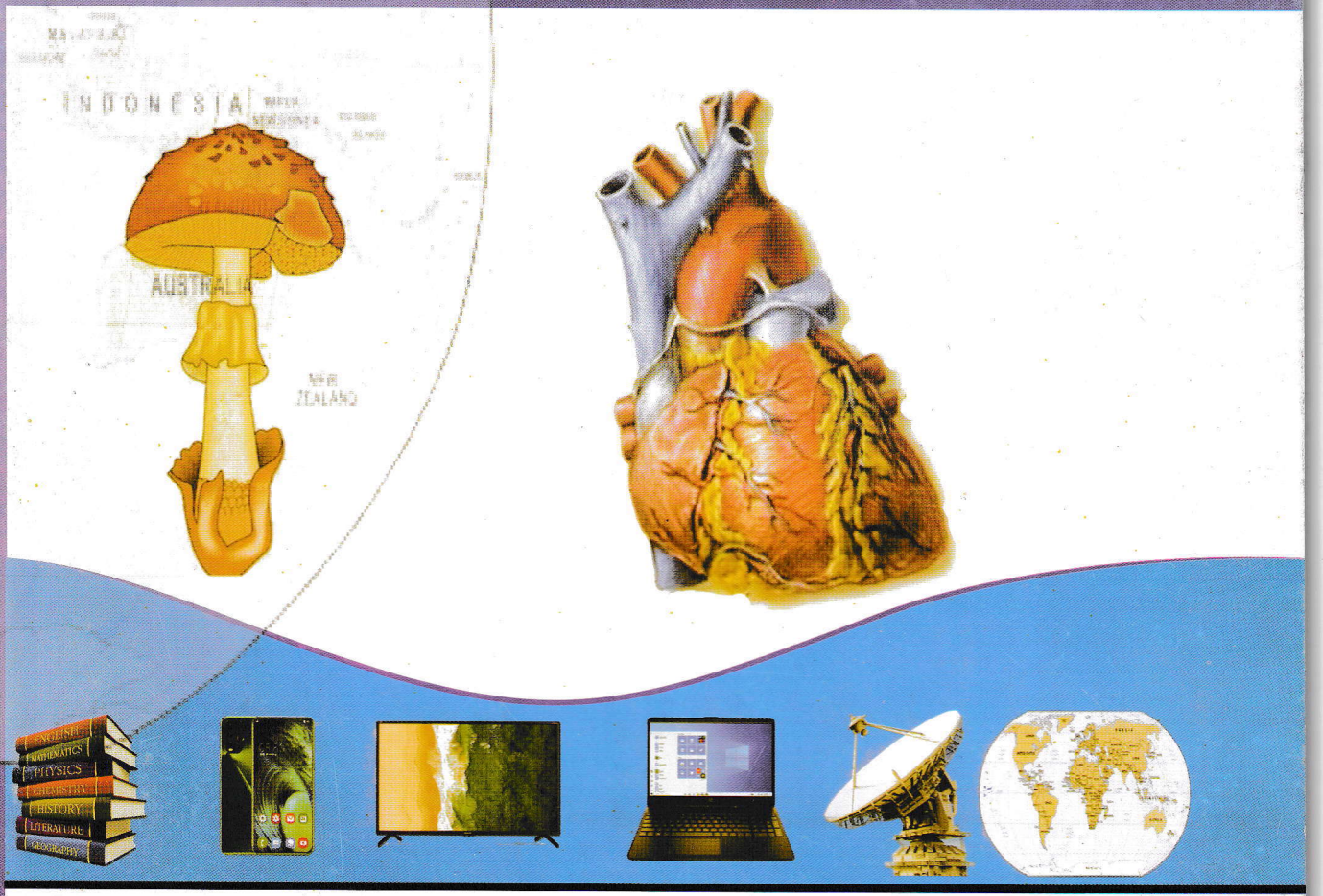
BIOLOGY

Stage I

Module 4

Demonstrating Gaseous Exchange and Respiration in Living Organisms



Institute of Adult Education
Alternative Secondary Education Pathway

BIOLOGY

Stage I

Demonstrating Gaseous Exchange and Respiration in Living Organisms

Institute of Adult Education
Alternative Secondary Education Pathway

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Institute of Adult Education

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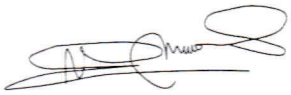

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Dr. Michael W. Ng'umbi

Director

Institute of Adult Education

Contents

About this Module

This module has been produced by the Institute of Adult Education. All modules produced by the Institute of Adult Education are structured in the same way, as outlined below.

How this Module is Structured

Course Overview

The module overview gives you a general introduction to the module. Information contained in the module overview will help you determine:

- If the module is suitable for you,
- What you need to know,
- What you can expect from the module,
- How much time you will need to invest to complete the module.

The overview also provides guidance on:

- Study skills,
- Where to get help,
- Unit assignments and assessments,
- Activity icons,
- Units.

We strongly recommend that you read the overview carefully before starting your study.

The module content

The module is broken down into units. Each unit comprises:

- An introduction to the unit content,
- Unit outcomes,
- New terms,
- Core content of the unit with a variety of learning activities,
- Unit reflection,
- Unit assignments.

Resources

For those interested in learning more on this subject, we provide you with a list of additional resources at the end of this module; they may be books, articles or web sites.

Your comments

After completing this module, we would appreciate if you take a few moments to give us your feedback on any aspect of this module. Your feedback might include comments on:

- Module content and structure,
- Module reading materials and resources,
- Module unit assignments,
- Module assessments,
- Module duration,
- Module support (assigned tutors, technical help, etc.)

Your constructive feedback will help us to improve and enhance this module.

Module overview

Welcome to this module

Dear learner, welcome to module 4 of Biology. This module consists of two units. Unit one discusses gaseous exchange and unit two will discuss about respiration. Dear learner, if you remember in module one, unit one of stage one, we learned about characteristics of living things; and one of characteristics is respiration. Thus, living things respire in order to get energy. Therefore, more clarifications on how this process takes place will be provided in this module.

General competence

By the end of this module, you should be able to apply knowledge, skills and principles of gaseous exchange and respiration in solving health related problems.

Study skills

As an out of school learner, your approach to learning will be different from that of your school days: you will choose what you want to study, you will have professional and/or personal motivation for doing so and you will most likely be fitting your study activities around other professional or domestic responsibilities.

Essentially you will be taking control of your learning environment. As a result, you will need to consider performance issues related to time management, goal setting, stress management, etc. Perhaps you will also need to learn about essay planning, coping with examinations and using the web as a learning tools.

Your most significant considerations will be time and space i.e. the time you dedicate to your learning and the environment in which you engage in that learning.

Your most significant consideration will be *time* and *space* i.e. the time you dedicate to your learning and the environment in which you engage in that learning.

We recommend that you take time now before starting your self-study to familiarize yourself with these issues. There are a number of excellent resources on the web. A few suggested links are:

- http://www.how-to-study.com/

The "How to study" web site is dedicated to study skills resources. You will find links to study preparation (a list of nine essentials for a good study place), taking notes, strategies for reading text books, using reference sources, test anxiety.

