

BIOLOGY FOR TTCs

TUTOR'S GUIDE

YEAR TWO

OPTION:

Sciences and Mathematics Education (SME)

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FOREWORD

Dear Tutor,

Rwanda Basic Education Board is honored to present tutor's guide for Biology in Science And Mathematics Education (SME) Option, Year Two of TTC which serves as a guide to competence-based teaching and learning to ensure consistency and coherence in the learning of Biology subject. The Rwandan educational philosophy is to ensure that student-teachers achieve full potential at every level of education which will prepare them to be well integrated in society and exploit employment opportunities.

In line with efforts to improve the quality of education, the government of Rwanda emphasizes the importance of aligning teaching and learning materials with the syllabus to facilitate their learning process. Many factors influence what they learn, how well they learn and the competences they acquire. Those factors include the relevance of the specific content, the quality of tutor' pedagogical approaches, the assessment strategies and the instructional materials available. We paid special attention to the activities that facilitate the learning process in which student-teachers can develop ideas and make new discoveries during concrete activities carried out individually or with peers. With the help of the tutor student-teachers will gain appropriate skills and be able to apply what they have learnt in real life situations. Hence, they will be able to develop certain values and attitudes allowing them to make a difference not only to their own life but also to the nation.

This is in contrast to traditional learning theories which view learning mainly as a process of acquiring knowledge from the more knowledgeable who is mostly the teacher. In competence-based curriculum, learning is considered as a process of active building and developing of knowledge and understanding, skills and values and attitude by the student-teacher where concepts are mainly introduced by an activity, situation or scenario that helps the student-teacher to construct knowledge, develop skills and acquire positive attitudes and values.

In addition, such active learning engages student-teachers in doing things and thinking about the things they are doing and they are encouraged to bring their own real experiences and knowledge into the learning processes. In view of this, your role is to:

- Plan your lessons and prepare appropriate teaching and learning materials.
- Organize group discussions for student-teachers considering the importance of social constructivism suggesting that learning occurs

more effectively when the student-teacher works collaboratively with more knowledgeable and experienced people.

- Engage student-teachers through active learning methods such as inquiry methods, group discussions, research, investigative activities and group and individual work activities.
- Provide supervised opportunities for student-teachers to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication and cooperation.
- Support and facilitate the learning process by valuing student-teachers' contributions in the class activities.
- Guide student-teachers towards the harmonization of their findings.
- Encourage individual, peer and group evaluation of the work done in the classroom and use appropriate competence-based assessment approaches and methods.

To facilitate you in your teaching activities, the content of this tutor's guide is self-explanatory so that you can easily use it. It is divided in 3 parts:

The part 1: Explains the structure of this tutor's guide and gives you the methodological guidance;

The part 2: Gives the sample lesson plans as reference for your lesson planning process;

The part 3: Provides the teaching guidance for each concept given in the student book.

This tutor's guide contains the Answers to all activities given in the student-teacher's book, you are requested to work through each question and activity before judging student-teacher's findings.

I wish to sincerely appreciate all people who contributed towards the development of this tutor's guide, particularly REB staff who organized the whole process from its inception. Special gratitude goes to University lecturers, school teachers, illustrators and designers who diligently worked to successful completion of this tutor's guide. Any comment or contribution would be welcome for the improvement of this tutor's guide for the next edition.

Dr. MBARUSHIMANA Nelson

Director General of Rwanda Basic Education Board

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PART I. GENERAL INTRODUCTION

1.0 About the tutor's guide

This book is a tutor's guide for Biology subject, Year two in TTC. It is designed to accompany student teacher's book and intends to help tutors in the implementation of competence based curriculum specifically Biology syllabus.

As the name says, it is a guide that tutors can refer to when preparing their lessons. Tutors may prefer to adopt the guidance provided but they are also expected to be more creative and consider their specific classes' contexts and prepare accordingly.

1.1 The structure of the guide

This section presents the overall structure, the unit and sub-heading structure to help tutors to understand the different sections of this guide and what they will find in each section.

Overall structure

The whole guide has three main parts as follows:

- **Part I: General Introduction.**

This part provides general guidance on how to develop the generic competences, how to integrate cross cutting issues, how to cater for student-teachers with special educational needs, active methods and techniques of biology and guidance on assessment.

- **Part II: Sample lesson plan**

This part provides a sample lesson plan, developed and designed to help the tutor develop their own lesson plans.

- **Part III: Unit development**

This is the core part of the guide. Each unit is developed following the structure below. The guide ends with references.

Each unit is made of the following sections:

- **Unit title:** This comes from the syllabus.
- **Key unit competence:** is found also in the syllabus.

- **Prerequisites (knowledge, skills, attitudes and values)**

This section indicates knowledge, skills and attitudes required for the success of the unit. The competence-based approach calls for connections between units/topics within a subject and interconnections between different subjects. The tutor will find an indication of those prerequisites and guidance on how to establish connections.

- **Cross-cutting issues to be addressed**

This section suggests cross cutting issues that can be addressed depending on the unit content. It provides guidance on how to come up with the integration of the issue. Note that the issue indicated is a suggestion; tutors are free to take another cross-cutting issue taking into consideration the learning environment.

- **Guidance on the introductory activity**

Each unit starts with an introductory activity in the student-teacher's book. This section of the tutor's guide provides guidance on how to conduct this activity and related answers. Note that student-teachers may not be able to find the right solution but they are invited to predict possible solutions or answers. Solutions are provided by student-teachers gradually through discovery activities organized at the beginning of lessons or during the lesson.

- **List of lessons/sub-heading**

This section presents in a table suggestion on the list of lessons, lesson objectives copied or adapted from the syllabus and duration for each lesson. Each lesson /subheading is then developed.

