and behave_____ ☐

Self-Test Exercise 1.1

I. True/ False items : Write "TRUE" for acorrect statement or "FALSE" for an incorrect statement.

1. The cell cycle normally has an internal controlling system that enables cells to follow regular pattern.
2. Cell division is the longest phase of the cell cycle.
3. During cell division, cytoplasmic division (Cytokinesis) is followed by nuclear division (Karyokinesis).
4. Mitosis is a nuclear division in which a daughter cell receives the same number of chromosomes as the parent cell.

II. Multiple Choice Items: Choose the correct answer and write the letter of your choice on a separate answer sheet.

1. One of the following statement is wrong about cancerous cells:
   A) They are excessively dividing.
   B) They are able to anchor themselves.
   C) They do not communicate with healthy cells.
   D) They are able to carry out normal cell functions.

2. The stage of acell cycle where some cell organelles are duplicated is:
   A) " M" phase B) G_1 phase C) "S" phase D) G_2 phase

3. Which of the following cell organelles is directly involved in mitosis ?
   A) Nucleus B)Golgi apparatus C) Mitochondrion D) Nucleolus

III. Short answer items

1. Why doesn't a cell diminish in size as it repeatedly divides?
2. What is "cell madness"? Anticipate its consequence on cell functions.

SECTION 1.2 CELL DIVISION

INTRODUCTION

 Dear learner! Even though what triggers a cell to start cell division is not yet known with certainty, a normal cell divides with distinct and regular pattern or phase. Cells can be body (somatic) cells or reproductive (sex) cells. Somatic cells increase their number through cell division for the purpose of growth and replacing dead or worn out cells. On the other hand, reproductive cells divide to increase the number of sex cells or gametes as a means to get young offspring.

Dear learner! You can Imagine the effect of scraping your elbow. In addition to being uncomfortable, you will lose a bunch of skin cells. Have you ever thought ,how your body makes new cells to replace cells that are damaged or lost as a result of injury or accident? You will get answer to this question after you study about mitosis. You will also learn how human gametes, sperm and egg cells are produced as initial cells of your body under the topic "Meiosis".

MINIMUM LEARNING COMPETENCIES

Upon completion of this sub-topic, you will be able to:

- Tell the causes of cell division,
- explain the importance of cell division in general,
- outline the pattern of mitotic and meiotic cell division,
- discuss difference between mitosis and meiosis, and
- indicate the importance of mitosis and meiosis.

1. 2. 1 What is cell division /cell reproduction?

Dear learner! In Grade 9 Biology, you have learned that a cell is the basic structural and functional unit of life. It is the ability of cells to reproduce that distinguishes living organisms from non-living organisms. There must be at least a single cell to have an organism. For example, amoeba is a single cell organism, known as unicellular organism. There are also multicellular

organisms with a huge number of cells. Even these multicellular organisms initially started with a single cell or few cells and became multicellular by repeated cell division.

Dear learner! You know that the cell theory includes the statement: "new cells arise from pre-existing cells" and this occurs as a result of cell division. This fundamental principle, known as the cell doctrine, was originally postulated by Rudolf Virchow in 1858, and it provides the basis for the continuity of life. In this sub section before learning how cells divide, you need to know what forces a cell to divide.


What necessitates a cell to divide?

Dear learner! Imagine what will happen if a cell keep growing indefinitely? As the cell grows, the volume of cytoplasm relative to the cell membrane will be small and will have small surface area to volume ratio. As a result, material transport across the cell membrane by simple diffusion will be inadequate for the cell to survive. Moreover, as the size of the cell increases the controlling power of the nucleus over the cell is highly minimized. Thus, to solve these problems, a cell employs a mechanism called cell division by which one cell becomes two or more.


What is the importance of cell division to organisms?

Dear learner! Now you know what forces a cell to divide, but you should be informed the particular importance of cell division. It goes without saying that a cell increases its number as it divides repeatedly. The increase in cell number in turn is important for many reasons. In unicellular organisms, cell division is a means of reproduction or getting new offspring. For instance, Amoeba is unicellular. When a single cell Amoeba divides, it increases its population, i. e. the number of Amoebae (offspring). However, in multicellular organisms, cell division is a means of increasing cell number either for growth or to replace damaged/dead cells and repair the body. In sexually

reproducing organisms, it occurs around reproductive organs as a means of getting gametes or sex cells.

Activity 1. 4

Dear learner!

Please consider the fascinating process of cell division in the human body. Take time to read the questions below with care and provide accurate answers by referring to biology books or searching the internet.

- Can you identify the primary location of cell division, where it mainly occurs to renew damaged cells rather than promote growth? Furthermore, do you know if this happens more frequently in a child's or an adult's body?
- Additionally, can you name a specific area of our body where cells undergo continuous division? What is the

1. 2. 2 Mitosis

Dear learner! You should know how duplicated chromosomes (genetic materials) of a single mother cell are distributed between two identical daughter cells. This is the result of nuclear division known as mitosis. Mitosis has sub distinct but continuous sub phases for proper arrangement and redistribution of duplicated chromosomes between daughter cells. As a result, the two daughter cells are identical to one another, in that they have the same number and kind of chromosomes (hereditary materials) as the parent nucleus. As a result, a diploid (2n) mother cell gives rise to two diploid (2n) identical daughter cells.

REMARK

- The term mitosis was first coined by Walther Flemming in 1882 when he discovered that chromosomes during cell division split longitudinally thereby distributing themselves equally between two daughter cells.
- The end result of mitosis is growth of the eukaryotic organism and replacement of damaged or dead cells.
- After fertilization (union of sperm cell and egg cell), the growth of the zygote occurs by cell division through mitosis. It divides into 2 – cell stage, then 4 – cell stage, 8 – cell stage, 16 – cell stage, and so. This is called **Cleavage.**

How does a cell divide by mitosis?

Dear learner !you will learn about the sub – phases of mitosis as illustrated in Figure 1. 2. Apart from cytokinesis (cytoplasmic division), mitosis as nuclear division (Karyokinesis) is divided into a series of sub-phases namely; **prophase, metaphase, anaphase and telophase.**

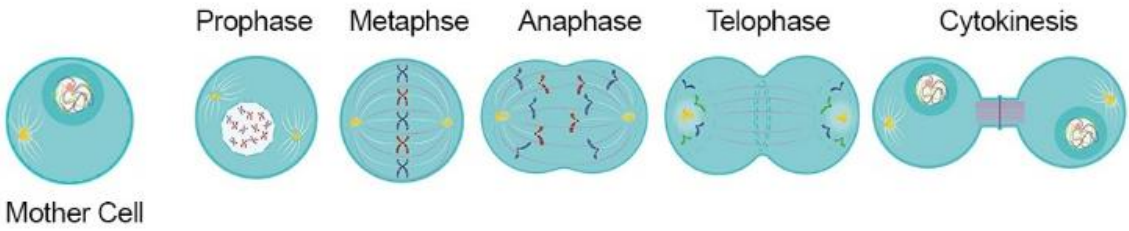


Figure 1.2 Illustration of cell division by mitosis

What happens in the different phases while a cell undergoes mitosis?

Dear learner! detailed description of what actually happens during the four phases of mitosis is presented as follows:

1. **Prophase(the "first phase"):** During this phase,
   - each duplicated chromosome, composed of two sister chromatids and containing identical genetic material, pairs up.
   - the nuclear membrane breaks down and the nucleolus disappears.

- chromosomes shorten, thicken and become visible.
- the centrosomes begin to move to opposite poles of the cell, and spindle fibres emerge from the centrosomes (two in numbers and located outside the nucleus)- Figure 1. 3

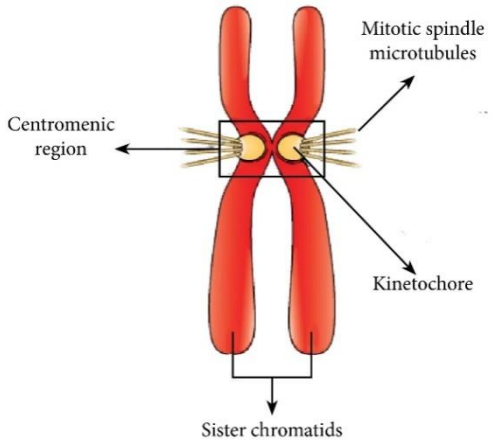


Figure 1.3 Sister chromatids: Mitotic spindle emerging from the centrosomes

2. Metaphase (arrangement phase):

During this phase

- mitotic spindles are fully developed with centrosomes at the opposite poles.
- chromosomes line up(arrange themselves) end–to–end along the centre or metaphase plate (equatorial plane) of the cell.
- each sister chromatid is attached to a spindle fibre originating from opposite poles.

3. Anaphase (migrating phase) :

During this phase

- cohesive proteins binding the sister chromatids together known as centromere, breakdown.
- separated sister chromatids are pulled apart by the mitotic spindle which drags one chromatid to one pole and the other chromatid to the opposite pole. This will ensure daughter cells receive chromosomes that are the same in number and kind.

4. Telophase (a reverse of prophase)

This phase is also known as a reversed prophase because what has disappeared during the interphase will reappear during the telophase and vice versa. Accordingly, during this phase

- Nuclear membrane reappears and surrounds each set of chromosomes to create two new nuclei arriving at opposite poles.
- The mitotic spindle breaks down and disappears.

Dear learner! After the completion of the four sub phases of nuclear division, the cell undergoes cytoplasmic division, which is known as Cytokinesis, However, its completion in animal cell is different from plant cell. As animal cell is surrounded only by cell membrane, cytokinesis enables the cytoplasm of the mother cell to constrict in the middle and ultimately pinch off. Consequently, the two daughter cells obtained by complete cytokinesis entirely separate.

Dear Learner! You have learned that a plant cell is surrounded by hard cell wall in addition to the cell membrane. As a result, the cytoplasm cannot simply pinch off and fully separate; instead, a new wall will be laid down between the two daughter cells. Thus, the two adjacent cells remain joined together by the middle wall – called **middle lamella.**

 What is the significance of cell division through mitosis?

The redistribution of duplicated chromosomes through mitosis is important to get two daughter cells that are identical in quality and quantity of chromosomes. Moreover, the process of mitosis is important to increase cell number, which in turn is essential for growth. We, human beings started as diploid (2n) zygote, which in turn is the result of the union of haploid (n) sperm and haploid (n) egg. Then the zygote by repeated cell division through mitosis develops into multicellular organism. This is how we human beings are made up of million cells.

Dear learner! You should know that cells have a finite life span; they wear out or become damaged; so they need to be replaced continuously. The

process of growth, repair and replacement of dead cells all rely on cell division through mitosis. Unicellular organisms like Amoeba also use cell division through mitosis to increase their number or population.

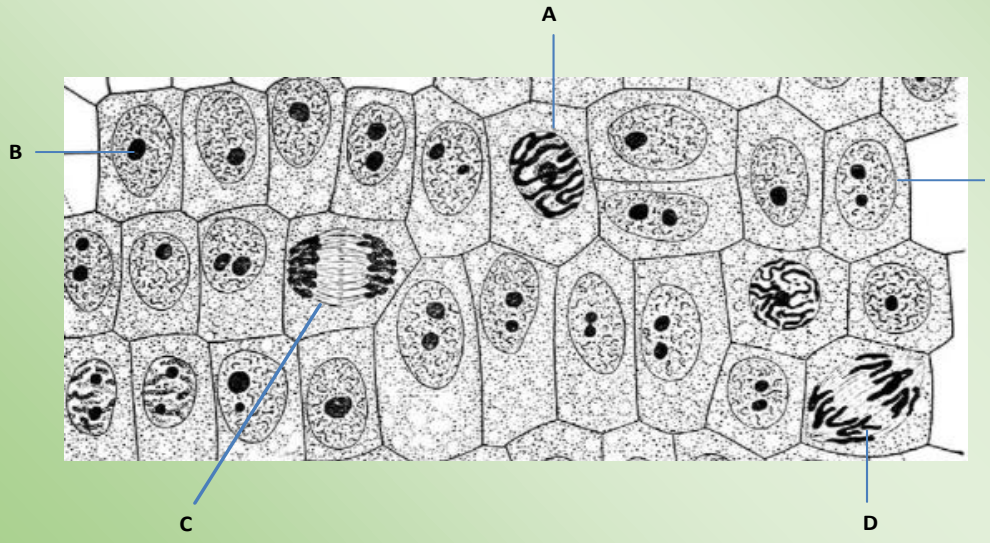
KEY TERMS

- **Spindle fiber** – is long protein fiber extending from structures called centrioles. It starts from the pole of the cell and extends up to the centre, where it is linked to duplicated chromosomes arranged for distribution. It is necessary to pull chromosomes separated towards the pole during the anaphase stage of cell division
- **Homologous chromosomes** – are couples of one maternal and one paternal chromosome paired up during fertilization. They are paired chromosomes, each of which represents a parent for a unit character such as height, body colour, sex etc. The best analogy for homologus chromosomes, is paired shoe with the same number . Every person like the unit character has same number, say shoe size 41, two in number and fit to the right and left feet of Mr/Mrs "X" or "Y". Likewise, in humans each diploid (2n) body (somatic) cell has 23 pairs of homologous chromosomes, giving a total of 46 (2 X 23) chromosomes.
- **Sister chromatids:** Two copies of one maternal or paternal chromosome linked together by cohesive protein on the centromere.
- **If you have access to internet read more about difference between homologous chromosomes and sister chromatids on:** http://www.differencebetween.net/science/difference-between-homologous-chromosomes-and-sister-chromatids/#ixzz72kDLiFk2

Activity 1. 5

Dear learner!

In this activity, you will be examining the different phases of mitosis in onion cells, as seen under the microscope. The figure below displays the different phases of mitosis, labeled with letters A to E. Your task is to carefully examine the figure and identify the specific phases represented by each letter. This will help you reinforce your understanding of mitosis and its phases.



1. 2. 3 Meiosis

What is meiosis? How does it differ from mitosis?

Dear learner! Do you know how gametes or sex cells (sperm cells and egg cells) are formed? You should be informed that gametes are different from the other body cells in that they are haploid (n) daughter cells obtained from diploid mother cell by meiosis. Meiosis involves two divisions of the nucleus (Meiosis I and Meiosis II) giving rise to four gametes or sex cells, each possessing half the number of chromosomes (n) present in the mother cell.

Meiosis is called **reduction division,** as the final daughter cells are haploid (n) as compared to the diploid (2n) mother division.

The process of meiosis is a characteristic feature of organisms that reproduce sexually. In this lesson, you will learn about meiosis as special type of nuclear division that occurs around reproductive organs only. These reproductive organs are ovaries of female animals and testes of male animals as well as anthers and ovules of flowering plants.

Why is meiosis so important?

Dear learner! imagine what would happen if the human gametes (sperm cell and egg cell) had 46 chromosomes like the other body cells. The answer is simple that there will be 92 chromosomes in the zygote, which will not be normal. Thus, during gametogenes is (gamete formation) in human ovaries and testes, the 46 chromosomes in the initial mother cell have to be reduced by half (23 chromosomes)and this is done by meiosis. As a result, the sperm or egg cells nuclei will have 23 chromosomes (haploid, abbreviated as n). So, when sperm and egg join together at fertilization, a zygote that contains the normal number of 46 chromosomes (23 pairs, Diploid abbreviated as 2n) will be formed. It is this initial diploid cell (zygote) that repeatedly divides by mitosis and forms all body(somatic) cells.

Dear learner! Figure 1.4 is a pictorial representation of meiosis. The figure shows the different phases of meiosis I and II. You should pay attention to the pattern of nuclear division, which is arrangement and distribution of duplicated chromosomes and how the mother cell divides twice and forms four haploid (n) daughter cells. A short description of each phase is also presented in Table 1. 1.

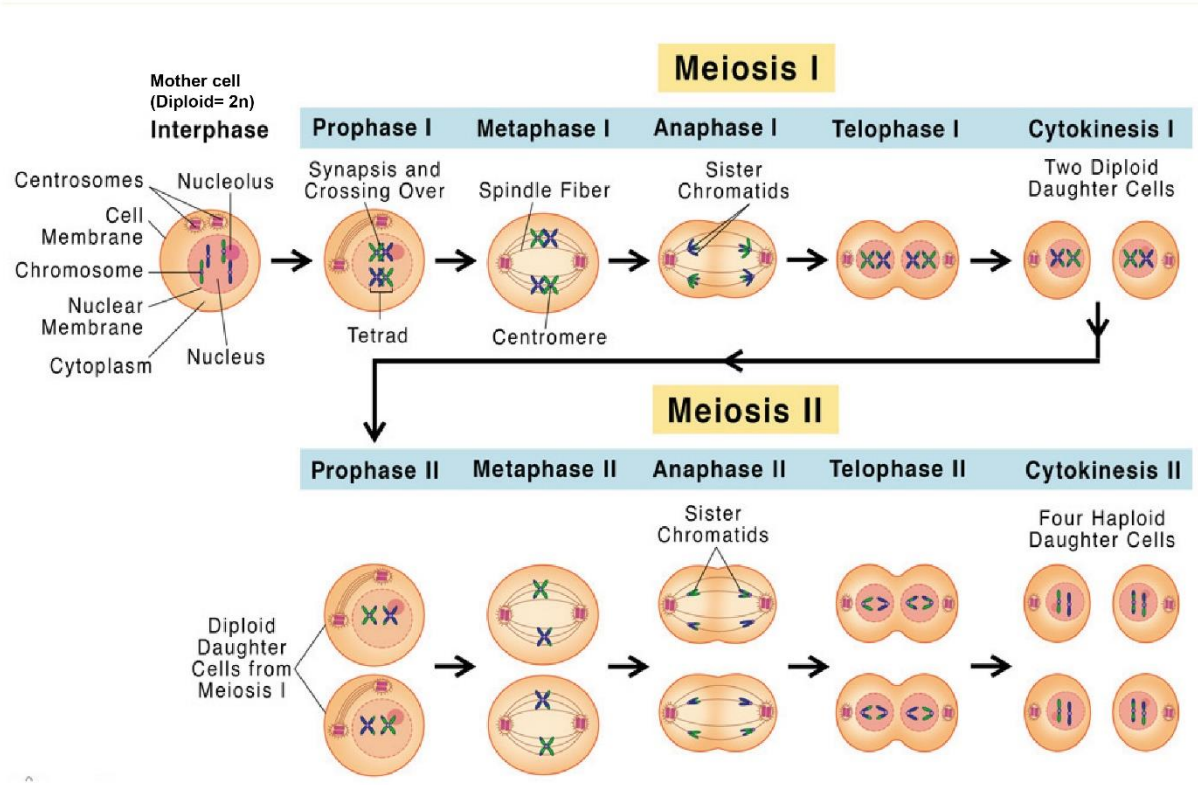


Figure 1.4 Illustration of meiosis I and Meiosis II

Table 1.1 Description of the different stages of Meiosis I and Meiosis II

Stage	Description
Prophase I	▪ Each chromosome appears shortened and thickened form two chromatids ▪ Homologous chromosomes pair up
Metaphase I	▪ Chromosomes align on spindle fiber; lining up in the middle or metaphase plate
Anaphase I	▪ The centromere joining sister chromatids do not separate ▪ The pair of chromatids from each homologous pair move to the end (pole) of the cell. ▪ Reduction to haploid (n) will take place because homologous chromosomes of male and female parents separate
Telophase I	▪ The nuclear membrane reforms and the cells begin to divide. ▪ In some cells, the cell continues to full cytokinesis while in other cells there may be prolonged interphase but with no further DNA duplication

Prophase II	▪ New spindles are formed and the chromosome, still made up of paired chromatids moves toward the middle of the cell.
Metaphase II	▪ The chromosomes line up in the metaphase plate , with the spindle attached to the sister chromatids of each chromosome coming from the opposite poles.
Anaphase II	▪ The centromeres divide and sister chromatids separate and pulled to the opposite ends of each cell
Telophase II	▪ Nuclear membrane reappears and the chromosomes return to the interphase state ▪ Cytokinesis follows giving four daughter cells each with half the chromosome number of the initial parent (mother) cell

Activity 1. 6

Attention learner!

Here, you have an interesting assignment to complete. The task requires you to carefully examine Figures 1.2 and 1.4 and answer two questions, namely:

1. Which of the two stages of meiosis (Meiosis I or Meiosis II) is most similar to mitosis, and why?

2. What are the fundamental similarities and differences between mitosis and meiosis?

Once you have answered the above questions, please prepare a table that clearly outlines the differences between mitosis and meiosis.

Next, perform the exciting activity - a game that will help us practice nuclear division. The main purpose of this game is to demonstrate the different stages of nuclear division using small pieces of colored threads. This helps to show the arrangements and redistribution of duplicated chromosomes that occur first in mitosis and then in meiosis.

✓ Self-evaluation checklist

Put a tick (√) mark against each of the following tasks, which you can perform. If you cannot perform any of these tasks, go back and read the lesson for that particular task.

I can:

- point out the causes of cell division_____ ☐
- Explain the importance of cell division in general _____ ☐
- outline the pattern of cell division in mitosis and meiosis _____ ☐
- tell the difference between mitosis and meiosis _____ ☐
- Distinguish the specific role of mitotic and meiotic cell division_____ ☐

Self-Test Exercise 1.2

I. True/ false items: Write "TRUE" for a correct statement or "FALSE" for an incorrect statement.

1. Generally, mitosis is frequent in tissues that require intense renewing due to their function.
2. Cell division in multicellular organism is a means of getting young offspring.
3. There must be at least a single cell to have an organism.
4. A cell increases its number as it divides repeatedly.
5. Homologus chromosomes are two copies of one maternal or paternal chromosomes.

II. Multiple Choice Items: Choose the correct answer and write the letter of your choice on a separate answer sheet.

1. Which of the following is necessary to pull chromosomes separated during the anaphase stage ?

A) Centriole B) Centromere C) Chiasma D) Spindle fiber

2. Which of the following undergoes meiosis ?

A) Skin cell B) Sex cell C) Nerve cell D) Liver cell

3. Cytoplasmic division occurs after:

A) Anaphase B)Metaphase C) Telophase D) Prophase

4. Which statement is correct about the cells produced by meiosis?

A) Four daughter cells are produced, each has the same number of chromosome as the parent cell

B) Two daughter cells are formed, each has half the number of of chromosomes of the parent cell

c) Four daughter cells are formed, each has half the number of of chromosomes of the parent cell

D) Two daughter cells are produced , each has the same number of chromosome as the parent cell

III. Short answer items

1. What would happen if cytokinesis did not occur after telophase?
2. What is the significance of chiasma in cell division by meiosis ?

UNIT SUMMARY

- A cell cycle is a sequence of events that take place in the parent cell as a means of distributing genetic materials thereby forming daughter cells. There are two main divisions of the cell cycle: Interphase and Cell division.
- Interphase is the stage of preparation where a cell exhibits growthand DNA (genetic material synthesis).
- Cell division is nuclear division either by mitosis or meiosis followed by cytoplasmic division (cytokinesis).
- Cell division is a basic process in all living things where a parent **or mother cell** divides into two cells called **daughter cells**.
- Cell division is a means of growth and replacing damaged or dead cells in multicellular organisms. It is equivalent to reproduction in unicellular organisms.
- Mitosis is a division of the somatic (body) cells to form identical daughter cells. It has four stages, namely prophase, metaphase, anaphase, and telophase.
- Meiosis is a division of reproductive cells, resulting in daughter cells sex cells (gametes) with half of the chromosomes in the initial or mother cell.
- In meiosis, a cell divides twice, Meiosis I and Meiosis II, resulting in four daughter cells.
- In meiosis I, homologous chromosomes separate and move to opposite cells. This is a reduction by half, going from diploid (2n) to haploid (n).
- In meiosis II, sister chromatids separate and move to opposite poles of the cell.
- Meiosis occurs only in reproductive organs such as testes and ovaries while mitosis occurs in body (somatic) cells.

Self–Assessment Questions

I. True / False items: Write "**True" for a correct statement or 'False' for an incorrect statement**.

1. It is meiosis II that resembles mitosis.
2. Sister chromatids are duplicated one parent chromosomes.
3. Mitosis results in two haploid daughter cells.
4. Cytoplasmic division is the longest phase of the interphase.
5. Meiosis is restricted to testis and ovaries

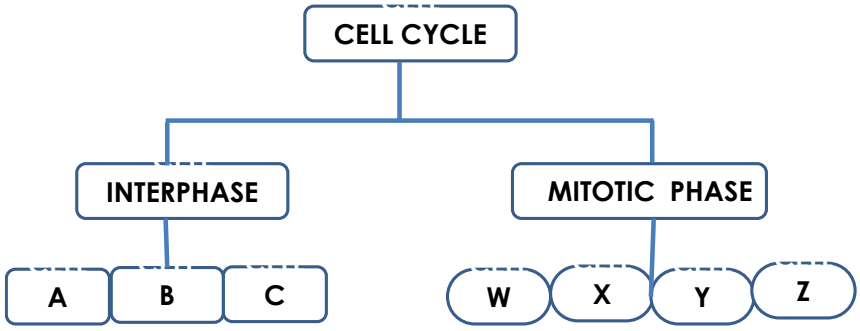
Matching items: Match the descriptions under **"Column A"** with phases or structures involved in cell division under **"Column B"**

Column A	Column B
1. Duplicated one parent chromosmes	A) Anaphase
2. Sister chromatids are pulled by spindle fiber	B) Cytoplasmic division
3. Known as cytokinesis	C) Homologous chromosomes
4. Paired paternal and maternal chromosomes	D) Interphase
5. Duplicated chromosomes are arranged on the equatorial plane	E) Metaphase
6. Termed as " Reversed prophase"	F) Sister chromatids
	G) Telophase

5. Short answers

1. What is the importance of mitosis to organisms?
2. Mention at least two important features of cancer cells.
3. What is the difference between Cytokinesis and karyokinesis? Which comes first?
4. Assume a cell is having 2n= 56 , then divide it by meiosis.
   A. How many cells are formed at the end of meiosis I? meiosis II?
   B. How many chromosomes are there in each daughter cells at the end of meiosis II?
   C. How many set of chromosome(s)/is/ are there at the end of meiosis I? meiosis II?

5. Based on the following summary chart , list down sub – phases of interphase denoted by letters: **A, B , C** and sub – phases of mitotic phase represented by letters : **W,X,Y , Z**



Answer Key to Self – test Exercises

Answer to Self – test1. 1

I. True – False items

1. True 2. False 3. False 4. True

II. Multiple choice items

1. B 2. D 3. A

III. Short answer items

1. There is cell growth before and after cell division. As a result a cell does not diminish in size upon repeated cell division,
2. "Cell madness" is abnormality in thedivision of a cell when the controlling factors over cell division and cell growth fail. It occurs in the absence of growth factors allowing a cell to divide continuously at very high density at the expense of other normal cells. These cells fail to communicate with healthy cells and do not carry out normal cell functions. More over, they may not securely anchor themselves to one site and this makes them more likely to travel somewhere and spread to other parts of the body

Answer to Self – test 1. 2

I. True – False items

1. True 2. False 3. True 4. True 5. False

II. Multiple choice items

1. B 2. B 3. C 4. D

III. Short answer items

1. If there is no cytoplasmic division occurring at the end of telophase, division of cell will be incomplete or the division will not end by giving daughter cells.
2. Chiasma is a structure that physically links homologus chromosomes during meiosis. It is joining and separation of homologus chromosomes. It is a unique feature of a cell undergoing meiosis. It is the separation of homologus chromosomes linked by chiasma in Meiosis I that enables the daughter cells to get half the number of chromosomes of the parent cell. As a result a cell will go from diploid (2n) haploid (n), which is required for sex cells or gametes before their union (fertilization) to form a diploid(2n) zygote. Thus, the presence of chiasma that links homologus chromosome is essential for sexually reproducing organisms as a means to get haploid sex cell.

Feedback to Activities

Feedback to Activity 1.1

- ✓ The nucleus is the control centre of cell multiplication including cell cycle and cell division .It acts as the cell's brain by directing it what to do, how to grow and reproduce under regular pattern. It contains the genetic material or chromosomes that controls the characteristics of the body.
- ✓ The nucleolus is a distinct structure covering nearly 25% of the nucleus of eukaryotic cells. It is primarily involved in the synthesis of proteins, the production of ribosomes and sensing cellular stress.
- ✓ The ddifference between nucleus and nucleolusis summarized in the following table.

Nucleus	Nucleolus
Large in size	Small in size
Surrounded by nuclear membrane	It is not bounded by membrane
It contains chromosomes	It does not contain any chromosomes
It is rich in DNA, the genetic material	It is rich in RNA

Feedback to Activity 1.2

- Approximately,95% of the cell cycle is spent in interphase. Cell division(mitosis & cytokinesis) can be completed in an hour .
- A cell spends most of its time during the interphase because it is engaged in growth, synthesis of DNA and assemblage of cytoplasmic organelles.
- Each stage of thecell cycle is not static. This means one phase does not stop for the other phase to start (no pause) and the process is continuous.

Feed back to Activity 1. 3

The information about cancer can be brief or detailed depending on the resource a distance learner have come across. The following points could be added if they are not included in the information, you have collected.

- Cancer is one group of disease characterized by the development of abnormal cell that divide uncontrollably and have the ability to infiltrate and destroy normal body tissue. It often has the ability to spread throughout the body.
- Cancer is basically caused by changes (mutations) to the DNA (genetic material), which contains a set of instructions that control the way our cells function, especially how they divide and grow. Errors in the instructions can cause the cell to stop its normal function. This in turn allows cells to divide and grow in uncontrollable manner and become cancerous. There are various causative factors (high risk factors) associated with cancer; these include: genetically engineered food, tobacco, alcohol, pollutants, life style(Eg. Obesity, fatty diet, lack of exercise) and artificial food additives (artificial flavours, colors and preservatives).

- The common cancers of the human body include breast cancer, lung cancer, colon and rectal (colorectal) cancer, pancreatic, Kidney (Renal cells and Renal pelvis), leukemia (blood cells) and prostate cancer.
- Cancer affects the normal functions of the body and causes imbalance and complication , some of which Include:
  - ✓ chemical imbalance(sign and symptoms: excessive thirst, (Frequent urination, constipation and urination),
  - ✓ brain and nervous system problems (Sign and symptoms: headaches, stroke or weakness on one side of the body)
  - ✓ Weight loss, difficulty in breathing , etc.
  - ✓ The prevention of cancer mainly focuse on reducing/minimizing or avoiding the risk factors associated with developing cancerous cells. Early diagnosis through regular medical check-up will help to control cancer and possibly cure the cancer patient through early treatment.

- The most common treatments of cancer are:
  - ✓ **Surgery** – is a common treatment for many types of cancer, where the surgeon takes out the mass of cancerous cells (tumour) and some of the nearby tissue.
  - ✓ **Chemotherapy**-refers to drugs used to kill cancer cells
  - ✓ **Radiation therapy**- uses high – powered radiation (such as X – rays or gamma rays) to kill cancer cells

Feedback to Activity 1.4

- Cell division is a means to increase cell number. These cells are means of repairing the body and renewal of tissue as well as growth. Tissue renewal is common in adults while growth is needed in a child. Hence, mitosis in adult is mainly for tissue renewal, while it is mainly for the growth in children.

- Skin and hair are parts of the body where cells undergo continuous replacement because skin and hair cells are damaged frequently.

Feedback to Activity 1.5

Letters "A" to "E" included in the figure (Activity 1. 5) represent the following phases of mitosis

A = Prophase B = Interphase C= Anaphase D = Telophase
D = Cytokinesis (two daughter nuclei, before cell plate formation)

Dear learner! You should know how cytokinesis in plant cell occurs differently from animal cell. Plant cells divide into two by constructing a cell plate in the middle plane between daughter nuclei after mitosis. A cell plate is deposition of hard carbohydrates (mainly cellulose) which will become the cell wall of the daughter cells.

Feedback to Activity 1.6

- It is Meiosis II which is similar to mitosis, because it is centromere division where sister chromatids are separated.
- Basic similarities between Mitosis and meiosis:
  - ✓ Both processes occur in the cell nuclei.
  - ✓ Both involve the interphase and cell division.
  - ✓ Both have common stages – Prophase, metaphase, anaphase and telophase.
  - ✓ Synthesis of DNA occurs in both.
  - ✓ Both produce daughter cells based on their parent cells' DNA.

The differences between mitosis and meiosis is summarized in table

Mitosis	Meiosis
▪ Involves one cell division	▪ Involves two cell divisions.
▪ Results in two daughter cells called somatic (body cells)	▪ Results in four daughter cells called sex cells (gametes)
▪ Daughter cells are diploid(2n), identical to one another and the diploid (2n) parent cell	▪ Daughter cells are haploid (n), chromosomes number is halved from the parent cell.
▪ Occurs where growth and replacement of damaged or worn out cells occur	▪ Restricted to gonads (testes and ovaries in animals), anthers and ovules of flowering plants
▪ No crossing over occurs in prophase	▪ Crossing over occurs in prophase

ANSWER KEY TO SELF-ASSESSMENT QUESTIONS

I. True –/False items

1. True 2. True 3. False 4. False 5.True

II. **Matching items**

1. F 2. A 3. B 4. C 5. E 6. G

III. **Short answer items**

1. Mitosis to unicellular organisms like Amoeba is a means of reproduction or getting new organisms.
   Mitosis in multicellular organisms is a means of increasing cell number . This is needed for repairing the body by replacing damaged /worn out cells or dead cells . It is also a means of growth.
2. Unlike normal cells, cancerous cells have the following features:
   - ✓ They have limitless replicative potential. They do not stop growing and dividing , this uncontrolled growth results in the formation of tumor.
   - ✓ They are insensitive to growth inhibitors' (antigrowth) signals.
   - ✓ They have the capacity to migrate and invade other tissues and organs , resulting in their spread throughout the body.
3. Cytokinesis is the process of cytoplasmic division, where the cytoplasm and organelles within the cell are divided.

Karyokinesis is the process of nuclear division, where the chromosomes within the nucleus are first duplicated (interphase), rearranged and redistributed between daughter cells (from prophase to telophase). It is karyokinesis that takes place first. It is followed by cytokinysis as continuous process.

4. Assume a cell is having 2n=56, then divide it by meiosis.

A) There will be two cells at the end of meiosis I and four cells at the end of meiosis II

B) There will be 28 chromosomes in each daughter cells at the end of meiosis II?

C) There will be haploid (n) sets of chromosomes at the end of both meiosis I and meiosis II

5. Sub phases of interphase denoted by letter : A = G_1, B = S , C = G ; while sub – phases of mitotic phase represented by letter: W = prophase, X = metaphase, Y = Anaphase, Z = Telophase. Note that each sub – phase is distinct and the process is continuous.

References

Cell cycle and cell division ; Available at https://ncert.nic. in/textbook/pdf /kebo110. pdf

Cell division , Genetics and Molecular Biology. Unit 30 C. Available at http://standring.weebly.com/uploads/2/3/3/5/23356120/8_-_unit_30c. pdf

David Sadava (2011). Life : The Science of Biology . 9th Ed. Planet friendly publishing , USA. Freely available at: https://www. pdfdrive. com/life-the-science-of-biology-9th-edition-d163931559. html

Jane, B. et al (2016). Campbell Biology.11th Ed. Pearson higher education Ltd

UNIT TWO: HUMAN BIOLOGY

INTRODUCTION

 Dear learner! The human body is made up of billions of smaller structures of four major types: cells, tissues, organs, and systems. An organ is a grouping of several different types of tissues that work together to perform a specific function. A system is an organization of various numbers and types of organs that work together to perform complex functions for the body. Skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive systems are among the ten major systems. The physiological functions of body systems are also known as body functions. The body's survival is dependent on maintaining or restoring homeostasis, or relative constancy of its internal environment. Organization, metabolism, responsiveness, movements, reproduction, growth, differentiation, respiration, digestion and excretion are all part of the human life process. All of these processes work in perfect harmony for the individual's well-being and the continuation of life. In human body, there are systems like nervous, skeletal and reproductive systems, which you will study in the following grades. In this unit, you will study these complex human body systems. The unit is subdivided into 6 sections and each section contains the content, checklists, self-test exercises, activities, feedback to activities and answers for all review questions in the laboratory activities.

LEARNINGOUTCOMES

Upon successful completion of this unit,you will be able to:

- Discuss the structure and function of the digestive system(alimentary canal and accessory organs
- Classify the types of digestion along the alimentary canal
- List the end products of carbohydrates, proteins, and fats after complete digestion

- Express the site of absorption of digested food, minerals, vitamins, and water
- Explore structural adaptations of the small intestine for the absorption
- Differentiate the absorption routs of different end products of digestion (hint: lacteals, capillaries)
- Group enzymes of the digestive system based on their roles and pH
- Demonstrate the structure of the heart using a heart model/diagram
- Differentiate between pulmonary and systemic circulations
- Compare and contrast arteries and veins based on their structure and function
- Debate on the importance of blood donation and the health implications on the donors and recipients
- Discuss the key functions and components of the lymphatic system
- Define the immune system
- Discuss the types of immunity
- Relate the types of immunity (innate and acquired)
- Relate the lymphatic system with immune system
- Discuss the diseases of the circulatory and lymphatic system (leukemia, varicose vein, elephantiasis, cardiovascular diseases)
- Draw and label the human breathing and excretory systems
- Show the link between the human breathing system and the circulatory system
- Demonstrate the mechanism of breathing usinglocally available materials
- Design a model of one of the systems (excretory, circulatory, digestive systems), and
- Examine the effects of smoking and cannabis on the normal functioning of the breathing system.