- http://www.ucc.vt.edu/stdysk/stdyhlp.html

This is the web site of the Virginia Tech, Division of Student Affairs. You will find links to time scheduling (including a "where does time go?" link), a study skill checklist, basic concentration techniques, control of the study environment, note taking, how to read essays for analysis, memory skills ("remembering").

- http://www.howtostudy.org/resources.php

Another "How to study" web site with useful links to time management, efficient reading, questioning/listening/observing skills, getting the most out of doing ("hands-on" learning), memory building, tips for staying motivated, developing a learning plan.

The above links are our suggestions to start with on your way. At the time of writing, these web links were active. If you want to look for more go to www.google.com and type "self-study basics", "self-study tips", "self-study skills" or similar.

Need help?

Dear learner, in the course of your study, you may need help in various issues such as the location and how to get support from resource centres, clarification of various issues pertaining to your study materials (modules) and so on. If this happens, you are advised to ask for the help from your centre coordinator or facilitator, you can also visit the website of the Institute of Adult Education which is www.iae.ac.tz or ask for help by using phone no. +255 22 2150838.

Module assessment

After each unit, you will be required to attempt one unit assignment. These are not meant for submission rather than reflection on what you have learned in the whole module. You will also be given tests and assignments for submission as you will be guided by your module facilitator. You will also sit for mock examinations to accomplish your continuous assessment.

Getting around this module

Margin icons

While working through this module you will notice the frequent use of margin icons. These icons serve to "signpost" a particular piece of text, a new task or change in activity; they have been included to help you to find your way around this module.

A complete icon set is shown below. We suggest that you familiarize yourself with the icons and their meaning before starting your study.

 Activity	 Assessment	 Unit assignment	 Case study
 Discussion	 Group activity	 Help	 Note it!
 Outcomes	 Reading	 Reflection	 Study skills
 Summary	 Terminology	 Time	 Tip
 Computer-Based Learning	 Audio	 Video	 Feedback
 General Competence	 Basic Competence	 Answers to Assessments	

Unit 1

Describing Gaseous Exchange

Introduction

Welcome to unit one of this module. This unit will help you to understand how gases are taken in and given out by animals as well as in plants. It will also help you to know how gases enter into the blood circulation.

Learning Outcomes

Upon completion of this unit you should be able to:

- Describe the processes of gaseous exchange in living organisms and its importance;
- Carry out experiments to demonstrate breathing mechanism; and
- Apply ways of preventing the spread of respiratory diseases.

The Concept of Gaseous Exchange

Living organisms take in and give out gases. Can you also do it? Organisms get the supply of oxygen from the air, in turn they give out the waste gas called carbon dioxide to the environment. The movement of these gases between the organism and its environment is what we call **breathing.**

How do living organisms take in air and take out air?

The process of diffusion of air in and out of the body across the surfaces of respiratory organs such as lungs, gills, skin and spongy mesophyll cells is called **gaseous exchange**.

You are now aware of respiratory organs, can you please make a table of a few organisms and their respiratory organs? Then compare your list with the given below.

Table 1.1: Organs responsible for gaseous exchange in living organisms

Organ	Example of organisms
Skin	Frog, toad
Lungs	Man, bird, lizard, frog, toad
Cell surface membrane	Unicellular organisms e.g. amoeba
Buccal cavity	Frog, toad
Tracheal system	Insect
Gills	Fish, tadpole
Stomata	Plant

Dear learner, the next section discusses parts of the body responsible for gaseous exchange.

Respiratory Surface

A respiratory surface is part of the body through which gaseous exchange takes place. It is characterized by the following characteristics /features:

Characteristics of respiratory surfaces

i. They have a large surface area to increase the rate of diffusion.
ii. They are always moist in order to allow easy diffusion of gases.
iii. They are extremely thin, in order to facilitate diffusion across short distances.
iv. They have a good network of blood capillaries. This allows the gaseous exchange to take place between the blood and the surrounding air or water.
v. They are well ventilated, that is they receive a steady flow of air or water.

Importance of gaseous exchange

Dear learner, why should we take in oxygen and give out carbon dioxide?

Try to cover your mouth and nostril for some few minutes, how do you feel? Is there any changes detected? Why?

In short gaseous exchange has the following importance:

- Gaseous exchange supplies respiring cells and tissues with oxygen which is required for breaking down food substances to get energy.
- Gaseous exchange helps respiring cells to get rid of carbon dioxide which is produced as waste product during cell respiration.

If carbon dioxide is not removed from the body, it may accumulate to toxic level. Thus, removing it gives room for other processes to take place effectively. Let us learn about gaseous exchange in mammals.

Gaseous Exchange in Mammals

In mammals, gaseous exchange takes place in the lungs. Mammals breath in mixture of gases which include nitrogen, oxygen, carbon dioxide and water vapour. They also breath out mixture of gases containing more carbon dioxide and water vapour. The following discussion will focus on how respiratory system in human beings takes place.

The human respiratory system

Dear learner, do you remember the diagram of human respiratory system that you learnt in primary school? If yes, mention some parts of it. But if you have forgotten, do not worry because you will learn about it in this section.

The human respiratory system starts from the nostrils to the lungs. The system consists of the following parts.

- Nasal passage – running from the nose to the trachea.
- Pharynx – the area at the back of the mouth cavity leading into the nasal cavity, gullet and windpipe.
- Larynx – the upper part of the windpipe which communicates with the pharynx.
- Trachea – conducts air from the nose and mouth to the bronchus.
- Bronchi (Bronchus-singular) – air pipe branching from the windpipe and going to the lungs.
- Bronchioles – a branch of bronchus.
- Alveoli or air sacs – found at the end of bronchioles and increases the surface area for gaseous exchange.

Draw a well labelled diagram of the human respiratory system, and then compare your diagram with the diagram in figure 1.1 which shows the different parts of the respiratory system in human.

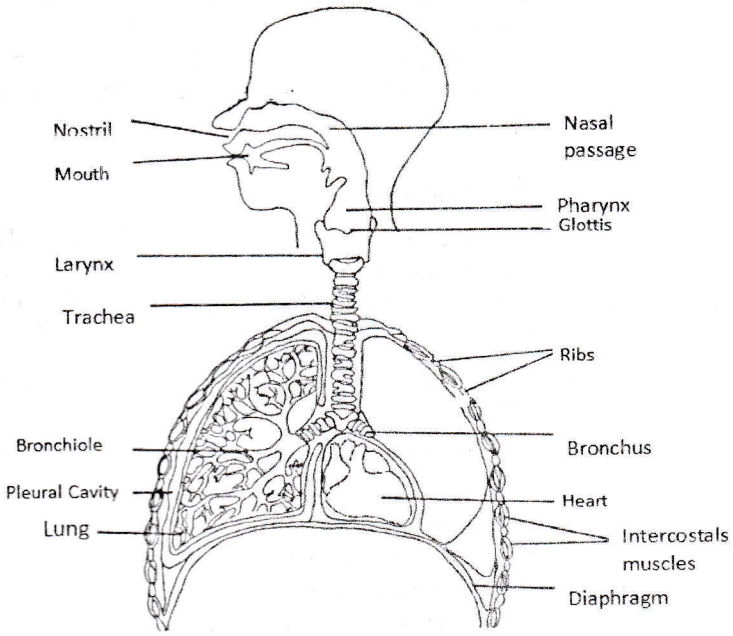


Figure 1: The structure of respiratory system in human

Dear learner, let us discuss the parts of respiratory system.