- **End of each unit**

At the end of each unit the tutor's guide provides the following sections:

- Summary of the unit which provides the key points of content developed in the student-teacher's book.
- Additional information which provides additional content compared to the student-teacher's book for the tutor to have a deeper understanding of the topic.
- End unit assessment which provides answers to questions of the end unit assessment in the student-teacher's book and suggests additional questions and related answers to assess the key unit competence.
- Additional activities : (remedial, consolidation and extended activities). The purpose of these activities is to accommodate each student-teacher (slow, average and gifted) based on the end of unit assessment results.

Structure of each sub heading

Each lesson/sub-heading is made of the following sections:

Lesson /Sub heading title 1:

- **Prerequisites/Revision/Introduction:**

This section gives a clear instruction to tutor on how to start the lesson.

- **Teaching resources**

This section suggests the teaching aids or other resources needed in line with the activities to achieve the learning objectives. Tutors are encouraged to replace the suggested teaching aids by the available ones in their respective schools and based on learning environment.

- **Learning activities**

This section provides a short description of the methodology and any important aspect to consider. It provides also answers to learning activities with cross reference to student-teacher's book.

- **Exercises/application activities**

This provides questions and answers for exercises/ application activities.

1.2 Methodological guidance

1.2.1 Developing competences

Since 2015 Rwanda shifted from a knowledge based to a competence based curriculum for pre-primary, primary and general secondary education. For TTCs, it is in 2019 that the competence based curriculum was embraced. This called for changing the way of learning by shifting from teacher centered to a learner centered approach. Tutors are not only responsible for knowledge transfer but also for fostering student-teacher's learning achievement, and creating safe and supportive learning environment. It implies also that a student-teacher has to demonstrate what he/she is able to do using the knowledge, skills, values and attitude acquired in a new or different or given situation.

The competence-based curriculum employs an approach of teaching and learning based on discrete skills rather than dwelling on only knowledge or the cognitive domain of learning. It focuses on what learner can do rather than what learners know. Student-teachers develop basic competences through specific subject unit competences with specific learning objectives broken down into knowledge, skills and attitudes. These competences are developed through learning activities disseminated in learner-centered rather than the traditional

didactic approach. The student-teachers are evaluated against set standards to achieve before moving on.

In addition to specific subject competences, student-teachers also develop generic competences which are transferable throughout a range of learning areas and situations in life. Below are examples of how generic competences can be developed in Biology:

Generic competence	Examples of activities that develop generic competences
Critical thinking	<ul style="list-style-type: none"> - Describe the relationship and interdependence of sciences - Observe, record, interpret data recorded during experiments - Identify and use the applications of Biology concepts to solve problems of life and society
Research and Problem solving	<ul style="list-style-type: none"> - Research using internet or books from the library - Design a project for making bioplastics - Design a questionnaire for data collection during field visit
Innovation and creativity	<ul style="list-style-type: none"> - Create an experiment procedure to prove a point - Develop a graph to illustrate information - Design a data collection survey/questionnaire - Conduct experiments with objectives, methodology, observations, results, conclusions - Identify local problems and ways to resolve them
Cooperation, Personal and Interpersonal management and life skills	<ul style="list-style-type: none"> - Work in Pairs - Small group work - Large group work

Communication	<ul style="list-style-type: none"> - Organise and present in writing and verbally a complete and clear report of an experiment - Observe, record, interpret the results of a measurement accurately. - Select and use appropriate formats and presentations, such as tables, graphs and diagrams.
Lifelong learning	- Exploit all opportunities available to improve on knowledge and skills. Reading scientific journals to keep updated.

1.2.2 Addressing cross cutting issues

Among the changes in the competence based curriculum is the integration of cross cutting issues as an integral part of the teaching learning process-as they relate to and must be considered within all subjects to be appropriately addressed. The eight cross cutting issues identified in the national curriculum framework are: genocide studies, environment and sustainability, gender, Comprehensive Sexuality Education (CSE), Peace and Values Education, Financial Education, standardization Culture and Inclusive Education.

Some cross cutting issues may seem specific to particular learning areas or subjects but the tutor needs to address all of them whenever an opportunity arises. In addition, student-teacher should always be given an opportunity during the learning process to address these cross cutting issues both within and out of the classroom so as to progressively develop related attitudes and values.

Below are examples on how crosscutting issues can be addressed in Biology:

Cross-cutting issues	Examples on how to integrate the cross-cutting issues
Inclusive education	<p>Involve all student-teachers in all activities without any bias.</p> <p>Eg: Allow a student-teacher with physical disability (using wheelchair) to take notes or lead the team during an experiment.</p>

Gender	<p>Involve both girls and boys in all activities: No activity is reserved only to girls or boys.</p> <p>Tutor should ensure equal participation of both girls and boys during experiments as well as during cleaning and tidying up related activities after experiments.</p>
Peace and Values Education	<p>During group activities, debates and presentations, the tutor will encourage student-teachers to help each other and to respect opinions of colleagues.</p>
Standardization culture	<ul style="list-style-type: none"> - Some lessons involve carrying out experiments. Instruction should be clear for student-teachers to always check if they are not using expired chemicals or defective apparatus. - In addition, when performing experiments student-teachers have to record data accurately. - For tasks involving calculations, they have to always present accurate results.
Environment and sustainability	<ul style="list-style-type: none"> - In order to avoid the environment pollution, before, during or after experiments student-teachers avoid throwing away chemicals anywhere; special places or appropriate containers should be used. - Student-teachers also have to be aware of the impacts of the use of hydrocarbons as fuels, halogenoalkanes, and plastics on the environment.
Financial Education	<p>When performing experiments, student-teachers are encouraged to avoid wasting chemicals by using the quantities that are just required. They are required to also avoid spoiling equipments and other materials...</p>

1.2.3 Attention to special educational needs specific to each subject

In the classroom, student-teachers learn in different way depending to their learning pace, needs or any other special problem they might have. However, the tutor has the responsibility to know how to adopt his/her methodologies and approaches in order to meet the learning needs of each student-teacher in

the classroom. Also tutor must understand that student-teachers with special needs need to be taught differently or need some accommodations to enhance the learning environment. This will be done depending on the subject and the nature of the lesson.