UNIT CONTENT

5. 1 Digestive system

5. 2 Circulatory and lymphatic system

5. 2. 1 Blood donation

5. 2. 2 Diseases of the circulatory and lymphatic systems

(leukemia, varicose vein, elephantiasis, cardiovascular diseases)

5. 3 Breathing system

5. 4 The excretory system

5. 5 The immune system

5. 6 Renowned physicians in Ethiopia

REQUIRED STUDY TIME

You are expected to spend 40 Learning hours(13 days) of the semester to learn this unit. You should use the allocated study time properly and efficiently to cover the lessons included in this unit.

LEARNING STRATEGIES

For your successful distance learning process, you can use the following learning strategies wherever they are appropriate to the topics/ subtopics of your lesson. These are mentally rehearsing, short visits/onsite observation, comparing and contrasting, drawing and taking pictures of real plants, creating analogies, paraphrasing, summarizing (outlining and preparing flow chart summaries), taking short notes, underlining or highlighting key points.

Section 2.1 The Digestive System

Introduction

Dear learner! All living organisms need nutrients to survive. Plants can obtain nutrients from their roots and the energy molecules required for cellular function through the process of photosynthesis. Animals, however, obtain their nutrients through the consumption of other organisms. At the cellular level, the biological molecules necessary for animal function are amino acids, lipid molecules, nucleotides and simple sugars. However, the food consumed consists of protein, fat and complex carbohydrates. Animals must convert these macromolecules into the simple molecules required for maintaining cellular function. The conversion of the consumed food to the nutrients required is a multi-step process involving digestion and absorption. During digestion, food particles are broken down into smaller components, which are later absorbed by the body. This happens by both physical means,

such as chewing and by chemical means, via enzyme-catalysed reactions. These processes take place in the human digestive system step-wise. In this unit, you will learn this step-wise digestion of the food we consume through the alimentary canal.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, you will be able to:

- discuss the structure and function of the digestive system (alimentary canal and accessory organs),
- classify the types of digestion along the alimentary canal,
- list the end products of carbohydrates, proteins, and fats after complete digestion,
- express the site of absorption of digested food, minerals, vitamins, and water,
- explore structural adaptations of the small intestine for the absorption,
- differentiate the absorption routs of different end products of digestion (hint: lacteals, capillaries), and
- group enzymes of the digestive system based on their roles and pH.

Activity 2.1

Dear learner! You have previously studied the human digestive system. Before studying this section, write down (for yourself) what you know about the human digestive system and the process that begins with the mouth and ends with the anus. Then, you can continue your studies.

What are the components and processes of the human digestive system?

Dear learner! The human digestive system is composed of four digestive processes:

1. **Ingestion**-It is the taking in of nutrients, in the mouth,
2. **Digestion** - It is the breakdown of complex organic molecules into smaller components by enzymes step-wise, physical, and chemical processes that begins in the oral cavity and extends to the small intestine,

3. **Absorption** - It is the transport of digested nutrients from the small intestine to the cells of the body though finger like projection called villi in the small intestine.

4. **Egesting** - It is the removal of food waste from the body. The distinction between excretion and egestion is based on the type of wastes excreted by an organism. Undigested food that remains after digestion is expelled in animals during the egestion process. Excretion is the process through which metabolic wastes are expelled in both plants and animals.

How long is the human digestive system? Where in the alimentary canal does physical digestion begin?

Dear learner! The digestive tract of adult humans is normally 6. 5 m to 9m long.It stores and breaks down organic molecules into simpler components. Physical (mechanical) digestion begins in the mouth, where food is chewed and formed a **bolus** (the Greek word for the ball) by the tongue. Physical digestion breaks food into smaller pieces, increasing the surface area for chemical digestion.

Activity 2. 2

Dear learner! This is the activity for you to do independently:

i. discuss why digestion is important;
ii. draw, label and study the location and function of accessory organs in human digestive system
iii. write the digestion end products for carbohydrates, lipids and proteins; and
iv. Use the internet and other resources to supplement your study with a virtual lab focused on the digestive system animation.

Where in the alimentary canal does the chemical digestion begins and how does it proceed?

Dear learner! The chemical digestion of carbohydrate (starch) starts in the oral cavity by an enzyme called salivary amylase or ptyalin. The food is then

swallowed and enters the **esophagus,** a long tube that connects the mouth to the stomach. Using **peristalsis**, wave-like smooth-muscle contractions, the muscles of the esophagus push the food toward the stomach. The stomach contents are extremely acidic, with a **pH** between 1. 5 and 2.5.This acidity kills microorganisms, breaks down food tissues, and activates digestive enzymes. The chemical digestion of protein starts in the stomach by the enzyme pepsin.

Further breakdown of food takes place in the **small intestine** where bile is produced by the liver, and enzymes produced by the small intestine and the pancreas, continue the process of digestion. The smaller molecules are absorbed into the bloodstream through the epithelial cells lining the walls of the small intestine. The waste material travels onto the **large intestine** where water is absorbed and the drier waste material is compacted into **faeces;** it is stored in the **rectum** until it is excreted through the **anus.** Dear learner! Now you can proceed studying the process of digestion from ingestion to ejection in detail.

The Oral Cavity

What is the process of digestion that takes place in the mouth?

Dear learner! In the oral cavity, both physical and chemical digestion begins. It is the point of entry (ingestion) of food into the digestive system. The process that takes place in the mouth includes:

i) the breakdown of food into smaller particles by mastication, the chewing action of the teeth.
ii) saliva, the watery fluid produced by the salivary glands contains amylase enzyme, and breaks down starches into simpler molecules.
iii) saliva dissolves food particles and makes it possible to taste what is being eaten.
iv) saliva lubricates the food so that it can be swallowed.
v) We detect the flavour when food particles dissolved in saliva penetrate the cells of the taste buds located on the tongue and cheeks.
vi) the tongue, positions and mixes food and forms a ball of food called **bolus** ready to be swallowed.

Activity 2. 3

Dear learner! Dry your tongue and put a piece of freshly-cut lemon on the surface. Wait a moment. What do you feel? Why?

If one ingests glucose, where will it be digested?

The teeth

What is the importance of the teeth in digestion? Can you mention the different types of teeth?

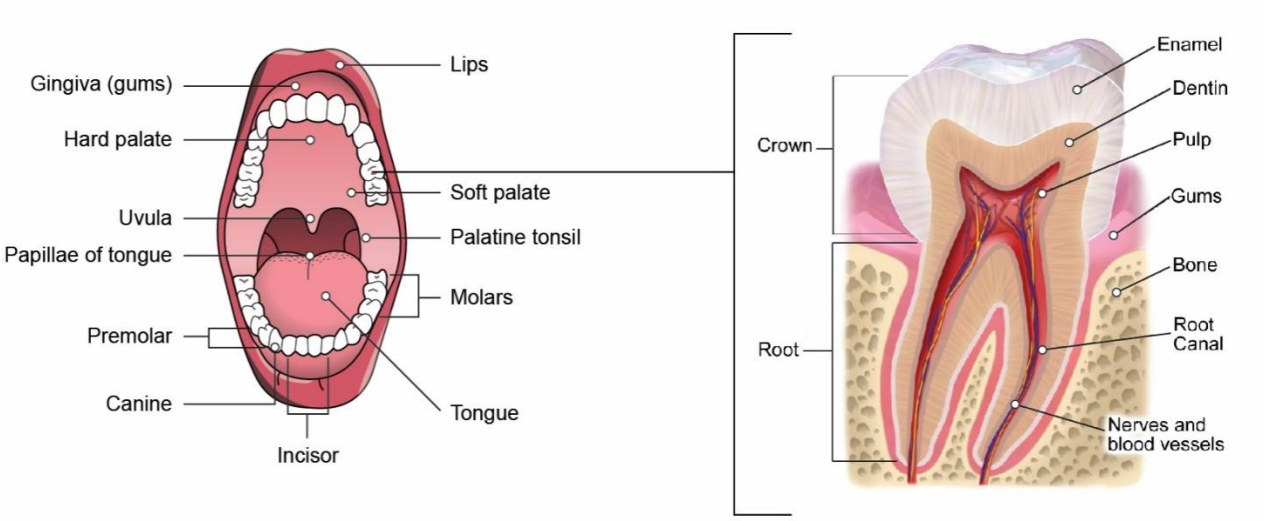
Dear learner! The teeth are important structures for physical digestion (**Figure2. 1**). There are 4 types of teeth:

i) **Incisors:** teeth that **are** eight chisel-shaped and are found in the front part of your mouth specialized for cutting.
ii) **Canine:** teeth that are sharp, dagger-shaped specialized for tearing.
iii) **Premolar:** teeth that are broad flattened specialized for grinding.
iv) **Molars:** teeth tend to be even broader and have cusps that are even more flattened. They are designed for crushing and grinding food. The last set of molars is the **wisdom teeth**, so-called because they usually do not emerge until we reach about 16 to 20 years of age. Each tooth is covered with enamel, which is the hardest substance in the human body.

Activity 4. 4

Dear learner! Answer the following questions for yourself:

i) Write the internal structures of a teeth.
ii) Draw and label the external structure of a teeth.
iii) Do you think feeding sweet food items protect our teeth from decay? If you answer is No., why? If your answer is yes, why?



A. Type of teeth

B. Structure of teeth

Figure 2.1. The structure and types of teeth

External and internal structures of teeth

Dear learner! The teeth are the hardest substances in the human body. Besides being essential for chewing, the teeth play an important role in speech. Parts of the teeth include:

i. **Enamel:** the hardest, white outer part of the tooth. Enamel is mostly made of calcium phosphate, a rock-hard mineral.
ii. **Dentin:** a layer underlying the enamel. It is a hard tissue that contains microscopic tubes. When the enamel is damaged, heat or cold can enter the tooth through these paths and cause sensitivity or pain.
iii. **Pulp:** the softer, living inner structure of teeth. Blood vessels and nerves run through the pulp of the teeth.
iv. **Periodontal ligament**- tissue that helps to hold the teeth tightly against the jaw.
v. Roots and holds the tooth in place. It makes up approximately two-thirds of the tooth
vi. **Gums.** Gums, also called gingiva, are the fleshy, pink connective tissue that's attached to the neck of the tooth and the cementum.
vii. **Crown:** the crown of a tooth is the top portion of the tooth that is visible.

Human dentition

Dear learner! The conventional way of expressing the total number of teeth in the human beings are represented as: incisor(I), canines(C), molars(M) and premolars(P). It gives a set like I:C:P:M. For example, if it is given 2:1:2:3 for upper teeth then, it indicates 2 incisors, 1 canine, 2 premolars and 3 molars of the upper mouth on one side. Include the dental formula
The dental formula of human beings (adults):
(2123/2123) × 2 = 32(2123/2123) × 2 = 32

There are 2 incisors, 1 canine, 2 premolars and 3 molars. In adults, dentition pertains to all types of teeth development. In a normal adult there are 32 teeth. There are two types of dentition: **temporary and permanent**. There are 20 teeth in the temporary dentition and 32 teeth in the permanent dentition. In a child, there are 20 teeth present which are called **milk teeth** or **deciduous teeth**. These teeth grow at the age of 6 years.
i. e. (2102/2102)×2=20(2102/2102) × 2=20. These are 2 incisors, 1 canine and 2 molars.

In order to represent the total number of the teeth in the jaw or mouth, the whole formula is multiplied by two as the formula for one side of the mouth. Both monkeys and human beings have the same set of teeth and the same dental formula.

Keeping teeth health

Dear learner! Have you ever seen peoples suffering from teeth disease? Which age groups suffer from it? Adult teeth should last for your life time. However, this doesn't always happen because your teeth can be affected by bacteria that cause dental caries. There are many different bacteria that are found naturally in your mouth. These bacteria, combined with food and saliva, form a thin film known as plaque on your teeth. If these bacteria are given a sugar-rich diet or if you eat a lot of sweet, sugary food, they produce a lot of acid waste. This acid attacks and dissolves the tough enamel coating of your teeth.

After the acid passes through the enamel, it also dissolves away some of the dentine and then the bacteria can get into the inside of your tooth. The bacteria will then reproduce and feed, eating away at your tooth until they reach the nerves of the pulp cavity causing toothache.

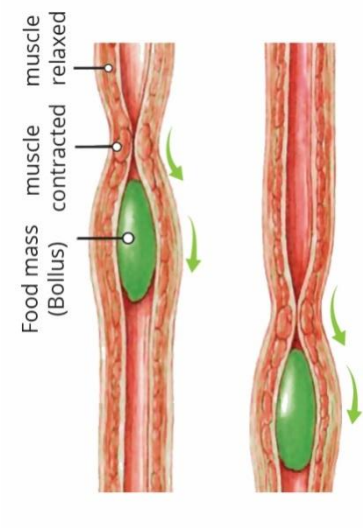
Dear learner! the same bacteria can affect your gums, causing **periodontal disease**. The symptoms include tender gums, bleeding when you clean your teeth and eventually the possible loss of all your teeth, not from tooth decay but from gum disease. Taking in lots of acidic food and drink, such as fruits and cola, can also weaken the enamel on your teeth. This is particularly the case if you clean your teeth straight after an acidic drink such as fruit juice or cola, when the softening effect on the enamel is strongest and brushing your teeth can actually wear the enamel away.

You know, tooth and gum disease are extremely common all over the world. They cause pain, bad breath, loss of teeth and difficulty eating. The good news is that they can both be avoided, especially if you have good dental care available. Ways to avoid tooth decay include:

- Regular brushing of your teeth and gums twice a day. This removes the plaque from the teeth, preventing the build-up of a sticky, acidic film over the enamel.
- Avoiding sweet, sugary foods – if the bacteria in your teeth are deprived of sugar, they cannot make acidic waste and your teeth are safe.
- Have regular dental check-ups. A dentist can clean your teeth more thoroughly than you can, and any early signs of decay can be treated. Your teeth won't heal themselves, but any tooth decay can be removed and replaced by a filling.

The esophagus

Dear learner! The swallowed food travels from the mouth to the stomach by way of the esophagus. The **bolus** of food stretches the walls the esophagus, activating muscles that set up waves of rhythmic contractions called peristalsis. Peristaltic contractions, which are involuntary, move food along the gastrointestinal tract (**Figure2.2**). Peristaltic action will move food or fluid from the esophagus to the stomach. Look at the process of peristalsis in figure 2. 2.



of

Figure 2.2 Rhythmic contractions of muscle move food along the digestive tract

Activity 2. 5 Answer to the questions

Dear learner! Please, respond to the following questions after learning about the oral digestive system and oesophageal sphincters:

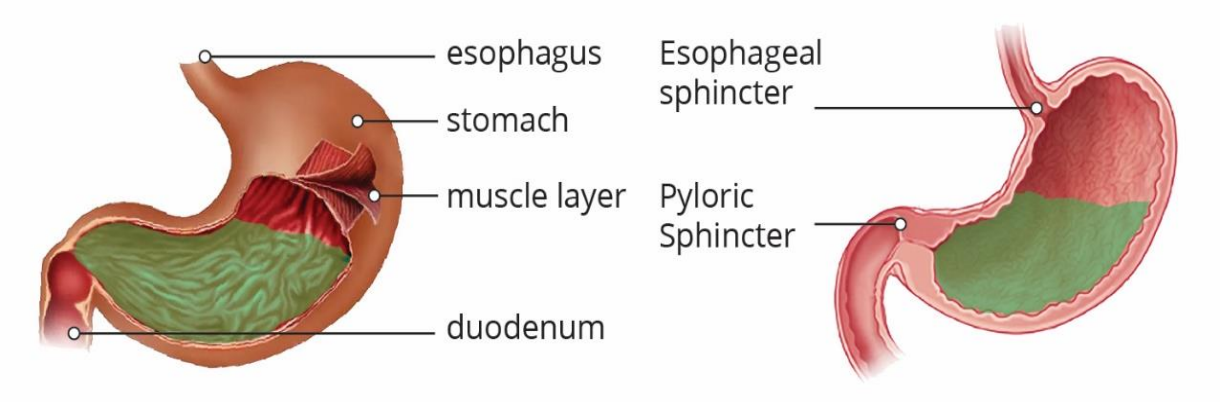
1. Do you have any idea about the function of teeth? How the structure of the teeth is related to its function?
2. Where in the alimentary canal begins the process of digestion? What is the enzyme that acts 1st?
3. Where does the amylase enzymes secreted? And what is their function?
4. What do we call the process that move the food along the oesophagus?

What are the processes of digestion that take place in the stomach?

The stomach

Dear learner! The stomach is the site of food storage and initial protein digestion. The stomach contains three layers of muscle, which run in different directions so that the muscle contractions can churn the food (**Figure 2. 3 (a)**). The movement of food to and from the stomach is regulated by circular

muscles called **sphincters**. Sphincters act like the draw strings on a bag. Contraction of the lower esophageal sphincter (LES) closes the opening to the stomach, while its relaxation allows food to enter. The lower esophageal sphincter prevents food and acid from being regurgitated up into the esophagus. The second sphincter, the pyloric sphincter, regulates the movement of food and stomach acids into the small intestine (**Figure2. 3(b)**).



a) **b)**

Figure 2.3 a) Muscle is responsible for the contractions of the stomach b) Sphincters regulate the movement of food.

The J-shaped stomach has numerous ridges that allow it to expand so that it can store about 1. 5L of food. Millions of cells line the inner wall of the stomach. Activities in the stomach include:

i) the cells secrete the various stomach fluids, called **gastric fluids or gastric juice**, that aid digestion,
ii) contractions of the stomach mix the food with the gastric fluids, and
iii) it is involved in both physical (churning action if stomach wall) and chemical digestion(e. g. digestion of proteins by the action of enzyme pepsin). Approximately 500mL of the fluids in the stomach are produced following a large meal.

What is the composition of gastric juice?

Dear learner! Gastric fluid includes:

- mucus,
- hydrochloric acid (Hydrochloric acid (HCl)),
- pepsinogens, and other substances.

Hydrochloric acid kills many harmful substances that are ingested with food. It also converts pepsinogen into its active form, pepsin, which is a protein-digesting enzyme. Pepsin breaks the long amino acid chains in proteins into shorter chains, called polypeptides.

The pH inside the stomach normally ranges between 2. 0 and 3.0 but may approach pH 1. 0. Acids with a pH of 2. 0 can dissolve fibers in a rug. It is the high acidity of hydrochloric acid that makes it effective at killing pathogens and allows pepsin to do its work.

 How does the stomach safely store these strong chemicals, both of which dissolve the proteins that make up cells?

Dear learner! A layer of alkaline mucus protects the stomach lining from being digested. Pepsinogen passes across the cell membrane and is activated by Hydrochloric acid (HCl) to become pepsin. The pepsin breaks down the proteins in the food, but not the proteins of the stomach's cells because these proteins are protected by the mucous layer. The esophagus does not have a protective mucous layer, so if the lower esophageal sphincter (LES) is weak, stomach acid may enter the esophagus and damage its lining. This causes pain known as heartburn.

 What do we call the partially digested food in the stomach?

The partially digested food and gastric juice mixture are called **chyme.** Gastric emptying occurs within two to six hours after a meal. Only a small amount of chyme is released into the small intestine at a time. The movement of chyme from the stomach into the small intestine is regulated by hormones, stomach distension, and muscular reflexes that influence the **pyloric sphincter.** The low pH of the stomach will denature the **amylase and lipase** that were secreted in the mouth. Therefore, over time, the chemical digestion of starches and fats will decrease in the stomach and their further digestion will take place in the small intestine.

What is the reason for the release of small amount of chyme into the small intestine at a time?

Absorption in the stomach

Dear learner! Although the stomach absorbs few of the products of digestion, it can absorb many other substances, including glucose and other simple sugars, amino acids, and some fat soluble substances, water, specific vitamins, alcohol, etc.

The small intestine

Dear learner! The small intestine is up to 7 m in length, but only 2. 5 cm in diameter (**Figure 2. 4a**).Most chemical digestion takes place in the small intestine. Parts of the small intestine:

i) **duodenum** the first 25 cm to 30 cm of the small intestine where the majority of digestion occurs,
ii) **jejunum** is the second component of the small intestine **and**
iii) **ileum** the third component

The small intestine secretes digestive enzymes and moves its contents along by peristalsis. The stomach absorbs some water, specific vitamins, some medicines, and alcohol, but most absorption takes place within the small intestine. Long finger like projections called villi (singular: villus) greatly increase the surface area of the small intestine (**Figure 2. 4(b)**). One estimate suggests that villi account for a tenfold increase in surface area for absorption. The cells that make up the lining of each villus have microvilli, which are fine, threadlike extensions of the membrane that further increase the surface for absorption.

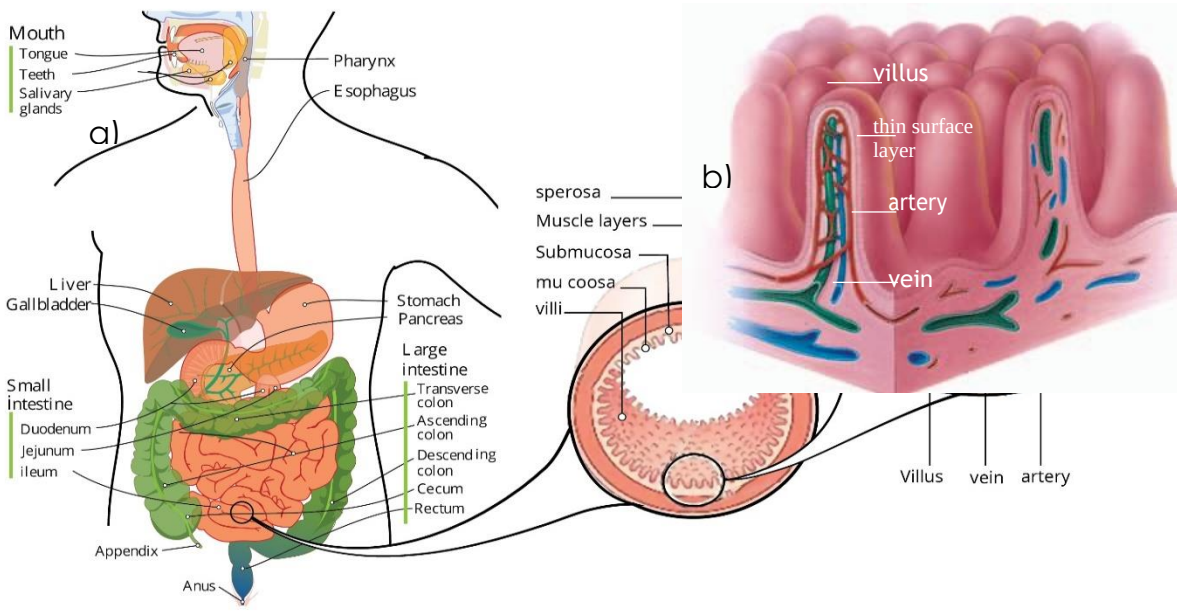


Figure 2.4 Parts of the digestive system and the absorption villi

Each villus is supplied with a capillary network that intertwines with **lymph vessels called lacteals** that transport materials. Some nutrients are absorbed by diffusion, but some nutrients are actively transported from the digestive tract. Monosaccharides and amino acids are absorbed into the capillary networks; **fats** are absorbed into the **lacteals**(**Figure 2. 5**).

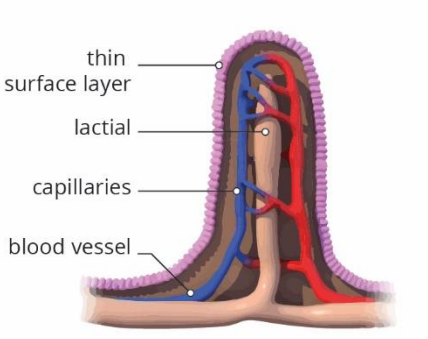


Figure 2.5 Anatomy of a villus and the lacteal

Activity 2. 6

Dear learner! Complete this task on your own, then try comparing your writings to that of colleague students in your area:

1. Discuss the structure in the small intestine though which digested food molecules are absorbed into the blood stream.
2. How glycerol and fatty acids are absorbed in the small intestine?

Your tutor will conclude by summarizing the absorption sites, including the functions of lacteals and capillaries as well as the small intestine's adaptations for absorption.

The accessory organs

What are accessory organs?

Dear learner! The organs discussed above are the organs of the digestive tract through which food passes. Accessory organs are organs that add secretions and enzymes that break down food into nutrients. Accessory organs include:

- the salivary glands,
- the pancreas,
- the liver, and
- the gall bladder.

The secretions of the pancreas, liver and gallbladder are regulated by hormones in response to food consumption. The liver is the **largest internal organ** in humans and it plays an important role in the digestion of fats and detoxifying blood. The liver produces bile, which is a digestive juice that is required for the breakdown of fats in the duodenum. The liver also processes the absorbed vitamins and fatty acids and synthesizes many plasma proteins. The gallbladder is a small organ that aids the liver by storing bile and concentrating bile salts. The pancreas secretes bicarbonate that neutralizes the **acidic chyme** and a variety of enzymes (**trypsin, amylase, and lipase**) for the digestion of proteins, carbohydrates, and fats, respectively. The details of the accessory organs are given below.

Activity 2. 7

Dear learner! Food travels from the stomach into the small intestine. Food that has not been fully broken down arrives in the small intestine already saturated in pepsin and hydrochloric acid. So, how are the cells within the small intestine are protected from damaging effects of these substances? Read and jot down brief notes for yourself.

Pancreas

The pancreatic secretions contain enzymes that promote the breakdown of the three major components of food: **proteins, carbohydrates and lipids**. Pancreatic secretions contain the following digestive enzymes:

a) **Trypsin**- a protein-digesting enzyme called **trypsinogen**isreleased from the pancreas. Once trypsinogenreaches the small intestine, an enzyme called **enterokinase**converts the inactive trypsinogen into **trypsin,** which acts on the partially digested proteins. Trypsin breaks down **long-chain polypeptides** into shorter-chain peptides.

b) **Erepsins** are released from the pancreas and small intestine. They complete protein digestion by breaking the bonds between short-chain peptides, releasing individual amino acids.

c) **Amylase** continues the digestion of carbohydrates that begun in the mouth by salivary amylase. The intermediate-size chains are broken down into disaccharides. The small intestine releases disaccharide enzymes, called **disaccharidases**, which complete the digestion of carbohydrates

d) **Lipases**-enzymes are released from the pancreas that breaks down lipids (fats). There are two different types of lipid-digesting enzymes:

   i. **Pancreatic lipase**, the most common lipase, breaks down fats into fatty acids and glycerol.

   ii. **Phospholipase** acts on phospholipids.

The summary of the enzymes found in the small intestine, where they are produced, and their actions that take place are given in **Table2. 1** below.

Table 2.1 Digestion in the Small Intestine

Enzyme	Produced by	Reaction
lipase	pancreas	Fatdroplets+H_2O+glycerol+fattyacids
trypsin	pancreas	protein + H_2O + peptides
erepsin	Pancreas, small intestine	peptides + H_2O + amino acids
pancreatic amylases	pancreas	starch + H_2O + maltose
maltase	small intestine	maltose + H_2O + glucose

Activity 2. 8 Library/Internet search

Dear learner! Search the internet or library for information on the groups of enzymes involved in the digestion of various food items, the locations where they act, and the pH levels needed for each group. Lastly, during tutorial, share your results with the other students. Your search results will be aided by your tutor.

Liver and Gallbladder

What is the importance of liver?

Dear learner! Do you know that our liver continually produces fluid called **bile.** Bile contains bile salts, which aid fat digestion. When the stomach is empty, bile is stored and concentrated in the gallbladder. When there are fats in the small intestine, the hormones trigger the gall bladder to release bile salts. Once inside the small intestine, the bile salts:

a) **Emulsify** or breakdown, large fat globules. The breakdown of fat globules into smaller droplets is physical digestion, not chemical digestion since chemical bonds are not broken. Physical digestion prepares the fat for chemical digestion by increasing the exposed surface area on which fat-digesting enzymes, such as pancreatic lipase, can work.

b) **Bile** also contains pigments. The liver breaks down haemoglobin from red blood cells and stores the products in the gallbladder for removal. The characteristic brown colour of feces results from haemoglobin breakdown.

c) Stores glycogen and vitamins A, B_{12}, and D.

d) **Detoxify** many harmful substances in the body. Harmful chemicals are made soluble and can be dissolved in the blood and eliminated in the urine. One of the more common poisons is alcohol.

Why liver is said to be unusual organ with regard to blood circulation?

Large Intestine

Dear learner! The human large intestine is much smaller in length as compared to the small intestine but is larger in diameter. It has three parts: the **cecum, the colon and the rectum**. The cecum joins the ileum to the colon and is the receiving pouch for the waste matter. The colon is home to many bacteria or intestinal flora that aid in the digestive processes. The colon has four regions, **the ascending colon, the transverse colon, the descending colon and the sigmoid colon** (**Figure 2. 4a**). The main functions of the colon are extracting the water and mineral salts from undigested food, and storing waste material.

Chemical digestion is completed by the time the food reaches the large intestine (**Figure 2. 4a**). The colon, the largest part of the large intestine, must store waste long enough to reabsorb water from it. During this time, some inorganic salts, minerals, and vitamins are also absorbed with the water.

The large intestine houses bacteria, such as *Escherichia coli (E. coli),* which are essential to life and use waste materials to synthesize vitamins B and K. Cellulose, the long-chain carbohydrate characteristic of plant cell walls, reaches the large intestine undigested. Although cellulose cannot be broken down by humans, it serves an important function: cellulose provides bulk. As wastes build up in the large intestine, receptors in the wall of the intestine provide information to the **central nervous system**, which, in turn, prompts a bowel movement. The bowel movement ensures the removal of potentially toxic wastes from the body.

Individuals who do not eat sufficient amounts of cellulose (roughage or fiber) have fewer bowel movements. This means that wastes and toxins remain in their bodies for longer periods. Scientists have determined that cancer of the colon can be related to diet. Individuals, who eat mostly processed, highly refined foods, are more likely to develop cancer of the colon.

The rectum (**Figure 2. 4a**) stores feces until defecation. The feces are propelled using peristaltic movements during elimination. The anus is an

opening at the far-end of the digestive tract and is the exit point for the waste material. Two sphincters regulate the exit of feces, the inner sphincter is involuntary and the outer sphincter is voluntary.

Table 2.2 Summary of digestion in human alimentary canal

Region of gut	Glands and secretion	Enzymes and optimum pH	Food digested, products and other activity
Mouth: mastication by jaws and tongue	Salivary glands: saliva 1-2 liters/daily	1. pH-7, slightly acid in adults, slightly alkali to neutral in children 2. amylase	1. mucin lubricates food bolus 2. (A) starch(amylase)----dextrin (B) cooked starch ----maltose
Oesophagus	None	None	Food bolus moves by peristalsis
Stomach churning action. Temporary storage 1 to3 hrs	➢ Gastric gland, stomach wall-gastric juice ➢ 2-4L; stores daily	1. pH 1, strongly acidic 2. rennin(in young children) 3. lipase(in young children) 4. pepsin	1. Hydrochloric acid (HCl) is bacteriocidal 2. clots milk protein-caesin 3. lipids---fatty acids and glycerine 4. proteins—amino acids Absorption: water, salts, vitamins and ethanol
Duodenum(Accessory organ secretions)	1. liver- bile juice, 700CM3-1. 2 litres daily 2 pancreas-pancreatic juices, 700Cm3 daily	1. pH 7-8, slightly alkaline 2. no enzyme	1. alters pH of stomach contents 2. bile salts emulsify or cream lipids
		1. pH 7-8,slightly alkaline 2. amylase 3. lipase 4. Trypsin 5. nuclease	1. food as chime propelled by peristalsis 2. starch(amylase)------maltose 3. lipids---- fatty acids and glycerol 4. peptones---- short peptides 5. nucleic acids----nucleotides
Small intestine and duodenum	Glands in intestine and duodenum wall-intestinal juice, 200cm3	1. pH 7-8 2. entrokinase changes trypsinogen into trypsin 3. lipase 4. glycosidases-maltase, lactase, sucrase	1_____ 2. dipeptides, peptides------- amino acids 3. lipids---fatty acids and glycerol(propanetriol) 4. maltase----maltose into glucose molecules Lactase-----lactose into glucose and galactose Sucrose---sucrose into glucose and fructose

			Absorption: large surface area, villi, and microvilli, main region of absorption of vitamins, minerals, amino acids, glucose, fatty acids and glycerol
Large intestine	Lining with mucous glands	pH 6-8 no enzymes	1. mucous lubricates faces 2. water absorbed from faces 3. bacteria synthesis vitamin B groups 4. faces mainly water 75%, bacteria, 8%, lipids, 6%, dietary fiber cellulose, 2% etc

√ **Self-evaluation checklist**

Put a tick (✓) against each of the following tasks, which you can perform.

I can:

- discuss the structure and function of the digestive system_____ ☐
- classify the types of digestion along the alimentary canal_____ ☐
- list the end products of carbohydrates, proteins, and fats after complete digestion_____ ☐
- express the site of absorption of digested food, minerals, vitamins, and water_____ ☐
- explore structural adaptations of the small intestine for the absorption__ ☐
- differentiate the absorption routs of different end products of digestion ☐
- group enzymes of the digestive system based on their roles and pH____ ☐

Self-Test Exercise 5.1

I. True-False Items

Write "**True" for correct statement or "False" for an incorrect one**.

1. Starch digestion begins in the mouth.
2. Adult digestive tract is 12 m long.
3. Wave-like muscle contraction in the oesophagus of the alimentary canal is named as peristalsis.
4. One of the methods to reduce tooth decay is eating more sugary foods and avoiding tooth brushing.
5. Protein digestion begins in the stomach.

6. Sulphuric acid is one of the components of gastric juice.
7. In the small intestine fats are absorbed into the lacteals.
8. Fat is emulsified by bile secreted from the liver.

II. Matching items

Instruction: Match digestive structure given in column **A** with the items in column **B.**

	Column A	**Column B**
1	Stomach	A. Bacterial synthesis of vitamins
2	Liver	B. entrance of pancreatic juice
3	Intestinal juice	C. HCl
4	Large intestine	D. Bile
5	Duodenum	E. Lactose
		F. Salivary amylase
		G. Reducatase

III. Multiple choice items

Instruction: Choose the best answer from the given alternatives (A, B, C, and D).

1. Which one of the following is the final digestion product of proteins?
   A. Amino acid B. Glucose C. Fatty acid D. Glycerol
2. Which one of the following is function of the bile salts from the liver?
   A. Killing bacteria C. Detoxification of harmful chemicals
   B. Release of urine D. Mucus Production
3. Pancreatic secretion
   A. Amylase B. Trypsin C. Lipase D. All
4. One of the following is not an accessory organ.
   A. Salivary gland B. Pancreas C. Intestine D. Gall bladder
5. The site in the alimentary canal for absorption of digested food:-
   A. Duodenum B. Stomach C. Small intestine D. Anus

IV. Short answer item

1. Mention parts of a teeth.
2. What is the function of pyloric sphincter?
3. What are some of the methods of control in g tooth decay?
4. What are the processes of digestion that take place in the mouth?
5. What is the function of hydrochloric acid in the stomach?

Section 2.2 The circulatory system

Introduction

 Dear learner! Because the majority of cells in the human body are not in direct contact with the outside world, the circulatory system serves as a transport system for these cells. The circulatory system is made up of two distinct fluids: ***blood and lymph.*** Blood transports oxygen and nutrients to the body's cells while also transporting waste away. Blood also transports hormones, which control body processes, as well as antibodies, which fight invading germs. The heart is the pump that keeps this transportation system moving. The circulatory system is made up of the **blood, heart, and blood vessels**.

The lymphatic system (lymph, lymph nodes, and lymph vessels) assists the circulatory system by draining excess fluids and proteins from tissues back into the bloodstream, preventing tissue swelling. It also serves as the body's defence system, filtering out pathogens and producing white blood cells and antibodies. In this section, you will learn about the structure and functions of the human cardiovascular and lymphatic systems and finally diseases of the circulatory and lymphatic systems.

Section 2.2.1 Cardiovascular (Blood) circulatory system

Introduction

 Dear learner! The heart, blood vessels and blood make up the circulatory system, also known as the cardiovascular system. The cardiovascular system moves nutrients, hormones, and oxygen to all of the body's cells. It also collects waste materials produced by metabolic processes and transports them to other organs for elimination. The muscle required to pump blood throughout the body is provided by the heart. Blood is circulated by the system in two ways: pulmonary and systemic. In this sub section you will learn about structure of the heart, different blood circulation types, blood and its components and blood donation.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this sub-section, you will be able to:

- Demonstrate the structure of the heart using a heart model/ diagram
- Differentiate between pulmonary and systemic circulations
- Compare and contrast arteries and veins based on their structures and functions
- Discuss types of blood
- Discuss the reason for blood donation
- Outline the conditions for blood transfusion
- Discuss blood type and Rh factor compatibility
- Debate on the importance of blood donation and its health implications on the donors and recipients.

What do you know about the movement of blood in your body?

Dear learner! The circulatory system is a means by which blood moves throughout your body. The circulatory system:

- carries nutrients to cells,
- remove wastes away from cells,
- carry chemical messages from cells in one part of the body to distant target tissues,
- distributes heat throughout the body and, along with the kidneys,
- maintain levels of body fluid,
- provide oxygen for the cellular respiration and
- transport of immune cells throughout the body to defend against invading organisms

Moreover, your circulatory system has 96 000 km of blood vessels to sustain your 100 trillion cells.