How air is taken in and out?

The nasal passage

Air enters through the nostrils then it is and drawn into the nasal passage. In the nasal passage the air is moistened and warmed to the body temperature by the warm blood in capillaries.

The membranes covering the roof of the nasal passage contain an organ (olfactory lobe) responsible for the sense of smell. The wall and the base of the nasal passages are lined with hair like structures called **cilia** which filter the air. Between the cilia there are goblet cells which produce a sticky fluid called **mucus**. The mucus traps dust and bacteria inhaled from the atmosphere. The dust and bacteria trapped are carried by the rhythmic beating of the cilia towards the back of the mouth where they are swallowed.

Pharynx (throat)

This is the part of respiratory system located between the nasal passage and larynx. It allows air to pass towards the trachea; it also allows the passage of food towards the oesophagus.

The larynx

The larynx or voice box is a cavity at the top of the trachea which contains vocal cords. There is an opening called glottis between the pharynx and larynx. This opening can be closed by a structure called epiglottis during swallowing to prevent food to enter the air passage (trachea). Can you ask any of your friends to open his/her mouth so that you can see an epiglottis?

Trachea

The trachea or wind pipe is a tube running from the pharynx to the bronchi. The tube is held permanently open by C-shaped rings of cartilage in its walls. This strengthening by cartilage rings enables it to remain open all the time. The inside surface of the trachea is coated with mucus which traps dust and other foreign particles. It is also lined with cilia which move trapped dust and other particles back towards the pharynx for their removal before reaching the lungs.

Bronchi

The lower end of the trachea is divided into two branches called bronchi (singular bronchus), one leading to each lung. Inside the lung, each bronchus divides to form **bronchioles.** The bronchioles finally end up in thin walled structures called *alveoli* or *air sacs*.

Lungs

The mammalian lungs occur in a pair and are found in the chest cavity (thoracic cavity). They are enclosed in double membranes called pleural membranes. These secrete a fluid which collects in the space, known as the pleural cavity that lies between the two membranes. The fluid acts as a lubricant which reduces friction between the lungs and the thoracic muscles during breathing.

Alveoli

These are the functional units of the lungs in which gaseous exchange takes place. See figure 1. 2.

The presence of numerous alveoli is what makes the texture of the lung spongy. The outer surface of each alveolus is covered with a dense network of blood capillaries. Blood flowing through these capillaries absorbs oxygen from the alveoli, and carbon dioxide diffuses from the blood to the alveoli.

The alveoli provide the lungs with a large internal surface area for the exchange of oxygen and carbon dioxide. In the alveolus there is high concentration of oxygen from outside. This oxygen diffuses across the moist wall of alveolus to the capillaries surrounding the alveolus. This gas is exchanged with carbon dioxide in the capillaries (blood vessels) where it is in high concentration. This carbon dioxide comes from respiration.

Dear learner, the following diagram shows a structure of human lungs. Observe the figure carefully and try to remember all the parts.

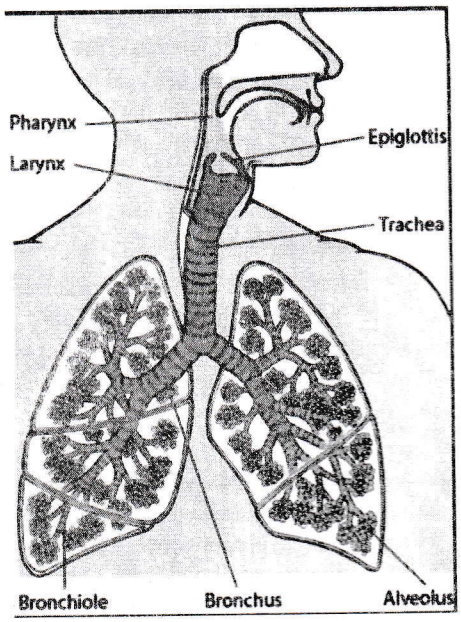


Figure 1.2: Structure of human lungs

Now you have learnt about parts of human lungs. It is important to understand how exchange of gases takes place in alveoli as seen in Figure 1.3.

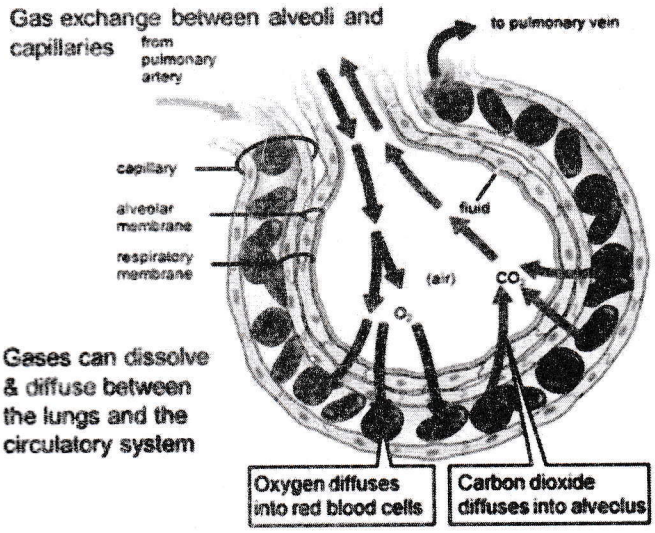


Figure 1.3: A simple diagram of Alveoli

Table 1.2 summarizes the parts of respiratory system and their functions.

Table 1.2: Structure and functions of respiratory organs

Structure	Adaptive feature	Function
Nasal passage	Have hair(cilia) and mucus lining	Warms, moistens, and filters air as it is inhaled
Trachea (windpipe), Bronchus	• Made of rings of cartilage tissues throughout • Lined by mucus and cilia	i. Keeps the trachea (windpipe) open ii. Traps dust and other foreign particles iii. Gives strength of the respiratory system as it is made of cartilages
Bronchioles	• Lined with blood vessels • Made of smooth muscles to allow constriction and dilation	Warming air that passes through
Glottis	Presence of epiglottis	Closes trachea during swallowing to prevent food from entering the respiratory system
Lungs	It is spongy with air spaces	An organ for gaseous exchange as it contains air spaces(alveoli)
Pleural membrane	Secrete pleural fluid for lubrication	To allow smooth movement of lungs during breathing
Diaphragm	It's a muscular sheet of tissues	Assist both exhalation and inhalation process
Intercostal muscles	Contract and relax antagonistically	Allows movement of ribs to create cavity in the thorax
Ribs	Made of bones	Protection of the lungs
Alveoli	• Has many blood capillaries • Have thin membrane • Highly moist • Highly ventilated • They are many in number	Sites for gaseous exchange

Mechanism of Breathing

Dear learner, can you do the following experiment? Very good!

Deeply take air in and note the changes in your chest, then take out air again note the changes in your chest.

Can you now tell how you are able to take air in or out? What happens to your chest, ribs and diaphragm when you are:

(a) Breathing in?

(b) Breathing out?

Breathing is a process of taking air in and out of the body through the nose or mouth. The process of taking air into the lungs is called **inspiration** or **breathing in (inhalation)** while that of taking air out is called **expiration** or **breathing out (exhalation).**

Breathing by lungs is brought about by alternating increase and decrease in volume in the thoracic cavity. Changes in volume occur as a result of the action of the intercostal muscles and the diaphragm. When the volume of the thoracic cavity increases, the pressure of air in the cavity decreases and air is taken in because of the higher pressure outside. As the volume decreases, the pressure in the lungs increases (i.e. becomes higher than the one outside) air is forced out.