In order to create a well-rounded learning atmosphere, tutor needs to:

- Remember that student-teachers learn in different ways so they have to offer a variety of activities (e.g. role-play, music and singing, word games and quizzes, and outdoor activities).
- Maintain an organized classroom and limits distraction. This will help student-teachers with special needs to stay on track during lesson and follow instruction easily.
- Vary the pace of teaching to meet the needs of each student-teacher. Some student-teachers process information and learn more slowly than others.
- Break down instructions into smaller, manageable tasks. Student-teachers with special needs often have difficulty understanding long-winded or several instructions at once. It is better to use simple, concrete sentences in order to facilitate them understand what you are asking.
- Use clear consistent language to explain the meaning (and demonstrate or show pictures) if you introduce new words or concepts.
- Make full use of facial expressions, gestures and body language.
- Pair a student-teacher who has a disability with a friend. Let them do things together and learn from each other. Make sure the friend is not over protective and does not do everything for the student-teacher. Both student-teachers will benefit from this strategy
- Use multi-sensory strategies. As all student-teachers learn in different ways, it is important to make every lesson as multi-sensory as possible. Student-teachers with learning disabilities might have difficulty in one area, while they might excel in another. For example, use both visual and auditory cues.

Below are general strategies related to each main category of disabilities and how to deal with every situation that may arise in the classroom. However, the list is not exhaustive because each student-teacher is unique with different needs and that should be handled differently.

Strategy to help student-teachers with developmental impairment:

- Use simple words and sentences when giving instructions.

- Use real objects that the student-teacher can feel and handle, rather than just working abstractly with pen and paper.
- Break a task down into small steps or learning objectives. The student-teacher should start with an activity that s/he can do already before moving on to something that is more difficult.
- Gradually give the student less help.
- Let the student-teacher work in the same group with those without disability.

Strategy to help student-teachers with visual impairment:

- Help student-teachers to use their other senses (hearing, touch, smell and taste) to play and carry out activities that will promote their learning and development.
- Use simple, clear and consistent language.
- Use tactile objects to help explain a concept.
- If the student-teachers has some sight, ask them what they can see. Get information from parents/caregivers on how the student-teacher manages their remaining sight at home.
- Make sure the student-teacher has a group of friends who are helpful and who allow the student-teachers to be as independent as possible.
- Plan activities so that student-teachers work in pairs or groups whenever possible.

Strategy to help student-teachers with hearing impairment:

- Strategies to help student-teachers with hearing disabilities or communication difficulties
- Always get the student-teacher's attention before you begin to speak.
- Encourage the student-teacher to look at your face.
- Use gestures, body language and facial expressions.
- Use pictures and objects as much as possible.
- Ask the parents/caregivers to show you the signs they use at home for communication use the same signs yourself and encourage other student-teachers to also use them.
- Keep background noise to a minimum.

Strategies to help children with physical disabilities or mobility difficulties:

- Adapt activities so that student-teacher who use wheelchairs or other mobility aids, or other student-teachers who have difficulty moving, can participate.
- Ask parents/caregivers to assist with adapting furniture e.g. The height of a table may need to be changed to make it easier for a student-teacher to reach it or fit their legs or wheelchair under.
- Encourage peer support friends can help friends.
- Get advice from parents or a health professional about assistive devices.

1.2.4 Guidance on assessment

Each unit in the tutor's guide provides additional activities to help student-teachers achieve the key unit competence. Results from assessment inform the tutor which student-teacher needs remedial, consolidation or extension activities. These activities are designed to cater for the needs of all categories of learners; slow, average and gifted learners respectively.

Assessment is an integral part of teaching and learning process. The main purpose of assessment is for improvement. Assessment for learning/ Continuous/ formative assessment intends to improve student-teachers' learning and tutor's teaching whereas assessment of learning/summative assessment intends to improve the entire school's performance and education system in general.

Continuous/ formative assessment

It is an ongoing process that arises out of interaction during teaching and learning process. It includes lesson evaluation and end of sub unit assessment. This formative assessment plays a big role in teaching and learning process. The tutor should encourage individual, peer and group evaluation of the work done in the classroom and uses appropriate competence-based assessment approaches and methods.

In Year two textbook, formative assessment principles is applied through application activities that are planned in each lesson to ensure that lesson objectives are achieved before moving on. At the end of each unit, the end unit assessment is formative when it is done to give information on the progress of students and from there decide what adjustments need to be done. Assessment standards are taken into consideration when setting tasks.

Summative assessment

The assessment done at the end of the term, end of year, is considered as summative. The tutor, school and parents are informed on the achievement of educational objectives and think of improvement strategies. There is also end of level/ cycle assessment in form of national examinations.

1.2.5 Student teachers' learning styles and strategies to conduct teaching and learning process

There are different teaching styles and techniques that should be catered for. The selection of teaching method should be done with the greatest care and some of the factors to be considered are: the uniqueness of subjects, the type of lessons, the particular learning objectives to be achieved, the allocated time to achieve the objective, instructional available materials, the physical/sitting arrangement of the classroom, individual student teachers' needs, abilities and learning styles.