Dear learner! Do you know that your heart is about the size of your fist and has a mass of about 300g. The heart beats about 70 times/min from the beginning of your life until death. Every minute, 5L of blood cycles from the heart to the lungs, picks up oxygen, and returns to the heart. The structure of the heart and the activities of its parts are given in the figure (**Figure 2. 6**).

Have you ever heard about a live pump?

Activity 2. 9

Dear learner! utilize supplies like sketch paper and markers to create heart diagrams. Additionally, build a heart model with materials that are readily available locally, and study the roles of each component of the heat. Your tutor will guide you in how to produce your diagram and the model.

Dear learner! Have you noticed that your heart beats continuously without stopping. What do you think will happen if your heart stops beating? In this section, you will explore the remarkable live pump - the heart that propels the blood into the vessels. There is no single better word to describe the function of the heart other than "pump" since its contraction develops the pressure that ejects blood into the major vessels: the aorta and pulmonary trunk. From these vessels, the blood is distributed to the other parts of the body. A field of study about the heart is called **cardiology** and the scientists, cardiologists.

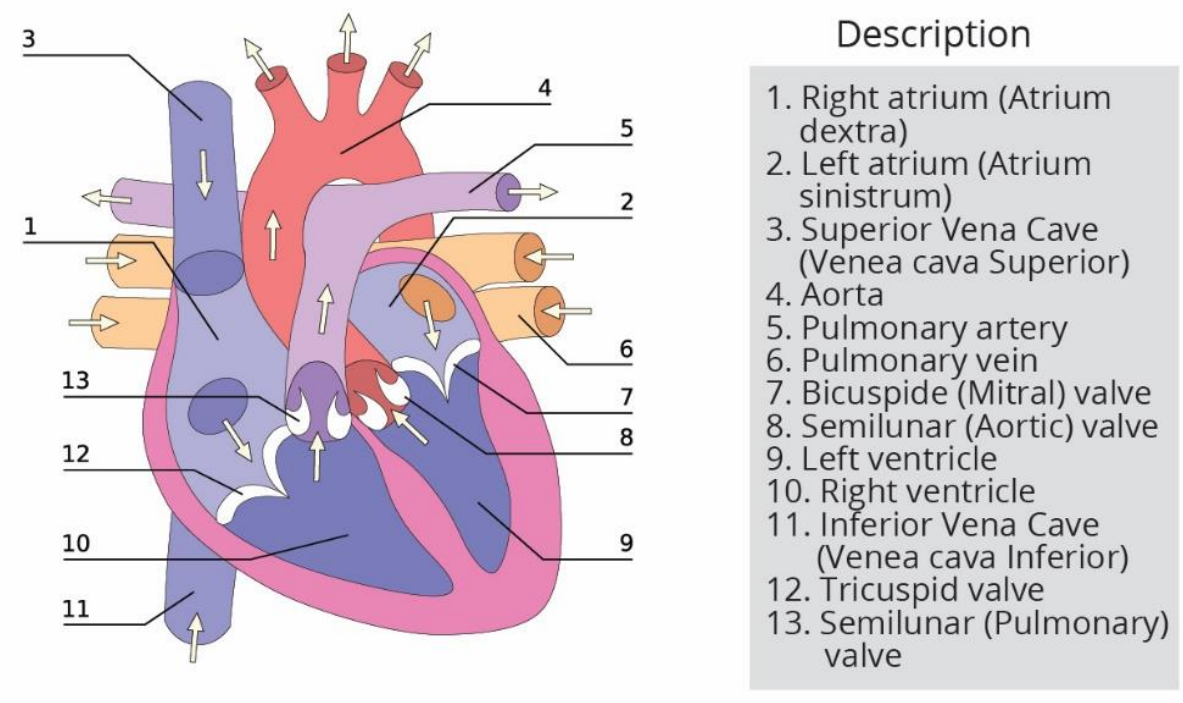


Figure 2.6 The heart anatomy

The heart is a muscular organ that pumps blood to circulate throughout the body. The heart wall consists of three layers: the **endocardium, myocardium, and epicardium**.

i) The **endocardium** is the thin membrane that lines the interior of the heart,

ii) The **myocardium** is the middle layer of the heart. It is the heart muscle and is the thickest layer of the heart, and

iii) The **epicardium** is a thin layer on the surface of the heart in which the coronary arteries lie.

The **pericardium** is a thin sac the heart sits in, often filled with a small amount of fluid, which separates the heart from the other structures in the chest such as the lungs.

What are the chambers of the heart?

Activity 2. 10

Dear learner! Answer the following questions for yourself based on your previous grade level knowledge, and then continue to study the section.

a) Discuss the position and functions of the auricles and ventricles of the heart.
b) How blood is transported to and from the body?
c) What do we call the blood vessel that transport deoxygenated blood from the heat to the lungs?

ATTENTION

The heart consists of two (right & left) parallel pumps separated by the **septum (Figure 2. 6).** The four-chambered human heart is composed of two thin-walled **atria** (singular: atrium) and two thick-walled **ventricles**. Blood from the systemic system enters the right atrium, and blood from the pulmonary system enters the left atrium. The stronger and more muscular ventricles pump the blood to the lungs and distant tissues.

Valves

What types of valves are there between the heart chambers?

Dear learner! In the cardiovascular system of the heart four valves prohibit the backflow of blood:

a) Tri-cuspid valve (Right atrioventricular(RAV)) - valve separates the right atria from the right ventricle.

b) Bi-cuspid valve (Left atrioventricular (LAV)) - valve separates the left atria from the left ventricle

Semi-lunar valves:

a) valve that separate the right ventricle from the pulmonary artery and

b) valve that separate the left ventricle from the aorta. The semi-lunar valves are half-moon-shaped (hence, the name *semi-lunar*), and they prevent blood that has entered the arteries from flowing back into the ventricles (**Figure 2. 7**).

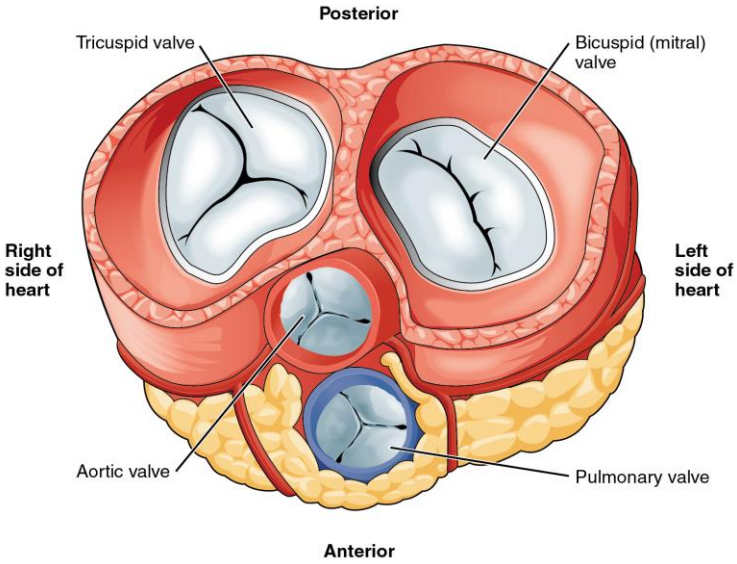


Figure 2.7 The valves of the heart

Dear learner! *After studying the section, do the laboratory activity listed below(*Dissection of a mammalian heart) *in the tutorial canter with the assistance of your tutor, and answer the questions at the end of this practical activity.*

Laboratory Activity 2. 11

Dissection of mammalian heart (cow or sheep)

Background

The human heart is a pump. It pumps blood around the body at different speeds and at different pressures according to the body's needs. It can do this because the wall of the heart is made from cardiac muscle. Cardiac muscles are unlike any other muscle. It never gets fatigued like skeletal muscles. On average, cardiac muscle fibres contract and relax about 70 times a minute. In a lifetime, this muscle will contract over two billion times. The objective of this activity, therefore, is to study the external and internal structure of this amazing mammalian heart.

Procedures:

1. Collect a freshly slaughtered sheep or cow heart from the butcheries
2. Carefully handle and observe:
   - the external structures (the outlets and inlets of the pulmonary artery and pulmonary veins)
   - the inlets (superior and inferior vena cava)
   - the epicardium
3. Using a dissecting knife carefully cut open the heart vertically and observe the following structures:
   - the right and left ventricles
   - the septum
   - the tricuspid and bicuspid valves and
   - the semi-lunar valves

Answer the following questions

1. What conclusions do you draw from your study of the structure of the mammalian heart?
2. Now, can you associate what you have studied in the classroom with your practical activity in the laboratory?
3. Write a short report on your activity in the laboratory

Activity 2. 12

Dear learner! Based on your previous studies in lower grades, answer the following questions:

1) What are systemic & pulmonary circulations?
2) Is there any difference between systemic and pulmonary circulations? Discuss.

What are the two types of blood circulation?

Dear learner! The human circulatory system is a double circulatory system. It has two separate circuits and blood passes through the heart twice: **pulmonary and systemic circulation**.

i) **Pulmonary circulation** - It is the movement of blood from the heart to the lungs for oxygenation, then back to the heart again. Oxygen-depleted blood from the body leaves the systemic circulation when it enters the right atrium through the **superior and inferior venae cavae**. The blood is then pumped through the tricuspid valve into the right ventricle. From the right ventricle, blood is pumped through the pulmonary valve and into the pulmonary artery. The pulmonary artery splits into the right and left pulmonary arteries and the blood in the arteries travel to each lung (Figure 2. 8).

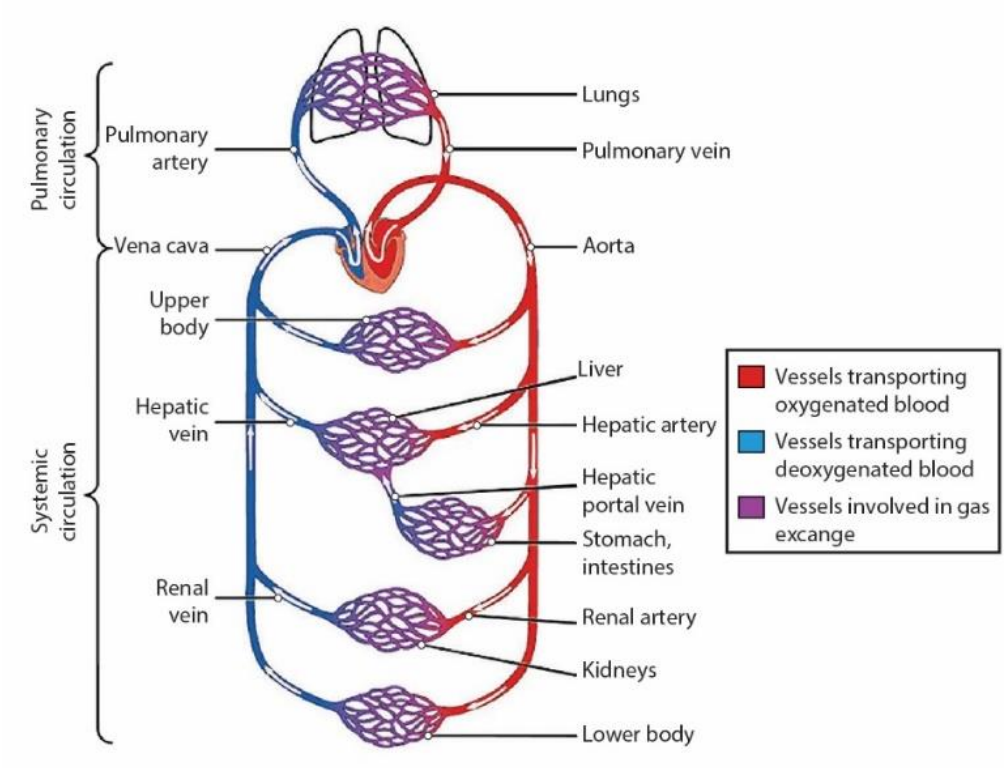


Figure 2.8 Pulmonary and systemic circulation

ii) **Systemic circulation** - is the movement of blood from the heart through the body to provide oxygen and nutrients to the tissues of the body while bringing deoxygenated blood back to the heart. Oxygenated blood enters the left atrium from the pulmonary veins (Figure 5. 8). The blood is then pumped through the mitral valve into the left ventricle. From the left ventricle, blood is pumped through the aortic valve and into the **aorta, the body's largest artery**. The aorta arches and branches into major arteries to the upper body before passing through the diaphragm, where it branches further into the **iliac, renal, and suprarenal** arteries which supply the lower parts of the body.

Dear learner! The arteries branch into smaller **arteries, arterioles, and finally capillaries**. Gas and nutrient exchange with the tissues occurs within the capillaries that run through the tissues. Metabolic waste and carbon dioxide diffuse out of the cell into the blood, while oxygen and glucose in the blood diffuse out of the blood and into the cell. Systemic circulation keeps the metabolism of every organ and every tissue in the body alive, except the parenchyma of the lungs, which are supplied by pulmonary circulation.

Dear learner! Our pulse rates show us the rate and efficiency of blood circulation in our body. In order to learn how the heart rate differs with our physical activities and at rest, do the following activity (activity 5. 13) independently. If you have any questions, you can ask your tutor during the tutorial period.

Activity 2. 13 Pulse rate

Dear learner! Walking or light exercise will increase your heart rate by 20 to 30%. Increased energy demands during extreme exercise can raise the heart rate to an incredible 200 beats per minute in healthy people. Although few people can maintain such a rapid heart rate, it indicates the heart's ability to adapt to changing situations.

i. Place your index and middle fingers near your wrist while sitting. The pulse you feel is caused by blood flowing through the brachial artery in your arm. Count the number of heartbeats in 30 seconds. At rest, take your pulse and convert it to beats per minute.
ii. Sit quietly and place your index and middle fingers on the side of your neck, just below your trachea. You will feel a blood pulse through the carotid artery, an artery that transports blood to the brain. Take your pulse for 30 seconds and then compute your heart rate for 1 minute.
iii. Run on the spot for approximately 2minutes.
iv. Take your pulse immediately after exercise using either the carotid artery or the brachial artery.
v. Record your heart rate.
   a) Compare the strength of the pulse in the carotid artery with that in your arm.
   b) Compare your heart rate before and after exercise.
   c) Do you think the difference between resting heart rate and the heart rate after exercise would be greater for athletes? Explain your answer.

ventricular relaxation. The period of contraction that the heart undergoes while it pumps blood into circulation is called systole. The period of relaxation that occurs as the chambers filled with blood is called diastole. Both the atria and ventricles undergo systole and diastole, and it is essential that these components be carefully regulated and coordinated to ensure blood is pumped efficiently to the body.

Heart Sounds

Dear leaner! You may have heard your heart pounding after you run or do any hard physical activity. What do you understand about these sounds? One of the simplest, yet effective, diagnostic techniques applied to assess the state of a patient's heart is auscultation (listening to various internal sounds) using a stethoscope. In a normal, healthy heart, there are only two audible heart sounds: Lub and Dup (or Dub). Lub (or rest) heart sound is the sound created by the closing of the atrioventricular valves during ventricular contraction. The second heart sound, "Dup" (or "Dub") is the sound of the closing of the semilunar valves during ventricular diastole.

The term murmur is used to describe an unusual sound coming from the heart that is caused by the turbulent flow of blood. Murmurs are graded on a scale of 1 to 6, with 1 being the most common, the most difficult sound to detect, and the least serious. The most severe is a scale of 6. Specialized electronic stethoscopes are used to record both normal and abnormal sounds.

When using a stethoscope to listen to the heart sounds, called asculation, it is common practice for the clinician to ask the patient to breathe deeply. This procedure not only allows for listening to air flow, but it may also amplify heart murmurs. Inhalation increases blood flow into the right side of the heart and may increase the amplitude of right-sided heart murmurs. Expiration partially restricts blood flow into the left side of the heart and may amplify left-sided heart murmurs.

Dear learner! In order to listen your heart sound, you can do the following activity. You can go to the nearby located hospital, clinic or other available health posts and ask the health practitioners to provide you with a

stethoscope. Then, perform the following activity for yourself independently. If you encounter a problem using the instrument, please, ask the health worker responsible. Finally, write the findings in your note book and discuss with your tutor.

Activity 2. 14 Heart sound

*Medical workers use **stethoscopes** to measure blood pressure and to listen to the heart, lungs, and intestines. You will use a stethoscope to listen to your heart. Disinfect the earpieces of the stethoscope with rubbing alcohol before and after use.*

i. *Place a stethoscope on your own chest and listen for a heart sound. Locate the area where the heart sounds are loudest and clearest.*
ii. *After 1min of moderate exercise(e. g., walking on the spot), listen for your heart sounds again.*

a) *Draw a diagram of a chest showing where you located the clearest sound.*
b) *Did the sound of your heart beat change after exercise? Describe what differences you heard.*

Blood Pressure

Dear learner! Do you know what is a blood pressure? Here is given valuable information on blood pressure.

Blood pressure is the force of the blood on the walls of the arteries. It can be measured indirectly with an instrument called a **sphygmomanometer.** A cuff with an air bladder is wrapped around the arm. A small pump is used to inflate the air bladder, thereby closing off blood flow through the brachial artery, one of the major arteries of the arm. A stethoscope is placed below the cuff and air is slowly released from the bladder until a low-pitched sound can be detected. The sound is caused by blood entering the previously closed artery.

Each time the heart contracts, the sound are heard. A **gauge** on the sphygmomanometer measures the pressure exerted by the blood during

ventricular contraction. This pressure is called **systolic blood pressure**. Normal systolic blood pressure is less than 120mmHg. Blood pressure is measured in the non-SI units of millimetres of mercury, or mmHg. The cuff is then deflated even more, until the sound disappears. At this point, blood flows into the artery during ventricular relaxation, or filling. This pressure is called diastolic blood pressure. Normal diastolic blood pressure is less than 80mmHg. Asystolic pressure of 120mmHg and a diastolic pressure of 80mmHg would be reported as 120/80(120 over 80). Reduced filling, such as that caused by an internal hemorrhage, will cause diastolic blood pressure to fall.

Blood Vessels

Do you have any idea about the lines of movement of blood in the body?

Blood vessels are the channels or conduits through which blood is distributed to body tissues. The vessels make up two closed systems of tubes that begin and end at the heart. One system, the pulmonary vessels, transports blood from the right ventricle to the lungs and back to the left atrium. The other system, the systemic vessels, carries blood from the left ventricle to the tissues in all parts of the body and then returns the blood to the right atrium. Based on their structure and function, blood vessels are classified as arteries, capillaries and veins.

Activity 2. 15 Compare and contrast

Dear learner! Using diagrams and models, compare and contrast the structures and functions of arteries, veins, and capillaries, and then create your own summarized notes.

START UP

Dear learner! Answer the following questions. Write the answers in your notebook.

1) What is blood?
2) What components of blood do you know?
3) What types of cells are there in blood?
4) When do you think the number of your white blood cells could be higher than the normal?
5) What are platelets?

Blood

 What is blood? What types of blood cells do you know?

Dear learner! Blood is a constantly circulating fluid providing the body with nutrition, oxygen, and waste removal. Blood is mostly liquid, with numerous cells and proteins suspended in it, making blood "thicker" than pure water. The average person has about 5 liters of blood. Liquid called plasma makes up about half of the content of the blood. Plasma contains proteins that help the blood to clot, transport substances through the blood, and perform other functions. Blood plasma also contains glucose and other dissolved nutrients. About half of blood volume is composed of blood cells.

Blood Components

Dear learner! Normally, 7-8% of human body weight comes from blood. This essential fluid carries out the critical functions of transporting oxygen and nutrients to our cells and getting rid of carbon dioxide, ammonia, and other waste products. In addition, it plays a vital role in our immune system and in maintaining a relatively constant body temperature. Blood is a highly specialized tissue composed of more than 4,000 different kinds of components. Three of the most important ones are:

i. Red blood cells, which carry oxygen to the tissues
ii. White blood cells, which fight infections
iii. Platelets, smaller cells that help blood clot

Red blood cells (erythrocytes)

Red blood cells, or erythrocytes, are relatively large microscopic cells without nuclei. Red blood cells normally make up 40-50% of the total blood volume. They transport oxygen from the lungs to all of the living tissues of the body and carry away carbon dioxide. The red cells are produced continuously in our bone marrow from stem cells at a rate of about 2-3 million cells per second. Hemoglobin (containing iron) is the gas transporting protein molecule that makes up 95% of a red cell. People who are anemic generally have a deficiency in red cells, and subsequently feel

fatigued due to a shortage of oxygen. The red colour of blood is primarily due to oxygenated red cells. Human fetal hemoglobin molecules differ from those produced by adults in the number of amino acid chains. Fetal hemoglobin has three chains, while adults produce only two. Consequently, fetal hemoglobin molecules attract and transport relatively more oxygen to the cells of the body.

What are adaptations of a red blood cell that equip it for efficient oxygen transport?

Red blood cell adaptation for efficient oxygen transportation:

- RBC have nucleus at the young stage and lose its nucleus when matured. Not having a **nucleus** means that there is more space inside for hemoglobin, so each red blood cell can carry more oxygen.
- **Biconcave shape** gives it a larger surface area for gaseous diffusion than a flat disc of the same volume.
- **Very thin cell surface membrane** enables oxygen and carbon dioxide can diffuse in and out rapidly.
- **Flexible cell surface membrane** allows it to squeeze along the narrowest blood capillaries.

White blood cells (leukocytes)

What are white blood cells? How the white blood cells are different from red blood cells?

Dear learner! White blood cells, or leukocytes, exist in variable numbers and types but make up a very small part of blood's volume; it normally exists in about only 1% in healthy people. Leukocytes are not limited to blood. They occur elsewhere in the body as well, most notably in the **spleen, liver, and lymph** glands. Most are produced in our bone marrow from the same kind of stem cells that produce red blood cells. Others are produced in the thymus gland, which is at the base of the neck. White blood cells (called lymphocytes) are:

- the first responders to our immune system. They seek out, identify, and bind to alien proteins on bacteria, viruses, and fungi so that they can be removed. Other white blood cells (called granulocytes and macrophages) then arrive to surround and destroy the alien cells.
- have the function of getting rid of dead or dying blood cells as well as foreign matter.
- Individual white blood cells usually only last for 18-36 hours before they are removed, though some types live as much as a year. There are several different kinds of white blood cells (Table 5. 3). The two important types are:
    - ✓ **Neutrophils** white blood cells that have a lobed nucleus, and
    - ✓ **Lymphocytes** white blood cells that are smaller than neutrophils and which have a large nucleus that takes up most of the cell.

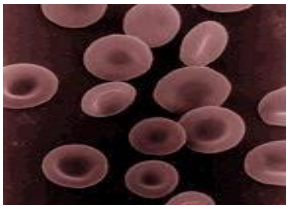
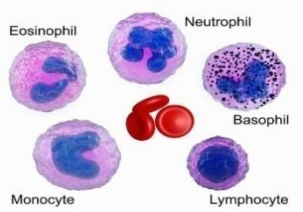
 What are platelets?

Dear leaner! Platelets or thrombocytes are tiny cell fragments **without nuclei** enclosed in a membrane. Platelets play an essential role in blood clotting. Clotting has two important functions: it helps to stop blood from flowing out of the damaged vessel, and it prevents disease-causing pathogenic microorganisms (viruses, bacteria) from getting into the body;

- They collect where a damaged blood vessel is leaking blood and form a temporary plug by combining with fibers of collagen, a protein of the blood vessel wall.
- They release an enzyme that sets off a chain of chemical reactions in the blood. The result of these reactions is to change **fibrinogen**, a soluble plasma protein into a network of insoluble **fibrin threads**. These networks of fibrin threads, then plug in the cut and clot the blood.

Dear learner! Some characteristics of the blood cells is given in table 2. 3 below.

Table 2.3 Red blood cells, white blood cells and platelets

Cell types	Number	Life span	Functions
Erythrocytes(red blood cells) 	5-6million	120 days	Transport oxygen and help transport carbondioxide
Leukocytes(White blood cells) 	5000-10000	18-36 hours, some can survive as long as a year	Defence and immunity
Platelets 	250000-400,000	9-10 days	Blood clotting

Plasma

Dear learner! What is plasma?

Plasma:

- Is a yellow-tinted water, sugar, fat, protein, and salt fluid that transports red blood cells, white blood cells, and platelets.
- Itmakes up 55 percent of our blood volume.
- provides nutrients to cells while also removing metabolic waste.
- blood clotting factors, carbohydrates, lipids, vitamins, minerals, hormones, enzymes, antibodies, and other proteins are all found in it.
- includes some of every protein generated by the body; so far, only about 500 proteins have been discovered in human plasma.

Activity 2. 16

Dear learner! Attempt question given below. And continue studying in the section.

1. Which blood group is known as Universal donor? why?
2. Which blood group is a Universal recipient? Why?
3. What are the criteria for blood grouping?

Blood groups

Dear learner! The blood grouping depends on which antigens are on the surface of the red blood cells. Antigens are molecules. They can be either proteins or sugars. The types and features of antigens can vary between individuals due to small genetic differences. The antigens in blood have various functions, including:

- transporting other molecules into and out of the cell,
- maintaining the structure of red blood cells, and
- detecting unwanted cells that could cause illness.

Scientists use two types of antigens to classify blood types:

- ABO antigens and
- Rh antigens.

Antigens and antibodies play a role in the immune system's defence mechanism. White blood cells produce antibodies. These antibodies will target an antigen if they consider it a foreign object. This is why it is essential to match blood types when a person needs a transfusion. If a person receives red blood cells with antigens that are not already present in their system, their body will reject and attack the new red blood cells. This can cause a severe and possibly life-threatening reaction.

What types of blood antigen and antibody do you know?

The ABO blood group system classifies blood types according to the different types of antigens in the red blood cells and antibodies in the plasma. They

use the ABO system alongside the Rh antigen status to determine which blood type or types will match for a safe red blood cell transfusion.

There are four ABO groups:

Group A: The surface of the red blood cells contains A antigen, and the plasma has anti-B antibody. Anti-B antibodies would attack blood cells that contain B antigens.

Group B: The surface of the red blood cells contains B antigen, and the plasma has anti-A antibody. Anti-A antibody would attack blood cells that contain A antigen.

Group AB: The red blood cells have both A and B antigens, but the plasma does not contain anti-A or anti-B antibodies. Individuals with type AB can receive any ABO blood type.

Group O: The plasma contains both anti-A and anti-B antibodies, but the surface of the red blood cells does not contain A or B antigens. Since these antigens are not present, a person with any ABO blood type can receive this type of blood.

Rhesus factor


Can you tell your friends what the Rhesus factor is?

Dear learner! During the 1940s, scientists discovered another antigen on the red blood cell, **the Rhesus factor**. Like the ABO blood groups, the Rhesus factor is inherited. Individuals who have this antigen are said to be Rhesus positive (Rh^+). Approximately 85 % of the populations have the antigen. The remaining 15% of individuals who do not have the antigen are said to be Rhesus negative (Rh^-). Individuals who are Rh^- may donate blood to Rh^+ individuals, but should not receive Rh^+ blood. The human body has no natural antibodies against Rh factors, but antibodies can be produced following a transfusion. Although Rh antibodies are produced in response to antigens, it should be pointed out that the immune reaction is subdued compared with that of the ABO group.


How does Rh^+ blood differ from Rh^- blood and what happens if the Rh factor of the blood transfused is incompatible?

Dear learner! Rhesus-factor incompatibilities become important for Rh^+ babies of Rh^- mothers. If the baby inherits the Rh^+ factor from the father, a condition called erythroblastosisfetalis (*a medical condition where an Rh negative mother's antibodies attack the red blood cells of an Rh positive fetus)* can occur with these condition and subsequent pregnancies. The first child is spared because the blood of the mother and baby are separated by the placenta (a membrane inside the uterus that exchanges materials between mother and baby). During birth, the placenta is shed from the uterus. Capillary beds rupture, and, for the first time, the blood of the baby comes into contact with the blood of the mother.

 Why does a fetus with erythroblastosis fetalis develop anaemia?

The mother's immune system recognizes the Rh^+ antigens and triggers the production of antibodies. But, by the time the antibodies are produced, the first baby is no longer connected to the placenta and has escaped the potentially dangerous situation. However, a second pregnancy presents problems if the fetus is Rh^+. The mother retains many of the antibodies from her first encounter with Rh^+ blood. If antibodies cross the placenta, they attach to the antigen on the red blood cells of the fetus, causing them to be destroyed. Symptoms *when an Rh negative mother's antibodies attack the red blood cells of an Rh positive fetus* include **anemia, jaundice, and an enlarged liver**.

Blood donation

Dear learner! Blood is a very vital component of the human body. In case of an injury, severe sickness, or during operations, loss of a large quantity of blood may result in death. In such cases, blood from a healthy person called the **donor** is given to the sick or a person that lost blood under some other unexpected condition. The sick person who receives blood is called the **recipient.** The process of transferring blood from a healthy person (donor) to a person deficient in blood (recipient) is called **blood transfusion**. Great care has to be taken by the doctors while transfusing blood from the donor to the recipient.

START UP

Before you proceed further on the study of blood donation, answer the following questions:

1. Why should a person donate blood?
2. Who can donate blood?
3. Is there any side-effect of blood donation?
4. Why do we say blood donation is "lifesaving" ?

Activity 2. 17 Individual activity

Dear learner! What is the importance of blood donation? Have you ever listened about any complication occurred as a result of blood donation? To get sufficient and accurate information on blood donation, please, go to the nearby hospital or health centre and ask the health professionals about the importance and possible complications that may occur as a result of blood transfusion. Then write a report and share with your tutor and colleague students.

Blood group compatibility

Dear learner! If the blood from two different blood groups is mixed and if it is not compatible, there may be a reaction between the antigen and the complementary antibody which makes the red blood cells stick together, a phenomenon known as **agglutination**. The agglutins block the capillaries and even larger blood vessels. But if someone loses a lot of blood in an accident, an injury, during giving birth or an operation, then they may need a blood transfusion. This is when blood taken from one person is given to another to save their life. Before a transfusion it is vital to know the blood groups of both the person giving the blood (the donor) and the person receiving the blood (the recipient).

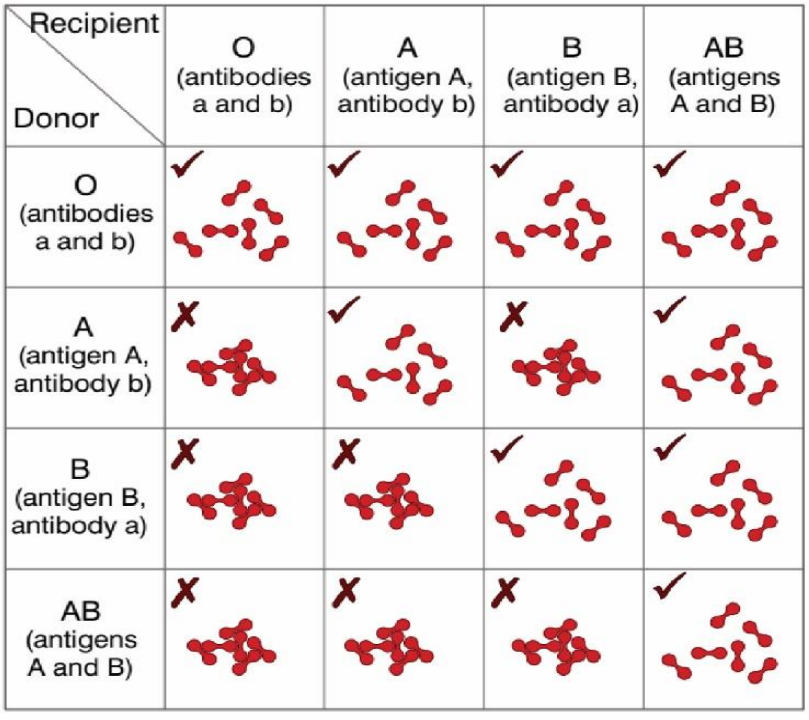
This means the right type of blood can be given to prevent agglutination. The blood groups must be compatible. It is not usually the case that only one type of blood can be given, simply that blood containing a particular

antigen must not be mixed with blood containing the matching antibody (summarized in table 2. 4). For example, blood group O has no antigens so it can be given to anyone, but someone who has blood group O has both antibodies so they can only receive group O blood. On the other hand someone with blood group AB which has no antibodies can receive any type of blood. Figure 2.9 summarizes the compatibilities of the different blood groups.

Table 2.4 Antigens and antibodies

Blood group	Antigen on red blood cells	Antibody in plasma
A	A	B
B	B	A
AB	AB	None
O	None	AB

The O blood groups is termed "Universal Donor" while the AB blood group is termed as a "Universal recipient".



Key: x-shows coagulation

Figure 2.9 Blood compatibility chart

√ Self-evaluation checklist

Put a tick (✓) against each of the following tasks which you can perform.

I can:

- Show the structure of the heart using a heart model/ diagram_____ ☐
- Differentiate between pulmonary and systemic circulations_____ ☐
- Compare and contrast arteries and veins based on their structures and functions_____ ☐
- Discuss types of blood_____ ☐
- Review the reason for blood donation _____ ☐
- Outline the conditions for blood transfusion _____ ☐
- Describe blood type and Rh factor compatibility_____ ☐
- Debate on the importance of blood donation and its health implications on the donors and recipients_____ ☐

Self-Test Exercise 2.2.1

I. True-False Items

Write "**True" for correct statement or "False" for the incorrect one.**

1. The circulatory system removes away waste from cells.
2. Blood group O is a Universal donor.
3. The middle layer of the heart is called epicardium.
4. The valve that protects movement of blood from the left ventricle to aorta in called semi-lunar valve.
5. The circulatory system provide CO_2 for the cellular respiration.
6. Platelets contain a nucleus.
7. Systemic circulation move blood from right ventricle to the lungs and back to the heart.
8. The smallest blood vessels are the capillaries.
9. Erythrocytes(red blood) cells protect our body from foreign substances.
10. Blood group AB is a universal recipient.

II. Matching items

Instruction: Match descriptions given in column **A** with the items given in column **B.**

	Column A	Column B
1	Inner layer of heart muscle	A. Systemic circulation
2	The instrument to measure heart sound	B. Agglutination
3	The instrument to measure blood pressure	C. Endocardium
4	Incompatible red blood cells stick together	D. stethoscope
5	Movement of blood from left ventricle to the body and back to the heart	E. Sphygmomanometer
		F. Pulmonary circulation
		G. Microscope

III. Short answer item

1. Mention the 4 chambers of the heart.
2. What Is the function of tri-cuspid valve?
3. What is plasma?
4. Mention the 4 valves of the heart that protect the back-flow of blood.
5. Mention the types blood cells and their functions.

Section 2.2.2 The Lymphatic System

Introduction

Dear learner! In the previous sub-section you have studied about the blood circulatory system. In this sub-section, you will learn about the amazing movement of tissue fluids (Lymph) in your body. Lymph, a colourless, watery fluid, is transported back into the circulatory system through a network of tissues, blood vessels, and organs known as the lymphatic system. Every day, your body's arteries, capillaries, and tiny arterioles transport roughly 20 litters of plasma. Approximately 17 litters of fluid are returned to circulation via veins after feeding the body's cells and tissues and removing waste items from them. The additional three litters penetrate the capillaries and tissues of your body. The lymphatic system collects this surplus fluid, now known as lymph, from various physiological tissues and transports it until it ultimately returns to the

bloodstream.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this sub-section, youwill be able to:

- Define what is lymph,
- Discuss the components of the lymphatic system,
- Describe the location of lymphatic vessels in human body, and
- Explain the key functions the lymphatic system.

☞ **START UP**

Dear learner! Do a library search about the lymphatic system and write a short note for yourself.

How is lymph formed and how does it move in the lymphatic system?

Dear learner! A little amount of protein spills from capillaries into tissue voids on a regular basis. Even if the leak is modest, the build-up of proteins in the extracellular fluid (ECF) would be a significant problem; osmotic pressure would drop and tissues would enlarge.

The proteins are emptied from the ECF and return to the circulatory system via the **lymphatic system**, a collection of vessels (Figure 2. 10). Lymph, a fluid similar to blood plasma, is transported through lymph vessels that are open-ended like veins. This low-pressure return system is driven by slow muscle contractions against the arteries, which are equipped with flap-like valves to prevent fluid back-flow. Through the right and left subclavian veins, the lymphatic system returns lymph to the venous system.