The muscular diaphragm separates the thoracic cavity from the abdominal cavity and hence helps in the process of inhalation and exhalation. There are two sets of muscles in between the ribs which help in the breathing action. These are external intercostal muscles and the internal intercostal muscles. These muscles are arranged diagonally to each other so that they function in opposite directions during inspiration and expiration.

So far you have learnt that breathing involves two main processes namely; inspiration and expiration. The more details about these processes are illustrated below.

Inspiration/inhalation

During Inspiration

- The intercostal muscles contract. This causes the ribs and sternum (breast bone) to move upwards and outwards.

- The diaphragm contracts, the contraction flattens out the diaphragm.
- The volume of the thoracic cavity (chest cavity) increases hence pressure decreases causing the lungs to expand.
- As the pressure of the lungs is reduced, air is drawn into the lungs through the nostrils, larynx, trachea, bronchi, bronchioles and finally to the alveoli.

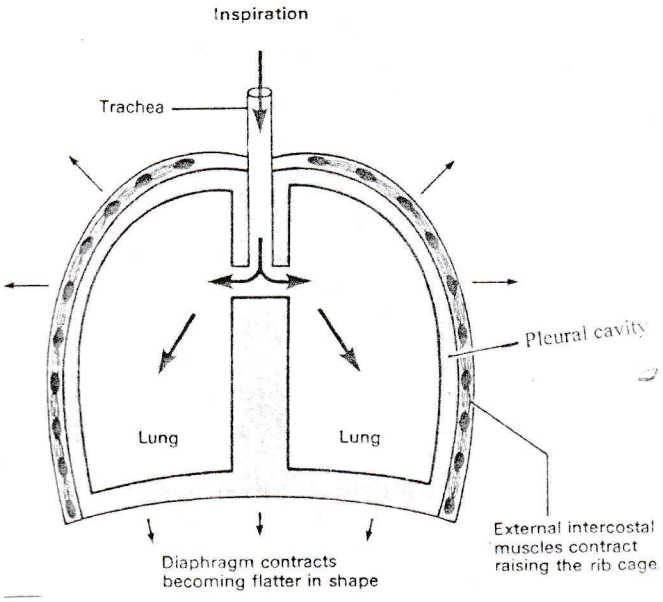


Figure 1.4: Ventilation of the lungs

Expiration/Exhalation

During expiration

- The intercostal muscles relax. This causes the ribs and breast bones move downward and inwards.
- Muscles of the diaphragm relax. This makes the diaphragm return to its original position i.e. its dome shape.
- Thoracic cavity decreases in volume.
- Air pressure in the lungs increases hence air from the lungs is forced out.

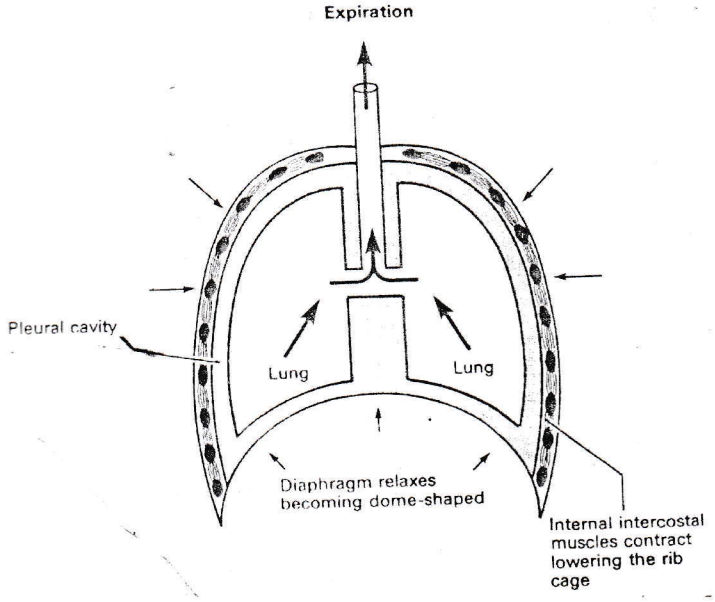


Figure 1.5: Ventilation of the Lungs

Well, the mechanism of breathing can be demonstrated as shown in the figure 5 using the following apparatus;

- Balloons stand for Lungs.
- Y – glass tube – stands for trachea.
- Bell jar stands for rib cage.
- Bladder (rubber sheet) stands for diaphragm.

When the rubber sheet (bladder) is pulled down the air flows into the balloons. Also when the rubber sheet is pushed up the air is pushed out of the balloons.

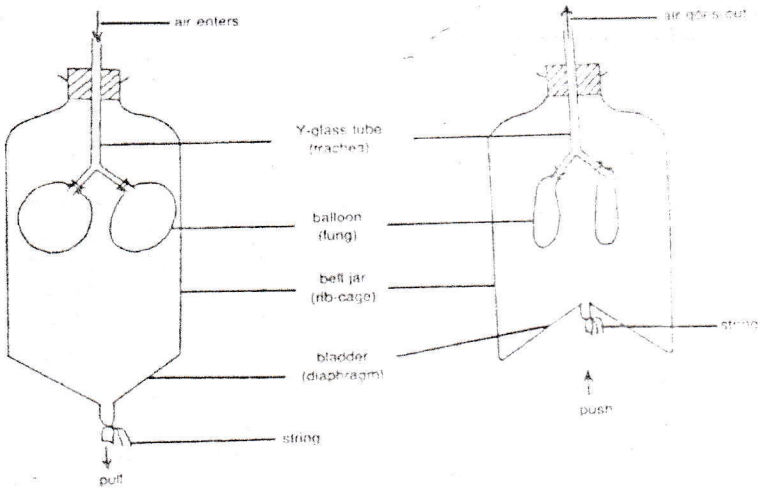


Figure1. 6: Apparatus to demonstrate breathing in and breathing out

Dear learner, how can you prove that exhaled air contain carbon dioxide? You can prove by doing the following experiment.

Before you start the experiment collect the following requirements.

Requirements:

Large test tube, delivery tube and lime water.

Procedure

- Pour half filled test tube with lime water
- Set the experiment as shown below
- Bubble in air from your mouth

Figure1.7: Performing experiment

- Put your mouth on the delivery tube and exhale strongly through the delivery tube 3 or 4 times and observe changes in the lime water.

Observation

What have you observed after the experiment? Hopefully you have seen that lime water turn milky.

Conclusion

Milky colour indicates the presence of carbon dioxide. Therefore exhaled air contains carbon dioxide.

Can you give other characteristics of exhaled air? What else does it contain?

Usually inhaled air has low concentration of carbon dioxide, low water vapour and high oxygen content than exhaled air. Inhaled air is cold while exhaled air is warm

Factors Affecting the Rate of Gaseous Exchange

Why does a person breathe quickly after a heavy exercise?

Do you know why breathing rate increases when you are running? Do you remember its process? Now, read on the factors which affect the rate of breathing.