There are mainly four different learning styles as explained below:

a) Active and reflective learners

Active learners tend to retain and understand information best by doing something active with it, discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.

b) Sensing and intuitive learners

Sensing learners tend to like learning facts while intuitive learners often prefer discovering possibilities and relationships. Sensors often like solving problems by well-established methods and dislike complications and surprises; intuitive learners like innovation and dislike repetition.

c) Visual and verbal learners

Visual learners remember best what they see (pictures, diagrams, flow charts, time lines, films, demonstrations, etc.); verbal learners get more out of words (written and spoken explanations).

d) Sequential and global learners

Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it."

1.2.6 Teaching methods and techniques that promote the active learning

The different student-teacher learning styles mentioned above can be catered for, if the tutor uses active learning whereby student-teachers are really engaged in the learning process.

What is Active learning?

Active learning is a pedagogical approach that engages student-teachers in doing things and thinking about the things they are doing. In active learning, learners are encouraged to bring their own experience and knowledge into the learning process.

The role of the tutor in active learning

- The tutor engages student-teachers through active learning methods such as inquiry methods, group discussions, research, investigative activities and group and individual work activities.
- He/she encourages individual, peer and group evaluation of the work done in the classroom and uses appropriate competence-based assessment approaches and methods.
- He provides supervised opportunities for student-teachers to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication and cooperation.
- Tutor supports and facilitates the learning process by valuing student-teachers' contributions in the class activities.

The role of learners in active learning

Learners are key in the active learning process. They are not empty vessels to fill but people with ideas, capacity and skills to build on for effective learning. A learner engaged in active learning:

- Communicates and shares relevant information with other learners through presentations, discussions, group work and other learner-centred activities (role play, case studies, project work, research and investigation)
- Actively participates and takes responsibility for their own learning
- Develops knowledge and skills in active ways
- Carries out research/investigation by consulting print/online documents and resourceful people, and presents their findings

- Ensures the effective contribution of each group member in assigned tasks through clear explanation and arguments, critical thinking, responsibility and confidence in public speaking
- Draws conclusions based on the findings from the learning activities.

Some active techniques that can be used in Biology

The teaching methods strongly emphasised in the competence Based Curriculum (CBC) are active methods. Below are some active techniques that apply in sciences:

A. Practical work/ experiments:

Many of the activities suggested in Biology curriculum as well as in the student-teacher's book are practical works or experiments.

Practical work is vital in learning Biology; this method gives the student-teacher the opportunity to implement a series of activities and leads to the development of both cognitive and hands-on skills. The experiments and questions given should target the development of the following skills in student-teachers: observation, recording and report writing, manipulation, measuring, planning and designing.

A practical lesson/Experiment is done in three main stages:

- **Preparation of experiment:** Checking materials to ensure they are available and at good state; try the experiment before the lesson; think of safety rules and give instructions to lab technician if you have any.
- **Performance of experiment:** Sitting or standing arrangement of student-teachers; introduction of the experiment: aims and objectives; setting up the apparatus; performing the experiment; write and record the data.
- **Discussion:** Observations and interpreting data; make generalisations and assignment: writing out the experiment report and further practice and research.

In some cases, demonstration by the tutor is recommended when for example the experiment requires the use of sophisticated materials or very expensive materials or when safety is a major factor like dangerous experiments and it needs specific skills to be learnt first.

In case your school does not have enough laboratory materials and chemicals, experiments can be done in groups but make sure every student-teacher participates. You can also make arrangements with the neighbouring science school and take your student-teachers there for a number of experiments.

B. Research work

Each student-teacher or group of student-teachers is given a research topic. They have to gather information from internet, available books in the library or ask experienced people and then the results are presented in verbal or written form and discussed in class.

C. Project work

Biology tutors are encouraged to sample and prepare project works and engage their student-teachers in, as many as possible. Student-teachers in groups or individually, are engaged in a self-directed work for an extended period of time to investigate and respond to a complex question, problem, or challenge. The work can be presented to classmates or other people beyond the school. Projects are based on real-world problems that capture learners' interest. This technique develops higher order thinking as the student-teachers acquire and apply new knowledge in a problem-solving context.

D. Field trip

One of the main aims of teaching Biology in Rwanda is to apply its knowledge for development. To achieve this aim we need to show to students the relationship between classroom science lessons and applied sciences. This helps them see the link between science principles and technological applications.

To be successful, the field visit should be well prepared and well exploited after the visit:

Before the visit, the tutor and student-teachers:

- agree on aims and objectives
- gather relevant information prior to visit
- brainstorm on key questions and share responsibilities
- discuss materials needed and other logistical and administrative issues
- discuss and agree on accepted behaviours during the visit
- Visit the area before the trip if possible to familiarise yourself with the place

After the visit

When student-teachers come back from trip, the tutor should plan for follow-up. The follow-up should allow student-teachers to share experiences and relate them to the prior science knowledge. This can be done in several ways;

either: Student-teachers write a report individually or in groups and give to the tutor for marking. The tutor then arranges for discussion to explain possible misconceptions and fill gaps. Or student-teachers write reports in groups and display them on the class notice board for everyone to read.

Main steps for a lesson in active learning approach

All the principles and characteristics of the active learning process highlighted above are reflected in steps of a lesson as displayed below. Generally, the lesson is divided into three main parts whereby each one is divided into smaller steps to make sure that student-teachers are involved in the learning process. Below are those main parts and their small steps:

1) Introduction

Introduction is a part where the tutor makes connection between the current and previous lesson through appropriate technique. The tutor opens short discussions to encourage student-teachers to think about the previous learning experience and connect it with the current instructional objective. The tutor reviews the prior knowledge, skills and attitudes which have a link with the new concepts to create good foundation and logical sequencings.