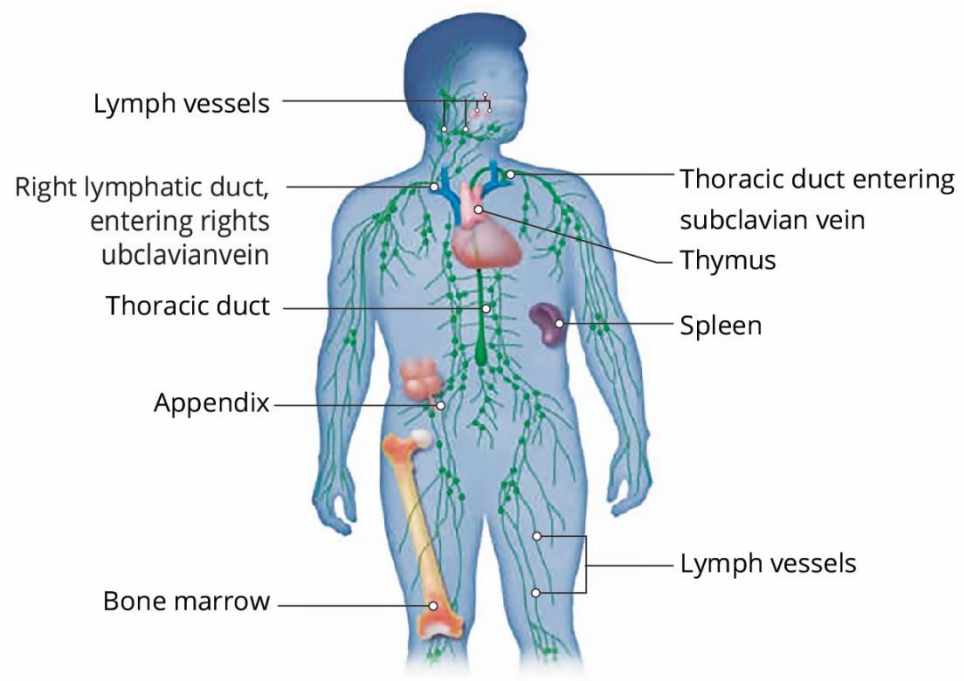


Figure 2.10 The lymphatic system

Dear learner! Lymph nodes are enlargements that appear in the lymph channel at regular intervals (Figure 2. 10). These contain white blood cells that, through the process of phagocytosis, filter out any bacteria present. Lymph nodes store lymphocytes in addition to screening damaged cells and debris from the lymph. The lymph nodes in your neck can expand when you have a sore throat.

Activity 2. 18 Outline the similarities and differences

Dear learner! Do you have any idea about the lymphatic circulatory system? If your answer is yes, what is the differences and similarities of between blood and lymphatic circulatory systems? Write a short note on their similarity and differences.

What are the functions of the lymphatic system?

Dear learner! The key functions of the lymphatic system are:

- It returns excess interstitial fluid(fluid between cells, tissues, or organs in the body) to the blood
- it absorbs fats and fat-soluble vitamins from the digestive system and the subsequent transport of these substances to the

venous circulation. The blood capillaries absorb most nutrients, but the fats and fat-soluble vitamins are absorbed by the lacteals. The lymph in the lacteals has a milky appearance due to its high fat content and is called **chyle.**

- It defends against invading microorganisms and disease. Lymph nodes and other lymphatic organs filter the lymph to remove microorganisms and other foreign particles. Lymphatic organs contain **lymphocytes** that destroy invading organisms.

Which components of the lymphatic system do you know?

Components of the Lymphatic System

Dear learner! The lymphatic system consists **of a fluid (lymph), vessels that transport the lymph and organs that contain lymphoid tissue.**

Lymph

Lymph is a fluid substance made up of lymphocytes and white blood cells that is clear to white in colour. Lymph is a component of the lymphatic system that is present in lymphatic veins and other cavities throughout the body. It transports white blood cells within lymph nodes and bones, removes interstitial fluid from organs, and fights disease-causing and infectious bacteria invading blood cells. Lymph serves a variety of purposes:

i. Removes metabolic wastes from tissue cells,
ii. Provides the body with nutrition,
iii. Aids in the invasion of microbe-caused pathogenic diseases,
iv. Through lymphatic vessels, absorbs fat-soluble vitamins and other digested fat molecules from the small intestine, and
v. Maintain the composition of tissue fluid.

Lymphatic vessels

Unlike blood vessels, lymphatic vessels transport only fluid away from tissues (Figure 2. 11). The lymph capillaries are the smallest lymphatic vessels, beginning in the tissue spaces as blind-ended sacs. Lymph capillaries can be found in every part of the body except the bone marrow, the central nervous

system, and tissues that lack blood vessels, such as the epidermis. The wall of the lymph capillary is made up of endothelium, which is made up of simple squamous cells that overlap to form a simple one-way valve. This configuration allows fluid to enter the capillary but prevents lymph from exiting the vessel.

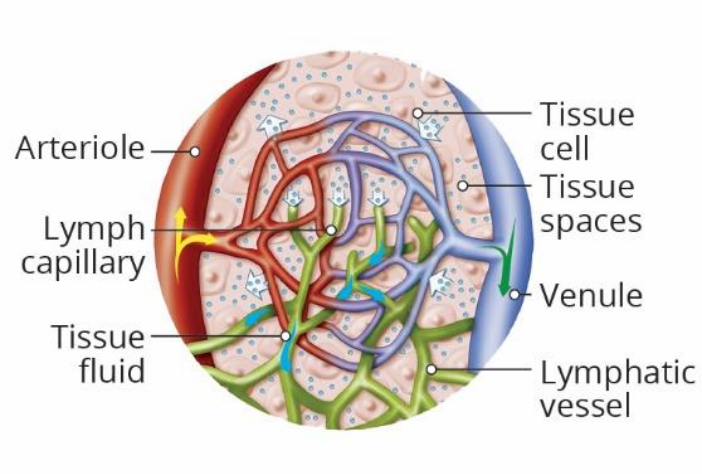


Figure 2.11 Lymphatic vessels

Lymphatic vessels are formed when microscopic lymph capillaries are connected. Small lymphatic vessels connect to form larger tributaries known as lymphatic trunks, which drain large areas. The lymphatic trunks join together until lymph enters the two lymphatic ducts. The right lymphatic duct drains lymph from the upper right quadrant of the body. The thoracic duct drains the remainder.

Why the lymphatic system is an open system?

Dear learners! Lymphatic tributaries, like veins, have thin walls and valves to prevent blood backflow. The lymphatic system lacks a pump like in cardiovascular system. The pressure gradients that move lymph through the vessels are caused by skeletal muscle action, respiratory movement, and smooth muscle contraction in vessel walls.

Which types of lymphatic organs do you know?

Organs of the lymphatic system

Dear learner! Clusters of lymphocytes and other cells, such as macrophages, are enmeshed in a framework of short, branching tissue fibres that distinguish lymphatic organs. Lymphocytes are formed alongside other types of blood cells in the red bone marrow and are transported in the blood from the bone marrow to the lymphatic organs. When the body is exposed to microorganisms and other foreign substances, lymphocytes proliferate within the lymphatic organs and are transported to the site of the invasion via the blood. This is a component of the immune response that seeks to eliminate the invading agent. Among the lymphatic organs are:

- Lymph nodes
- Tonsils
- Spleen, and
- Thymus.

i. Lymph nodes

Have you ever encountered injury on your hands, legs or somewhere on your limbs and felt tenderness, pain, and uncomfortable at your groin area and armpits? What do you think is the reason?

ATTENTION

Dear learner! Lymph fluid flows in the lymph nodes throughout the body before finally making its way back to the blood stream. While doing so, it collects and traps harmful matter, such as bacteria, viruses, and bodily waste products. The lymph nodes filter the fluid and release it back into the bloodstream. Lymph nodes also contain immune cells that help fight infection by attacking the germs that the body's lymph fluid has collected. The lymph nodes may swell when a person has a temporary infection. The swelling occurs as a result of immune cell activity in the lymph nodes. The location of the swelling often relates to the affected area. For example, an ear injury/infection may cause swollen lymph nodes near the ear, while someone with an upper respiratory tract infection may notice swollen lymph nodes in their neck.

Tonsils

You may have experienced tonsillitis in your early child hood with red swollen tonsils? Do you know why the tonsils are swollen? What are the causative agents for this ?

ATTENTION

Dear learner! Tonsils are lymphatic tissue clusters located just beneath the mucous membranes that line the nose, mouth, and throat (pharynx) (Figure 5. 12). The tonsils' lymphocytes and macrophages protect us from harmful substances and pathogens such as bacteria and viruses that enter the body through the nose or mouth.

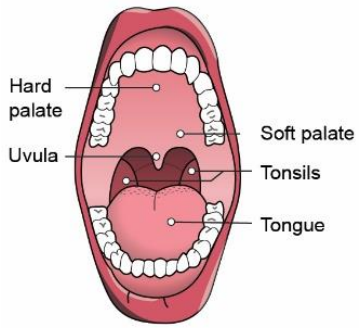


Figure 2.12 Locations of Tonsils

Spleen

Where in your body is located spleen and what is its function?

Dear learner! The spleen is found in the upper left abdominal cavity, just below the diaphragm and posterior to the stomach (Figure 2. 10). Its shape and structure are similar to that of a lymph node, but it is much larger. The spleen performs the following functions:

– filters blood in the same way that lymph nodes filter lymph;

– lymphocytes in the spleen react to pathogens in the blood and attempt to destroy them;

– macrophages engulf debris, damaged cells, and other large particles;

– removes old and damaged erythrocytes from the circulating blood; and

– it produces lymphocytes, particularly in response to infection.

Thymus

What is thymus? Where in the body is it found?

Dear learner! The thymus is a soft organ with two lobes anterior to the ascending aorta and posterior to the sternum (breastbone) (Figure 2. 10). It is relatively large in infants and children, but after puberty, it begins to shrink in size until it is quite small in older adults. The thymus' primary function is to process and mature special lymphocytes known as T-lymphocytes or T-cells. Pathogens and foreign agents are not recognized by lymphocytes while they are in the thymus. After maturing, lymphocytes enter the bloodstream and travel to other lymphatic organs, where they aid in disease defence. Thymosin, a hormone produced by the thymus, stimulates the maturation of lymphocytes in other lymphatic organs.

√ **Self-evaluation checklist**

Put a tick (✓) against each of the following tasks which you can perform.

I can :

- Define what is lymph_____ ☐
- Discuss the components of the lymphatic system_____ ☐
- Describe the location of lymphatic vessel1 in human body_____ ☐
- Explain the key functions the lymphatic system_____ ☐

Self-Test Exercise 2.2.2

I. True-False Items

Write "**True" for correct statement or "False" for the incorrect one.**

1. The lymphatic vessels do not have valves.
2. the lymphatic nodes filter potentially pathogenic bacteria.
3. Lymph is made up of red blood cells.
4. Lymph removes metabolic waste from the body.
5. Lymph vessels transport food from blood to the cells.

II. Short answer item

1. What is lymph?
2. Mention components of the lymphatic system.
3. What is the function oflymph nodes?
4. Mention all lymphatic organs.
5. Draw the human body and show the location of lymphatic system.

Section 2.2.3. Diseases of the circulatory and lymphatic systems

Introduction

Dear learner! In the previous sections, you have studied about blood and lymph circulation and their importance to human body. In this sub-section will you will learn about the major diseases of the cardiovascular and lymphatic systems. Cardiovascular infectious diseases infect the blood, blood vessels, and heart. In many cases, the infections are contained within these areas, but in others, they spread to secondary organs. In addition to infectious diseases, there are non-infectious diseases that cause serious heart complications. Also, Lymphatic system diseases affect the lymph, lymph vessels, lymph nodes, and lymphoid organs like the spleen, tonsils, and thymus.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, youwill be able to:

- Name diseases of the circulatory system,
- Mention the diseases of the lymphatic system,
- Discuss what is leukemia,
- Outline the causative agents for elephantiasis,
- Discuss reasons for stroke, and
- Mention reason for heart failure.

Activity 2.19

Dear learner! Align cardiovasular diseases given below with their description.

A. Stroke B. Leukemia C. Elephanthiasis D. Variose vein
E. Heart attack

1. Caner that affects blood forming tissue including bone marrow
2. Enlarged, swollen and twisting veins
3. A blood clot that blocks blood flow
4. Caused by *Wuchereria bancrofti*
5. Cerebrovascular diseases that during which brain does not receive enough oxygen or nutrients.

Leukemia

Dear learner! Leukemia is a type of cancer that affects blood-forming tissues, including bone marrow (Figure 2. 13). There are several types of leukemia, including acute lymphoblastic leukemia, acute myeloid leukemia, and chronic lymphocytic leukemia. For example, many patients with slow-growing leukemia are asymptomatic, and rapidly progressing types of leukemia can cause fatigue, weight loss, frequent infections, and easy bleeding or bruising. Also, the treatment varies greatly. Treatment for slow-growing leukemia may include monitoring. Chemotherapy, sometimes followed by radiation and stem-cell transplant, is used to treat aggressive leukemia.

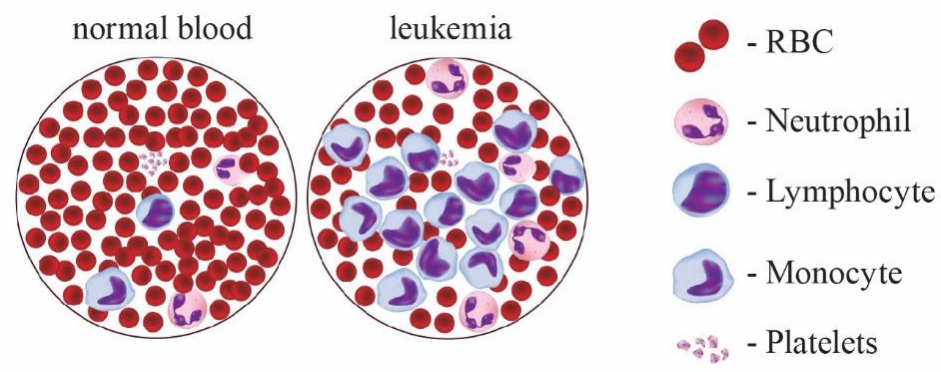


Figure 2.13 Leukemia

Varicose veins

What are varicose veins?

Dear learner! Varicose veins are enlarged, swollen, and twisting veins that often have blue or dark purple color (**Figure 2. 14)**. They occur when faulty vein valves allow blood to flow in the wrong direction or pool. Varicose veins are thought to affect more than 23% of all adults. It is common in:

- pregnant women which are more prone to varicose veins, and
- overweight people are more prone to varicose veins.

Aching legs, swollen ankles, and spider veins are some of the symptoms. It occurs when the valves in the veins fail to function properly, allowing blood to flow inefficiently. Treatment for varicose veins is rarely necessary for health reasons; however, if swelling, aching and painful legs occur, and there is significant discomfort, treatment is available. There are several options, including some home remedies. In severe cases, a varicose vein may rupture or develop into varicose ulcers on the skin.

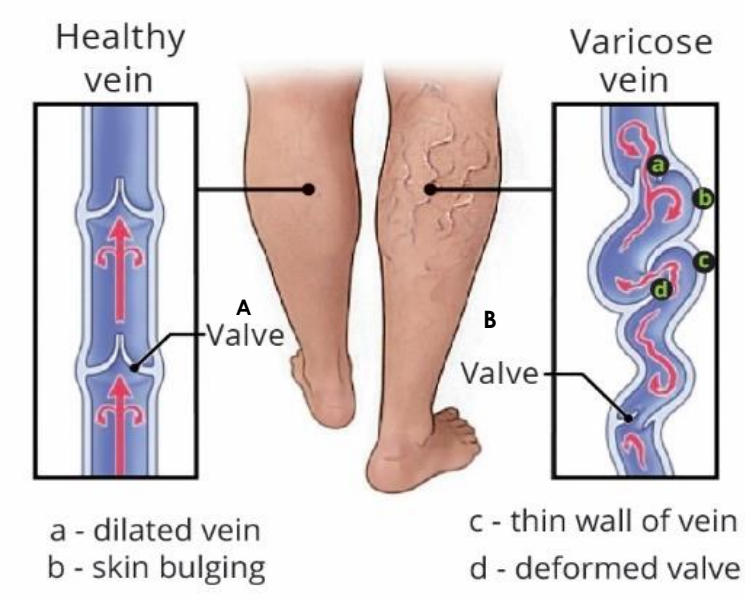


Figure 2.14A, shows a normal vein with a properly working valve. In Figure B, the varicose vein has a faulty valve; the walls of the vein are thin and stretched.

Elephantiasis

What is elephantiasis?

Dear learner! You may have observed that some peoples have abnormally enlarged body parts. What do you think is the reason for such enlargement? One of such reasons may be effect of parasitic worms. Elephantiasis is a condition that causes a large enlargement of a part of the body, usually the limbs (Figure 2. 15). External genitals are another area that is frequently affected. Elephantiasis is caused by a blockage in the lymphatic system, resulting in an accumulation of a fluid known as lymph in the affected areas. Elephantiasis is caused by parasitic worms transmitted by mosquitoes. *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori* are the three worms involved.

Figure 2.15 Elephantiasis

Worms have an impact on the body's lymphatic system. The lymphatic system is in charge of eliminating waste and toxins. If it becomes clogged(blocked by a parasite), it is unable to properly remove waste. This causes a build-up of lymphatic fluid, resulting in swelling.

Individual Activity 2. 20 Reflection

Dear learner! think about circulatory and lymphatic system disorders based on your knowledge from the previous lessons. If you're unsure, learn more about the two systems by using your smart phone or reading books.

Cardiovascular diseases

What are cardiovascular diseases?

Dear learner! Cardiovascular diseases are classified into several types. Among them are:

– Abnormal heart rhythms, also known as arrhythmias;
– Aorta disease and Marfan syndrome are two examples,
– Congenital heart disease is a condition that occurs at birth,
– Coronary artery disease is a condition that affects the arteries in the heart (narrowing of thearteries),
– Deep vein thrombosis (DVT) and pulmonary embolism (PE),
– A heart attack,
– Heart failure, and
– Muscle disease of the heart (cardiomyopathy).

Have you heard about any type of heart disease? If yes, mention and share your classmates.

Heart disease

Dear learner! Heart and blood vessel disease (also known as heart disease) encompasses a wide range of issues; many of which are linked to a process known as atherosclerosis. Atherosclerosis is a condition that occurs when a substance called plaque accumulates in the artery walls. This buildup narrows the arteries, making blood flow more difficult. When a blood clot forms, it can obstruct blood flow. This can result in a heart attack or a stroke.

Heart attack

Dear learner! A heart attack occurs when a blood clot blocks blood flow to a portion of the heart. If the clot completely obstructs blood flow, the part of the heart muscle supplied by that artery begins to die. Most people recover from their first heart attack and go on to live normal lives, gaining many more years of productive activity. However, having a heart attack means that you must make some changes. The medications and lifestyle changes

recommended by your doctor may differ depending on how badly your heart was damaged and the degree of heart disease that caused the heart attack.

Stroke

 What is the reason for stroke?

Dear learner! Stroke is a cerebrovascular disease. It occurs when a blockage or bleed of the blood vessels either interrupts or reduces the supply of blood to the brain. When this happens, the brain does not receive enough oxygen or nutrients, and brain cells start to die.

There are 2 types of stroke:

1. An ischemic stroke (the most common type of stroke) occurs when a blood vessel that supplies the brain becomes blocked, typically due to a blood clot. When a part of the brain's blood supply is cut off, some brain cells begin to die. This can lead to the loss of functions controlled by that part of the brain, such as walking or speaking.
2. When a blood vessel in the brain bursts, it causes a hemorrhagic stroke. Uncontrolled hypertension is the most common cause of this (high blood pressure). Some stroke effects are permanent if too many brain cells die as a result of oxygen deprivation. This population of cells is never replenished.

The good news is that brain cells do not always die during a stroke; instead, the damage is only temporary. As injured cells repair themselves, previously impaired function improves over time. In other cases, nearby undamaged brain cells may take over for the injured areas of the brain. In any case, strength may return, speech may improve, and memory may improve.

Heart failure

Dear learner! Heart failure, also known as congestive heart failure, occurs when the heart does not pump blood as efficiently as it should. Heart failure does not imply that the heart ceases to beat; this is a common misconception. Instead, the heart continues to beat, but the body's need for blood and oxygen is unsatisfied. If left untreated, heart failure can worsen. It is critical to follow the doctor's orders if your loved one has heart failure.

Arrhythmia

What is arrhythmia?

Dear learner! An abnormal heart rhythm is referred to as **arrhythmia**. Arrhythmias come in a variety of forms. The heart can beat too slowly, too quickly, or in an irregular pattern. **Bradycardia** or a slow heart rate, occurs when the heart rate is less than 60 beats per minute. **Tachycardia**, or an abnormally fast heart rate, is defined as a heart rate of more than 100 beats per minute. An arrhythmia can impair the function of your heart. Your heart may not be able to pump enough blood to meet your body's needs if it has an irregular heartbeat.

Activity 2. 21

Dear learner! You are familiar with some cardiovascular and lymphatic system diseases. It is now time to look for other types of diseases. To create a list of these diseases, read books, search online resources, and consult with health professionals in your area. Then show your collection to your classmates and tutor.

√ Self-evaluation checklist

Put a tick (✓) against each of the following tasks which you can perform.

I can:

- Mention the diseases of the circulatory system_____ ☐
- Mention the diseases of the lymphatic system_____ ☐
- Explain what is leukemia_____ ☐
- Mention the causative agents for elephantiasis _____ ☐
- Discuss reasons for stroke_____ ☐
- Mention reason for heart failure_____ ☐

Self-Test Exercise 2.2.3

I. True-False Items

Write "**True" for correct statement or "False" for the incorrect one.**

1. Varicose vein occurs when faulty vein valves allow blood to flow in the wrong direction or pool.
2. Elephantiasis causes the leg to be very thin.
3. Heart failure occurs when the heart does not pump blood efficiently.
4. Arrhythmia is an abnormal heart rhythm.
5. Congenital heart disease is a condition that occurs at adult hood.

II. Short answer item

1. Mention parasitic works that cause elephantiasis.
2. Mention types of cardiovascular diseases.
3. What are the reasons for stroke?

Section 2.3 The breathing system

Introduction

Dear learner! The respiratory system is a network of organs and tissues that assist in breathing. Your respiratory tract, lungs, and blood vessels are all part of it. The respiratory system also includes the muscles that power your lungs. These components collaborate to transport oxygen throughout the body and eliminate waste gases such as carbon dioxide. In this section you will learn about the whole breathing system including trachea, the lungs, and the mechanisms of inhalation and exhalation, as well as the muscles involved in the breathing system.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, you will be able to:

- Draw and label the human breathing systems,
- Show the link between the human breathing system and the circulatory system,
- Demonstrate the mechanism of breathing using locally available materials, and
- Mention diseases of the breathing system.

START UP

Hold your breath and see how long you can hold your breath as you continue reading. How long can you do it? May be you are feeling uncomfortable already. Why do you feel uncomfortable? Then, write down the reasons why this happens.

Now, have you understood why you felt uncomfortable?

Dear learner! You cannot stop breathing for longer than three minutes, and even then, your autonomic nervous system would take control. This is because every cell in the body needs to run the oxidative stages of cellular respiration, the process by which energy is produced in the form of adenosine triphosphate (ATP). Oxygen is used as a reactant, and carbon dioxide is released as a waste product, in order for oxidative phosphorylation to take place. Although cells require oxygen, your need to breathe is primarily driven by the accumulation of carbon dioxide.

Dear learners! The respiratory system, which includes muscles to move air into and out of the lungs, passageways through which air moves, and microscopic gas exchange surfaces covered by capillaries, allows carbon dioxide to be exhaled and oxygen to be inhaled. Gases are transported from the lungs to tissues throughout the body via the circulatory system. If your breathing is disrupted by a variety of conditions, such as what you did in your activity above, or diseases of the respiratory system, such as asthma, emphysema, chronic obstructive pulmonary disorder (COPD), and lung cancer, you will experience difficulties in the normal functioning of your breathing system, which can be quite severe at times.

Activity 2. 22 Individual work

Dear learner! Have you ever seen lung models? In your tutorial center, you may encounter at least one. In order to study the structure of lungs you can construct lung model/charts using locally available resources. You can also use virtual lab (simulation software, animation and video).

What is the primary function of the breathing system in human body?

Dear learner! The primary functions of the organs of the breathing system are to:

- provide oxygen to body tissues for cellular respiration,
- remove the waste product, carbon dioxide,
- help to maintain acid-base balance, and
- portions of the breathing system are also used for non-vital functions such as sensing odours, producing speech, and coughing.

The nose, larynx, pharynx, trachea, bronchi, bronchioles, and alveoli (Figure 2. 16) are the major structures of the breathing system. The following parts of the section go over these structures and their functions one by one.

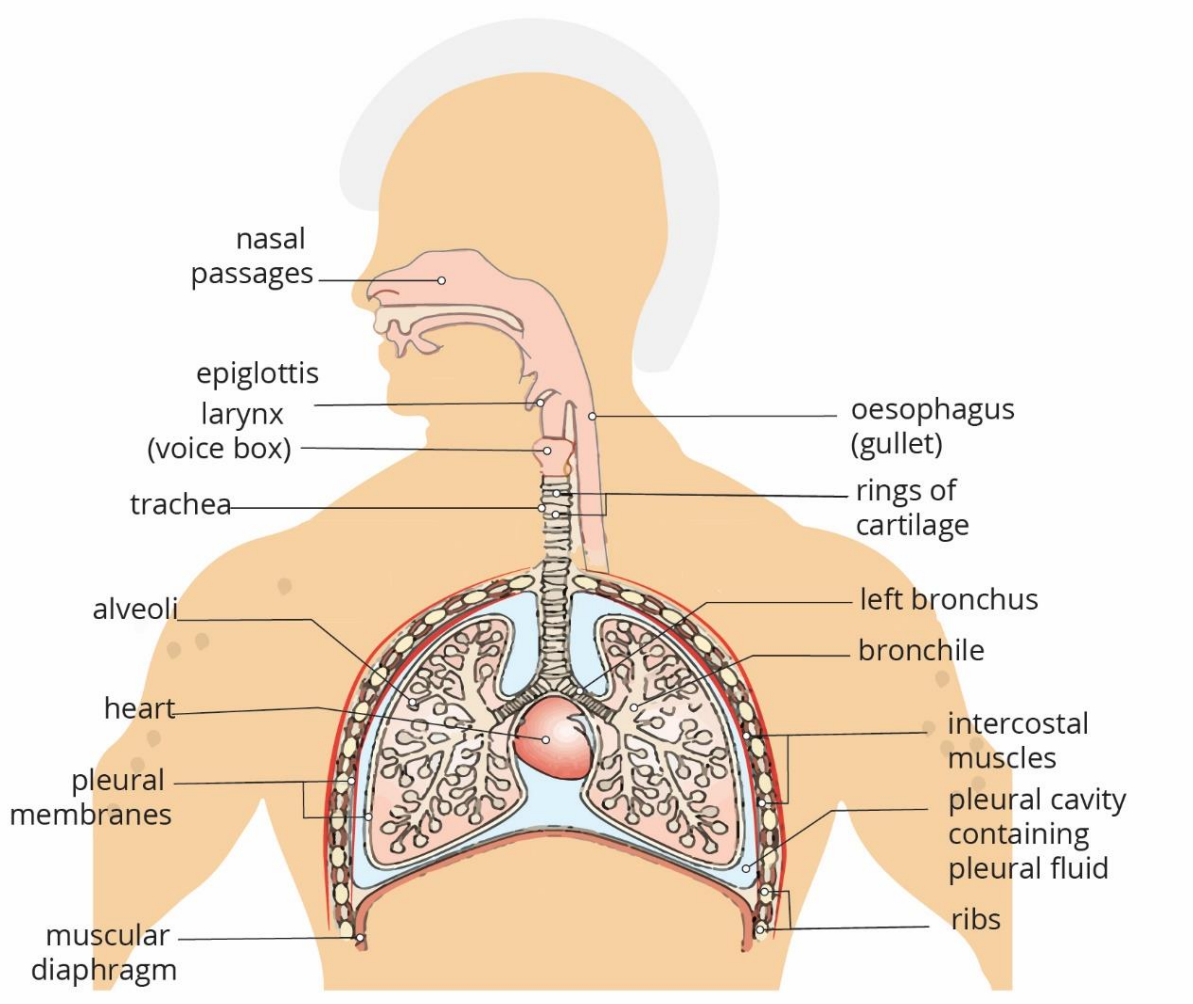


Figure 2.16. The human breathing system

Major breathing structures and their functions

The Nose

Activity 2. 23 Individual work

Dear learner! You might temporarily lose your ability to smell when you have the common cold or influenza, but you will eventually regain it. What do you think is the reason for the loss of your sense of smell?

Dear learner! After doing activity 2.23,you can proceed learning the following part. The nostrils (Figure 2. 16) are the main entry and exit points of breathing system, which are located in the nose. The nasal cavity, which is divided into left and right sections by the nasal septum, receives the inhaled air. The air moves from the nasal cavities to the pharynx. Mucous membranes line portions of the nasal cavities, which contain sebaceous glands and hair follicles that prevent large debris, such as dirt, from passing through the nasal cavity.

Why is nasal cavity considered as a good air conditioner?

Goblet cells, a type of specialized columnar epithelial cell that produces mucus to trap debris, are found in the nasal epithelium. With a constant beating motion, the cilia of the breathing epithelium help remove mucus and debris from the nasal cavity, sweeping materials towards the throat to be swallowed. Cold air, on the other hand, slows the movement of the cilia, resulting in the accumulation of mucus, which can lead to a runny nose in the winter. This moist epithelium warms and humidifies the incoming air. The incoming air is warmed by capillaries just beneath the nasal epithelium. Because the thick mucus produced to defend you from pathogens blocks the surface of the receptors on the nasal epithelium, you lose your ability to smell during a common cold or influenza.

Pharynx

Dear learner! The pharynx (Figure 2. 17) is a tube made up of skeletal muscle and mucous membrane that runs parallel to the nasal cavities. The pharynx, also known **as the throat**, is a tube that runs from the base of the skull to the sixth cervical vertebra. It receives air from the nasal cavity and air, food, and water from the oral cavity, serving the breathing and digestive systems. It opens into the larynx and esophagus from the back.

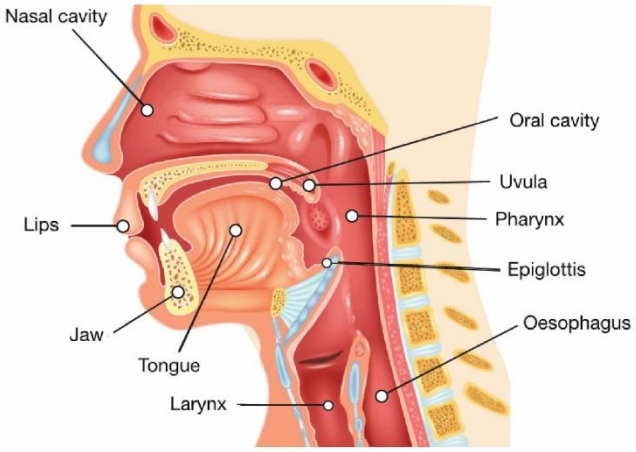


Figure 2.17. The pharynx

Only air can pass through the upper part of the pharynx (throat). Air, food, and fluids can pass through the lower parts. The pharynx contains the pharyngeal, palatine, and lingual tonsils. Sometimes the pharynx can be infected by microorganisms. The pharyngeal tonsil has a large number of lymphocytes (a type of white blood cell) and is covered with ciliated epithelium that traps and destroys pathogens that enter through inhalation.

Larynx

The larynx is a structure that connects the pharynx to the trachea and helps regulate the amount of air that enters and leaves the lungs (Figure 5. 18). Several pieces of cartilage make up the structure of larynx.

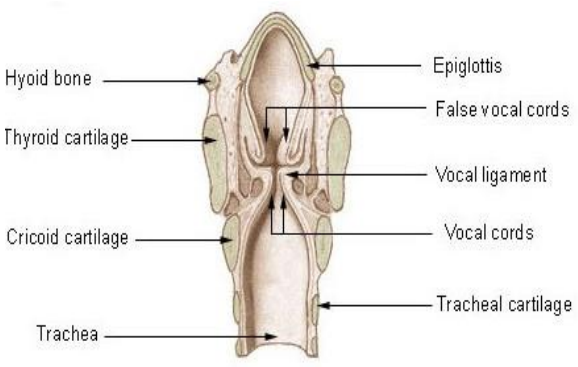


Figure 2.18. The larynx extends to the trachea.

The epiglottis is a thin, elastic cartilage that covers the trachea's opening and is attached to the thyroid cartilage. When the epiglottis is closed, the

unattached end of it rests on the glottis. The glottis is made up of the vestibular folds, true vocal cords, and space between them (Figure 2. 19).

Do you know how sound is formed in the voice box?

Dear learner! The inner borders of the real vocal cords (Figure 2. 19) are free, allowing oscillation to make sound. The size of true vocal cord membranous folds varies from person to person, resulting in voices with various pitch ranges. Males have greater folds than females, which gives them a deeper voice.

What happens if pieces of food or fluid you swallow-in wrongly enters into your trachea? Which structure of your laryngeal area prevents you from such drop-ins?

During swallowing, the pharynx and larynx lift upward, allowing the pharynx to expand and the laryngeal epiglottis to swing downward, closing the trachea opening. Because of these movements, food and liquids cannot enter the trachea, which creates a bigger region for food to travel through.

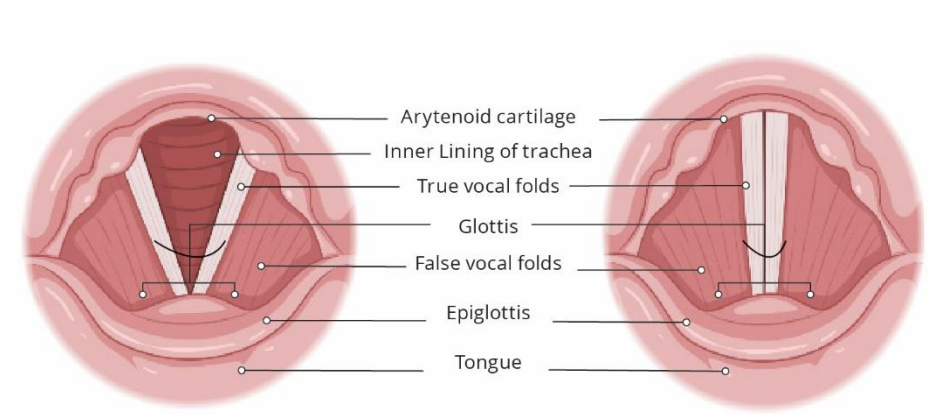


Figure 2.19 The vocal cords

Trachea

The trachea (windpipe) extends from the larynx toward the lungs (Figure 2. 20). The trachea is formed by 16 to 20 stacked pieces of cartilage that are connected by connective tissue. The elastic membrane of the trachea allows it to stretch and expand slightly during inhalation and exhalation, whereas

the rings of cartilage provide structural support and prevent the trachea from collapsing.

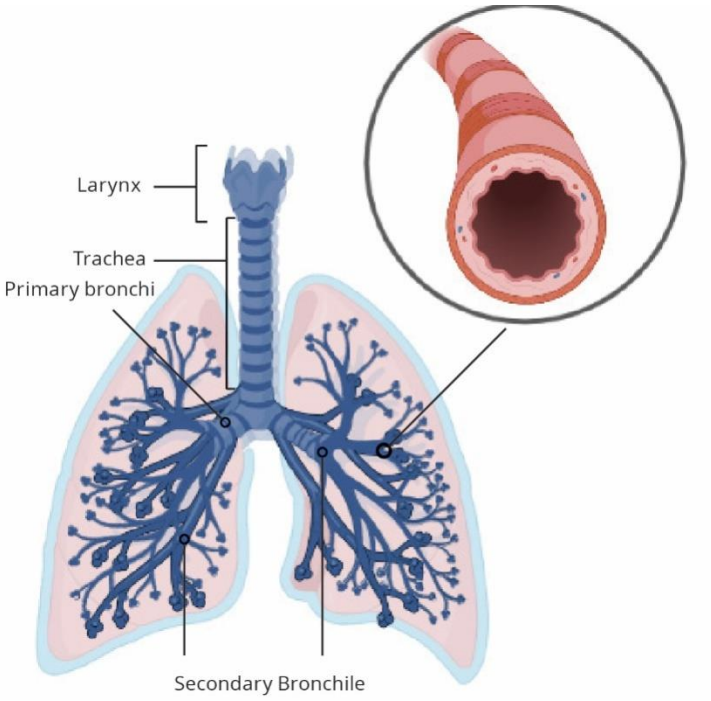


Figure 2.20 The trachea

Bronchi and Bronchioles

Dear learner! The right and left primary **bronchi** branch from the trachea towards the right and left lungs. The primary bronchi further branch into the secondary and tertiary bronchi. A **bronchiole** branches from the tertiary bronchi. Bronchioles, which are about 1 mm in diameter, further branch until they become the tiny terminal bronchioles, which lead to the structures of **gas exchange**. There are more than 1000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage-like those of the bronchi. However, smooth muscle can change the size of the tubing to increase or decrease airflow through it.

Activity 2. 24 Individual work

Dear learner! determine the interactions between the respiratory and circulatory systems before moving on to the next topic. How do the circulatory and respiratory systems interact? Explain.

Breathing Gas Exchange

Structures involved directly in gas exchange are found in the breathing zone. The breathing zone begins when the terminal bronchioles join a breathing bronchiole (Figure 2. 21), the smallest type of bronchiole which leads to an alveolar duct and opens into a cluster of alveoli.