The rate of breathing is controlled by the medulla oblongata of the brain. A relaxed human adult breathes about 16 to 18 times per minute. However, this rate can be affected by the following factors:

a) Carbon dioxide concentration.
b) Altitudes.
c) Haemoglobin concentration.
d) Activity of an individual.
e) Age.
f) Health status.

a) Carbon dioxide concentration

An increase in the levels of carbon dioxide in the blood stimulates an increase in the breathing rate, so that more oxygen can be taken in and more carbon dioxide is removed from the body.

b) Altitude

At high altitude, the atmospheric pressure is lower than that in the lungs. This makes inhalation difficult. This problem is overcomed by deep breathing.

c) Haemoglobin concentration

Haemoglobin are red pigments found in the red blood cells which transports oxygen to different tissues in the form of oxyhaemoglobin. When concentration of haemoglobin in the blood is high the body is adequately supplied with oxygen, but when the person is anaemic the amount of oxygen transported becomes low. Therefore, the higher the concentration of haemoglobin the low rate of gaseous exchange and vice versa.

d) Activity of an individual

During active exercise like running, the body needs more energy and this also means more oxygen. Therefore, the rate of breathing has to be increase.

e) Age

Growth and other metabolic processes are highly taking place in young people compared to old people. These processes require a lot of respiratory energy which promote breathing rate. Hence, gaseous exchange is high in young people than in old people.

f) Health Status

A sick body will have high metabolic rate because of the liver fighting against the toxins produced by pathogens as well as breaking down the drugs taken. These processes promote the rate of gaseous exchange. However, some diseases tend to weaken the body to the extent of decreasing the rate of gaseous exchange.

After you have finished studying about gaseous exchange in animals particularly human being, it is time now to look at gaseous exchanges in plants. Welcome!

Gaseous Exchange in Plants

Do plants exchange gases like mammals? What types of gases are taken in by plants? What gases are released by plants?

Dear learner, I hope you are aware that, it is not wise to share a room with plants at night and close the doors and windows. The following part will give you hints on how to answer the above questions.

Now, let us see the gaseous exchange in plants. Do you think the gaseous exchange in animals will be the same as that in plants?

How do plants exchange air?

Gaseous exchange in plants takes place through holes called stomata in the cuticle of leaves particularly on the lower side, petals, and young stems and through cracks/holes in the bark called *lenticels*.

Gaseous exchange through stomata

Leaves are the main sites of gaseous exchange. During the day, they take in carbon dioxide from the atmosphere and give out oxygen where at night they take in oxygen and give out carbon dioxide.

Gaseous exchange through lenticels

Lenticels are small openings in the bark of woody stems and roots. These openings are loosely packed with cells with air spaces in between them. Gases diffuse in and out of the plant through these spaces. Gaseous exchange takes place on the moist surfaces of cells beneath the lenticels (Look at Figure 1.9).

The following diagrams demonstrate the process of gaseous exchange through stomata and lenticels:

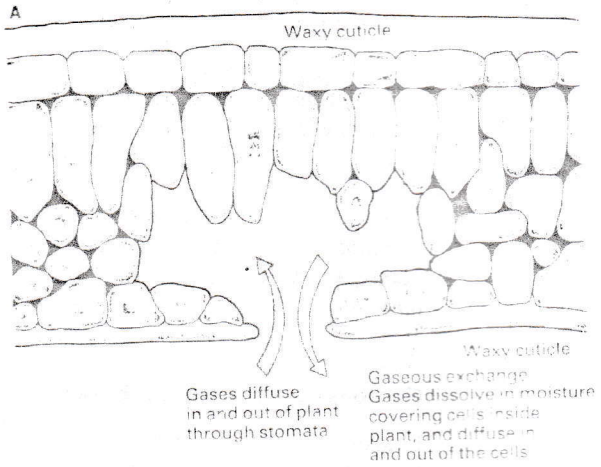


Figure 1.8: Gaseous exchange through stomata

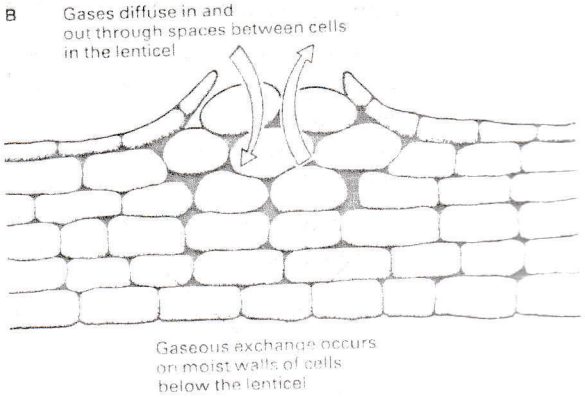


Figure 1.9: Gaseous exchange through lenticels

You are now through with the process of gaseous exchange in plants. Before you proceed with respiration, it is important for you to be aware of the importance of gaseous exchange in plants.

Importance of gaseous exchange in plants

i. Plants get oxygen for respiration

ii. They also get carbon dioxide as a raw material for photosynthesis

iii. Enables plants to remove excess gases

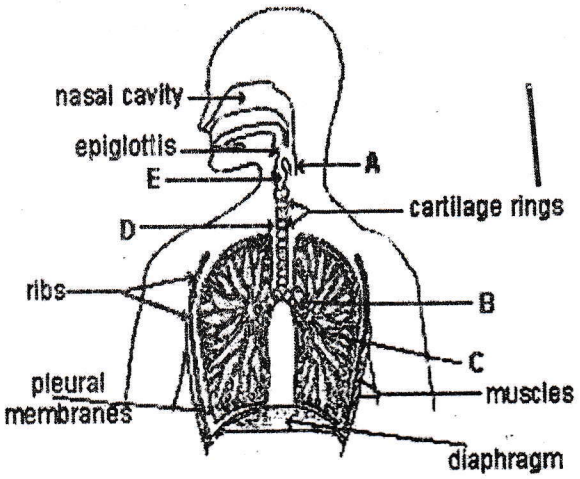
Unit Reflection

1. Which part in this unit you think is the most important to your life? How? Which part did you find difficult and why?
2. Some people still smoke in public areas. From what you have learnt, what do you think such people they lack? How can you help them for the benefit of the society?

Unit Assignment

Answer the following questions; remember to put your work in your portfolio:

1. Study the diagram and answer the questions that follow:-



(a) Identify the parts labelled A, B, C, D and E.
(b) What are the three things which happen to the air in the nasal cavity as we breath in?
(c) How are the lungs protected and supported?

(d) In which way do the ribs move when we inspire?
(e) In which way does the diaphragm move when we expire?
(f) How does the epiglottis protect the lungs?
(g) Why do the trachea and the bronchi have cartilage rings around them?
(h) Explain briefly the appearance of a real set of lungs. (You can choose from the following adjectives: hard, soft, smooth, red, pink, grey, spongy, wet, dry).

2 (a) What are the differences between exhaled air and inhaled air?

(b) How would you show that exhaled air contains:

(i) Carbon dioxide.

(ii) Water vapour.

3 Explain how gaseous exchange in plants takes place.

4 Write down factors that affect rate of breathing.

5 Rearrange the following parts of respiratory system to obtain a correct pathway of Oxygen from the atmosphere to the blood system;

Pharynx, nostrils, bronchus, trachea, alveoli, bronchioles.