2) Development of the new lesson

The development of a lesson that introduces a new concept will go through the following small steps: discovery activities, presentation of student-teachers' findings, exploitation, synthesis/summary and exercises/application activities, explained below:

- **Discovery activity**

Step 1

- The tutor discusses convincingly with student-teachers to take responsibility of their learning
- He/she distributes the task/activity and gives instructions related to the tasks (working in groups, pairs, or individual to instigate collaborative learning, to discover knowledge to be learned)

Step 2

- The tutor let the student-teachers work collaboratively on the task.
- During this period the tutor refrains to intervene directly on the knowledge

- He/she then monitors how the student-teachers are progressing towards the knowledge to be learned and boost those who are still behind (but without communicating to them the knowledge).
 - **Presentation of student-teachers' productions**
- In this episode, the tutor invites representatives of groups to present the student-teachers' productions/findings.
- After three/four or an acceptable number of presentations, the tutor decides to engage the class into exploitation of the student-teachers' productions.
 - **Exploitation of student-teachers's productions**
- The tutor asks the student-teachers to evaluate the productions: which ones are correct, incomplete or false
- Then the tutor judges the logic of the student-teachers' products, corrects those which are false, completes those which are incomplete, and confirms those which correct.
- **Institutionalization (summary/conclusion/ and examples)**
- The tutor summarises the learned knowledge and gives examples which illustrate the learned content.
- Exercises/Application activities
- Exercises of applying processes and products/objects related to learned unit/sub-unit
- Exercises in real life contexts
- Tutor guides student-teachers to make the connection of what they learnt to real life situations. At this level, the role of tutor is to monitor the fixation of process and product/object being learned.

3) Assessment

In this step the teacher asks some questions to assess achievement of instructional objective. During assessment activity, student-teachers work individually on the task/activity. The tutor avoids intervening directly. In fact, results from this assessment inform the tutor on next steps for the whole class and individuals. In some cases, the tutor can end with a homework assignment.

PART II: SAMPLE LESSON PLANS

Teacher's name..... School Name:

Term	Date	Subject	Class	Unit N°	Lesson N°	Duration	Class size
1 st	14th January 2020	Biology	Year II, SME	1	1 of 5	80 minutes	40 students
Type of Special Educational Needs and number of learners				2 students with visual impairments			
Unit title		Concept of Ecosystem					
Key Unit Competence:		Explain components of an ecosystem and how energy flows in an ecosystem.					
Title of the lesson		Description of an ecosystem					
Plan for this Class (location: in / outside)		Inside and outside the class					
Instructional Objectives (inclusive to reflect needs of whole class)		Through field visit of ecosystems, students will be able to explain effectively components and the types of ecosystem.					
Learning Materials		A nearby school environment, worksheet, textbooks,					
References		1. Rwanda Education Board (2015). Advanced Level Biology Syllabus (S4-S6). Kigali 2. Kent M. (2000). Advanced Biology. Oxford University Press, Oxford, UK. 3. Campbell, N.A, et al. (2008). <i>Biology, Pearson international Edition, San Francisco, USA, 8th edition</i>					

Timing for each step	Description of teaching and learning activity		Competences and cross cutting issues to be addressed
	Tutor's activities	Learner's activities	
1.Introduction (10 minutes)	<p>Tutor introduces the lesson by asking questions on ecosystems.</p> <p>S/he asks them to predict the components and types of ecosystems.</p> <p>S/he organizes student-teachers in groups and gives the instructions about the field visit to be done and provides Clear guiding worksheet to each group.</p> <p>S/he shares the objectives of the lesson</p>	<p>Student-teachers define the ecosystem individually.</p> <p>Student-teachers predict the components and types of ecosystems.</p> <p>Student-teachers join their respective groups, follow the instructions from the teacher and receive the clear guiding worksheet.</p>	<p>Student-teachers develop communication through listening, answering tutor question and following the instruction.</p> <p>Student-teachers develop critical thinking while thinking and predicting the components and types of ecosystems.</p> <p>Inclusive education is addressed through providing clear guiding worksheet to each group.</p>
2.Development of the lesson			
40 Minutes			

<p>2.1. Discovery activity (10 minutes)</p>	<p>The tutor asks student-teachers to move out in the field visit in school environment nearby the school with their guiding worksheet.</p> <p>Through questioning technique, tutor helps student-teachers to identify the components and types of ecosystem. Guiding worksheet should be clear to everyone.</p> <p>Tutor instructs student-teachers to take care of environment while walking towards the field to visit.</p> <p>Tutor asks to follow guiding worksheet and answer all questions of guiding worksheet.</p> <p>Tutor monitors how the student-teachers activities</p>	<p>Student-teachers follow the direction of the tutor who orients the class to the nearest school environment</p> <p>Observe individually the school environment and answer the questions written on guiding worksheet.</p> <p>Student-teachers follow the instruction of taking care the environment while walking towards the field to visit.</p> <p>Student-teachers follow guiding worksheet and answer questions on guiding worksheet</p> <p>Exchange and supplement ideas to brainstorm the characteristics and components of environment.</p>	<p>Environment and sustainability is addressed while taking care of environment during field visit.</p> <p>Student-teachers develop communication through listening and discussing while answering the guiding questions.</p> <p>Student-teachers develop critical thinking through answering questions</p> <p>Student-teachers develop Cooperation through working together and helping each other in answering questions.</p>
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<p>2.2. Presentation of findings (15minutes)</p>	<p>Bring students back in the classroom and gives them opportunity to present their findings in form of brainstorm</p> <p>Ask further questions to make sure that even students with special education need are involved in the learning process.</p>	<p>Present their findings and supplement to each other</p> <p>The visited area is school environment containing living things such as plants, insects, flies, maggot, cows, pigs etc and live on land and non-living things such as stones, houses.</p>	<p>Communication through making presentation of their works, working in groups, and from producing a poster</p> <p>Inclusive education</p> <p>During observation, the teacher will assist blind students and provide them as much as possible information related to the area visited. If possible, allow them to use other senses that will allow them to have an idea on the area visited. They will also be given time to present what has been discussed in groups.</p>
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<p>2.3. Exploitation of students findings (10 minutes)</p>	<p>Asks learners to relate what they discussed with ecosystem</p>	<p>By using critical thinking and logical reasoning, learners relate what they have seen to the ecosystem</p> <p>The group of those living (e.g. insects, cows) and non-living things (e.g. stones) together with their environment make an ecosystem. They are considered as the components of school ecosystem.</p> <p>They live on land but other living things (e.g. fish live in water)</p>	<p>Student-teachers develop critical thinking through answering questions.</p> <p>Gender education is addressed through inviting both girls and boys to make presentation.</p>
<p>2.4. Conclusion: 5 minutes</p>	<p>Choose randomly at least three students and ask them to summarize (one by one) what they have learnt from this lesson.</p>	<p>The students summarize the lesson</p>	<p>Communication skill expressed through their confidence to answer the question</p>