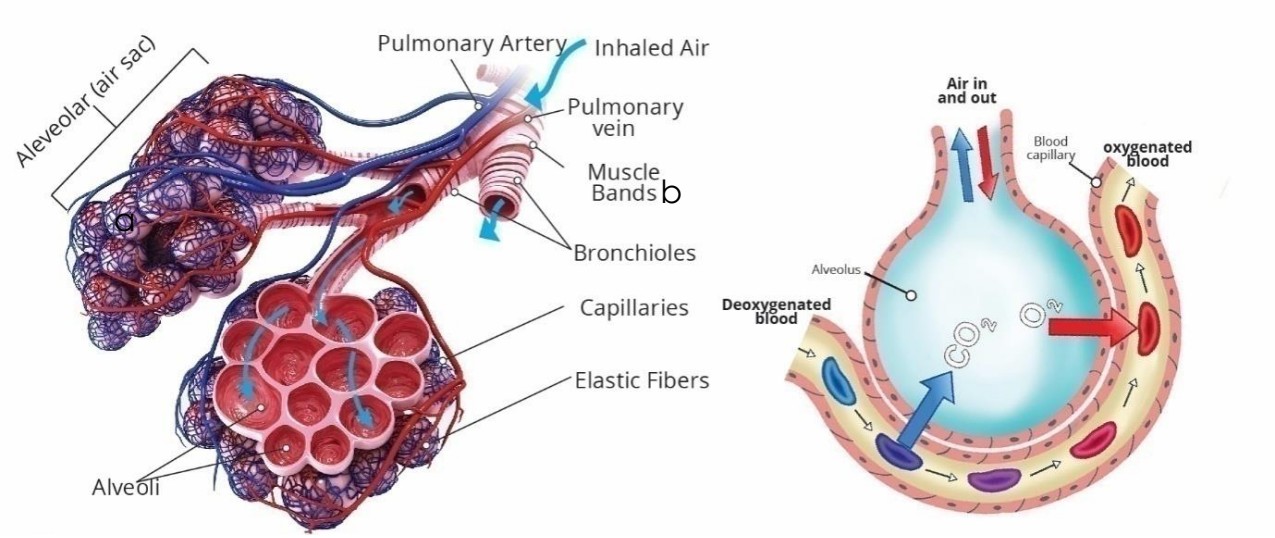


Figure 2.21 Bronchioles (a) lead to alveolar sacs (b) in the breathing zone, where gas exchange occurs.

Where in the breathing system does the actual gas exchange take place?

Alveoli

Dear learner! An alveolar sac is a cluster of many individual alveoli that are responsible for gas exchange. An alveolus with elastic walls, stretch during air intake which greatly increases the surface area available for gas exchange. Alveoli are connected to their neighbours by alveolar pores, which help maintain equal air pressure throughout the alveoli and lung (Figure 2. 21).

What is the composition of atmospheric and exhaled air?

In the following table is shown the composition of atmospheric and exhaled air.

Table 2.5 Comparison of atmospheric and exhaled air

Component	Atmospheric air	Exhaled air
oxygen	21%	16%
Nitrogen	78%	78%
Carbon dioxide	0. 04%	4%
Temperature	37 degree centigrade	variable
Moisture	saturated	variable

Breathing Movements

How the process of breathing takes place in the lungs?

Dear learner! Pressure differences between the atmosphere and the chest, or thoracic cavity determine the movement of air into and out of the lungs. Atmospheric pressure remains relatively constant, but the pressure in the chest cavity may vary. An understanding of breathing hinges on an understanding of gas pressures. The mechanism of breathing is shown in Figure 2. 22.

Gases move from an area of high pressure to an area of low pressure:

- Inspiration occurs when the pressure inside the lungs is less than that of the atmosphere, and
- expiration occurs when the pressure inside the lungs is greater than that of the atmosphere.

Activity 2. 25 Individual work

Dear learner! Mechanism of breathing involves two opposing activities in the lungs and the respiratory muscles. In order to fully understand the process answer the following questions.

i. Describe the mechanism of exhalation
ii. What happens to your diaphragm and external and intercostals muscles during the inhalation process.?
iii. What happens with your ribs as you inhale and exhale?

What is the role of the diaphragm during breathing?

Dear learner! The **diaphragm**, a dome-shaped sheet of muscle that separates the thoracic, or chest cavity from the abdominal cavity, can regulate the pressure in the chest cavity.

- During inspiration, the diaphragm muscle contracts, or shortens, pulling downward. The chest volume increases and pressure in the lungs decreases. The atmospheric pressure is now greater than the pressure in the chest cavity, and air moves into the lungs.

- During expiration, the diaphragm relaxes and returns to its dome shape due to the force exerted by the organs in the abdomen. The chest volume decreases and pressure increases. The pressure in the chest cavity is now greater than the atmospheric pressure, and air moves out of the lungs (Figure 2. 22).

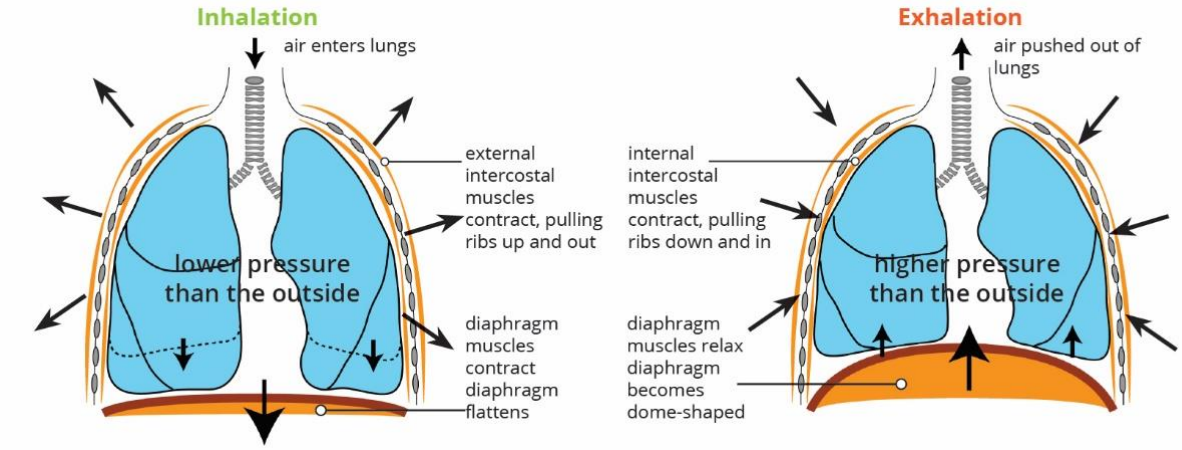
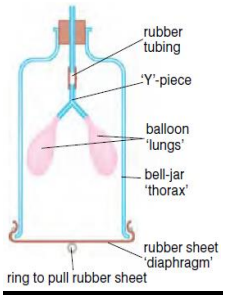


Figure 2.22 Breathing movements: a) Inspirationb) Expiration

Changes in chest volume during inspiration and expiration:

a) The intercostals muscles contract and the rib cage pull upward. Because the pressure in the chest cavity is lower than the atmospheric pressure, air moves into the lungs.
b) The intercostals muscles relax and the rib cage falls. Because the pressure in the chest cavity is higher than the atmospheric pressure, air moves out of the lungs.

Activity 2.26 Observing the mechanism of breathing



In order to observe the breathing movement of your lungs, prepare a lung model from locally available materials as indicated in the left hand corner. Materials you may need for this activity: 1. A bell jar 2. Plastic tubing (like juice straw) 3.Threads 4. The stopper and rubber tubing.
Finally, produce the model and observe how your lungs move during inhalation and exhalation.

How does a blood circulatory system interact with the respiratory system?

ATTENTION

The respiratory and circulatory systems work together to provide oxygen to the body and remove carbon dioxide from the body. While the former deals with air and the latter with blood, they work together to coordinate the operations of each system's components. Other body systems, such as the digestive and neurological systems, are crucial as well, but the circulatory and respiratory systems must work continually even without a few minutes of rest.

The circulatory and respiratory systems take oxygen from the air and transport it throughout the body while the digestive and respiratory systems take carbon dioxide from the body and release it into the atmosphere. The lungs expand and fill with fresh air as a person inhales. The respiratory system works in collaboration with the circulatory system to transport oxygen from fresh air to red blood cells in the arteries of the lungs, as well as to release carbon dioxide from the blood into the lungs' air. This used air leaves the body when a person exhales. The heart circulates blood from the lungs, carrying oxygenated red blood cells, down the arteries to the cells, where oxygen is released and carbon dioxide is absorbed. Then the used blood is sent back through the veins to the lungs, and the cycle begins again.

Table 2.6 Summary: Comparison of inspiration and expiration

Parts of respiratory system	Inspiration	Expiration
1. Diaphragm	Contracts and flattens downwards	Relaxes and moves upwards to dome shape
2. External Intercostal Muscles	Muscles contract	Muscles relaxes
3. Internal Intercostal Muscles	Muscles relax	Muscles contract
4. Ribcage And Sternum	Move upwards and out wards	Moves downwards and inwards
5. Thorax Volumes	Increases	Decreases
5. Air Pressure	Decrease in pressure inside thorax and lung	Increases in pressure inside thorax and lung
6. Air Movement	External air pressure drives air into lungs at low pressure	Air forced out of lungs by thorax compression and elastic recoil of lungs

Disorders of the Breathing System

Do you know any disorder that can affect the breathing system?

Dear learner! There are several disorders of the breathing system. All breathing disorders share one common characteristic: they all decrease oxygen delivery to the tissues. The following activity will help you to explore the different types of breathing disorders.

Activity 2. 27 Individual presentation

Dear learner! We observe peoples smoking at their own convenience elsewhere. What do you think is the effect of tobacco/cigarette smoking and cannabis use on our respiratory system? In order to come up with answers to this question, go to the nearby hospital or health post and interview health professionals about the effects of cigarette smoking and cannabis use on the normal functioning of the breathing system. Finally, present your findings to your colleague students in the presence of your tutor.

Some of the breathing disorders are discussed below:

i. Bronchitis

Breathing difficulties can be caused by bacteria or viral illnesses, as well as reactions to environmental pollutants. Bronchitis is a condition in which the airways narrow and the mucous lining of the bronchial tubes becomes inflamed. Excess mucus production, tissue swelling, constriction of the airways, and restricted airflow through the bronchi are all symptoms of this condition. In the bronchioles, the situation becomes even more acute. The bronchioles, unlike the trachea and bronchi, are not maintained by cartilage bands to keep them open.

ii. Emphysema

The alveolar walls become irritated in emphysema. The air sacs lose their flexibility, stretch, and eventually rupture as a result of this. As a result, exhaling becomes difficult, and air is trapped in the lungs. Because there are fewer alveoli, the surface area available for gas exchange is reduced, resulting in lower oxygen levels. Emphysema is caused by smoking, which is by far the most common cause. Chronic bronchitis has been linked to emphysema. COPD (chronic obstructive pulmonary disease) is the name given to both of these conditions. COPD, like bronchitis, causes the bronchioles to become more resist[pant to air movement. Although air moves freely into the alveoli, the smaller diameter of the bronchioles increases barrier to air movement out of the lungs, making exhalation difficult. The breathing rate increases as the body attempts to maintain homeostasis. The circulatory system responds by speeding up the heartbeat.

i. Bronchial Asthma

The inflammation of the bronchioles is linked to bronchial asthma. Exhaling requires more work than inhaling in asthma. The imbalance between the amount of air entering and leaving the lungs must be addressed by increasing the exertion of expiration. Common causes for asthma are tobacco smoking, pollution, and allergens such as pollen, mold, dust, etc.

√ Self-evaluation checklist

Put a tick (✓) against each of the following tasks which you can perform.

I can:

- Draw and label the human breathing systems_____ ☐
- Show the link between the human breathing system and the circulatory system_____ ☐
- Demonstrate the mechanism of breathing using locally available materials _____ ☐
- Mention diseases of the breathing system_____ ☐

Self-Test Exercise Section 2.3

I. True-False Items

Write "**True" for correct statement or "False" for the incorrect one.**

1. Mucus membrane of the nasal cavity prevent the entrance of dust particles to the lungs.
2. Mucus is secreted by goblet cells in the nasal epithelium.
3. Air, food and fluids pass through the upper part of the pharynx.
4. Sound is formed by the vibration of vocal cords.
5. Gas exchange takes place in the trachea.
6. During exhalation, air enter into the lungs.
7. Chronic bronchitis has been linked to emphysema.

II. Short answer item

1. Write the primary functions of the organs of the breathing system.
2. What are the major structures of the breathing system?
3. What causes asthma?
4. Mention causes for bronchitis.

Section 2.4 The Human Urinary system

Introduction

Dear learner! Blood is filtered by the urinary system, which also produces urine as a waste product. The ureters, bladder, kidneys, renal pelvis, and

urethra are among the urinary system's organs. The body transforms nutrients from food into energy. Waste products are left in the blood and bowel after the body has absorbed the nutrients it needs from the food. The kidney and urinary systems aid in the body's elimination of urea, a type of liquid waste, and in maintaining the proper balance of chemicals like potassium and sodium with water. When foods high in protein, like meat, poultry, and some vegetables, are digested by the body, urea is produced. Urea is transported by the bloodstream to the kidneys, where it is eliminated in the form of urine along with water and other wastes. In this section, you will learn about the structure and function of the urinary system, and the process of urine formation in the kidney.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, you will be able to:

- describe the structure and function of the kidney,
- discuss the process of urine formation,
- tell the role of the excretory system in the homeostatic process,
- Define what is nephron,
- outline section of the kidney,
- Explain the three steps in urine formation, and
- Discuss secretions that take place in the nephron.

START UP

Dear learner! Collect diagrams or models of the human excretory system(kidney) from a nearby high school or browse from internet, books and school digital libraries and draw, label, and study the structure and function of the excretory system(Kidney). Further, you can share your collections with your colleague students in your area.

What do you know about the excretory system of human beings?

Dear learner! You might be familiar with the functions of excretory system, which include waste removal and blood filtration. On the other hand, the system carries out additional, equally important tasks. Consider blood buffers like carbonic acid (H_2CO_3) and bicarbonate anion (HCO^{3-}) that the lungs

and blood share for pH control in order to maintain blood pH between 7. 35 and 7.45 because a value higher than 7. 8 or lower than 6. 8 can result in death.

 What do you know about regulating the concentration of solutes in the blood?

Dear learner! The kidneys produce 85% of the erythropoietin (EPO) needed to drive red blood cell formation. The kidneys also undertake the final synthesis step in the creation of vitamin D. When the kidneys fail, these functions are weakened or removed entirely, causing homeostasis to be disrupted. Weakness, fatigue, shortness of breath, anemia, generalized edema (swelling), metabolic acidosis, increased potassium levels, heart arrhythmias, and other symptoms may occur in the affected person. Each of these functions is critical to your survival and well-being.

This section explains the anatomy of the excretory system and how it facilitates the physiologic tasks required for equilibrium. The kidney should be thought of as a plasma regulator rather than a urine maker. As you read through each section, consider the following scenario: What if this doesn't work? This inquiry will assist you in comprehending how the urinary system maintains homeostasis and influences all other bodily systems as well as one's quality of life.

Activity 2. 28 Individual work

Dear learner! Draw a diagram of the internal structure of the kidney and study its structure and functions for yourself. You can also present your diagram to your tutor during your tutorial period.

External structure of kidney

The kidneys are a pair of bean-shaped organs in the abdominal cavity that are placed directly below the liver. The endocrine system includes the adrenal glands, which are located on top of each kidney. Blood is purified and filtered by the kidneys. The kidneys filter all of the blood in the human

body on a daily basis, consuming over 25% of the oxygen taken by the lungs in the process. Through aerobic respiration, oxygen enables kidney cells to produce chemical energy in the form of ATP.

What do we call the filtrate that leaves the human urinary system?

Dear learner! Urine is the filtrate that comes out of the kidneys. The ureters, which are around 30 cm long, transport urine from the kidneys to the urinary bladder. Urine is driven through the ureters by waves of peristalsis, rather than passively draining into the bladder (smooth muscle contractions). Urine from both ureters is collected in the bladder. Its capacity is diminished during late pregnancy because to compression by the increasing uterus, resulting in increased urination frequency. Urine is transported from the bladder to the exterior of the body via the urethra. The only urologic organ that differs significantly between males and girls is the urethra; all other urine transport systems are identical. Female urethras are shorter than male urethras, measuring around 4 cm in length, and provide less protection against fecal germs (approximately 20 cm). The increased frequency of urinary tract infections (UTIs) in women can be explained by this length disparity. In males, the urethra also serves as a reproductive organ, transporting sperm (sperm and accessory fluids).

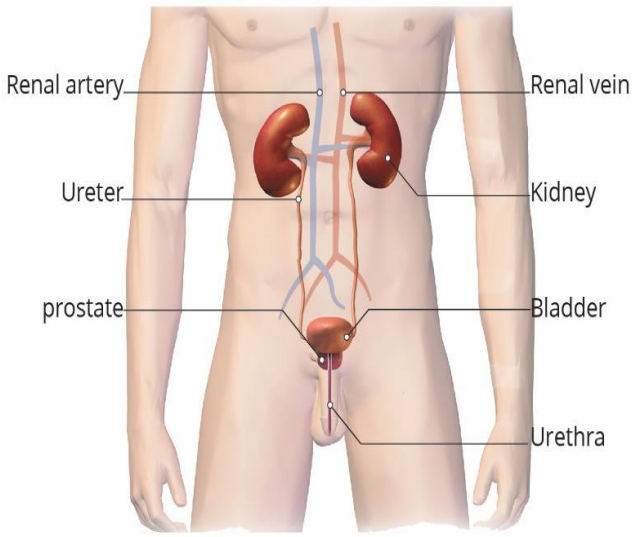


Figure 2.23 Kidneys filter the blood and produce urine that is stored in the bladder before removal

Internal structure of kidney

Dear learner! The kidney is divided into three sections on the inside: an outer cortex, a medulla in the middle, and the renal pelvis in the hilum of the kidney. The hilum is the concave portion of the bean form where blood arteries and nerves enter and exit the kidney, as well as where the ureters

exit. The presence of renal corpuscles causes the renal cortex to be granular, and nephron tubules can be observed throughout the renal cortex and renal pyramids, which make up the majority of the renal medulla. Each kidney has an average of eight renal pyramids. The urine produced by the nephrons passes via the renal pelvis and into the ureters, which transport it to the bladder (2. 24).

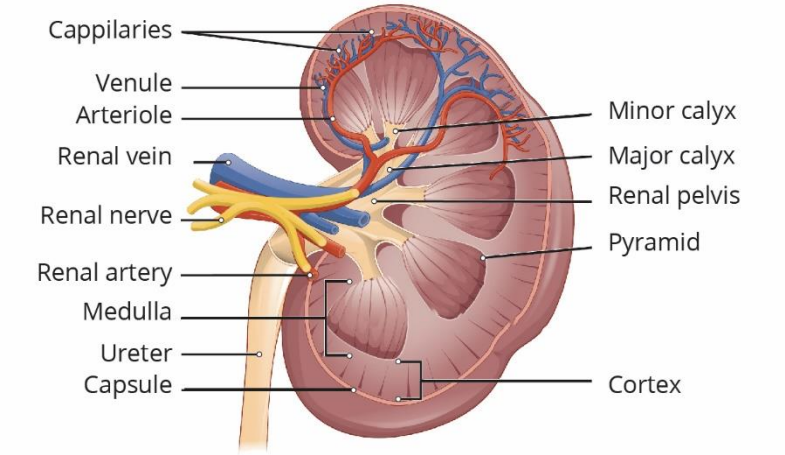


Figure 2.24.The internal structure of the kidney

What is the importance of blood arteries in the kidney?

The network of blood arteries in the kidney is an important part of its anatomy and function because it filters blood. The renal hilum is where the arteries, veins, and nerves that supply the kidney enter and exit. Renal blood flow begins with the aorta branching into renal arteries and finishes with the renal veins exiting to join the inferior vena cava, which takes blood back to the heart's right atrium. Before branching into several afferent arterioles and entering the capillaries supplying the nephrons, the renal arteries split multiple times to form additional blood vessels. As mentioned previously, the functional unit of the kidney is the **nephron,** illustrated in figure 2. 25. Each kidney is made up of over **one million nephrons** that dot the renal cortex. A nephron consists of three parts:

- a renal corpuscle,
- a renal tubule, and
- the associated capillary network. :

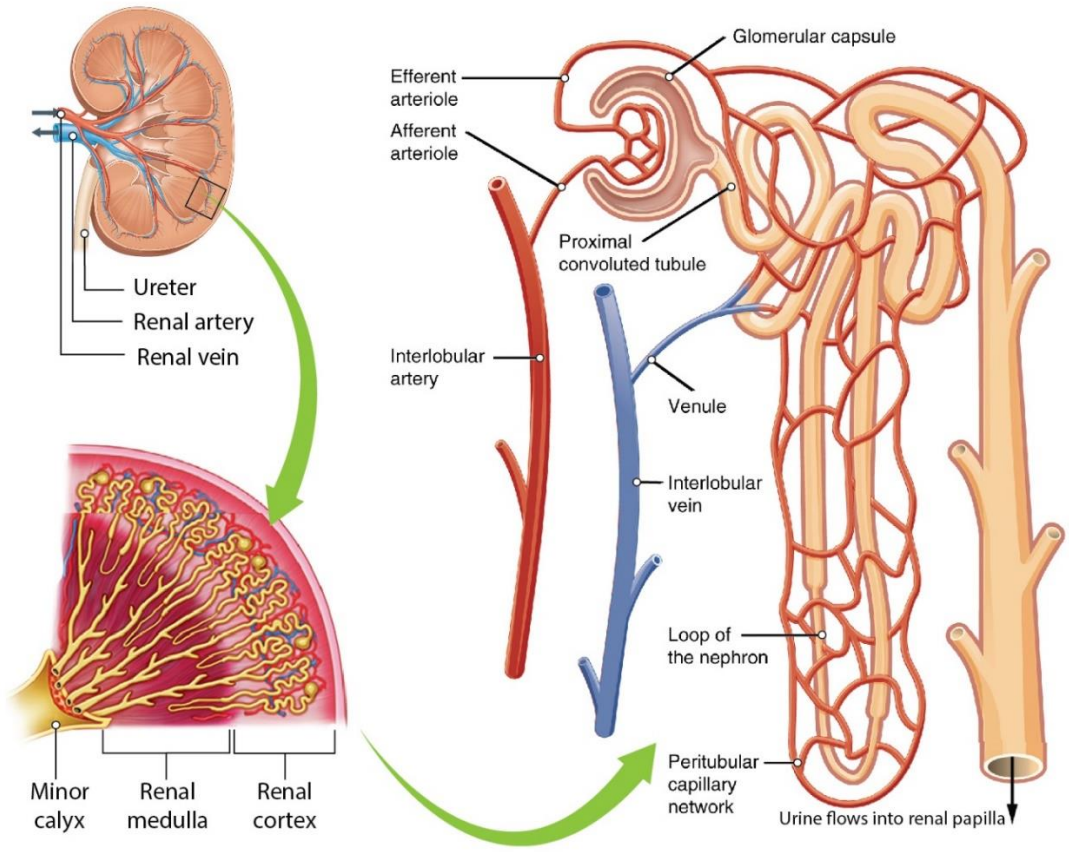


Figure 2.25. The Structure of a nephron.

Renal corpuscle

What is Bowmans' capsule?

The glomerulus, a network of capillaries that surrounds the renal corpuscle in the renal cortex, is made up of the glomerular or Bowman's capsule, a cup-shaped chamber that surrounds it (Figure 2. 25).

Renal Tubule

Do you know the three parts of the renal tubule? What are they?

The renal tubule is a long, convoluted structure that emerges from the glomerulus and can be split into three segments based on function:

i. the Proximal Convoluted Tubule (PCT),

ii. the loop of Henle, which forms a loop (with descending and ascending limbs), and
iii. the Distal Convoluted Tubule (DCT). The DCT, or distal collecting duct, joins and discharges the nephron's contents into collecting ducts. Urine will eventually pass via the renal pelvis and into the ureters.

Capillary Network within the Nephron

What do you know about the capillary network within the Nephron?

The nephron receives blood that needs to be filtered via a capillary network that branches off from the renal arteries. Afferent arterioles are the branches that enter the glomerulus. Efferent arteriole refers to the branch that leaves the glomerulus. The glomerular capillary bed is the capillary network that runs through the glomerulus. The peritubular capillary network surrounds and interacts with portions of the renal tubule after the efferent arteriole exits the glomerulus.

What are the functions of the kidney?

The formation of urine: glomerular filtration, reabsorption and secretion.

Kidneys filter blood in a three-step process:

i) The nephrons filter blood as it passes through the glomerulus' capillary network. Except for proteins, almost all solutes are filtered out into the glomerulus by a process known as glomerular filtration.
ii) The filtrate is collected in the tubules of the kidneys. Tubular reabsorption is the process by which most of the solutes are reabsorbed in the PCT. The filtrate continues to exchange solutes and water with the peritubular capillary network in the Henle loop. During this phase, water is also reabsorbed.
iii) Tubular secretion, which is essentially the inverse of tubular reabsorption, secretes extra solutes and wastes into the renal tubules. The collecting ducts collect filtrate from the nephrons, which are then carried into the renal pelvis and eventually to the ureters as urine. The full procedure is depicted in Figure 2. 26.

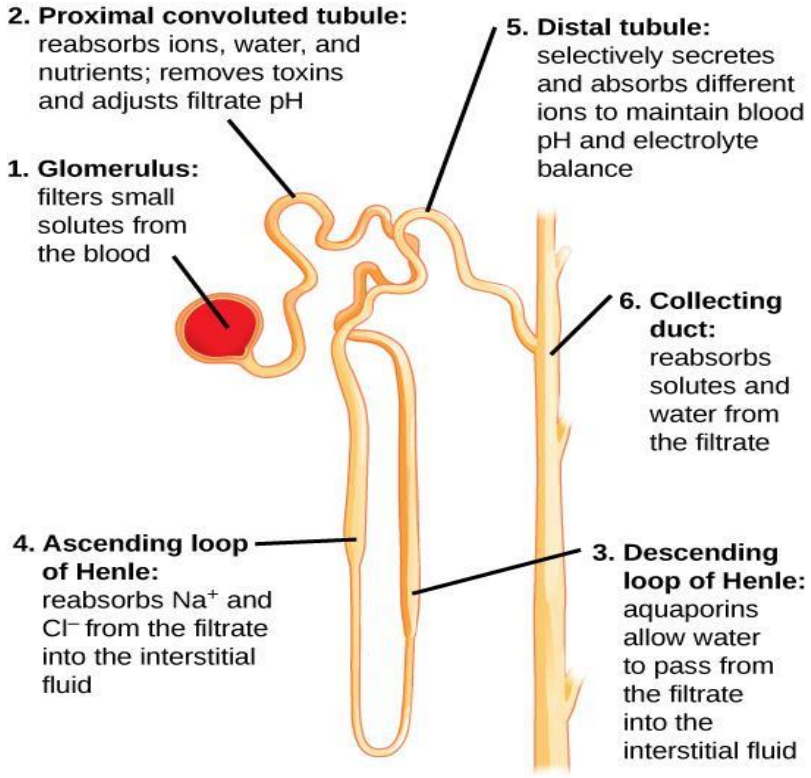


Figure 2.26.The process of urine formation in the kidney

Each part of the nephron performs a different function in filtering waste and maintaining Homeostatic balance:

i) The glomerulus forces small solutes out of the blood by pressure.

ii) The proximal convoluted tubule actively transfers toxins and medications from the interstitial fluid into the filtrate, reabsorbing ions, water, and nutrients from the filtrate. By selectively secreting ammonia (NH_3) into the filtrate, where it interacts with H+ to generate NH_4^+, the proximal convoluted tubule also regulates blood pH.More ammonia is secreted when the filtrate is acidic.

iii) Aquaporin-containing cells border the descending loop of Henle, allowing water to flow from the filtrate into the interstitial fluid.

iv) Na^+ and Cl^- ions diffuse into the interstitial fluid in the thin section of the ascending loop of Henle. These same ions are actively transferred into the interstitial fluid in the thick region. The filtrate becomes increasingly dilute as it passes up the leg because salt but not water is lost.

v) K^+ and H^+ ions are selectively secreted into the filtrate in the distal convoluted tubule, while Na^+, Cl^-, and HCO_3^- ions are reabsorbed to

maintain blood pH and electrolyte balance.

vi) Solutes and water from the filtrate are reabsorbed by the collecting duct, resulting in dilute urine.

Activity 2. 29 Answer to the following questions

Dear learner! Here are given some questions to answer.

a. Do you know of any connections between the excretory and circulatory systems? Explain if you know any.

b. Kidney disorders now affect a large portion of our society. What might be the cause? How can we solve such a health problem?

√ Self-evaluation checklist

Put a tick (✓) against each of the following tasks which you can perform.

I can:

- discuss the structure and function of the kidney ☐
- identify the process of urine formation ☐
- tell the role of the excretory system in the homeostatic process ☐
- Describe what is nephron ☐
- Discuss section of the kidney ☐
- Explain the three steps in urine formation ☐
- Discuss secretions that take place in the nephron ☐

Self-Test Exercise Section 2.4

I. True-False Items

Write "**True" for correct statement or "False" for the incorrect one.**

1. The urinary system maintain homeostasis.
2. Blood is purified by kidney.
3. Urine moves to the bladder by external pump.
4. Male and female urethra are similar in structure.
5. Functional unit of the kidney is the cortex.
6. In kidney, tubular secretion is the inverse of tubular re-absorption.

II. Short answer items

1. Write the three sections of the kidney

2. What are the three parts of the nephron?

3. Write the three parts of the renal tubules.

Section 2.5 The immune system

Introduction

 Dear learner! The immune system consists of a collection of organs, white blood cells, proteins (antibodies), and chemicals. This system collaborates to keep you safe from foreign invaders that cause infection, illness, and disease (bacteria, viruses, parasites, and fungi). Its job is to keep germs out of your body, destroy them, or limit the extent to which they can harm you if they do get in. In this section, you will learn about the innate and adaptive immune systems and the cells involved.

Learning outcomes

Upon successful completion of this section, you will be able to:

- define what is immunity,
- mention types of immunity,
- discuss what is innate and acquired immunity,
- Discuss hormones and the immune system,
- Differentiate between antigen and antibody, and
- Explain cells of the immune system.

START UP

☞ Dear learner! Before starting to study the next part of the section, please, write a short note on: 1) The immune system and 2) Types of immunity 3) Organs and cells involved in immunity, for yourself, based on your previous knowledge.

The Immunity system

What is the immune system?

Dear learner! Immunity is defined as the **body's ability to prevent the invasion of pathogens**. The immune system includes varieties of defences against **viruses, bacteria, fungal** infections, and parasites (such as threadworms). The lymphatic system is part of the broader immune system. The types of immune systems include **innate and adaptive (Acquired) immune systems**.

Mothers are recommended to breastfeed their kids immediately after delivery. Do you know why?

a) Innate immune system

Dear learner! The body's initial line of defence against invading microbial diseases is innate immunity. Pattern recognition receptors (PRRs), which are produced by innate immune cells, help to maintain homeostasis by regulating endogenous processes including inflammation and cell death.

These are the non-specific, unchanging lines of defences which include:

- Physical and chemical barriers to pathogens.
- To attract immune cells to infection locations, cytokines and other chemical agents are produced.
- To recognize bacteria, stimulate cells, and facilitate the clearance of dead cells or antibody complexes, the complement cascade is activated.
- Specialized white blood cells identify and remove foreign compounds found in organs, tissues, blood, and lymph.

What do you know about the vaccines against certain diseases e. g. vaccine against COVID-19?

ii) Adaptive (Acquired) immune system

Dear learner! After an initial reaction to a new pathogen, adaptive (or acquired) immunity is formed, resulting in an increased response to future exposure to the same disease. Vaccination is based on this acquired immunity process. Because bacteria and viruses are always changing and

evolving in an 'arms war' with our immune systems, this is critical. The adaptive immune system has the following characteristics:

- During the antigen presentation process, particular "non-self" antigens are recognized.
- The development of targeted responses to eradicate specific infections or pathogen-infected cells.
- Immunological memory is the process through which signature antibodies or T cell receptors "remember" each infection. If another infection arises, these memory cells can be summoned to eliminate the invader swiftly.

Cells of the immune system

 Do you have any idea about the cells of the immune system? What types of cells of the immune system do you know?

Dear learner! The immune system is made up of numerous different cell types and subtypes. The following are some of the most common types:

- **Lymphocytes**: White blood cells that travel between the bloodstream and the lymphatic system. They are crucial in the battle against infection. T cells, B cells, and natural killer cells are the three most common types of lymphocytes. Lymphocytes are formed in the bone marrow. Some move to the thymus and mature into T cells, while others mature into B cells in the bone marrow.
- **Neutrophils**: The most common form of white blood cell, neutrophils play a vital role in the innate immune system. A type of phagocyte is neutrophils (cells that engulf and then digest cellular debris and pathogens). They are ordinarily located in the bloodstream, but chemical signals like Interleukin-8 cause them to be promptly recruited to the site of injury or infection.
- **Macrophages**: phagocytes that play a role in both the innate and adaptive immune systems are another form of phagocyte. Foreign chemicals, pathogenic bacteria, and cancer cells are all targets for them. Lymphocytes and other immune cells are also stimulated by macrophages to respond to infections.

- **Dendritic cells**: Antigen-presenting cells serve as intermediaries between the innate and adaptive immune systems. They are frequently found in tissues that come into contact with the outside world, such as the skin, nose, lungs, stomach, and gut linings. They travel to lymph nodes in response to infections, where they interact with T cells and B cells to start the adaptive immune response.

Antigens and antibodies

 What are antigens and antibodies?

Antibodies (also called immunoglobulins) are Y-shaped proteins produced by B-cells that bind to antigens on the surface of foreign substances like bacteria and viruses. This recognizes and identifies the foreign thing as "non-self," prompting other immune cells to attack it.

Hormones and the immune system

 How hormones function in the immune system?

The immune system produces a wide range of hormones. Lymphokines are the common name for these hormones. The immune system is suppressed by steroids and corticosteroids (adrenaline components).

√ **Self-evaluation checklist**

Put a tick (✓) against each of the following tasks which you can perform.

I can:

- define what is immunity_____ ☐
- mention types of immunity_____ ☐
- discuss what is innate and acquired immunity_____ ☐
- Discuss hormones and the immune system_____ ☐
- Differentiate between antigen and antibody_____ ☐
- Explain cells of the immune system_____ ☐

Self-Test Exercise Section 2.4

I. True-False Items

Write "**True" for correct statement or "False" for the incorrect one.**

1. Innate immunity is the body's initial line of defence against invading organisms.

2. Vaccines are innate immunity.

3. Lymphocytes are made in the bone marrow.

4. antibodies are also called immunoglobulin.

5. The immune system is suppressed by steroids(hormones).

II. Short answer items

1. Mention the types of the immune system.

2. What is immunological memory?

3. Mention types of lymphocites.

4. Write the most common types of cells of the immune system.

Section 2.6 Renowned Physicians in Ethiopia

Introduction

Dear learner! Ethiopia, like many other countries around the world, has illustrious physicians. They make significant contributions to serving the country in various hospitals, research centres, and communities across the country. They worked hard to help during the HIV/AIDS and COVID-19 pandemics and are still working hard to alleviate the effects of killer infections such as the Malaria pandemic and cancers of all kinds, which is a severe case today. You are given two renowned physicians as examples in this section, and you are expected to list more and research their contributions. You can use internet resources, books, and resource people from research centers, hospitals, and universities during your studies.

Learning outcomes

Upon successful completion of this section, youwill be able to:

- mention renowned Ethiopian physicians,
- discuss contributions of renowned Ethiopian physicians, and

- appreciate the contributions of Ethiopian physicians.

Activity 2. 30 Individual work

Dear learner! In Ethiopia, as it is true in all countries of the world, the history of medicine began much earlier and the number of physicians that contributed to their country has increased time to time. Here are mentioned two of the most renowned pioneer Ethiopian physicians. Now, using books, internet and interviewing people as a source of information:

i) List down names of the renowned Ethiopian physicians.
ii) Write a report on their contributions to Ethiopian society and the world.

Finally, share your findings to your colleague students in your area and to your tutor during tutorial period.

Two of the renowned Ethiopian physicians:

1. Professor Asrat Woldeyes (1928-1999) was the first distinguished Ethiopian surgeon and professor of medicine in Addis Ababa University. He was the first Ethiopian to qualify in this field of medicine in the West after medical studies at Edinburgh University.

He devoted the majority of his working life to surgery at Addis Adaba's two main hospitals, as well as the deanship of medicine at the university.

Figure 2.27 Prof. AsratWoldeyes

2. Dr. Widad KidaneMariam was born to an Ethiopian emigrant family in Palestine during the Italian occupation of her country of origin. She studied medicine at the American University of Beirut and became the "first female" medical practitioner and topmost physician administrator in charge of the medical services division in the Ministry of Health in the 1960s-1970s. When she was asked to be the first Ethiopian gynecologist to volunteer for the Swedish Save the Children Fund project in Addis Abeba, she also became a founding organizer responsible for the establishment of the first Ethiopian Family Planning Association as well as Maternal and Child services for the homeless in Addis Abeba Municipality.

Figure 2.28 Dr. Widad KidaneMariam

UNIT SUMMARY

- The digestive tract is made up of the alimentary canal and its auxiliary organs, which break down food into molecules that may be absorbed and used by the body's cells.
- In the body, food travels through four different processes: ingestion, digestion, absorption, and excretion.
- The digestive system has six actions or tasks that prepare nutrients for use by body cells: ingestion, mechanical digestion, chemical digestion, motions, absorption, and elimination. The wall of the digestive tract has four layers or tunics: mucosa, submucosa, muscular layer, and serous layer or serosa.
- The alimentary tract and accessory organs are the two primary components of the digestive system.
- The mouth, pharynx, esophagus, stomach, small and large intestines, rectum, and anus are all parts of the digestive system's alimentary tract.
- The salivary glands, liver, gallbladder, and pancreas are all accessory organs that are connected to the alimentary system.