Unit 2

Demonstrating how Respiration takes place in Living Organisms

Introduction

Dear learner, welcome to unit two of this module which is called Respiration. I believe you are now aware of how organisms get Oxygen in and out of their bodies. However, I am not sure if you really know much about the actual role of Oxygen in the bodies of organisms. In this unit, you will learn the process in which Oxygen is used to produce energy needed for various body activities.

Learning Outcomes

Upon completion of this unit you should be able to:

- Describe the mechanism of respiration.
- Carry out experiments to demonstrate the application of
- Aerobic and Anaerobic Respiration.
- Discuss the problems and control of disorders of the respiratory system.

Concept of Respiration

Do you remember where the energy to run the process of photosynthesis comes from? What is the final product of this process? How does it differ from Carbon dioxide and water? Do you remember the end product of digestion of Carbohydrates. What is its function in the body?

Why is respiration important?

The question is easy, to give energy. How living organisms obtain energy from food substances is what we call **respiration**. Do you know the steps involved in this process?

You have learnt that organisms take in Oxygen and breath out Carbon dioxide. Oxygen is transported by the blood to all living cells. In the living cells there are absorbed food substances such as carbohydrates (glucose), fats and proteins. These stored food substances cannot be directly used by cells to provide the required energy. They have to be converted into a chemical form which can be utilized by cells either for movement, growth or production of heat. Thus, the oxygen in living cells breaks down (oxidizes) food substances like glucose to release energy. This is what we call *respiration.*

Respiration is the process of breaking down food substances to release energy. It occurs in all living cells, hence called cellular respiration. This process occurs in stages and is controlled by enzymes.

Dear learner, you are aware that there are other processes which also produce or release energy. Burning is an example of a process which also produces energy.

However, cellular respiration differs from burning even though both release heat energy. The table below shows differences between respiration and burning.

Table 3: The Differences Between Respiration and Burning

Respiration	Burning
Controlled process	Uncontrolled process
Energy is released in small quantities over time	Energy is released in large quantities all at once.
Carbohydrates, proteins and fats are used as fuels.	Any combustible material can be used as fuel.
Energy produced is stored in energy bonds (ATP) and released instantly when needed	Energy produced is utilized at once, hence no storage of energy.
No rise in temperature	There is a remarkable rise in temperature

After learning about the meaning of respiration, now let us see the types of respiration in living cells.

Types of Respiration

You have learnt that respiration take places in the presence of Oxygen. Respiration can however, also take place in the absence of Oxygen. Based on this, there are two types of cellular respiration namely: *aerobic* and *anaerobic respiration.*

Aerobic Respiration

Aerobic respiration occurs in the presence of Oxygen and relatively, a large amount of energy is produced. Aerobic respiration occurs in the mitochondria. Organisms that respire aerobically are termed as *aerobes*. During the process, food substances such as glucose molecules are completely broken down to release energy. The energy released is stored in the form of Adenosine Triphosphate (ATP). Carbon dioxide and water are also released. Aerobic respiration occurs in the mitochondria.

The process of aerobic respiration can be represented by the following equation:

Glucose+ Oxygen $\longrightarrow$ Carbon dioxide + Water + Energy

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 38ATP$

1. **Experiment to Demonstrate the Application of Aerobic Respiration**

Aim: To find out whether heat energy is liberated during aerobic respiration.

Materials and Apparatus

Take two vacuum flasks, two thermometers, beakers, cotton wool, water and seeds.

Procedure

- Take two equal batches; A and B of bean seeds.
- Put batch A in a beaker of water and boil for few minutes to kill all the seeds. Cool down the boiled seeds and drain the water and rinse thoroughly.
- Put batch A and B in separate beakers and cover each with 1% formalin and leave it there for five minutes to kill all fungi and bacteria on the surface of the seeds.
- Drain away all the formalin and rinse with water.
- Put batch A in a vacuum flask labelled A and batch B in another thermos flask labeled B.
- Plug the mouth of each flask with cotton wool in order to allow Oxygen to enter the flasks.
- Insert a thermometer into each flask through the cotton cool. Make sure that the bulb of the thermometer is well in contact with the seeds so that the temperature can be recorded accurately.
- Set the experiment as shown in the diagram below.

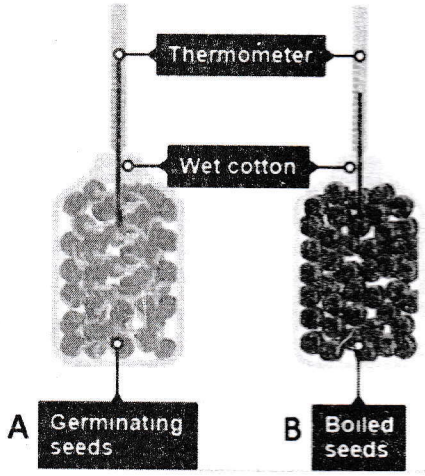


Figure 11: Experimental set up to investigate the form of energy released during respiration

- Leave the experiment for five days. Each day at a fixed time record the temperature of the contents of each flask.

Observation

- After few days, you may observe that, there is an increase in temperature in flask A containing the germinating seeds. This increase shows that, heat energy comes from the respiring seeds.
- Flask B containing boiled seeds does not show any marked temperature change. This means that there is no noticeable output of heat energy in this flask. Boiled seeds generally do not respire as germinating seeds.

Conclusion

- The seeds in flask A was germinating the process which needs energy, therefore respiration process was taking place. But the seeds in flask B was killed by boiling hence did not show any signs of germination because respiration was not occurring. Flask B was a control experiment while flask A was a Test experiment.

Factors Affecting the Rate of Respiration

Let us look at the factors which affect the rate of respiration.

i. Internal Temperature

An increase in temperature to optimal level inside the organism is followed by an increase in enzyme activities and that means an increase in respiration. Lowering body temperature slows down the rate of respiration because the enzymes becomes inactive.

ii. Environmental Temperature

In cold climates organisms (e.g. lizards) lose more heat to the environment until their body temperatures equalize to that of the environment. However, other animals such as mammals and birds keep their body temperature relatively constant by increasing their respiration rate.

iii. Body Volume

If the body volume is large, like that of an elephant, its surface area relative to volume becomes small. Thus, the heat loss is relatively small. If the volume of the body is small, like in a mouse, its surface area in relation to the volume is large. Therefore, the heat loss from the body surface is high. Thus small organisms require a lot of energy to replace the lost one and hence have high rate of respiration.

iv. Age

The respiration rate in young organisms is higher because of growth and higher activity. Generally, old people need less energy since they are no longer growing and are less active.

v. Activity

All activities require energy. When an organism is active, it requires more energy than when it is inactive. The rate of respiration increases with the increase in the activity of the organism.

Anaerobic Respiration

Let us now continue with another type of respiration called anaerobic respiration.

Anaerobic respiration is the type of respiration which occurs in the absence of Oxygen. It occurs without using Oxygen. Organism that respire anaerobically are termed as *anaerobes.*

There are two types of anaerobes which are;

i. *Obligate anaerobes* - these are organisms which can only survive and respire in absence of Oxygen. Any presence of xygen will kill obligate anaerobes.

ii. *Facultative anaerobes* - these are organisms which can survive and respire both in the presence and in the absence of Oxygen.