<p>3. Assessment (30 min)</p>	<p>Put the following questions on a Manila paper and organizes a gallery walk to answer them:</p> <ol style="list-style-type: none"> 1. Define an ecosystem 2. Describe the components of ecosystem 3. Explain the types of ecosystem 	<p>Learners move around the classroom to read questions and answer the questions:</p> <p>An ecosystem consists of a natural unit consisting of all the living organisms in an area functioning together with all the non-living physical factors of the environment</p> <p>Abiotic (non-living things) and biotic (living things)</p> <p>Aquatic and terrestrial</p>	<p>Cross cutting issue:</p> <p>Environment and sustainability awareness as they learn the ecosystem.</p> <p>Inclusive education:</p> <p>The students with visual impairments can do the assessment orally or using computer if they have the right software installed in the machine.</p>
<p>Comments on the lesson delivery</p>	<p>The lesson was conducted very nicely since every learner was involved and is capable to achieve the key competence of the lesson</p>		

PART III: UNIT DEVELOPMENT

UNIT 1

CONCEPT OF ECOSYSTEM

1.1 Key unit competence :

Explain components of an ecosystem and how energy flows in an ecosystem.

1.2 Prerequisite

To understand more this unit, make sure that the learners have learned and have understood well the unit “Introduction to biodiversity” of year I integrated science which is closely related with the concept of ecosystem. Before starting to introduce this unit, make sure also that the learners have already revised well the knowledge, skills, attitudes and values of introduction to biodiversity

1.3 Cross cutting issues to be addressed

Within this unit, environment and sustainability in addition to inclusive education will be addressed by this unit.

a. Environment and sustainability will be addressed when students will acknowledge the interdependence between species living in the same area. They will understand it when they can express what will happen if one component in an area is missing or exist in a big number and suggest what can be done since there is relationship among the living things. Learners should be encouraged to maintain the environment and sustainability in proper way by avoiding the depletion or degradation of natural resources and thereby supporting long-term ecological balance. The learners should know that when one of the components of environment either biotic or abiotic component is damaged/ destroyed or removed; it affects automatically the life of all living things.

b. Inclusive education

Since, there are many pictures within this unit; special attention arrangement should be paid for catering the students with special needs. You should provide braille/ tactile or using a scenario for visual impairment learners. There is also need to use sign languages for involving the learners in class activities.

If you may make the pictures by yourself or using projector, the attention should be made for the clarity as well as visibility. Since some learning activities require to take students outside the school, students without disabilities should be sensitized to support their colleagues. To seek for the information regarding the child from the parents about how they often communicate with children at home.

1.4 Guidance on introductory activity 1

Introduce the unit by using pictures of introductory activity 1 and proceed as follow:

- Invite the learners to observe the pictures of introductory activity

Give time to think about the given questions and allow them to express their ideas:

- Living things e.g animals like giraffe, zebra and zebra, and antelope
- It gains energy by eating plants, because it is herbivore , it feeds on plants.
- Once the plant species are removed from picture C, the life will be possible for some species. First because, the herbivores feed on plants in order to survive meaning that, the herbivores will die, once they die, the carnivores found in the ecosystem will be affected then will die

- Consider their ideas and then inform what they will learn in this unit

1.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1	Description of an ecosystem	<ul style="list-style-type: none"> - Describe the main components of an ecosystem - Explain the ecological factors influencing the life of organisms in an ecosystem. 	2 periods
2	Energy flow in ecosystems	<ul style="list-style-type: none"> - Analyze the relationship between organisms and their trophic levels. - Explain the relative merits of pyramids of numbers, biomass and energy. 	2 periods

3	Ecological succession	- Distinguish between primary and secondary succession in biotic communities	1 period
4	Bioaccumulation and Bio magnification	- Beware of the effect of bioaccumulations at different trophic levels.	1 period
5	Efficiency of production	- Compare gross primary, net primary production and secondary production.	2 periods
6	End unit assessment		2 periods

Lesson 1: Description of an ecosystem

a) Learning objective

- Describe the main components of an ecosystem
- Explain the ecological factors influencing the life of organisms in an ecosystem.

b) Teaching resources

- Charts and illustrations indicating the ecosystems.
- Video/ movies of ecosystem downloaded from you-tube
- The school environment.
- Projector
- Student books, pictures
- Water bodies, such as lakes, ponds, dams, school aquarium

c) Prerequisites/Revision/Introduction

The prerequisites of the lesson definition, components and types ecosystem are some ecological terms that learners learned in year I, unit 1 introduction to biodiversity, those terms will facilitate the learners to understand more about this unit. Those terms are: ecology, biodiversity, species, population, community and niche.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups

- Provide an activity 1.1 given in student textbook and ask learners to do the related questions, attribute to each group,
- Facilitate them in that activity
- Harmonize the lesson by using student findings and conclude the lesson by asking some questions related to the lesson
- Ask some questions to check whether they agree with the findings from their colleagues
- Learners in their groups present their findings. In their groups, the learners are going to do an activity 1.1 in student book

Answers for activity 1.1

1. a. The table showing the observable differences between A, B, C and D

A	B	C	D
<ul style="list-style-type: none"> - One species of animal (antelope/ goat) - One species of plants 	<ul style="list-style-type: none"> - three animals which are the same (antelopes/ goats) in physical appearance - Two different plants 	<ul style="list-style-type: none"> - four different animals (bird, rabbit, antelope and dog) - 3 different plants - soil 	Three different animals (bird, crocodile and lion) <ul style="list-style-type: none"> - soil - plants - water - sky

a. Living things : animals (bird, crocodile and lion), plants of different species

Non -living things/components: soil, water

2. G → D → B → A or G → F → B → A or G → F → C → B → A

e) Application activity 1.1

Guidance

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 1.1.

Answers for Application activities 1.1

Three aquatic ecosystems found in Rwanda lakes: (Kivu, Muhazi), rivers: (Nyabarongo), ponds. Three terrestrial ecosystems found in Rwanda: forest, grasslands, savanna

3. An ecosystem consists of a natural unit consisting of all the living organisms in an area functioning together with all the non-living physical

factors of the environment. The concept of an ecosystem can apply to units of different sizes. For example, a large body of fresh water could be considered an ecosystem, and so could a small piece of dead wood. Both contain a community of species that interact with one another and with the abiotic components of their environment.

Lesson 2: Energy flow in ecosystems

a) Learning objective

- Analyze the relationship between organisms and their trophic levels.
- Explain the relative merits of pyramids of numbers, biomass and energy

b) Teaching resources

- Charts and illustrations indicating different types of ecosystems.
- Video/ movies of ecosystem downloaded from you tube
- Student books, pictures, internet
- Projector

c) Prerequisites/Revision/Introduction

Introduce this lesson by this scenario. I am driving a car. Arriving at a certain area, my car stops moving. Brainstorm on the cause of such an event? From the learners' ideas, probe what will happen if the similar case of lacking fuel/energy occurs to a cow or any other animal?

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form pairs.
- Provide an activity 1.2 to the learners and ask them to do the related questions, attribute to each pair, the activity 1.2 given in student textbook
- In their pairs, the learners are going to do an activity 1.2
- Facilitate them in that activity
- Let learner pairs to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson

Answers for activity 1.2

Producers absorb energy from sun by the help of chlorophyll, then it is converted into chemical energy during photosynthesis, A consumes the producer and gets that energy, then B kills A, it gets it from A, lastly C breaks down B and it gets that energy from B. Remember that the energy is not recycled but however some energy is lost in form of heat. Some energy from A to C is lost as heat during excretion, egestion and breathing out.

- 1) A= Primary consumer, B= Secondary consumer, C= decomposer
- 2) Decomposers are generally located on the bottom of ecosystem diagrams such as food chains, food webs, and energy pyramids, decomposers in the biosphere are crucial to the environment. By breaking down dead material, they provide the nutrients that other organisms need to survive. As decomposers feed on dead organisms, they leave behind nutrients. These nutrients become part of the soil. Therefore, more plants can grow and thrive. E.g. Bacteria and fungi
- 3) When A is removed from the diagram.
- 4) When A is removed from the diagram, B will die due to lack of food, while producers will increase

Guidance

Ask student-teachers to work individually or in pairs or in groups to answer the questions of application activity 1.2.

Answers for application activities 1.2

a. The continued trampling of numerous animals in an average forage land will act to accelerate the death of plants and vegetation cover. This is because the animals will graze even on the slightest shoots of new growth. Without the plants or vegetation cover, the soil is left bare and exposed to harsh weather such as heavy downpour and high temperatures which disintegrates the rocks and carries the top soil away. Animals also prefer gathering at specific areas, like next to water sources, and such areas can get eroded.

b. Herbivores are animals that consume only plants for their dietary needs. The extinction of an herbivore would have a debilitating effect for the carnivores that probably fed on this type of animal. Now the carnivores have one less meal choice to choose from. So that will put a strain on the other animals considered prey for the carnivores.

c. Soil erosion, land degradation, loss of valuable species will appear in Akagera national park

Lesson 3: Ecological succession

a) Learning objective

- Distinguish between primary and secondary succession in biotic communities

b) Teaching resources

Books, charts showing ecological succession.

c) Prerequisites/Revision/Introduction

Introduce this lesson by telling the learners that when bushes are cleared by fire, after sometimes the bushes will appear.

d) Learning activities 1.3

- Facilitate them in that activity
- Let learner pairs to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson

Answers for activity 1.3

The first species to colonize a disturbed area are called pioneer species including bacteria and lichens that can live on bare rock. These species change the environment and make the way for other species to come into the area. Along with wind and water, they help weather the rock and form soil. Once soil begins to form, plants can move in from pioneer species to intermediate stages and finally to climax communities

d) Application activity 1.3

Guidance

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 1.3.

Application activities 1.3

This type of succession is faster because the soil is already in place. In this case, the pioneer species are plants such as grasses, birch trees, and fireweed. Organic matter from the pioneer species improves the soil and lets other plants move into the area.