Secretions of organs and glands in the digestive system

Organ/gland of	Secretion(s)	Function

secretion		
Salivary glands	Salivary amylase	Initiates the breakdown of polysaccharides to simpler carbohydrates
Stomach	Hydrochloric acid	Converts pepsinogen to pepsin; kills microbes
	Pepsinogen	when converted to pepsin, initiates the digestion of proteins
	Mucus	protects the stomach from pepsin and Hydrochloric acid (HCl)
Pancreas	Pancreatic Amylase	Continues the breakdown of carbohydrates into disaccharides
	Bicarbonate ions	neutralize Hydrochloric acid (HCl) from the stomach
	Trypsinogen	when activated to trypsin, converts long-chain peptides into short-chain peptides
	Lipase	Breaks down fats to glycerol and fatty acids
Small intestine	Erepsin	Completes the breakdown of proteins
	Disaccharidases (e. g. , maltase)	breakdown disaccharides (e. g. , maltose) into monosaccharide
Liver	Bile	Emulsifies fat
Gallbladder	Bile	Stores and secretes concentrated bile from the liver
Large intestine	Mucus	Helps the movement of food waste

- The cardiovascular system is made up of a muscle pumping apparatus called the heart, as well as a closed system of vessels called arteries, veins, and capillaries.
- The heart is a muscle pump that provides the required force to circulate blood throughout the body's tissues.
- The epicardium, myocardium, and endocardium are the three layers of the heart.
- The right atrium, right ventricle, left atrium, and left ventricle is the four chambers of the heart.
- Atrioventricular valves and semi-lunar valves are two types of heart valves.
- The right atrium pumps blood to the right ventricle, which then pumps it to the lungs, where it receives oxygen. Blood goes from the lungs to the left atrium and subsequently to the left ventricle. It is then injected into the systemic circulatory system.

- The conduction system of the heart is made up of specialized cardiac muscle cells that coordinate the contraction of the chambers.
- Blood travels from the right ventricle to the lungs and returns to the left atrium via the pulmonary arteries.
- The systemic vessels transport blood from the left ventricle to all regions of the body's tissues before returning it to the right atrium.
- Diffusion, filtration, and osmosis are all ways for substances to flow past the capillary wall.
- Ventilation, external respiration, gas transfer, internal respiration, and cellular respiration are all part of the respiration process.
- The pharynx also referred to as the throat, is a tract that runs from the base of the skull to the sixth cervical vertebra.
- The larynx, often known as the voice box, is an airway that connects the pharynx above and the trachea below.
- The major airway to the lungs is the trachea, sometimes known as the windpipe.
- The trachea is divided into the right and left principal bronchi, which branch off into smaller and smaller passages until they reach alveoli, which are tiny air sacs.
- Beyond the major bronchi, the two lungs contain all of the bronchial tree's components.
- The right lung is narrower, wider, and divided into three lobes than the left lung.
- The left lung is longer, narrower, and divided into two lobes than the right lung.
- The urinary system eliminates waste products from the body, controls fluid volume, maintains electrolyte concentrations in body fluids, regulates blood pH, and secretes erythropoietin and renin.
- The kidneys, ureters, urinary bladder, and urethra are all parts of the urinary system.
- The parenchyma of the kidney is made up of the cortex and medulla.
- The renal pelvis is located in the center of the kidney and collects urine as it is produced.
- A nephron, which is made up of a renal corpuscle and a renal tubule, is the functional unit of the kidney.
- Urine is transported from the kidney to the urinary bladder via the ureters.
- The urinary bladder serves as a temporary urine storage reservoir.
- The urethra is the last tube through which urine flows.
- An involuntary internal urethral sphincter and a voluntary external urethral sphincter govern the passage of urine through the urethra.
-

SELF-ASSESSMENT QUESTIONS

I. True False Items: Say "**True**" or "**False**" for the following statements.

_____ 1. Immunity is defined as the body's ability to prevent the invasion of pathogens.

_____2. Blood pressure is highest in arteries.

_____3. An abnormal heart rhythm is referred to as stroke.

_____4. white blood cells are blood cells that fight infections.

_____5. The partially digested food and gastric juice mixture are called chime.

_____6. Most absorption of nutrients takes place in the large intestine.

_____ 7. For good health, you should never eat vegetables and fruits.

_____ 8. Emphysema causes the irritation of the alveolar wall in lungs.

II. Multiple Choice Items: Choose the correct answer from A - E and write your answers on your exercise book.

1. Which of the following is not a tube through which air the we breath passes? A. Larynx B. Trachea C. Pharynx D. Rectum.
2. Part of the alimentary canal where protein digestion begin is:
   A. Stomach B. Mouth C. Liver D. Small Intestine
3. The location in the digestive system where pancreatic juice enters is:
   A. Mouth B. Esophagous C. Small Intestine D. Duodenum
4. The organ that produces bile is:
   A. Gall Bladder B. Liver C. Stomach D. Mouth
5. Digestive enzyme pepsin is produced in:
   A. Salivary glands B. Pancreas C. Stomach D. Liver
6. One of the following <u>is not</u> an organ that produces insulin?
   A. Gall Bladder B. Liver C. Pancreas D. A & B produce insulin
7. Which one of the following <u>is not</u> a major task of the digestive system?
   A. Circulation B. Digestion C. Absorption D. Elimination
8. Which one of the following is considered as an accessory gland to the digestive system?
   A. The teeth B. Anus C. Duodenum D. Pancreas

9. Rank the following blood vessels in order of their average pressure, from highest to lowest:

artery, vein, arteriole, venule, aorta, capillary.

A. Aorta > artery > arteriole > capillary >venule> vein

B. Capillary > vein >venule> arteriole > artery > aorta

C. Capillary > arteriole >venule> artery > vein > aorta

D. Aorta > arteriole >venule> artery > vein > capillary

10. What is the other name for Red blood cells?

A. Lymphocytes B. Monocytes C. Erythrocytes D. basophils

11. Plasma is?

A. a protein synthesized in the liver.

B. a liquid that contains only lipids and antibodies.

C. a blood component that is separated by spinning blood.

D. an antibody produced in the mucosal lining.

12. One of the following is a function of the breathing system?

A. absorption of nutrients C. structural support

B. gas exchange D.A and C

13.Thebronchi leads to the:

A. bronchioles B. Oesophagus C. pulmonary vessel D. Nasal cavity

14. Oxygen from the air enters the bloodstream through:

A. cardiac notchB. pulmonary vein C. AlveoliD. paranasal sinuses

15. When the diaphragm relaxes (is pulled up), _____ occurs.

A. inhalation B. hiccup C. Exhalation D. Lung collapse

16. Which one of the following is the correct path urine takes as it moves through the urinary system?

A. kidneys - ureters - bladder – urethra

C. bladder - kidneys -urethra – ureters

B. ureters - kidneys - bladder - urethra

D. Uretra – kidneys – Ureters – badder

17. The functional unit of the kidney is known as_____.

A. Villus C. Lymph node B. Alveoli D. Nephron

18. Substances that must be reabsorbed back into the blood from the convoluted tubule and loop of Henle are?

A. Water B. Salts C. Glucose D. All of the above

19. The major composition of Urine is _____.

A. Lymph B. Water C. Carbon dioxide D. Red blood cells

20. Which one of the following is the role of liver in the maintenance of homeostasis?

A. Stores extra carbohydrates in the form of glycogen

B. Produces bile to aid in fat digestion

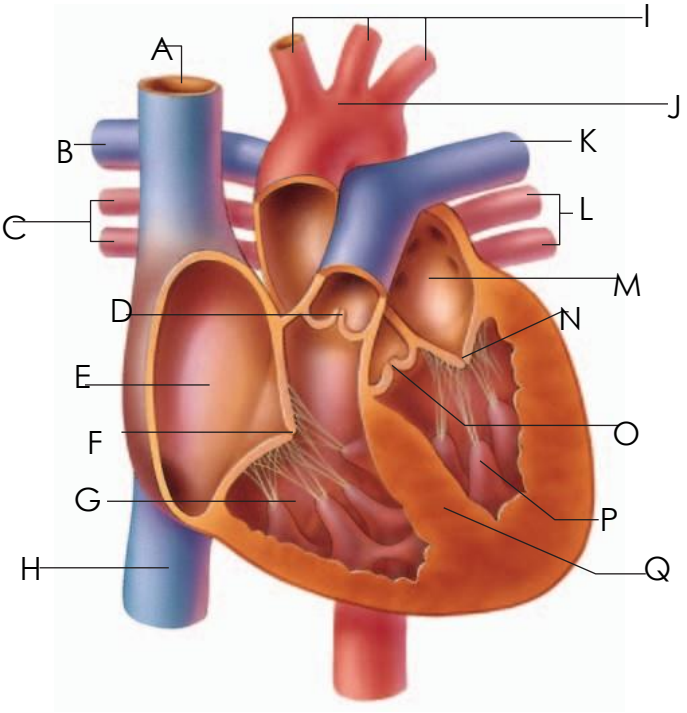
C. Produces clotting proteins D. All of the above

III. Fill in the Blanks

Fill in the blank with the term that best completes the sentence.

1. The instrument to measure blood pressureis termed as_____.
2. The liquid part of blood is referred to as _____.
3. Blood cells that defend our body from disease causing organisms is termed as_____.
4. Tiny sacs in the lungs where gas exchange takes place are called _____.
5. The disease in which air passages of the lungs periodically become too narrow is _____.
6. The food passage way from the mouth to the stomach of the digestive system is called _____.
7. The physical breakdown of chunks of food into smaller pieces is referred to as _____ digestion.
8. The partly digested food from the stomach enters into the duodenum through _____sphincter.
9. Solid waste that leaves the large intestine is known as _____.
10. Nutrients needed in large amounts for the body to function properly are_____.

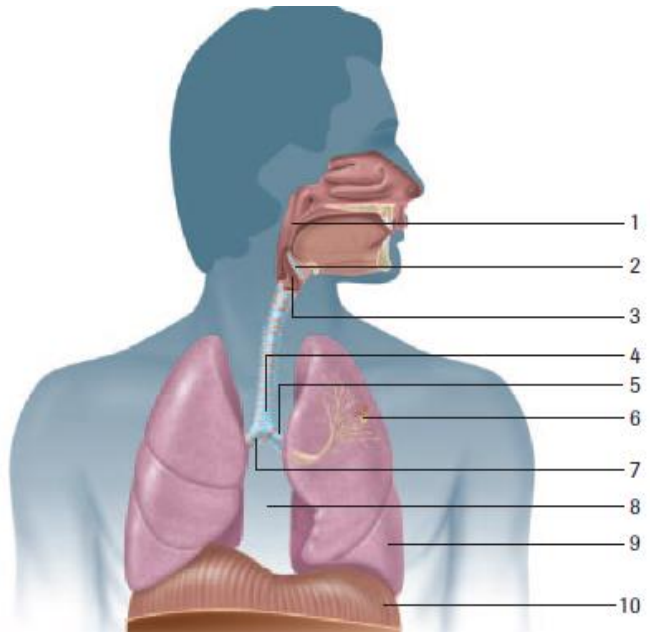
11. Label the structure of the heart in the figure given below.



Write the structures A-Q

A._____
B. _____
C. _____
D. _____
E. _____
F. _____
G. _____
H, _____
I. _____
J. _____
K. _____
L. _____
M. _____
N. _____
O. _____
P. _____
Q. _____

12. Label the respiratory structures given in the figure below.



IV. Short Answer Items

1. Which enzymes secreted by the pancreas promote digestion?
2. Explain the chemicals and processes involved in protein and carbohydrate digestion. Why are carbohydrates not digested in the stomach?
3. List the lipid-digesting enzymes secreted from the pancreas. Do these enzymes allow for a complete breakdown of lipids?

4. How is the duodenum protected against stomach acid? Why does pepsin remain inactive in the duodenum?
5. Describe what the inside of the small intestine looks like and how this organ increases the efficiency of its operation.
6. Discuss functions of the circulatory system?
7. Mention the types of blood circulation in human body?
8. Define pulmonary Circulation.
9. What is the difference between pulmonary and Systemic circulation?
10. Discuss the effect of fat deposits on the artery walls.
11. State functions of the right atrium.
12. What is the function of the right ventricle?
13. Why muscles of the heart on the left side are thicker?

ANSWERS FOR THE SELF-ASSESSMENT QUESTIONS

I. True-False items II. Multiple-choice items

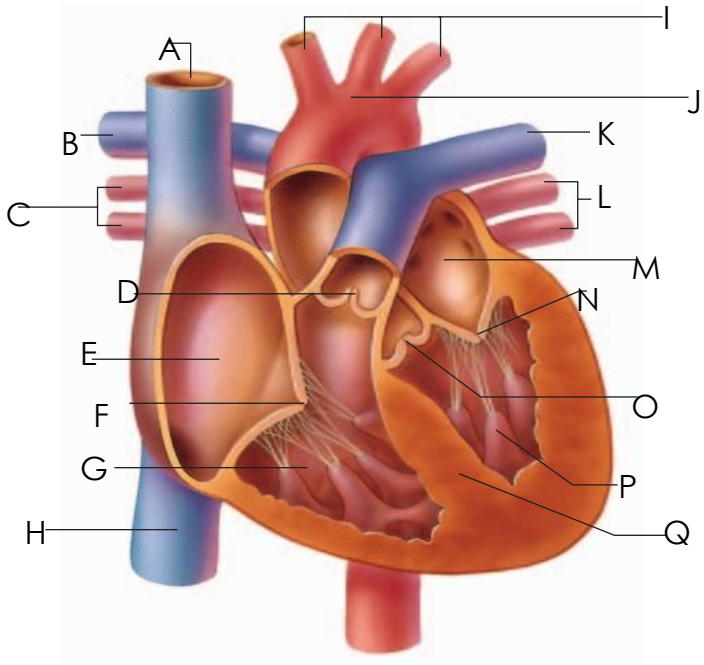
1. True
2. True
3. False
4. True
5. True
6. False
7. False
8. True

1. D	6. D	11. C	16. A
2. A	7. A	12. B	17. D
3. D	8. D	13. A	18. D
4. B	9. A	14. C	19. B
5. C	10. C	15. C	20. D

III. Fill in the blanks/spaces given

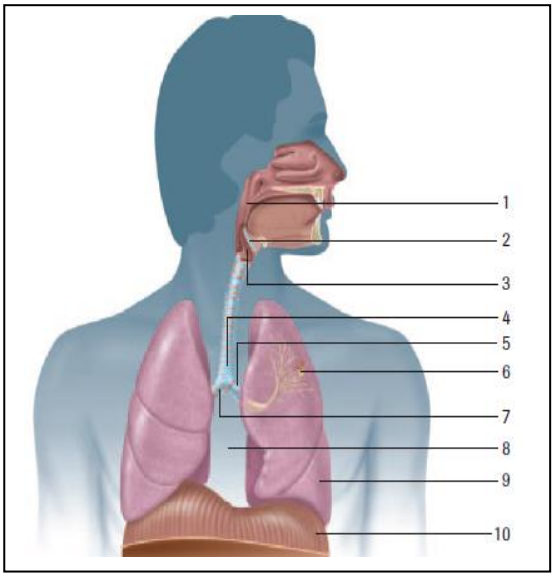
1. Sphygmomanometer
2. Plasma
3. White blood cells
4. Alveoli
5. Asthma
6. Oesophagus
7. Digestion
8. Pyloric sphincter
9. Bowl/face
10. Macromolecules

11. The heart structures labelled:



Answers
A. Superior vena cava
B. Right pulmonary artery
C. Right pulmonary vein
D. Semi-lunar valve
E. Right atrium
F. Tri-cuspid valve
G. Right ventricle
H. Inferior vena cava
I, Arteries
J. Aorta
K. Left pulmonary artery
L. Left pulmonary vein
M. Left atrium
N. Bi-cuspid valve
O. Semi-lunar valve
P. Left ventricle
Q. Septum

12. the Respiratory structures labelled:



Answers
1. Nasal cavity
2. Pharynx
3. Larynx
4. Trachea
5. Right bronchi
6. Bronchioles
7. Left bronchi
8. Oesophagus
9. Lung
10. Diaphragm

Answers for short-answer items

1. Amylase, lipase, trypsin, nuclease
2. Mechanical digestion of carbohydrates and proteins starts in the mouth. Chemical digestion of carbohydrates begin in the mouth by salivary amylase and protein digestion starts in the stomach by pepsin enzyme. Carbohydrates are not digested in the stomach because, here, the enzymes that further digest it are not available. Its digestion completes in the small intestine after addition of enzymes from the pancreas.

3. Lipase. Yes it allows the complete digestion of lipids.
4. Duodenum is protected by a mucus layer of the duodenum epithelium. Pepsin is inactive in the stomach, because the duodenum is alkaline while pepsin needs acidic environment to function.
5. The inside of the small intestine is covered by a fingerlike projection called villi. During absorption of the digested food such as glucose, amino acids and glycerol and fatty acids the surface of the villi increased.
6. Circulatory system is a system composed of the heart, the blood vessels and blood. The circulatory system also contains the lymphatic system by which the tissue fluids called lymph returns back to the heart.
7. There are two types of blood circulation: Pulmonary circulation and systemic circulation
8. Pulmonary circulation is the movement of blood from the right ventricle to the lungs though pulmonary artery and back to left auricle through pulmonary vain.
9. Pulmonary circulation is the movement of deoxygenated blood to the lungs and return of oxygenated blood from the lungs to the left auricle, while the systemic circulation is movement of blood from the left ventricle to the body through aorta and back to the heart through superior and inferior vena cava, that opens into the right auricle.
10. Fat deposition on the artery walls narrows blood vessels and reduces the normal flow of blood causing blood pressure that may end-up with a phenomenon known as stroke.
11. Right atrium collects the deoxygenated blood from the body through superior an inferior vena cava.
12. The right ventricle pumps blood to the lungs.
13. Muscles of the heart on the left side is thick, because, the left side of the heart pump-out blood, particularly from the left ventricle to the already full aorta, artery and arterioles. This pump needs energy.

Answer Key to Self – test Exercises

Self-test exercise 2. 1

I. True-False item	Matching Item	III. Multiple-choice item
1. True	1. C	1. A
2. False	2. D	2. C
3. True	3. E	3. D
4. False	4. A	4. C
5. True	5. B	5. C
6. False		
7. True		
8. True		

IV. Short Answer item

1. Enamel, dentin, pulp, periodontal ligament, roots, gum and crown
2. Moves food or fluid from the oesophagus to the stomach.
3. A) regular brushing, B) avoid eating sweet sugary food, C) Have regular dental check-up
4. Food ingested is crushed and masticated to smaller pieces, acted by saliva that contain salivary amylase. Carbohydrate digestion begins and the food chewed be rolled by the tongue and form a bolus, that is swallowed to the oesophagus.
5. HCl kills bacteria and other pathogenic organism and convert pepsinogen into pepsin which digest proteins.

Self-test exercise 2. 2. 1

I. True-False Item		II. Matching Item
1. True	6. False	1. C
2. False	7. False	2. D
3. False	8. True	3. E
4. True	9. False	4. B
5. True	10. True	5. A

III. Short answer item

1. i. Left auricle ii. Right auricle iii. Left ventricle iv. Right ventricle
2. Separates the right atrium(auricle) from the right ventricle
3. Plasma is a yellow-tinted water, sugar, fat protein, and salt fluid that transports red and white blood cells and the platelets.
4. The 4 valves are: Tri-cuspid valve, bi-cuspid valve and 2 semi-lunar valves.
5. The blood cells are: Red blood cells (Erythrocytes), White blood cells (leucocytes) and Platelets (thrombocytes)

Self-test exercise 2. 2. 2

I. True-False Item

1. False 2. True 3.False 4.True 5.False

II. Short answer item

1. Lymph is a fluid substance made up of lymphocytes and white blood cells that is clear to white in colour. It is present in lymphatic veins and other cavities throughout the body.
2. Components of the lymphatic system are lymph, vessels that transport the lymph and organs that contain lymphoid tissue.
3. The lymph nodes filter the fluid and release it back to the blood stream. It also contains immune cells that help fight infection-causing organisms.
4. Limphatic organs are: lymph nodes, tonsils spleen and thymus.

Self-test exercise 2. 2. 3

I. True-False Item

1. True 2. False 3. True 4. True 5. False

II. Short answer item

1. Elephantiais is caused by: *Wucherertia bancrofti, Brugia malayi, and Brugia timori.*
2. Types of cardiovascular system: abnormal heart rhythms, aorta disease an Marfan syndrome, congenital heart disease, coronary artery disease, heart attack, heart failure, etc.
3. Reasons for stroke: Stroke occurs when a blockage or bleed of the blood vessels either interrupts or reduces the supply of blood to the brain.

Self-test exercise 2. 3

I. True-False Item

1. True 2. True 3. False 4. True 5. False 6. False 7. True

II. Short answer Item

1. The primary functions of the organs of the breathing system are: to provide oxygen to body tissues for cellular respiration, to remove waste in the form of carbondioxide, to maintain acid-base balance, etc.
2. The major structures of the breathing system are: the nose, larynx, pharynx, bronchi, bronchioles and alveoli.
3. The causes for asthma are: tobacco smocking, pollution, allergens such as pollen, molds, dust, etc.
4. Causes for bronchitis are: bacteria and viruses

Self-test exercise 2. 4

I. True-False Item

1. True 2. True 3. False 4. False 5. False 6. True

II. Short answer Item

1. The three sections of the kidney are: Cortex, medulla, and renal pelvis
2. The nephron consists of: a renal corpuscle, a renal tubule and associated capillary network.
3. The three parts of the renal tubule are: the proximal convoluted tubule (PCT), the loop of Henle and the distal convoluted tubule.

Self-test exercise 2. 5

I. True-False Item

1. True 2. False 3. True 4. True 5. True

II. Short answer Item

1. Types of the immune system are: innate immunity and adaptive (acquired immunity)
2. Immunological memory is the process through which signature antibodies or T cell receptors "remember" each infection.
3. Types of lymphocytes are: T cells, B cells and natural killer cells.

4. The most common types of cells of the immune system are: lymphocytes, neutrophils, macrophages and dendritic cells.

Feedback to activities

Feedback to activity 2.1

Dear learner! Here you should write all what you know about the structure and function of the digestive system. As all the information is given in section 1 of this unit, so writing all the details here is not necessary. You can start writing the structure of the digestive system(mouth, teeth, esophagus, stomach, duodenum, the small intestine and the large intestine. Then, write the process that takes place in each of the parts of the alimentary canal.

Feedback to Activity 2.2

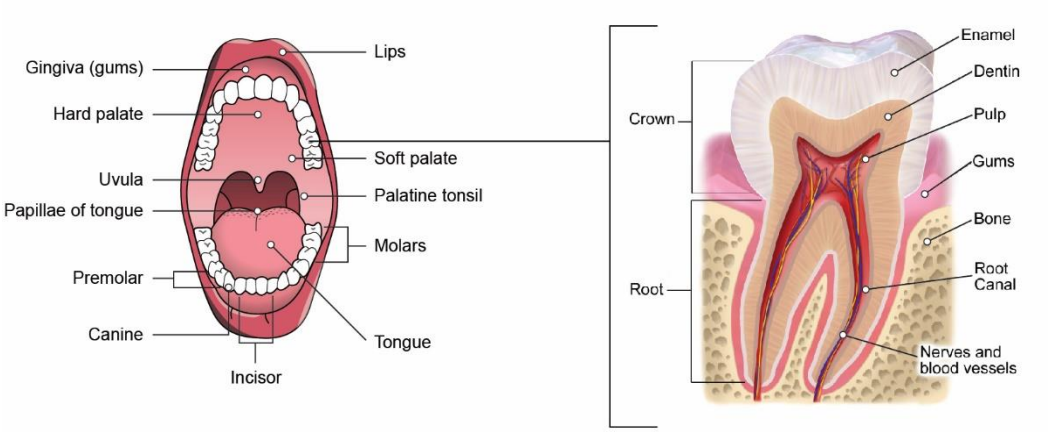
Dear learner! You are working independently on this project. Using your previous knowledge from the lower grades, discuss why digestion is important. The reason for our food consumption is just to get sufficient energy for our daily activities, growth and repair, and to maintain our body activities. Having these in mind you can draw, label, and study the location of accessory organs in our body that secrete enzymes necessary for digestion; salivary glands, pancreas, the live, and pancreas. Finally, remember the digestion end products; glucose, glycerol and fatty acids and amino acids. Additionally, you can use the internet and other resources and supplement your study with a virtual lab focused on the digestive system animation.

Feedback to activity 2.3

Based on the information that is transported from the tongue to the brain, there are thought to be at least five basic qualities of taste. Many dishes are made up of a combination of different tastes. Some dishes taste sweet-sour, for example, while others are salty and savoury. Lemon test beater. The acidity of lemon is the acidity of citric acid. Lemon has a lot of citric acid, so it feels very sour. When this sour juice floods the surface of our tongue we feel it. Because, our tongue taste buds immediately transfer the feeling to our central nervous system.

Feedback to activity 2.4

The feedback to this activity is based on the diagram next pager.



Functions of each teeth type: external and internal structure of a teeth.

i) Incisors eight chisel-shaped teeth at the front of your mouth specialized for cutting.

ii) **Canine** teeth that are sharp, dagger-shaped specialized for tearing.

iii) **Premolar** teeth that are broad flattened specialized for grinding.

iv) **Molars** tend to be even broader and have cusps that are even more flattened. They are designed for crushing food. The last set of molars is the **wisdom teeth** that do note merge until we reach about 16 to 20 years of age. Each tooth is covered with enamel, which is the hardest substance in the human body.

Reasons for teeth decay includes:

i. Bacteria in the mouth feed on sugary, starchy foods and drinks (fruit, candy, bread, cereal, sodas, juice, and milk)
ii. Bacteria, acid, food, and saliva mix to form plaque
iii. Without proper brushing and flossing, acids in plaque dissolve tooth enamel, creating cavities, or holes.

Feedback to activity 2.5

After studying the digestive system in the mouth answer the following questions:

1. Do you have any idea about the function of teeth? How the structure of the teeth is related to its function?

The basic function of the teeth is breaking down food particles into pieces.

The 4 categories of our tooth; incisors, canine, premolars, and molars have their own specific functions. The incisors are used for biting and cutting food, the canines are used for tearing and grasping food, the premolars are used for crushing and grinding food, and the molars are used for chewing and grinding food.

2. Where in the alimentary canal begins the process of digestion? What is the enzyme that acts 1st?

   Saliva moistens the food we eat and contains salivary amylase that digests carbohydrates in the mouth. Therefore, initial digestion begins in the mouth.

3. Where does the amylase enzymes secreted? And what is their function?

   Amylase is a hydrolytic enzyme that breaks carbohydrates into lower-grade molecules such as disaccharides. In the human body, amylase is predominantly produced by the salivary glands and the pancreas.

4. What do we call the process that move the food along the oesophagus?

   The process by which the food moves from the oesophagus to the stomach is known as Peristalsis. Peristaltic contractions, which are involuntary, move food along the gastrointestinal tract

Feedback to Activity 2.6

The top surface of each villus has many microscopic projections called microvilli. The epithelial cells of these structures absorb nutrients from the digested food(glucose, glycerol and fatty acid, and amino acid) and release them to the bloodstream on the other side. Absorption of fatty acids and glycerol and water-insoluble molecules in the small intestines takes place in the form of micelles. These micelles are soluble in nature. By the help of micelles, the fatty acids and glycerol are absorbed into the intestinal cell.

Feedback to activity 2.7

The thick mucus that is secreted by the intestinal glands protects the inner wall of the small intestine from the effects of the strong hydrolytic enzyme. Here the students are expected to discuss and present to their classmates.

Feedback to activity 2.8

Dear learner! Conduct library/internet search on groups of enzymes associated with digestion of different food staffs, the sites of their action, and the required environment (pH) for each group. Finally, present to the class for discussion. Refer to Table 5. 2 where summarized enzymes associated with digestion and their pH level of action.

Feedback to activity 2.9

Dear learner! Construct a heart model from locally available materials and a heart chart and present it to your tutor and colleague students. The general heart structure is given in figure 2. 6.

Feedback for Activity 2.10

The heart consists of two (right & left) parallel pumps separated by the **septum.** The four-chambered of human heart is composed of two thin-walled **atria** (singular: atrium) located above and two thick-walled **ventricles located below**. Blood from the systemic system enters the right atrium, and blood from the pulmonary system enters the left atrium. The blood vessel that transport blood from the right ventricle to the lungs is known as pulmonary artery.

Feedback for Activity 2.11

Answers to the activity

- When you dissect the heart, observe the structures that make it a live pump. The septum that separates the right and left parts, and the muscles that transmit impulses constantly.
- Make associations between what you have noticed during the dissection of the heart and what you have learned in the classroom. Now, illustrate the various parts of the heart structure.
- Finally, write a short laboratory report to you tutor.

Feedback to activity 2.12

Systemic circulation is the movement of oxygenated blood from the left ventricle to the body through pulmonary vein and the pulmonary circulation is the type of circulation in which doxygenated blood moves from the right ventricle to the lungs through pulmonary artery. Here, normally the arteries

carry oxygenated blood while veins transport deoxygenated blood. However, in the case of pulmonary artery and pulmonary vein the opposite is true.

Feed back to activity 2. 13: The pulse rate

Dear learner! Do this activity following the guideline given in activity 5. 13. This activity will help you to understand the function of the heart and the difference of the pulse rate during the rest time and during intensive activities. Finally, not to perform excessive activities that may hart you during your activity.

Feed back to activity 2. 14: Heart sound

In order to perform this activity, you can go to a health worker from the nearby health centers. Ask them to provide you with a stethoscope and let them participate in the teaching-learning process, listening your heart sound, for instance. You can also select and perform exercises and measure your heart sound immediately.

Feed back to activity 2. 15

When your blood pressure is measured by sphygmomanometer, the top number is called systolic pressure. This is the pressure in the arteries when the heart beats. The bottom number is called diastolic pressure. This is pressure in the arteries between heartbeats.

Feedback to Activity 2.16

Blood group O is known as universal donor and blood group AB is termed as universal recipient. Blood group O can be given to almost anyone because you do not have **A** or **B** antigens on your red blood cells, so they will not be attacked by the antibodies of someone receiving a transfusion. A person with blood group AB is considered as the universal recipient as it contains both antigens such as **A** and **B** but no antibodies in plasma and thus, can accept all the blood type. Finally, the basis for blood grouping is the antigen on the surface of red blood cells.

Feedback to activity 2.17

Dear learner! Go to the nearby blood bank, hospital, health centers, or posts and gather information on the importance of blood donation and its health implication (if any) on the donor and/or the recipients. Finally, write a short report to your tutor and share with your colleague students in your area.

Feedback for Activity 2.18

Similar to the circulatory system, the lymphatic system is made up of a number of vessels, and a fluid known as lymph. It is a one-way system as opposed to the circulatory system. Unlike blood, lymph does not circulate in a continuous loop. Tissue-derived lymph is transferred to the bloodstream.

Feedback to Activity 2.19

1. B 2. D 3. E 4. C 5. A

Feedback for Individual Activity 2.20

Susceptibility to infections is dependent on an individual's immunity. Individuals with strong immune systems withstand some bacterial, viral, or fungal infections, while the week is once and susceptible.

Feedback for Activity 2.21

In the textbook are mentioned some cardiovascular and lymphatic system diseases. Yet there are others to mention. Therefore, browsing internet resources list cardiovascular and lymphatic system diseases as much as they can, and discuss them with your colleague students in your area and let your tutor know about your activity. Some of them are: Plague(bubonic, pneumonic, and septicemic), anthrax, sepsis, etc.

Feedback to Activity 2.22

Dear learner! Prepare diagrams/models of the respiratory system (e. g. Figure 5. 16) or use prepared diagram/model of the human breathing systems may be available in your tutorial centre. Using the diagram/model, study the breathing system. During you activity you can use virtual lab (simulation software, animation, and video). Further, you can study the detailed note given in the section.

Feedback for Activity 2.23

When we catch common cold or influenza, we may lose our smelling ability for some time and regain it back when we get better of the common cold. This is simply because the epithelial lining of the nasal cavity is filled with a thick layer of mucus secreted as a response to the infection. This is an immune response of the organism.

Feedback for Activity 2.24

For proper functioning, each cell in your body requires nutrients, oxygen, and a way to eliminate waste. The body system responsible for moving materials around is the circulatory system. It transports the cells' waste and supplies them with necessary resources. Blood that is low in oxygen does not mix with blood that is high in oxygen thanks to the way the blood vessels are arranged in the circulatory system. The body system that handles gas exchange is the respiratory system. Consider your respiratory system as a storage facility where excess carbon dioxide can be expelled and excess oxygen (O_2) can be taken in by the blood (CO_2). The only location in your body where blood gases and airborne gases are exchanged is in the lungs, which are part of the respiratory system. The respiratory system moves gases into and out of the body through the nose, sinuses, and trachea. In the face of ongoing change, the respiratory and circulatory systems collaborate closely to maintain homeostasis. Your requirements for oxygen and nutrients change every time you exercise, lay down to rest, or simply stand up.Consequently, depending on your activity, your heart rate increases or decreases and you breathe more quickly or more slowly. You can get an overview of the main components and their functions of the respiratory and circulatory systems in this section.

Feedback to Activity 2.25

Dear learner!

Possible answers: as you inhale the chest cavity increases and lowers when you exhale. Besides, as you inhale the ribs move upwards and the distance between the ribs increase and when you exhale the ribs lower and the distance between the ribs decrease. In other words the intercostal muscles contract and relax respectively.

Feedback to Activity 2.26 Observing the mechanism of breathing

Dear learner! Prepare a lung model and use a Bell jar experiment to demonstrate the mechanism of breathing as shown in this activity. The balloons are examples for the two lungs. When you inflate the balloons with air it expands and when you open the inlet the balloons collapse. This is somewhat analogous to the mechanism of breathing in the lungs. Here you are also demonstrating the structure of the lung and its location in the chest cavity.

Feedback to Activity 2.27

Conduct internet searches/consult health professionals/users about the effects of smoking and cannabis on the normal functioning of the breathing system. After your search you may come up with findings such diseases as; asthma, bronchitis, lung cancer as result of smocking and mental disorder, lung cancer, hallucination, illegality and criminal engagements, etc as a result of cannabis use. You may also come up with other results during your search. Finally, present your findings to your tutor and fellow students during your tutorial period.

Feedback for Activity 2.28

Dear learner! You might find diagram of internal structure a kidney in the lab of the local high school. Use the diagram in the school laboratory to learn more about the kidney's internal structure in addition to what is provided in your diagram. Based on your observations, write in-depth information about the anatomy and physiology of the kidney. Then, make a comparison between your information and the kidney's diagram found in the laboratory.

Feedback for Activity 2.29

1. Do you find any relationship between the circulatory system and the excretory system?
   What are they?

The excretory system is **a close partnership with both the circulatory and endocrine systems**. The circulatory system connection is obvious. Blood that circulates through the body passes through one of the two kidneys. Urea, uric

acid, and water are removed from the blood and most of the water is put back into the system.

2. Nowadays our society is affected by kidney diseases. What could be the reason? Forward your possible solution (mechanisms) to solve the problem

Who is at risk for chronic kidney disease?

Millions of peoples in the world are living with kidney disease. Anyone can get kidney disease. You are more at risk for kidney disease if you:

- Have diabetes
- Have high blood pressure
- Have heart disease
- Have a family history of kidney disease
- Have abnormal kidney structure
- Are over 60 years of age
- Have a long history of taking painkillers, including over-the-counter products such as aspirin and ibuprofen
- malformations at birth that occur as a fetus develops
- immune diseases
- obstructions such as kidney stones or an enlarged prostate; and
- repeated urinary tract infections, which can also lead to kidney infections and can cause long-term damage to the kidneys.

How Do You Prevent Kidney Disease?

1.Early Detection

Early detection is the most effective way to combat kidney disease. Early detection helps the patients to properly treat the disease. There are two tests to detect kidney disease:

A **kidney damage urine albumin-creatinine ratio (uACR) test** measures the amount of protein called albumin in your urine. Damaged kidneys leak protein into your urine; it should be in your bloodstream.

A kidney function blood test, creatinine, is used to measure your glomerular filtration rate (GFR), which tells how well your kidneys are working to remove wastes from your blood. It is the best way to check kidney function.

Keep your kidney healthy

People with kidney disease should:

Lower high blood pressure

- Manage blood sugar levels
- Reduce salt intake
- Avoid usage of painkillers frequently
- Moderate protein consumption

Every one should:

- Exercise regularly
- Control weight
- Follow a balanced diet
- Quit smoking
- Drink alcohol only in moderation
- Stay hydrated
- Monitor cholesterol levels
- Get an annual physical check up
- Know your family medical history

Feedback to Activity 2.30

As in all countries of the world, in Ethiopia, the history of medicine begins much earlier and the number of physicians that contributed to their country increased from time to time. Here are mentioned two of the most renowned pioneer Ethiopian physicians. Using books, the internet, and interviewing resource persons from hospitals, research centers and local elders as a source of information:

i) List down names of the renowned Ethiopian physicians in addition to the once given in the section, and

ii) Write a report on their contributions to Ethiopian society and the world

Finally, share your findings with colleague students in your area and your tutor during the tutorial period.

References

Unit- D-textbook Nelson Biology Converted. Human systems

Anna Chruscik, Kate Kauter, Louisa Windus, and Eliza Whitside Fundamentals of anatomy and physiology. University of Southern queensland.