Anaerobic respiration is sometimes referred to as *fermentation.*

Most fermentation reactions result in products which are incompletely oxidized. Good examples of such products are alcohol (ethanol), acetic acid and citric acid. Certain bacteria and yeast can respire anaerobically. Fermentation in presence of yeast makes bread and beer. In fermentation, Carbon dioxide is released, the release of Carbon dioxide is also useful in making bread.

Plants can also respire anaerobically for a short time but animals cannot survive under anaerobic conditions. For example, plants submerged under floods can survive for some days, but animals cannot.

The fermentation of glucose is represented as:

$C_6 H_{12} O_6 \longrightarrow 2C_2 H_5 OH + 2 CO_2 + Energy$

Glucose $\longrightarrow$ ethanol + Carbon dioxide + Energy

Since alcohol is formed during this process anaerobic respiration is sometimes referred to as *alcoholic fermentation.*

Anaerobic Respiration in Animal Tissues

Let us now see about anaerobic respiration in animals.

Animal muscle cells respire anaerobically when the supply of Oxygen becomes insufficient. This happens during vigorous exercise when the concentration of Oxygen is low to meet the body's demand. As a result, an overworked muscle cell uses anaerobic respiration to provide extra energy required. This is accompanied with the production of lactic acid as byproduct. The equation is written as follows:

Glucose $\longrightarrow$ lactic + Energy

$C_6 H_{12} O6 \longrightarrow 2 CH_3 CH (OH) COOH + Energy$

The lactic acid produced is accumulated in the muscle cells. The accumulation prevents them from contracting due to its toxicity and pain is felt. When this occurs, Oxygen is required to oxidize the lactic acid into water and Carbon dioxide. Quick deep breathes following any vigorous exercise increases the amount of Oxygen in the body. The amount of Oxygen required to take a complete breakdown of lactic acid in the muscles into Carbon dioxide and water is commonly known as ***Oxygen debt.***

Anaerobic Respiration in Plants

Sometimes plant cells cannot get enough Oxygen to carryout aerobic respiration but they still need energy to survive. So they use an emergency system of reaction that is anaerobic respiration. In plants, anaerobic respiration involves the breaking down of glucose by bacteria or fungi to produce alcohol, arbon dioxide and energy, as shown in the following equation.

Glucose $\longrightarrow$ Ethanol + Carbon dioxide +Energy

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + Energy$

Importance of Fermentation

The following are the importance of fermination.

a) Production of alcohol like beer, wine and whisky.
b) Formation of carbon dioxide which is used in preservation of food especially soft drinks and beers.
c) Carbon dioxide produced is used in bakery industry for raising the dough of bread.

Experiment to Demonstrate the Application of Anaerobic Respiration

Aim: To investigate the products produced during anaerobic respiration.

Materials and Apparatus

Yeast cell, Glucose, Test tube, Warm water, Cotton wool.

Procedure

- Add 1 spatula of glucose in $5cm^3$ of warm water in a test tube.
- Add half spatula of yeast cell in the content above, then shake the test tube.
- Cover the mouth of test with cotton wool.
- Leave the test tube for 10 minutes.
- Remove the cotton wool and smell the contents in the test tube.

Questions

i. How do the contents smell?
ii. Name the gas that is evolved from the test tube after removing the cotton wool.
iii. Explain the importance of covering the mouth of the test tube.
iv. Name the biological process taking place between yeast and glucose.
v. What is the importance of the process in industrial development?

Similarities Between Aerobic and Anaerobic Respiration

i. Glucose is broken down.
ii. Carbon dioxide is released.
iii. Energy is liberated.

However, aerobic respiration differs from anaerobic respiration. The table below shows these differences:

Table 4: Differences Between Aerobic and Anaerobic Respiration

Aerobic respiration	Anaerobic respiration
A lot of energy is released	Little energy is released
Carbon dioxide and water are the end products.	Lactic acid or alcohol is the end product depending on the organism.
Glucose molecules are completely broken down	Glucose molecules are not completely broken down.
Is dependent on oxygen.	Is not dependent on oxygen.
Mitochondria and cell membrane are the sites of respiration	Cytoplasm is the sites of respiration

Infectious Diseases and Disorders of Respiratory System

Let us now learn about some of the diseases and disorders of the respiratory system, but before you proceed look at Table 5 which shows the summary of these diseases.

Table 5: Diseases of respiratory system and their effects

Diseases	Effect
Asthma	Severe allergic reaction characterized by the constriction of bronchioles.
Bronchitis	Inflammation of lining of the bronchioles
Emphysema	Condition in which the alveoli deteriorate, causing the lungs to lose their elasticity.
Pneumonia	Condition in which the alveoli become filled with fluid preventing the exchange of gases.
Lung cancer	Irregular and uncontrolled growth of tumours in the lung tissue.

Having seen the general picture of infectious diseases you can now learn them in deep.

1. Asthma

Asthma includes a group of long lasting (chronic) disorders which restrict the airways of the lungs. This may be due to muscular spasms, inflammation and production of excess mucus. Can you tell what causes asthma?

(a) Causes

The factors which trigger an asthma attack are such as anxiety, stress, infection, cold air and specific substances to which an individual is allergic.

For example, certain foods (e.g. milk or eggs), pollen grains, fungal spores and animal hair can provoke an asthma attack to some individuals. These factors prevent air flow to the alveoli which may result into asthma. Asthma is also inherited from the parents. Let us see how people with asthma can be treated.

(b) Treatment and Prevention

The treatment of asthma varies and it can include a number of drugs as outlined below:

i) Taking substances/chemical which can open up the constricted airways of the lungs.

ii) Taking agents which prevent the accumulation of cells at inflammatory sites.

iii) Using antihistamine to prevent inflammation.

iv) Avoiding exposing yourself in the situation such as dirty, smoke, pollen grains, stress, and cold air.

Let us see how the breakdown of alveoli (emphysema) can also affect the respiratory tract.

2. Emphysema

This refers to breakdown of alveoli. Alveoli are sac like substances of the lungs which provide the surface area for exchanging gases (gaseous exchange).

(a) Causes

It is caused by the smoke from different substances such as tobacco.

(b) Effects

The irritant substances in the smoke causes cough and the coughing bursts some of the weakened alveoli. The absorption capacity of the lungs is greatly reduced. Hence the Oxygen in the blood is also reduced.

(c) Symptoms

In its early stages, the only symptom is slightly breathlessness. People with emphysema usually die of respiratory failure. This is because the heart becomes enlarged and overworked by trying to pump blood through constricted arteries as a result of lack of oxygen.

(d) Prevention and Control

Emphysema cannot be cured and the disease cannot be reversed. The only way to minimize the chance of getting it is to stop smoking.

Dear learner, how will you feel if your bronchioles are constantly irritating with a lot of inflammation, how are you going to feel? Let us see now the causes of this situation in some people.

3. Chronic Bronchitis

The tars in tobacco irritate the epithelia lining of the bronchial tubes causing them to produce excess mucus. This leads to inflammation called **bronchitis.** The only way of removing this mucus is by coughing. However, at times it leads to narrowing and scarring of the bronchial tubes causing breathlessness.

Over 95% of people suffering from bronchitis are smokers and have a twenty times greater chance of dying from bronchitis than non-smokers.

What are the effects of smoking?