Lisa Bartee, Walter Shriner, and Catherine .Principles of Biology. OpenStax, Biology. OpenStax CNX. May 27, 2016

http://cnx.org/contents/s8Hh0oOc@9. 10:RD6ERYiU@5/The-Process-of-Science. https://openoregon. pressbooks. pub/mhccmajorsbio/?p=42\

UNIT THREE: ECOLOGICAL INTERACTIONS

INTRODUCTION

 Dear learner! Welcome to unit three of module 2 of grade 10 Biology. This unit deals with two important sections of ecological interactions, namely **Trophic level and Cycling of materials in the ecosystem**. It is well known that our ecosystem is maintained by the flow of energy and recycling of nutrients through its living (biotic) and non-living (abiotic) components. The biotic components include plants (producers), animals (consumers) and microbes (decomposers) while the abiotic components include the air (atmosphere), the water (hydrosphere) and the soil (lithosphere).

Dear learner! In this unit, you will first learn how solar energy transformed into chemical energy (food energy) by green plants is transferred from organisms to organisms at different positions or levels (trophic levels). You will also study cyclic exchange of materials such as carbon, nitrogen, water and phosphorous between the living organisms and their non – living environment forming a cycle called **Biogeochemical cycle.**

LEARNING OUTCOMES

Upon successful completion of this unit, you will be able to:

- describe trophic level, food chain and food web with examples,
- show the flow of energy and materials in an ecosystem,
- draw and label the water, carbon, nitrogen and phosphorus cycles,
- relate the carbon cycle with global warming,
- relate nitrogen cycle with soil fertility and agriculture,
- investigate why farmers in their locality use crop rotation in cultivation, and
- appreciate the role of soil organisms in soil fertility.

UNIT CONTENTS

This unit includes the following two major contents organized inspections:

a. Trophic levels
b. Cycling of materials in the ecosystem

REQUIRED LEARNING TIME

You are expected to spend 17 Learning hours (6 days) of the semester to learn this unit. You should use the allocated study time properly and efficiently to cover the lessons included in this unit.

LEARNING STRATEGIES

Dear learner! For successful distance learning, you can use the following learning strategies / learning methods wherever they are appropriate to the section under study:

Mentally rehearsing, modelling, comparing and contrasting, Drawing, creating analogies, paraphrasing, summarizing (Outlining and preparing flow chart summaries), Taking short notes, underlining or highlighting key points and self-reflection.

Section 3.1 Trophic Levels

INTRODUCTION

 Dear learner! Have you ever imagined that the ultimate or final source of energy is the sun? For instance, the energy that we use to jump, walk, dance, speak and laugh comes from the food that we eat. The energy in foodis a transformed form of solar energy by photosynthesizing plants. We human beings get this energy either by eating directly plants or animals that eat plants. Thus, it is transformed form of solar energy transferred through a series of organisms that is used in performing all life activities. The trophic level actually shows the position or order of receiving energy. Green plants are at the first trophic level and animals that eat plants will be at the second trophic level and so on.

Dear learner! In this unit, you will learn the mechanism of energy transfer in series of organisms with different positions or levels (trophic levels). You will

also study what will happen to energy as it is transferred from low to high trophic level.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, you will be able to:

- define trophic level, food chain and food web,
- construct food chain and food web-based on observed feeding relationship among common organisms in their locality,and
- outline the flow of energy from the sun to plants then to different trophic levels.

3. 1. 1 Food chain and food web

What is the ultimate source of energy in life? How is energy transferred from organism to organism**?**

Dear learner! have you observed solar panels usually placed at the roof of buildings ? Do you know what they are doing? These are devices used to collect energy from the sun. They transform the solar energy to electrical energy that can be used for different purposes. This is actually what green leaves of plant are actually doing. The chlorophyll of the leaf traps solar energy and uses it for the synthesis of food. This energy stored in the form of foodis transferred to other living organisms that eat plants and in turn eatenby other organisms.

Dear learner! You are already informed that plants are the first to trap solar energy and produce their food. They are called **producers**, and also known as **autotrophs (self – feeding)**. Animals feed on either plants or other animals as a source of energy. They are known as **consumers or heterotrophs**, feeding on plants (**herbivores**) or other animals (**carnivores**) or feed on both plants and animals (**omnivores**). Thus, energy is transferred from plants through a chain of organisms, employing ***"to eat or to be eaten"*** process. It is this process thatis known as the **food chain or food web.**

How does energy flow in food chain?

Dear learner! The following are characteristic features of a food chain.

- There is repeated process of **"to eat or to be eaten"**, so the food chain represents nutritive interaction among biotic components of the ecosystem.
- Plants (producers) are at the base or at the beginning of the food chain.
- There is a unidirectional flow of energy from the sun to the producers and then to series of consumers.
- Omnivorous (animals that feed both on plants and other animals) occupy more than one position in the food chain.

Is it the unidirectional flow of energy that is commonly observed in the ecosystem?

Dear learner! You are daily observing that one organism eat another organism. You have also noticed that one organism does not eat one organism only. Every organism eats different organisms and it can be eaten by other different organisms. Therefore, ecosystems normally exhibit multidirectional energy flow, which is more than a direct chain of**" who – eats – what".** What is actually occurring in the ecosystem is a complex web structure, called the **food web.**

A food web is an interconnected food chain that makes interwoven or web-like structure. Food chain and food web can be represented by a generalized schematic illustration as shown in Figure 3. 1. Actual example of a food chain and food web is provided to you in activity 3. 1. As to Figure 3. 1 it is a generalized route of flow of energy, which enables you to construct food chain and show the interwoven nature of food web. Please give attention to single path or unidirectional energy flow in food chain and the multiple paths or multidirectional energy flow in food web.

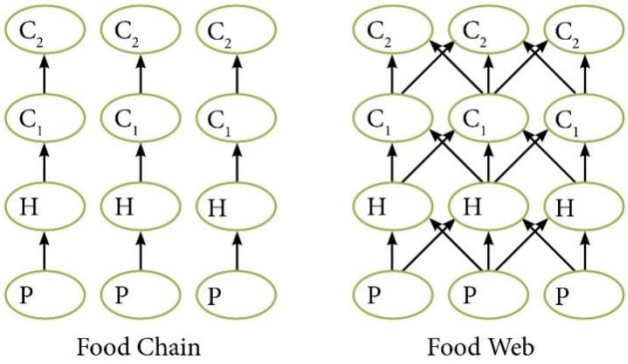


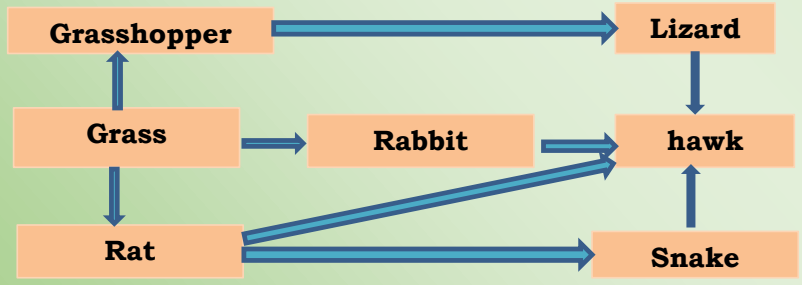
Figure 3.1 Schematic illustrations of the food chain and food web (P = producer, H= Herbivore, C_1= Primary carnivore, C_2 = Secondary carnivore).

Activity 3. 1

Dear learner!

This activity invites you to take a closer look at the fascinating feeding relationships that exist among organisms in your local environment. With keen observation, you should be able to identify a possible feeding relationship between two or more organisms. Once you have done so

- Take a moment to identify whether what you have observed is a food chain or a food web, and explain why you think that is the case.
- In addition to this, use the food web provided below to construct as many short food chains as you can. By doing so, you will be able to gain a better understanding of how different organisms are interconnected in a given ecosystem.



What is a trophic level? How is it different from feeding level?

Each organism occupies a specific position in the food chain, which is known as **trophic level**. Basically, a trophic level indicates the position of the organism in the order of receiving energy.

Dear learner! Trophic level usually goes up to 3 or 4 levels. You will learn soon why this is so. Before knowing this, you can refer to Figure 3. 2 andrank the trophic levels as follows

- Trophic level 1 (Producers) - These are green plants and algae , which are the first to trap solar energy and transform it to chemical energy stored as food.
- Trophic level 2 (Primary consumers) – These include herbivores that feed on or consume the producers.
- Trophic level 3 (Secondary consumers) – These are carnivores (meat eaters) that eat the primary consumers (herbivores).
- Trophic level 4 (Tertiary consumers) – These are the carnivores that eat other carnivores (Secondary carnivores).

Dear learner! You can also rank the level based on the order of feeding or eating, which is known as **feeding level**. The feeding level is the order of consuming or eating one another. Herbivores are at the first feeding level, as they are consuming plants. They are also known as primary consumers. Carnivores that eat herbivores stand at the second feeding level(secondary consumer) and so on.

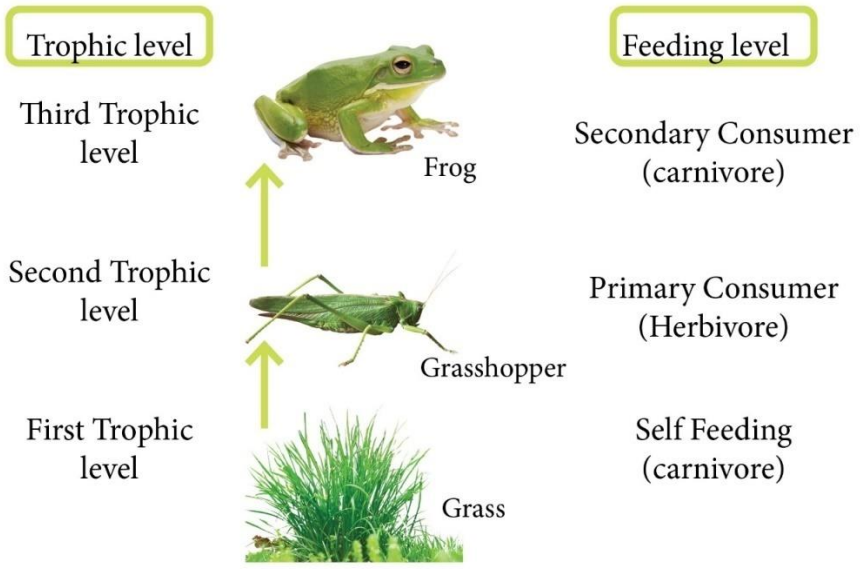


Figure 3.2 Illustration of Trophic and feeding level

Activity 3. 2

Dear learner!

We hope that Activity 3.1 inspired you to explore the natural world around you and learn something new. Why not plan a short visit to a nearby grassland or garden to witness the fascinating feeding relationships among various organisms?

During your visit, you might encounter insects such as grasshoppers, who play a crucial role in the food chain. Observe what these insects eat and which predators hunt them.

Take detailed notes on the unique feeding relationships you observe, and try to identify the different organisms' roles in the ecosystem. Once you have completed your trip, prepare a comprehensive report on what you have learned.

You could construct a food chain or web to demonstrate the organisms' feeding relationships. Keeping a record of your observations and findings in a notebook will allow you to reflect on them later and facilitate meaningful discussions during tutorial sessions.

3. 1. 2 Flow of energy and nutrient through ecosystem

How does energy flow in an ecosystem ? What about nutrient recycling?

Dear learner! you already know that the primary energy source of life on earth is the sun. You have also learned that sunlight or solar energy trapped by the producers (plants) is used for photosynthesis. As a result, the sun light or solar energy is converted in to chemical energy, stored as an organic material or food in plants. Food chain or food web is the mechanism of energy flow or transfer of energy in food through a series of organisms.

Dear learner! critically look at Figure 3. 3 and notice that the energy from the sun flows through organisms, but this energy cannot go back to the sun. This is why we say energy cannot be recycled – it only flows in forward direction through the ecosystem. However, nutrients in food (organic matter) recycle within an ecosystem and are reused over and over again. This is the result of composition (synthesis) and decomposition (breakdown), which take place in the ecosystem.

Dear learner! you have learned that plants synthesize food (organic matter) from simple inorganic matter. The food is in turn used by consumers. Fungi and other decomposers obtain energy by breaking down dead producers or consumers. During decomposition key nutrients like nitrogen are release to the soil and producers use them as raw materials for photosynthesis.

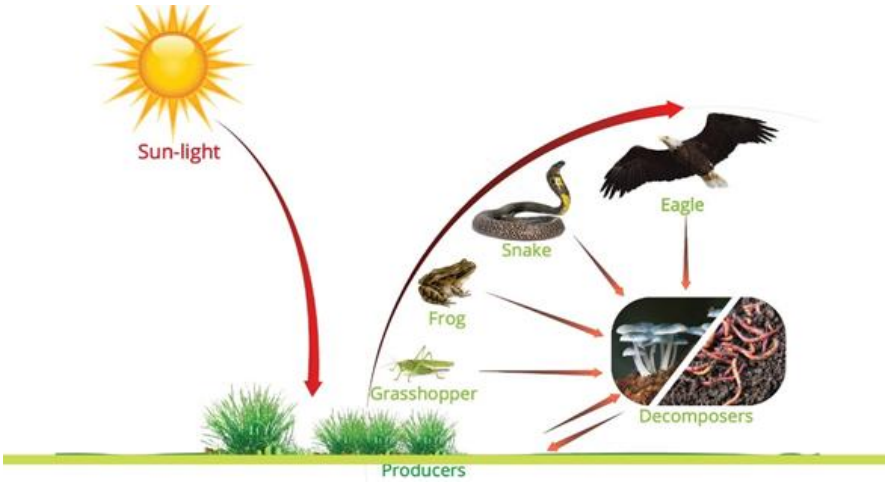


Figure 3.3 Flow of energy and matter (inorganic and organic matter) in an ecosystem

What happens to energy as it is transferred from one trophic level to the next trophic level?

Dear learner! critically look at Figure 3. 4 and focus on how energy successively declines in amount as it flows from one trophic level to the next level. You can check how energy contained in the grass (producer) is not fully transferred to a cow (consumer) that feeds on the grass. It is only about 10% of the energy in grass that will turn to biomass (living organic mass) in the body of the cow. The rest (90% of the total energy) is lost as heat or used as a source of energy for different activities of the cow or removed from the cow's digestive system as an undigested and indigestible food item (excreta).

Figure 3.4 Energy transfer from grass (producer) to cow (herbivore)

What is an ecological pyramid ? How is it constructed ?

Dear learner! the flow of energy at each trophic level in a particular ecosystem can be shown using an ecological pyramid. As shown in Figure 3. 5 , this pyramid is constructed by using horizontal bars, where each bar represents organisms of specific trophic levels in an order of receiving energy and feeding order, which is based on who eats what.

Look at Figure 3. 5 once again and focus on the horizontal bars that represent a trophic level in the flow of energy. The first bar represents the producer(first trophic level), followed by the primary consumers (Herbivores), then secondary consumers (carnivores), and so on, with the highest trophic level being on the top of the pyramid. This is how ecological pyramid is constructed , where the producers are at the base of the pyramid.

Dear learner! The ecological pyramid is constructed to represent the amount of energy, biomass or number of organisms at each trophic level. Accordingly, there are three types of ecological pyramids namely: **the pyramid of energy**, the **pyramid of number** and **the pyramid of biomass**. The pyramid of energy is always upright ,narrowing sharply from the base to the top-level carnivore because there is commonly 90% energy loss at each trophic level as demonstrated inFigure 3. 5.

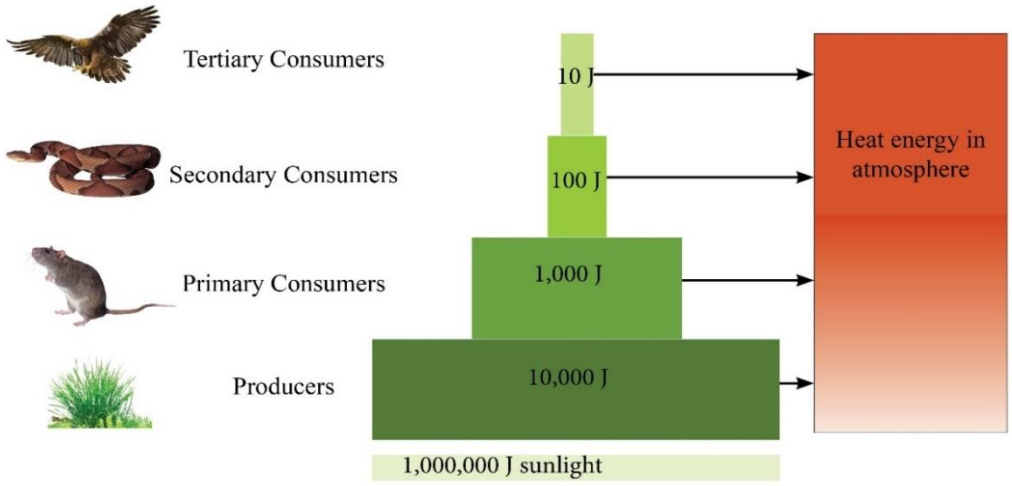


Figure 3.5 Pyramid of energy

Figure 3.5 is an Idealized pyramid of energy. [In this example, a trophic efficiency of 10% is assumed in the transfer of energy for each link in the food chain. Notice that the producer - Grass, is capable of converting only 1% of solar energy by photosynthesis].

KEY TERMS

- **Biomass**. is the weight of living organic matter contained or assimilated to the body of an organism per unit time
- **Ecological pyramid.** This is a graphical representation of the feeding relationship of a group of organisms in the form of a pyramid. A horizontal bar is constructed to represent the different trophic level or feeding level. The bars at the base of the pyramid always represent plants (producers). The length of the bar shows the amount of energy (pyramid of energy), biomass (pyramid of biomass) or number of organisms (pyramid of number) present at each trophic level.

Activity 3. 3

Dear learner! In this activity, you will explore the concept of trophic levels in an ecosystem. To complete this activity, you can use various resources such as books available in your school or local library, browse the internet for information or use Fig. 3.3 to 3.5 as a reference. In order to proceed, please answer the following questions:

1. Why is trophic level typically limited to 3 or 4? Why can't it be more?
2. What is your trophic level as a human being? Please explain.

Is pyramid of biomass or pyramid of number always upright like pyramid of energy?

Dear learner! as opposed to pyramid of energy which is always upright, pyramids of biomass or number can be upright (with the long bar at the base and shorter bar at the apex) or inverted (with longer bar at the apex and shorter bar at the base depending on the type of ecosystem and the particular food chain . This is well illustrated in Figure 3. 6, where the given aquatic food chain is represented by pyramid of number , which is up right while the pyramid of biomass is inverted.

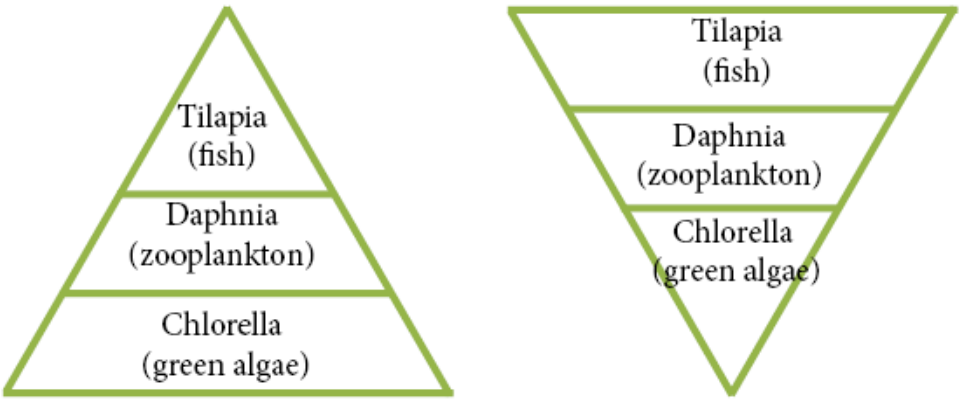


Figure 3.6 Illustration of the pyramid of number (A) and pyramid of biomass (B) in the aquatic food chain (Note: the producer is always at the base of the pyramid).

Dear learner! the next activity (Activity 3. 4)will demonstrate to you that pyramid of number can be inverted, while pyramid of biomass can be up right.

Activity 3. 4

Dear learner!

We would like to invite you to apply your knowledge of food chains to construct a pyramid of numbers and a pyramid of biomass for the given food chain: Tree – Bird – Bird flea.

In addition, we encourage you to make a thorough comparison of your pyramid with Figure 3.5 and point out the differences you observed.

Finally , based on your analysis, please write your conclusion on the pyramid of numbers and the pyramid of biomass. This will be greatly appreciated if reflected during your tutorial sessions.

✓Self- assessment Checklist

Put a tick (√)mark against each of the following tasks which you can perform. If you cannot perform any of these tasks, go back and read the lesson for that particular task.

I can:

- define trophic level, food chain and food web,_____ ☐
- distinguish the difference between food chain and food we_____ ☐
- construct food chain and food web on observed feeding relationship in my locality _____ ☐
- outline the flow of energy from the sun to plants then to different trophic levels _____ ☐
- construct ecological pyramid of energy, number and biomass if based on a given food chain _____ ☐

Self-Test Exercise 3.1

I. True – False items: Write "TRUE" for the correct statements or "FALSE" for the incorrect statements.

1. Primary consumers always belong to the first trophic level of a food chain.
2. Energy is successively decreasing as it goes from higher trophic level to lower trophic level.
3. The producer is always placed at the base of ecological pyramid.
4. The final source of energy of life on earth is the sun.
5. Plants are capable of using both solar energy and chemical energy stored in food.

II. Matching items: Use an arrow and connect the food chain position with the trophic levels.

Trophic Level 1	Tertiary consumers
Trophic Level 2	Producer
Trophic Level 3	Secondary consumers
Trophic Level 4	Primary consumers

III. Multiple Choice Items: Choose the correct answer and write the letter of your choice on a separate answer sheet.

1. In the food chain: Grass – Grasshopper – snake – Eagle, the position of Grasshopper is at

_____feeding level and _____ trophic level.

A. 1, 2 B) 2, 1C) 3, 2D)2, 3

2. A consumer thateat a carnivore is a(an) _____.

A) Omnivore B) Herbivore C) Decomposer D) Carnivore

3. The percentage of energy that is wasted at each trophic level is roughly_____.

A) 1% B)10%C) 90%D) 100%

4. Which of the following is placed at the top of ecological pyramid ?

A) Herbivore B) Producer C) Omnivore D) Carnivore

IV. Short answer items

1. What is the advantage of being vegetarian (feeding on plants and plant product)?

2. Suggest two reasons why only 10% of energy or biomass is transferred between two trophic levels?

Section 3. 2 Cycling of Materials in the Ecosystem

INTRODUCTION

 Dear learner! have you ever thought that living organisms including human being are continuously using the oxygen in the atmosphere but still we have sufficient oxygen in the air – How come? Why doesn't oxygen get depleted and we still have enough oxygen to breathe? This last section of unit 3 as well as module 2 has sufficient answer for the above question as it deals with cycling of materials in the ecosystem.

Dear learner! It is not only oxygen but other materials such as nitrogen and water are also found in a limited amount. There is always a danger of depleting them if there is no process of replenishing them. However, the danger is avoided by recycling of materials in nature where materials are utilized and regenerated.

In this unit, you will learn about material cycle, which is sometimes called nutrient cycle. The cycle shows the flow of matter from the non- living to the living and vice versa. As this happens, materials can be temporarily stored, transformed into different forms, transferred from organisms to organisms and returned to its initial form.

MINIMUM LEARNING COMPETENCIES

Upon successful completion of this section, you will be able to:

- draw and label the water, carbon, nitrogen, and phosphorous cycle,
- relate the carbon cycle with global warming,
- associate nitrogen with soil fertility and agriculture,
- appreciate the role of soil organisms in soil fertility, and
- identify why crop rotation is important to farmers.

What is meant by cycling of materials in the ecosystem?

Dear learner! what do you know about nutrient or material cycle? Nutrient cycle is an essential process in the ecosystem. In the nutrient cycle, the use of nutrients, their transformation and their recycling process are described. As materials in the ecosystem are found in a limited amount, it is essential that the same material (nutrient)should continuously be recycled and reutilized over and over again. This is what we call **cycling of materials** in the ecosystem.

Dear learner! do you know how cycling of materials in ecosystem practically occurs? It actually occurs when organisms feed, breathe, respire and excrete. Nutrients are released when the waste products or dead bodies are decomposed. What is a waste product to one organism becomes a vital nutrient to the other. For example, animal excreta (a waste product) will be broken down by decomposers, release nitrogen and phosphorous (vital nutrients) which will be used for plant growth, thereby increasing agricultural yield. Note that the **waste product, instead of polluting the environment, can be a rich source of organic fertilizer**.

REMARK

- Decomposers are bacteria and fungi commonly found in soil. They play a key role in returning nutrient to the ecosystem.
- Unlike in ingesters, animals that swallow food (organic matter) and digest inside their gut, digestion in decomposers takes place outside the living body in the soil, or wherever the dead matter happens to be.
- Decomposers exhibit extracellular digestion by releasing enzymes on to the dead matter, digesting the complex organic matter into simpler and smaller ones and absorb these products of decomposition. Since the products released are accumulated in the external environment (soil), they serve as "nutrient pool" and increase soil fertility as well as plant productivity.

Activity 3. 5

Dear learner! It will be very interesting to know about the importance of the cycling of materials in an ecosystem. The best method to collect information is refer to biology books available in nearby schools, public libraries or on the internet. Once you have gathered the necessary information, you are expected to prepare a short note that will provide answers to the following questions :

- Why is the cycling of materials in an ecosystem so important?
- What will happen to living organisms or life if decomposers are absent from the ecosystem?

What are the important materials that cycle through the ecosystem**?**

Dear learner!you have learned about thewater cycle in previous grades and subjects other than Biology. In addition to water, there are 4 elements (nutrients) that cycle through the ecosystem: **oxygen, carbon, nitrogen and phosphorous**. These elements take the path from the non - living environment to living organisms and then go back to the non – living environment. It is the path that includes biological, geological and chemical processes that form a cycles known as a biogeochemical cycle. In this, subsection you will learn about the cycles of the aforementioned materials in detail, beginning with the widely known water cycle .

3. 2. 1 Water cycle

What happens during the water cycle?

Dear learner! Do you know that water on earth does not stay still? No, it is always on move. Rain that falls at a particular place can be the result of evaporation that occurred at a distant ocean days before. Likewise, water in a river may have been rainfall somewhere at a distance or melting ice or snow from the top of high mountains. It is water cycle that is responsible for water movement in the ocean, on the land and in the atmosphere.

Dear learner! Are you aware that the earth has a limited amount of water. This limited water keeps on move within the Earth's atmosphere system in what we call the **water cycle** or the **hydrologic cycle**. In this cycle, water continuously circulates between the oceans, atmosphere, land and organisms, as illustrated in Figure 3. 7.

What is the driving force of water cycle?

Dear learner! from chemistry lesson you have learned that water occurs in three state or forms, namely **Solid** (Ice or snow), **Liquid** (liquid water) and **Gas** (water vapour).You have also learned that the change in state of water is brought by change in temperature as a result of heating and cooling. This indicates that the driving force in water cycle is a change in temperature due to heating and cooling. Among the many processes involved in the water cycle, the most important ones are evaporation, transpiration, condensation, precipitation and runoff.

Dear learner! you should know that water cycle is primarily sun driven process. It is the solar heating that helps the cycle to start with evaporation. Evaporation of water from the earth and surface of the leaf by transpiration rises in the atmosphere in the form of water vapour. Then, the water vapour cools and condenses in the atmosphere into rain or snow, and falls again to the earth's surface as precipitation (rain fall or snowfall).

The water falling on the earth through the surface as run off collects in rivers, lakes, soil and soft rocks, where some water is taken up by plant roots and much of it flows into oceans. Some of the water also infiltrates the soil and isaccumulated as ground water. It is the surface water that will restart the cycle by evaporation and evapotranspiration.

Dear learner! it is not only water on earth surface that is included in the water cycle. Water accumulated in the ground can also come to the surface as a spring or stream. Groundwater can also be pumped out for different purposes such as drinking and irrigation andthenjoins the water cycle by the surface evaporation.

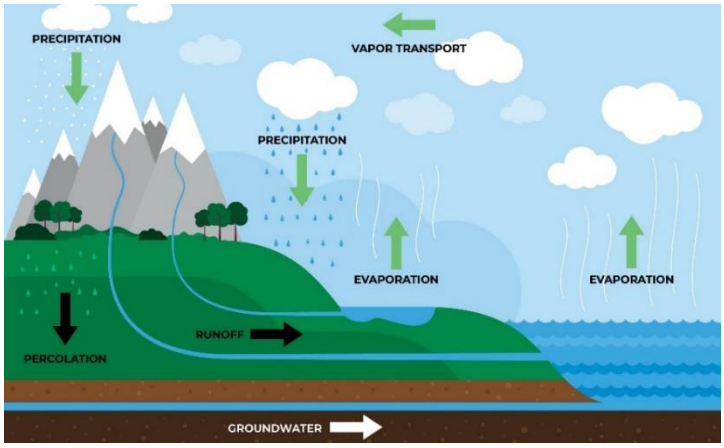


Figure 3.7 Water cycle

Activity 3. 6

Dear learner! We suggest an experiment you can conduct at home that is both fun and educational. You will have the opportunity to observe an interesting phenomenon and learn about the science behind it.

For this experiment, you will need to gather some materials, including a small plastic cup or glass jar that is transparent, some water, a transparent plastic bag, and a string or large rubber band.

Once you have the required materials, follow these steps to conduct the experiment:

1. Take a small plastic cup or glass jar and fill it with water until it is about 2/3 full. Make sure not to overfill it as the water might spill out of the cup.
2. Take a plastic bag that can be sealed and carefully place the cup inside it. If you don't have a plastic bag that can be sealed, you can use string or a rubber band to tie the bag in order to close it.
3. Seal the plastic bag carefully to create a closed system that resembles the atmosphere. This will allow you to observe the natural processes that occur in the environment.
4. Place the setup in an area that receives direct sunlight for a few hours. This will help in the process of evaporation.
5. After a few hours, observe what happens to the water in the cup. You might see some changes in the water level or bubbles forming on the surface.
6. Look for water vapor on the plastic bag's walls. This will help you understand the process of condensation.
7. Move the setup to a shaded or cool place and observe if water droplets form inside the plastic bag. This will help you understand the process of precipitation Finally prepare a short report on how the above activity demonstrated the water cycle and explain why the water cycle is said to be a physical change of water driven by change in temperature

Remark: Please keep your note and short report of this activity for reflection and /or discussion during tutorial session.

3. 2. 2 Carbon cycle

What happens during a carbon cycle?

Dear learner! From the lesson on photosynthesis you have learned that water from the soil and carbon dioxide from the atmosphere are raw materials needed in food synthesis. The carbon element stored in the plant is transferred to animals that eat the plant. When plants and animals die, their dead bodies are decomposed and release carbon dioxide back to the atmosphere. This illustrated with Figure 3. 8, which shows that the amount of carbon in the atmosphere is maintained by a process that continuously takes it from the atmosphere and various processes that release it back to the atmosphere.

Dear learner! All living organisms including plants and animals release carbon dioxide through respiration in their entire life time. Furthermore, over a long period of time, dead bodies of organisms become a fossil fuel which can be used by factories, power stations and vehicles. The combustion or burning of the fossil fuel also releases carbon dioxide into the air.

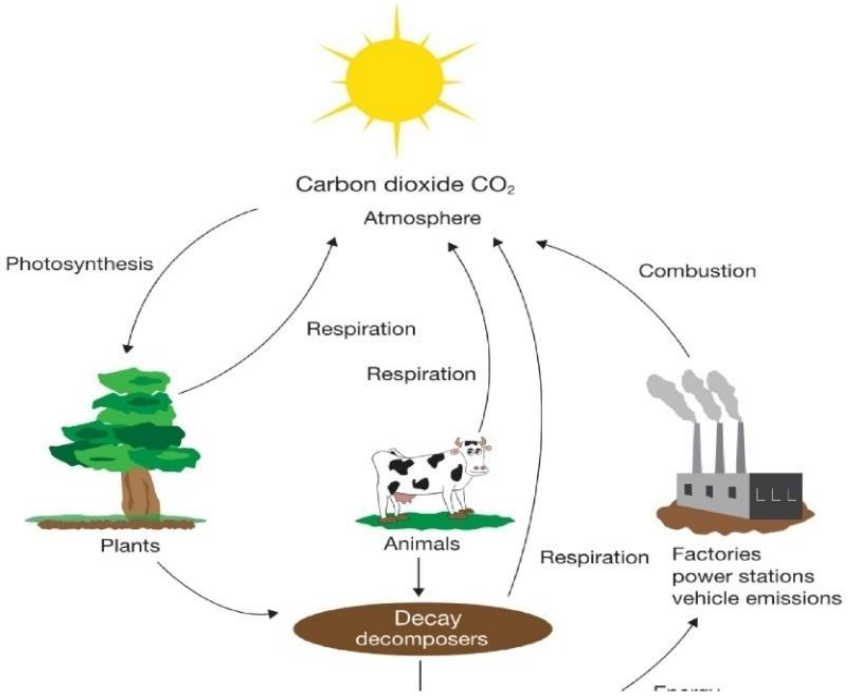


Figure 3.8. The carbon cycle(Note that carbon dioxide is utilized during photosynthesis while it is released from decomposition, cellular respiration and ccombustion of fossil fuels).

How is carbon dioxide linked with climate change?

Dear learner! it is frequently mentioned that carbon dioxide accumulation in the atmosphere causes global warming. This is linked to climate change because there is increase in global temperature .Even though carbondioxide is naturally part of the Earth's atmosphere, human beings produce more of it every year, and that's changing our climate. The atmospheric concentration of CO_2 has significantly increased since the industrial revolution (late 18^{th} century).

Dear learner! how does carbon dioxide cause global warming? This is the result of its accumulation, in that atmospheric CO_2 acts like a heat-trapping blanket, absorbing the heat and holding it in the atmosphere, thereby causing global warming. Global warming is a rise in the overall temperature of the earth's surface.

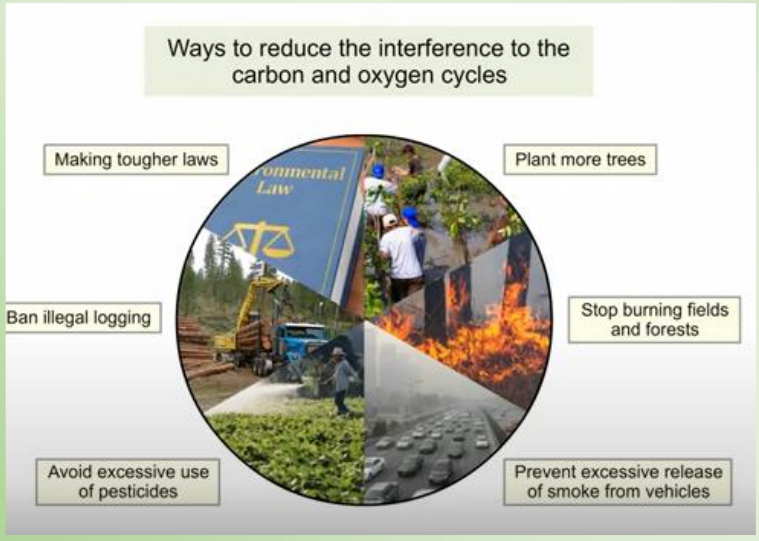
Dear learner! you should know that there are also other heat-trapping gases, such as methane and nitrous oxide (commonly called Greenhouse gases) in the atmosphere, As opposed to these gases, CO_2 is continuously released to the atmosphere over 24 hour by respiring plants and animals. Moreover, burning of the fossil fuels (coal, oil, natural gas), from industries and forest burning are the major sources of CO_2. Furthermore, forest clearing will reduce sequestration (uptake from the atmosphere)of CO_2 through photosynthesis and its accumulation in the atmosphere. Thus, excess accumulation of CO_2 into the atmosphere due to human activities is the major or root cause of climate change.

Activity 3. 7

Dear learner !

Illegal logging (cutting trees) and forest burning are serious problems that affect the carbon cycle and can lead to climate change. We are inviting you to prepare a comprehensive report on these issues. we recommend that you gather detailed information from books and experts in related offices.

Your report should mainly include the impact of these illegal human activities on the carbon cycle and how it can lead to climate change, such as global warming. In your report, please examine the illustration below, which summarizes ways to reduce human interference in the carbon cycle. Choose at least two ways of reducing human interference in the carbon cycle and explain them clearly and concisely in your report



REMARK

- Photosynthesis and cellular respiration are the major processes that maintain the balance of oxygen and carbon dioxide in the atmosphere
- If sunlight and chlorophyll are left out, the reactant for photosynthesis is the product of respiration and vice versa as shown below:

$$CO_2 + H_2O \underset{\text{Respiration}}{\overset{\text{Photosynthesis}}{\rightleftharpoons}} C_6H_{12}O_6 + O_2$$
(Food)

- While photosynthesis occurs in the chloroplast of the leaf cell, aerobic cellular respiration takes place in the mitochondrion of a cell of aerobic organisms.

3. 2. 3 Nitrogen cycle

What is nitrogen cycle?

Dear learner! In previous sections, you have learned that proteins are made up of the elements **C, H, O, N** and **S**. You also know that the immediate result of photosynthesis is carbohydrate (glucose), which consists of **C, H, and O** and is transformed to protein upon the addition of nitrogen. This is how amine group of amino acids are formed. Nitrogen is available to the plant from the soil through the nitrogen cycle.

Dear learner! In the nitrogen cycle illustrated with Figure 3. 9, you should focus that nitrogen cycle is a repeating pathway

- of major processes involved in the cycling nitrogen are **nitrogen fixation, ammonification, nitrification, assimilation** and **denitrification.**
- during which nitrogen in different forms moves through both biotic (plants, animals, bacteria and fungi) and abiotic (atmosphere, soil, water) components of the ecosystem.

.

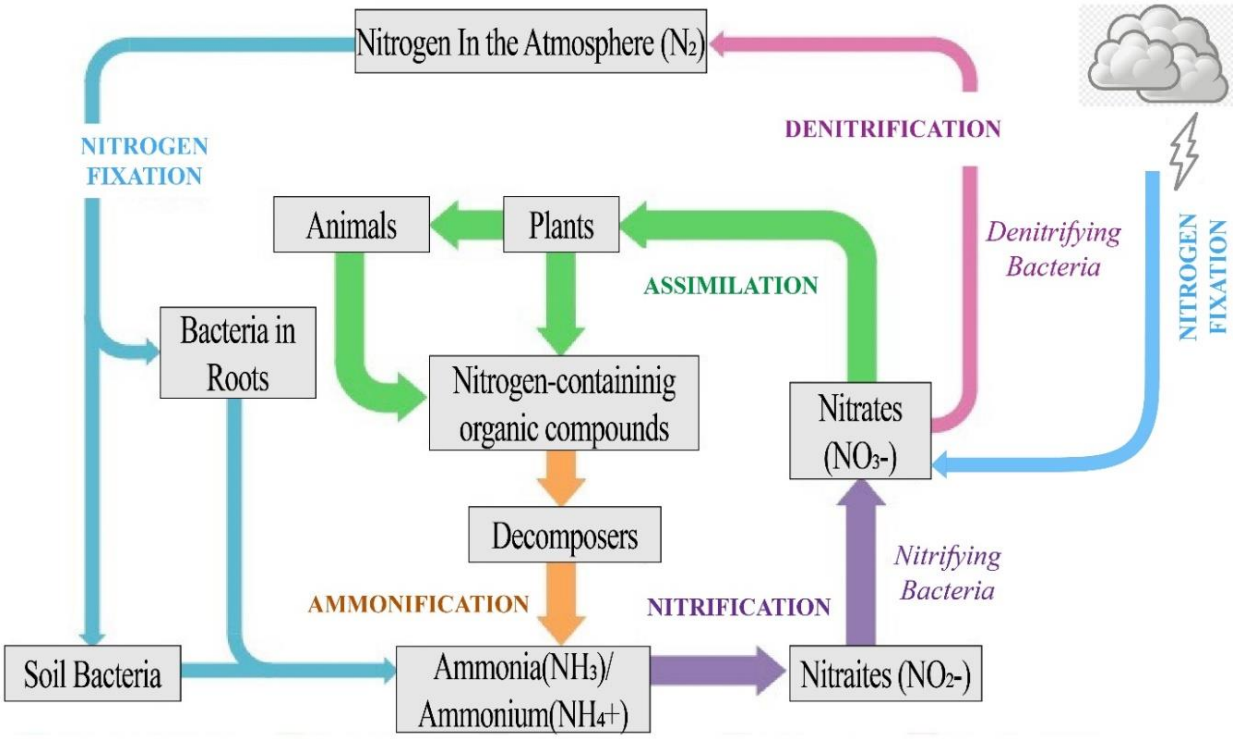


Figure 3.9. The Nitrogen cycle

Dear learner! Brief descriptions of the different processes of the nitrogen cycle, which are mediated by microorganisms (mainly bacteria)are presented for you as follows:

1. Nitrogen fixation

Nitrogen accounts for about 78% of the atmosphere. Most living organisms are unable to incorporate atmospheric nitrogen, N_2, into their systems. To be usable, the N_2 should be fixed into usable forms such as ammonia or nitrate. Nitrogen fixation is the conversion of N_2 into ammonia either biologically (mediated by bacteria) or non-biologically (atmospheric fixation by lightning and industrial fixation in the laboratory). In this lesson, the biological fixation of nitrogen will be given emphasis.

Dear learner! based on the group of bacteria involved, the biological N_2 fixation may be categorized into two:

i) Symbiotic nitrogenfixation and
ii) Non – symbiotic fixation.

i) **Symbiotic Nitrogen Fixation**

This form of biological nitrogen fixation is carried out in the root nodules of leguminous plants(such as peas, beans, and peanuts) by the group of soil bacteria known as **rhizobia**. Rhizobia form a symbiotic association with leguminous plants and form the root nodules where N_2 is reduced into ammonia (Figure 3. 10). The nitrogen fixation reaction(conversion of N_2) is catalyzed by an enzyme known as **nitrogenase**.

The ammonium ions produced by this process are passed to the legume plant (assimilated) and used to synthesize amino acids- building units of protein.

$$N_2 + 8e^- + 8H^+ + 16ATP \longrightarrow 2NH_3 + H_2 + 16ADP + 16Pi$$

Figure 3.10. Root nodules of legume plant

How are rhizobia linked to the global climate?

Dear learner !you are well informed that concentrations of carbon dioxide and other greenhouse gases in the atmosphere have increased since the beginning of the industrial era due to human activities. Among these gasses, is nitrous oxide (N_2O), an intermediate product of microbial denitrification in the nitrogen cycle. The emission of N_2O is one risk to global climate change because of its high ability to trap heat released to the atmosphere .It has high global warming potential (over 300 times than carbon dioxide) and long atmospheric residence time. Excessive use of synthetic N fertilizer in the agricultural system is the major source of N_2O emissions.

Dear learner! biological N_2 fixation by rhizobia could be an alternative source of fixed N to synthetic N fertilizer. This will serve as **biofertilizer** and improves or sustains agricultural productivity and at the same time mitigate emission of N_2O to the atmosphere. Thus,N_2O can be either oxidized into NO_3 and taken by plants or denitrified into N_2 and released to the atmosphere. Both processes are the results of soil bacteria.

ii) **Non - symbiotic nitrogen fixation**

Dear learner! in addition to symbiotic nitrogen fixation, the non – symbiotic nitrogen fixation is carried out by free living soil bacteria (belonging to the genera *Azotobacter* and *Klebsiella*). These bacteria reduce nitrogen gas into ammonium ions, which can either be used by plants or oxidized immediately into nitrates by nitrifying bacteria.

2. Nitrification

Dear learner! Nitrification is a microbial process by which ammonia is sequentially oxidized first to nitrite and then to nitrate. In the first step of nitrification, ammonia-oxidizing bacteria (belonging mainly to the genus *Nitrosomonas*) oxidize ammonia to nitrite according to the following equation:

$$NH_3 + O_2 \xrightarrow{NO_2} + 3H^+ + 2\,e^-$$

In the second step of nitrification, nitrite-oxidizing bacteria (mainly belonging to the genus *Nitrobacter*) oxidize nitrite to nitrate according to the following equation:

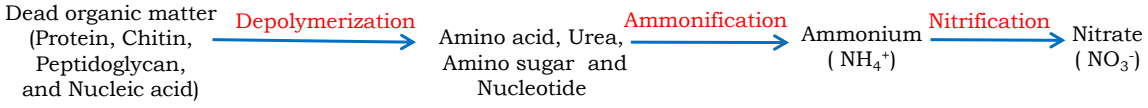
$$NO_2^- + O_2 \xrightarrow{NO_3} + 2H^+ + 2\,e^-$$

3. Assimilation of ammonium and nitrate by plant

Dear learner! do you know that plants cannot use atmospheric nitrogen (N_2) to synthesize protein? They commonly absorb nitrogen in inorganic forms either as nitrate (NO_3^-) or as ammonium (NH_4^+). Plants preferentially take up the reduced ammonium (NH_4^+) rather than the oxidized nitrate (NO_3^-) because the energy expenditure for the NH_4^+ assimilation is much lower than for NO_3^-. Both ammonium and nitrate assimilated by plants are used in the synthesis of several amino acids which in turn are polymerized into different proteins.

4. Ammonification

Dear learner! ammonification is an essential process that converts reduced organic matter having amine group (of general formula R – NH_2) present in the soil to reduced form of inorganic nitrogen (NH_4^+) through the action of microorganisms. Ammonification is the last step of the nitrogen cycle involving an organic compound and is an intermediary step between depolymerization of large organic molecules and the nitrification process as presented hereunder



5. Denitrification

Dear learner! Do you know that continuous fixation of atmospheric nitrogen (N_2) and uptake of inorganic forms of nitrogen by plants will successively lower the percentage of nitrogen in the atmosphere? Utilization of nitrogen has to be compensated by its regeneration. This means that the flow of atmospheric nitrogen and its various forms through soil, microorganisms, plants and animals should involve a process of returning nitrogen (N_2) to the atmosphere to maintain balance. This process is called **denitrification,** where oxidized forms of nitrogen are converted sequentially to nitrogen gas (N_2) and returned to the atmosphere. Unlike nitrification, denitrification is an anaerobic process, occurring mostly in waterlogged soils that are anoxic (without oxygen) layers of sediments in lakes and oceans.

$$NO_3^- \longrightarrow NO_2^- \longrightarrow NO + N_2O \longrightarrow N_2$$

Dear learner! It is important to know that the biological processes of the nitrogen cycle is largely mediated by different microorganisms, mainly bacteria. This is summarized in Table 3. 1.

Table 3.1 Summary of the Nitrogen cycle

Biological process	Microorganisms involved
1. Nitrogen Fixation	Nitrogen fixing bacteria living in legume root nodule (*Rhizobium*) Nitrogen fixing bacteria living in soil (*Azotobacter* and *Klebsella*)
2. Nitrification	Nitrifying bacteria (*Nirtrosomonas, Nitrobacter*)
3. Ammonification	Ammonifying bacteria (Aerobic and anaerobic bacteria, fungi)
4. Denitrification	Denitrifying bacteria (*Pseudomonas, Thiobacillus, Micrococcus*)

Why is cycling nitrogen important?

Dear learner! You should know that the nitrogen cycle is key to life because nitrogen is the most important component in an organism in the form of DNA, RNA and proteins. You know that DNA contains a unique genetic code to

guide all activities in living organisms. Like a recipe book, it holds the instruction for making all the proteins, both structural and functional, in our bodies.

KEY TERMS

- **DNA (deoxyribonucleic acid)** is an organic compound of complex structure that is found in all prokaryotic and eukaryotic cells. It is organic molecule composed of a long chain of monomers, the nucleotides. Each nucleotide consists of a five carbon sugar (deoxyribose) which is attached to a phosphate group and a nitrogenous base (contains nitrogen).
- **DNA** codes genetic information for the transmission of inherited traits. DNA is key to life because it determines how a cell replicates and performs its various activities.
- **Functional proteins** perform different functions that play a key role to life. These key roles can be catalytic (E. g. enzymes), Storage (E. g albumin in egg, casein in milk), transport (E. g haemoglobin transport oxygen), protective (E. g. antibodies, blood clotting factors). . . etc.
- **Structural protein**, unlike functional proteins, are involved in producing structures such as bones and muscles as well as cell membrane and skin that covers the cell and the external body respectively.

How do you relate nitrogen cycle, soil bacteria and soil fertility?

Dear learner! You already know that atmospheric nitrogen (N_2) cannot be directly used by both plants and animals. Plants use nitrogen in the inorganic form as ammonium and nitrate and convert it to organic forms such as amino acids and proteins. Then,animals that feed on plants get the organic form and transform, use and store itin their body.

Dear learner! It is the different soil bacteria, like the nitrogen fixing bacteria and nitrifying bacteria that initially provide plants with ammonium and nitrate. Additionally, the ammonifying bacteria, decomposing dead organic matter, liberate ammonium. In general, soil bacteria play a key role in cycling nitrogen increase soil fertility, which in turn results in increased plant growth and higher agricultural productivity.

Dear learner !Are you aware that the nitrogen-fixing bacteria can be used as biofertilizers? These group of bacteria have big capacity of fixing a huge amount of atmospheric nitrogen (N_2), there by increasing soil fertility without causing any harmful effect on air and soil environment. They also improve soil structure and serve as a continuous source of natural fertilizer without being leached easily.

What is the role of larger soil organisms such as earthworms in increasing soil fertility ?

Dear learner! nitrogen cycle is mostly related with microorganisms. However, there are soil macro organisms, such as earthworms that are visible to the naked eye (Figure 3. 11), which are one of the major decomposers of organic matter. The mutual action of earthworms and microbes brings faster decomposition of organic matter, and enhances cycling of nutrients thereby facilitating plant growth and increase crop productivity. Having an abundance of earthworm is a good indicator of fertile soil and ensures higher agricultural yield. As a result, earthworms are nicknamed as **"friends of farmers".**

When earthworms move in the soil, they form tubular channel or burrows. These burrows improve soil structure, particularly soil porosity which increases the amount of air and water holding capacity.

Dear learner! inyour lesson on seed germination, you have learned that air and water are essential for seed to break dormancy (resting stage) and start growth and development of seedling(seed germination).

Figure 3.11. Earthworms – Larger soil organisms

REMARK

- **Bio-fertilizers** are microbial preparations containing living cells of different microorganisms which have the ability to mobilize essential plant nutrients such as nitrogen and phosphorus in soil from unusable to usable form through biological processes.
- **Bio-fertilizers,** being cost effective, non-toxic and eco-friendly, serve as good substitute for expensive and harmful chemical fertilizers. They increase crop yield, ensure food security and sustainable agriculture.
- **Vermicompost** or worm compost is organic fertilizer obtained by using worms. These are commonly earthworms that decompose food scraps, dungs, other wastes and dead organic matter and facilitate nutrient recycling.
- Farmers that use organic fertilizers (Organic farmers) usually grow legumes such as peas and beans for dual purpose. First, they harvest the legumes as a crop as these plants are freely supplied with nitrogen fertilizer due to the nitrogen fixing bacteria in their root nodules. After harvesting yield, the organic farmers grow a non-legume crops to take an advantage of all nitrogen fixed and accumulated in the soil and root of the legumes; none is lost in a crop.

Activity 3. 8

Dear learner!

What do you know about crop rotation? You can find information on this topic from a variety of sources, such as books, the internet, or experts at the nearby office of the Ministry of Agriculture. Once you have gathered the necessary information, we would like you to prepare a brief note that explains why farmers use crop rotation and how they practice it.

Once you have gathered the necessary information, we would like you to prepare a brief note that explains why farmers use crop rotation and how they practice it. This report will be crucial for reflection during the tutorial session

3. 2. 4. Phosphorus cycle

How is phosphorus recycled?

Dear learner! Phosphorus, like nitrogen, is needed by organisms to build proteins. Moreover, it is an essential component of the nucleotides of DNA, which is a key for life. Phosphorous is also needed in the synthesis of ATP, known as the energy currency of a cell. Phosphorus usuallyexists in the form of phosphate ions in soil and rock.

Dear learner !Phosphorus cycle which is illustrated in Figure 3.12, can be summarized as follows:

- phosphate ions in soil or water are taken up by plants and aquatic algae are converted to organic phosphate.
- organic phosphate synthesized by the producers is passed along food chains to various consumers or feeders.
- dead bodies of plants and animals are decomposed by bacteria and fungi and phosphate ions are released from different compounds like phospholipids, ATP, DNA and returned to the soil and water bodies. Phosphate is also excreted from animals and aquatic organisms.

- phosphate will enter the soil in the form of fertilizers obtained by mining phosphate rocks and applying them in agricultural lands to boost crop yield. Phosphate fertilizer from farmlands can be leached by rainfall, reaches the nearby water bodies and causes eutrophication.

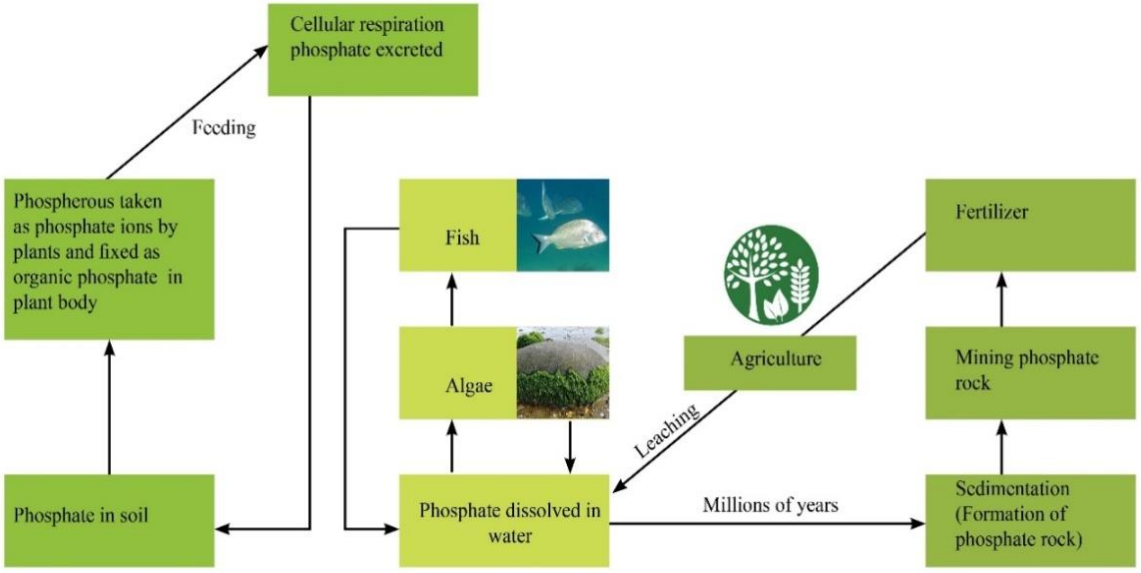


Figure 3.12. Phosphorous cycle

KEY TERMS

- **ATP**, abbreviation for Adenosine, is the immediate source of energy (instantly liberates energy) needed for various activities of a cell. Energy released during cellular respiration is harvested and stored as ATP.
- **Eutrophication** is undesirable excessive growth of aquatic plants (hydrophytes or macrophysics) and massive growth of algae (algal bloom). It is induced by leaching of fertilizers (rich in nitrogen and phosphorus from nearby farmlands or water loaded.

Activity 3. 9

Dear learner! Pollution is a serious threat to your environment . Why not you prepare a short report on pollution , particularly on the potential risks associated with the release of agrochemicals, including fertilizers and pesticides. We recommend you to focus on the dangers of these agrochemicals being released from farmlands into nearby water bodies, such as lakes or reservoirs.

To complete your task, you may refer to various sources such as books, the internet, or experts at the nearby office of the Ministry of Agriculture. Your report will be important for reflection during the tutorial sessions.

✓Self- assessment checklist

Put a tick (√) mark against each of the following tasks which you can perform. If you cannot perform any of these tasks, go back and read the lesson for that particular task.

I can:

- outline and describe the water, carbon, nitrogen, and phosphorous cycle _____ ☐
- Discuss how the carbon cycle is related to global warming _____ ☐
- point out how nitrogen cycle, soil fertility and agriculture are interconnected_____ ☐
- explain the role of soil organisms in soil fertility_____ ☐
- discuss how crop rotation is important to farmers _____ ☐

Self-TestExercise3.2

I. True– False items : Write "TRUE" for correct statements or "FALSE" for incorrect ones.

1. Nutrients in an ecosystem are found in limited amount.
2. Condensation is the result of solar heating .
3. Plants do not release carbon dioxide to the atmosphere.
4. Most living organisms including plants are unable to use N_2.
5. Atmospheric carbon dioxide acts like heat trapping blanket.

II. Multiple Choice Items: Choose the correct answer and write the letter of your choice on a separate answer sheet. [Please prepare answer sheet]

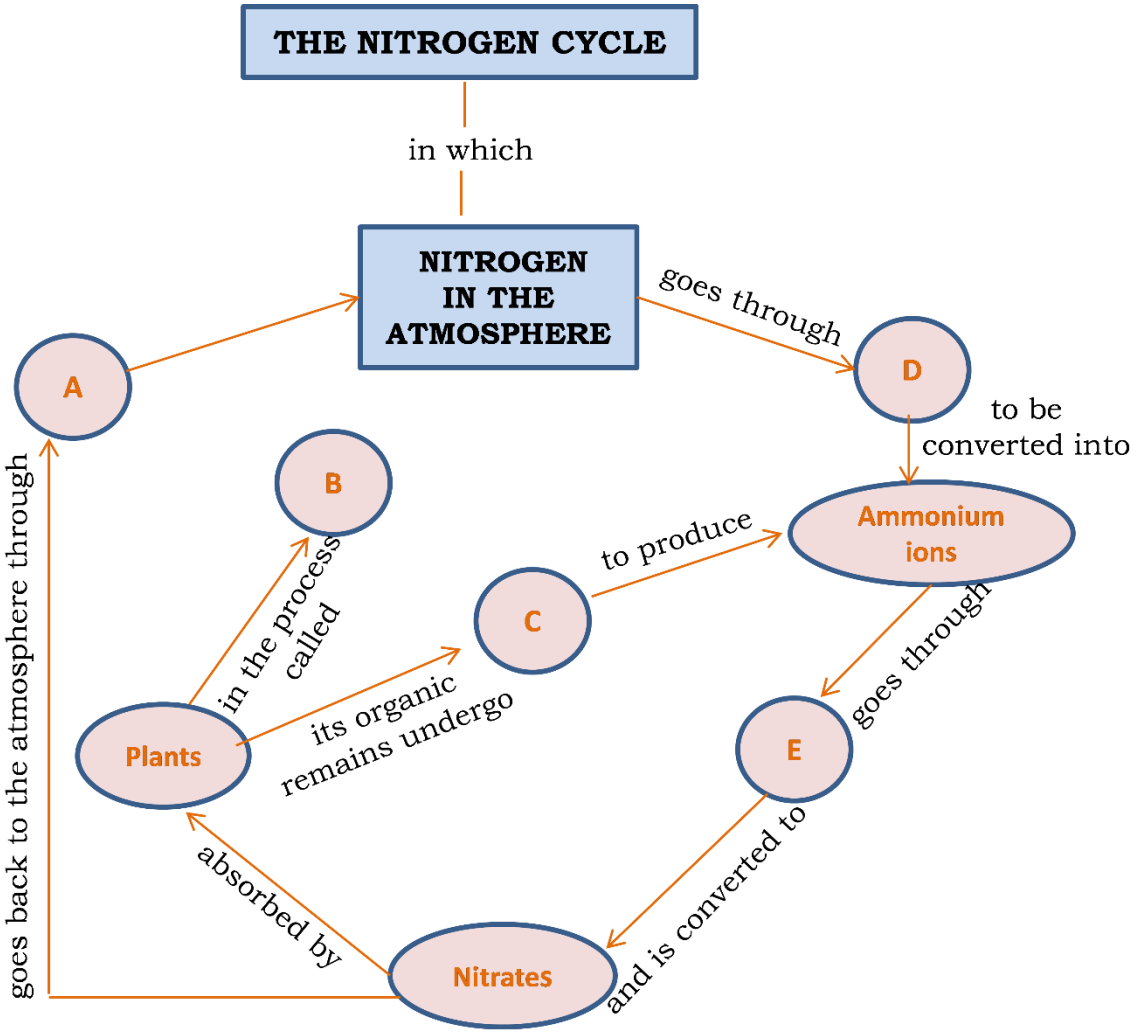
1. Carbon is removed from the atmosphere by
   A) Transpiration B)Photosynthesis C) Respiration D)Nitrogen fixation
2. What is the possible path of nitrogen ?
   A) Atmosphere-micro organisms– plants – soil -animals-atmosphere
   B) Soil – atmosphere–micro organisms -plants – atmosphere – soil
   C) Atmosphere – micro organisms - soil - plant – animals- atmosphere
   D) Atmosphere–soil –micro organisms - plants – animals – soil – atmosphere

3. One of the following elements is contributing to significant increase in global temperature.
   A) Nitrogen B) Carbon C) Phosphorus D) Hydrogen

4. Which of the following is the result of physical change due to temperature
   A) Nitrogen cycle B) Carbon cycle C) Water cycle D) Phosphorus cycle

IV. Short answer item

1. After studying the brief description of major steps in the nitrogen cycle as illustrated in Figure 3. 9 (Nitrogen cycle), complete the following mental map and label the processes represented by the letters (A to E).



2. What would have happened to human beings if there were no nitrogen in the atmosphere?

3. What is the importance of soil bacteria in cycling nitrogen?

4. Bacteria are mostly taken as harmful and dangerous to human beings. Give your comment.

UNIT SUMMARY

- The Earth obtains energy which is trapped by plants for photosynthesis and transferred to animals that feed on them.
- A food chain is a unidirectional energy flow from the sun to producer and then to a series of consumers.
- Food web is interconnected food chains that make interwoven or web-like structures where energy flows in different directions (multidirectional) from producers to different consumers.
- The order of receiving solar energy is known as trophic level in that plants (producers) are at the first trophic level and animals that feed on plants will be at the second trophic level or first feeding level and so on.
- The flow of energy at each trophic level in a particular ecosystem can be shown using an ecological pyramid.
- The ecological pyramid can be a pyramid of energy, number and biomass.
- As energy is successively decreasing as it is transferred from one level to another level, the pyramid of energy is always upright. As a result, the number of trophic where energy transferred is sufficient to sustain life will be limited from 4 to 5.
- Ecological pyramid of number and biomass, depending on the particular ecosystem and food chain, pyramid of number and biomass can be upright or inverted.
- Materials in an ecosystem are found in a limited amount and the same nutrients are continuously re-used, over and over again. This is what we call the cycle of materials.
- The most important cycle of materials in an ecosystem include: water, carbon –oxygen cycle, nitrogen and phosphorus cycles
- Water (hydrologic) cycle is a change in the state of water as water vapour (gas), ice or snow (solid) and liquid water is driven by solar heating and mainly due to change in temperature.
- Among the many processes involved in the water cycle, the most important are: **evaporation, transpiration, condensation, precipitation and runoff**

- The carbon cycle maintains the amount of carbon in the atmosphere by process(es) that continuously take it from the atmosphere and release it back to the atmosphere.
- In cycling carbon, atmospheric carbon dioxide is continuously taken by plants as raw material for photosynthesis and the uptake is balanced by respiration, decomposition and combustion, all of which release carbon dioxide back to the atmosphere.
- As opposed to the carbon cycle, in the oxygen cycle,where oxygenis continuously taken from the atmosphere by processes like respiration, decomposition, combustion and rusting is balanced by photosynthesis which releases it back to the air.
- The nitrogen cycle is a repeating pathway of processes during which nitrogen in different forms moves through both biotic (plants, animals, bacteria and fungi) and abiotic (atmosphere, soil, water) components of the ecosystem.
- The major processes involved in cycling nitrogen are nitrogen fixation, ammonification, nitrification, assimilation and denitrification.
- The phosphorus cycle is mainly the transfer of phosphate ions from the soil, water and rock to plants and aquatic algae, first converted to organic phosphate in the producers and transferred to consumers through the food chain. Phosphate ions are released from consumers through their excreta and as their dead bodies are decomposed by soil bacteria and fungi.

SELF–ASSESSMENT QUESTIONS

I. **True – False items:** Say "**True**" or "**False**" to the following statements.

1. There is less energy at the third trophic level than at the fourth trophic level.
2. Ammonium is more preferred by plants than nitrogen .
3. Plants can release fromas well utilize oxygen in their cells
4. Denitrifying bacteria are anaerobic bacteria.
5. It is food chain, not food web, that actually exists in ecosystem.

II. Matching items: Match the description under **"Column A"** with processes or terms under **"Column B"**.

Column A	Column B
1. It occurs in the chloroplast of plant cell	A) Ammonification
2. It is process of converting protein (organic to inorganic nitrogen	B) Condensation
3. It is one way to eat or to be eaten process	C) Denitrification
4. This process converts nitrate to nitrite and then to atmospheric nitrogen into	D) Food chain
5. It is multidirectional energy flow	E) Food web
6. This is the result of cooling of water vapour heating falling on surface water	F) Nitrogen fixation 4
	G) Photosynthesis2
	H) Respiration
	I) Trophic level

III. Multiple-choice items: Choose the correct answer and write the letter of your choice ona separate answer sheet you have prepared.

1. Organisms that break down organic matter (waste or dead matter are known as

A)Omnivore B)Decomposer C) Herbivore D) Carnivore

2. If the producers in the ecological pyramid have a total of 300, 000 Kcal of energy, which of the following will be **wrong**?

A) The organism at the second trophic level would have a total of 30,000 Kcal energy

B) The organism at the third trophic would have a total of 3000 Kcal energy.

C)The organism at the first feeding level would have a total of 300 Kcal energy.

D) The organism at the first trophic level would have a total of 300,000 Kcal energy.

3. The total mass of living organisms in an ecosystem is known as :

A) Biomass B) Biosphere C) Bioenergy D) Ecological pyramid

4. Fee atmospheric nitrogen (N_2) is changed to ammonium by the process called

A) Nitrogen fixation B)Nitrification C) Ammonification D) A and C

5. What is the correct term for rising water as vapour to the atmosphere by solar heating ?

A)Dehydration B)Precipitation C) Evaporation D) Condensation

IV. Short Answer Items

1. Why do you have usually a small number of organisms at the top of an ecological pyramid?

2. Can green plants use atmospheric nitrogen (N_2)? Explain

3. List down the advantage of using natural or organic fertilizers such as dead bodies and waste products of animals instead of .chemical or inorganic fertilizers

4. What is the disadvantage of Deforestation and the advantage of Afforestation in terms carbon dioxide concentration in the atmosphere and effect on global warming?

Answer Key to Self – test Exercises

Answer to Self – test 3. 1

I. True – False items

1. False 2. False3. True 4.True5.True

II. Matching Items

Arrows from food chain position should point to trophic levels as follows

- Producer to trophic level 1
- Primary consumers to trophic level 2
- Secondary consumers to trophic level 3
- Tertiary consumers to trophic level 4

III. Multiple choice items

1. A 2. D 3. C 4. D

IV. Short answer items

- Being vegetarian one consumes plants (producers) and will get proportionally high energy transferred to it than being a carnivore(secondary consumer or eating other animals and their products such as meat, milk and egg)
- Possible reasons for low energy transfer (only 10%) from one trophic level include the following
  - Not all parts of an organism are eaten by consumers
  - Not all parts of an organism are digested and absorbed by a consumer
  - Part of the food absorbed is used to release energy and heat by cellular respiration
  - There are by products lost from the consumer as faeces and urine

Answer to Self – test 3. 2

I. True – False items

1. True 2. False 3. False 4. True 5. True

II. Multiple choice items

1. B 2. D 3. B 4) C

III. Short answer items

1. A = Denitrification; B = amination; C = Ammonification
   D = Nitrogen fixation; E = Nitrification
2. The proteins and DNA of your body contain lots of nitrogen. In the absence of nitrogen,both of these literally fall to pieces and nobody will be there. Protein is structural(building) compound needed for growth and repair of your body. Moreover, functional proteins such as enzymes or hormones are absolutely essential for biochemical activities taking in your body.
   DNA, which instructs and regulates all your body function requires the nitrogenous bases, which are the basic nucleotide components. So basically, without nitrogen, there would not be human body or human

life. This holds true for all living being in general. We cannot think about life without nitrogen.

3. Basically, the nitrogen cycle is the result of biological processes mediated by soil bacteria. They play key role at the different phases or stages of the nitrogen cycle, which includes nitrogen fixation, nitrification, ammonification and denitrification.
4. As there are harmful bacteria which are pathogenic, there are also huge number of bacteria with beneficial role. Bacteria are useful in the production of biofuel, biofertilizer and during food processing such as milk. Thus, it is a misconception that bacteria are mostly taken as harmful and dangerous to human beings

Feedback to activities

Feed back to activity 3. 1

Possible food chain:

- Grass – grasshopper – lizard - hawk
- Grass – rat – snake -hawk
- Grass – rat – hawk

Remark: Note that hawk receives the least energy in the first food chain

Feed back to activity 3. 2

Dear learner, the food chain or food web you will construct depends on what you have observed in your locality.

Feed back to activity 3. 3

Trophic level is usually limited to 3 or 4, because energy is successively decreasing as it is transferred from one level to other level and sufficient energy for life will not reach for organisms above 4 trophic level.

Human beings are omnivore; they eat either plants or other animals that feed on plants .Thus, they can be herbivore at one time and carnivore at another type , which correspond to Second of Third trophic level respectively.

Feed back to activity 3. 4

The pyramid of energy is always upright. However, pyramid of number and biomass can be upright or inverted and this depends on the given food chain and the particular ecosystem as demonstrated in Figure 3. 6 (sub section 3. 1. 2) and this activity (Tree – bird – bird flea).

Feed back to activity 3. 5

- Nutrients/materials such as nitrogen, carbon, oxygen are found in limited amount in nature. If we continuously usethem, they will be depleted; hence there must be a means of cycling or regenerating them. Thus cycling of materials in an ecosystem is so important for sustainable use of resource and existence of organisms.
- Decomposers such as bacteria and fungi are important to break down complex compounds such as organic matter. By doing so, they release nutrients essential for life. They are also important in the transformation of substances as it is seen in nitrogen cycle. Therefore, life will cease and the ecosystem collapses in the absence of decomposers. For example, proteins that are essential to build our bodies cannot by synthesized in the absence of bacteria involved in the nitrogen cycle. For example, nitrogen fixing bacteria convert atmospheric nitrogen (N_2) to ammonium and nitrate to be used by green plants in the synthesis of proteins.

Feed back to activity 3. 6

- The water cycle starts with evaporation due to the warmth(increase in temperature). Here water is change from liquid to vapour state. The evaporated water due to cooling will form droplets that will eventually roll down the sides of the bag and collect at the bottom as observed in activity. This process is called condensation and is a critical part of the water cycle
- It is Condensation followed by precipitation that results in rainfall, where water returns to its liquid state and falls to the small cup of activity 3.6 or to the ground in the case of the actual environment.

Feed back to activity 3. 7

- Illegal logging (cutting trees) and forest burning interferes in the carbon-oxygen cycle, because they will contributeto an increase in carbon dioxide and decrease in oxygen concentration.
- An increase in carbon dioxideis the cause for climate change because it causes global warming.

Feed back to activity 3. 8

Crop rotation is an essential technique for maintaining soil health and improving crop yields, It is the practice of planting different crops one after the other on the same plot to increase soil fertility. For instance, a farmer can plant maize first. After harvesting the maize, the farmer may plant beans (legumes) on the same field. Maize consumes a lot of nitrogen and beans that contain nitrogen fixing bacteria in their root nodule return nitrogen to the soil.

Feed back to activity 3. 9

Agrochemicals such as fertilizers containing nitrate and phosphate reaching water bodies can cause unwanted fertilization known as eutrophication. This is the cause for excessive algal growth, which can be followed by massive fish death. On the other hand, pesticides, insecticides, weedicides and fungicides entering water bodies such as lakes and reservoirs are toxic to aquatic organisms, including fish.

Answers to self – assessment questions

I. True – False items

1. False 2. True 3. True 4. True 5. False

II. Matching items

1. G 2. A 3. D 4.C 5. E 6. B

III. Multiple choice items

1. B 2. C 3. A 4. A 5. C

IV. Short answer items

1. It is usual for small number of organisms to be present at the topof ecological pyramid because the available energy will be minimum as energy successively declines as it is transferred from lower to higher trophic level.
2. Plants cannot use atmospheric nitrogen (N_2). It should be first transformed to inorganic form of nitrogen (NH_4 or NO_3), which will be absorbed by the root and transported to the leaf for the synthesis of either amino acids or proteins. It should be noted that animals cannot use inorganic nitrogen. They use organic forms of nitrogen, which are either amino acids or proteins. Animals are capable of transforming one amino acid to another amino acid which they first get from plants. They can also convert amino acids to proteins.
3. Organic fertilizers such as compost and bio-slurry are better than chemical (inorganic) fertilizers as the latter can be washed away easily by rain. Organic fertilizers slowly decompose and release nutrients that plants can absorb. They also act as nutrient pools and enhance soil texture and water movement (infiltration) into the soil. It is important to note that inorganic fertilizers that are easily washed away by rain can contaminate nearby water bodies such as rivers and lakes.
4. Deforestation has a major disadvantage because it involves clearing forests and removing trees that could otherwise absorb CO_2 from the atmosphere. This leads to a higher accumulation of CO_2 in the atmosphere, which increases the risk of global warming. On the other hand, afforestation has a clear advantage. Growing new forests or trees helps to remove CO_2 from the atmosphere during photosynthesis through a process called carbon sequestration. This means that there will be less CO_2 in the atmosphere, which helps to cool the environment. In addition, plants also have a cooling effect on their surroundings on hot days because they absorb excess heat from the atmosphere during evapotranspiration.

References

Ecosystem ecology: Freely available at

https://www. lkouniv. ac.in/site/writereaddata/siteContent/20200402191015766 4amit_singh_bot_Energy_budget. pdf

General Ecology: Freely available at

https://ia800104. us. archive. org/31/items/GeneralEcology/General%20Ecology. pdf

Essentials of ecology: Freely available at

- https://www. Booksfree. org/essentials-of-ecology-third-edition-by-colin-michael-john-pdf-free-downlaod/
- https://www. download. booksfree. org/download-book/?dlm-dp-dl=24262