Dear learner, have you realized that smoking is dangerous to you or anyone else? Let us continue, and see another respiratory disease (lung cancer) which is killing many people in this world.

4. Lung Cancer

Cancer can occur at any time and age. However, overall incidences rise rapidly with age and they cause death in men than in women. The most common lung cancer is **bronchial carcinoma.**

Its major cause is smoking tobacco. The tars in tobacco smoke may induce the epithelial cells lining the bronchial tubes to become cancerous i.e. get cancer. If not treated early, it may completely disrupt the functioning of the lung. The only quick treatment of tumours could be surgical removal which is also very complicated.

A highly persistent coughing of blood in the sputum and chest pains are all symptoms of lung cancer.

Note: Most of the respiratory diseases and disorders can be prevented by avoiding smoking, strong alcohol and others.

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5. Tuberculosis

Tuberculosis (TB) can attack any part of the body such as the kidneys, ureter, bladder, uterus, bones or the skin. The most common is lung tuberculosis.

Cause

This disease is caused by a bacillus bacterium known as *Mycobacterium tuberculosis*. It is a bacterium which can live for a long time in dust.

Symptoms

The patient has fever, cough, pain in the chest on breathing, tiredness, loss of appetite, sweating especially at night, loss of body weight and becomes very thin.

Mode of Transmission

When a patient suffering from tuberculosis coughs, she/he discharges bacteria into the air. When the contaminated air or dust is inhaled by another person the bacteria enter the respiratory system, settle in the lungs and cause pulmonary tuberculosis. The bacteria break down lung tissue and a cavity may form. This causes a large part of the lung to be destroyed. Overcrowding helps the spread of tuberculosis too.

Prevention

BCG vaccination of children causes immunity which reduces the dangers of spreading the disease. The Bacillus of Calmette and Guerin vaccine (BCG) is commonly used for preventing TB.

Treatment

It is treated by the use of drugs, i.e. antibiotics. It is important to start treatment as early as possible. The disease takes some time to be cured. In certain cases it may become necessary to remove part of the lung by an operation. However, a healthy body normally withstands TB attacks. In this case, HIV/AIDS patients who have low body immunity are more vulnerable to be attacked by respiratory diseases such as Tuberculosis.

Ways of Preventing and Controlling Infections and Diseases of the Respiratory System

i. Avoid smoking.

ii. Exercise regularly.

iii. Stay warm because cold weather makes the body more susceptible to bacterial infections.

iv. Avoid things that cause allergic reactions eg. animal fur, pollen grains, dust, body sprays.

v. Stay in well ventilated buildings.

vi. Avoid overcrowding places.

vii. Make use of face masks when necessary.

Unit Reflection

1. How can you use the knowledge gained in this unit to help you and your society to improve the economy?
2. Do you think this unit can help you to specialize in which field you wish later on? How?
3. Which part in this unit was difficult to you? Give reasons.
4. How did you overcome difficulties stated in no. 3 above?
5. What is the most important information you learned from this unit?

Unit Assignment

After completing this unit, now answer the following questions then keep your work in your portfolio:

1. Why is energy production without oxygen is of great importance to man and plants? What benefit do we get from this kind of energy production?
2. (a) Discuss four diseases of the respiratory system in human being.

   (b) Explain causes, symptoms and effects of the three disorders of the respiratory system.
3. (a) Differentiate between aerobic respiration and anaerobic respiration.

   (b) Write down the importance of fermentation.

   (c) Explain what Oxygen debt is.

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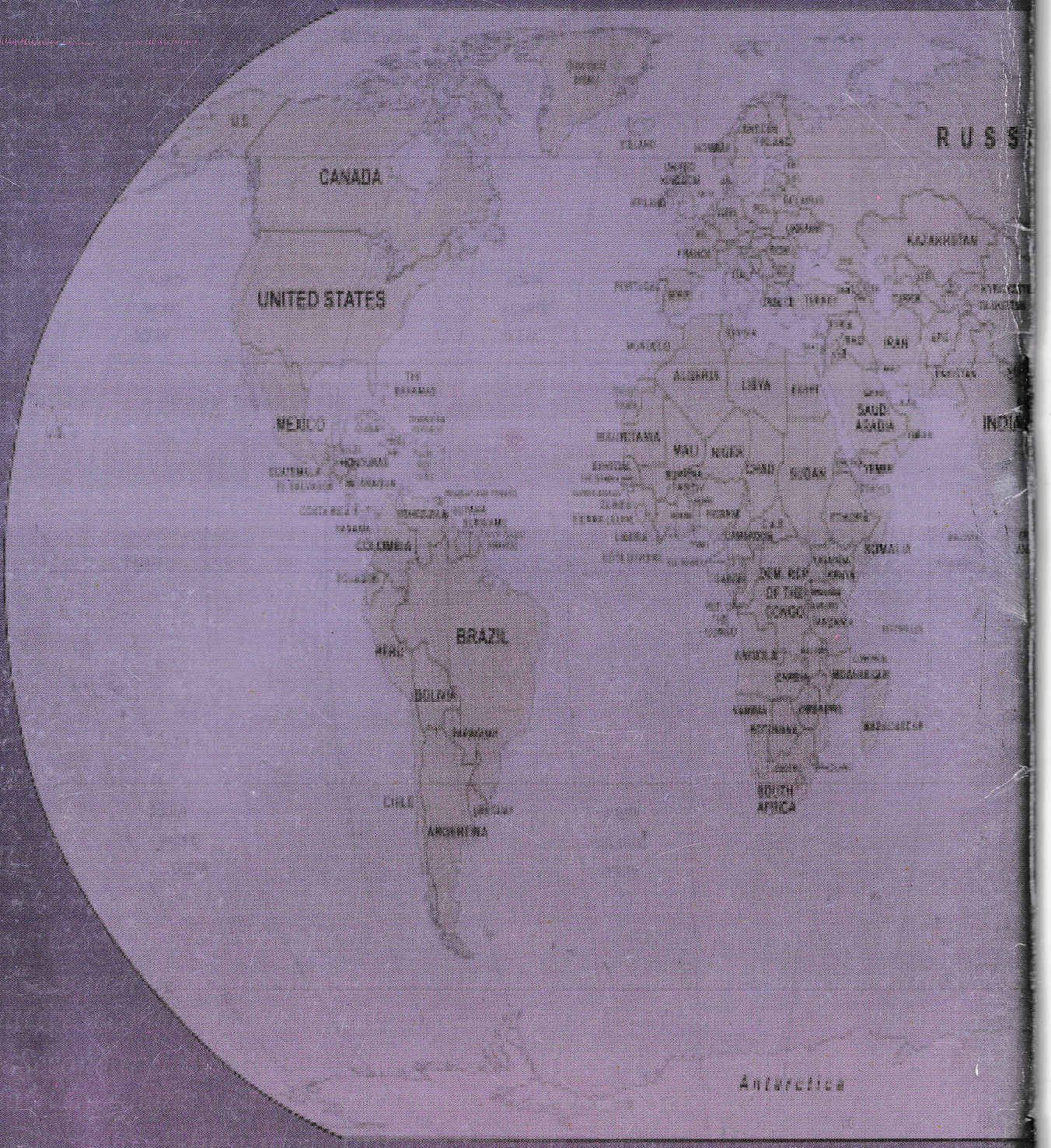

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