Lesson 4: Bio-accumulation and Bio-magnification

a) Learning objective

- Analyze the relationship between organisms and their trophic levels
- Beware of the effect of bio-accumulations at different trophic levels

b) Teaching resources

- Charts and illustrations indicating different types of ecosystems.
- Resourceful person like agriculture and veterinary officers
- Insecticides, herbicides, acaricides and fertilizers.
- Video/ movies showing bioaccumulation and bio magnifications downloaded from you tube
- Student books, pictures showing the bioaccumulation and bio-magnifications, internet
- Projector

c) Prerequisites/Revision/Introduction

Introduce this lesson by asking the learners to make critical thinking on this scenario. A sample of milk was taken from a breast feeding mother by the doctor in a certain hospital. It was tested and results indicated that it contained an insecticide DDT. Suggest one reason to explain why there was DDT in breast milk

d) Learning activities

Help the learners in developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups
- Provide activity 1.4 given in student textbook ask them to do the related questions
- Facilitate them in that activity
- Let learner groups to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize together with students and conclude the lesson

Answers for activity 1.4

Bioaccumulation refers to the accumulation of toxic / chemical substances (such as pesticides, or other chemicals in the tissue of a particular organism while Bio magnification is a process by which chemical substances become more concentrated at each trophic level.

e) Application activity 1.4

Guidance

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 1.4.

Answers for application activities 1.4

At a lower trophic level, it is where the biological magnification increases the concentration of toxins up the food chain.

Lesson 5: Efficiency of production

a) Learning objective

Compare gross primary, net primary production and secondary production

b) Teaching resources

- Charts and illustrations indicating different types of ecosystems.
- Video/ movies showing the efficiency of ecological production downloaded
- Student books, pictures, internet
- Projector

c) Prerequisites/Revision/Introduction

Introduce this lesson by challenging the learners through questions related to energy flow, do you think all the food energy obtained by any organism will be given off or maintained? Allow learners to give their point of view, use them and move to the activities of this lesson.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups
- Attribute the activity 1.5 given in student textbook.
- Allow the learners to use the school library and the internet
- facilitate them in that activity
- Let learner groups to present their findings

- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson
- In either individually, pairs or groups, the learners are going to do activity 2.5 in student book

Answers for activities 1.4

The efficiency at which energy is transferred from one trophic level to another is called ecological efficiency. On average it is estimated that there is only a 10 percent transfer of energy.

Consumers convert the chemical energy of their food into their own biomass is called secondary productivity.

Ecosystems are full of energy and how that is transferred is important. First we start with the biomass, the total potential energy from biological material within an ecosystem

Gross primary production (GPP) is the amount of chemical energy as biomass that primary producers create in a given length of time. (GPP is sometimes confused with Gross Primary productivity, which is the rate at which photosynthesis or chemosynthesis occurs.) Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues (i.e., “growth respiration” and “maintenance respiration”).

The remaining fixed energy is referred to as net primary production (NPP).
 $NPP = GPP - \text{respiration}$

Net primary production is the rate at which all the plants in an ecosystem produce net useful chemical energy; it is equal to the difference between the rate at which the plants in an ecosystem produce useful chemical energy (GPP) and the rate at which they use some of that energy during respiration. Some net primary production goes toward growth and reproduction of primary producers, while some is consumed by herbivores.

Both gross and net primary production are in units of mass per unit area per unit time interval. In terrestrial ecosystems, mass of carbon per unit area per year ($\text{g C m}^{-2} \text{ yr}^{-1}$) is most often used as the unit of measurement.

e) Application activity 1.5

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 1.5.

Answers for application activities 1.5

- 1) There are many things they could do to reduce their production efficiency. For example, exercising vigorously will use energy that might otherwise go to biomass, and keeping the house cool will force their bodies to use energy to stay warm
- 2) Nicotine protects the plant from herbivores
- 3) a) Insect's net secondary production = $100\text{J} - 50\text{J} - 30\text{J} = 20\text{J}$.
b) The production efficiency: In their respective groups, the student calculates the production efficiency basing on the formula they learned

1.6 Summary of the unit

Ecology is branch of biology that focuses on how living things interact with each other and with their environment. The environment includes abiotic (nonliving) e.g. soil, water, temperature) and biotic (living: e.g. animals, plants) factors.

An ecosystem consists of all the biotic and abiotic factors in an area and their interactions. A niche refers to the role of a species in its ecosystem. A habitat is the physical environment in which a species lives and to which it is adapted. Two different species cannot occupy the same niche in the same place for very long that is the competitive exclusion principle. Ecosystems require constant inputs of energy from sunlight or chemicals.

Producers use energy and inorganic molecules to manufacture their own food. Consumers take in food by eating producers or other living things.

Decomposers break down dead organisms and other organic wastes and release inorganic molecules back to the environment. Food chains and food webs are diagrams that represent feeding relationships. They model how energy and matter move through ecosystems. The different feeding positions in a food chain or web are called trophic levels. Generally, there are no more

than four trophic levels because energy and biomass decrease from lower to higher levels.

Chemical elements and water are recycled through biogeochemical cycles. The cycles include both biotic and abiotic parts of ecosystems. The water cycle takes place on, above, and below Earth's surface. In that cycle, water occurs as water vapour, liquid water, and ice. Many processes are involved as water changes state in the cycle. The atmosphere is an exchange pool for water. Ice masses, aquifers, and the deep ocean are water reservoirs. In the carbon cycle, carbon passes among sedimentary rocks, fossil fuel deposits, the ocean, the atmosphere, and living things.

1.7 Additional Information for teachers:

You should also know the phosphorus cycle even if it does not appear in curriculum syllabus, but in many books, that cycle appears. Phosphorus is a component of biological molecules such as RNA, DNA, phospholipids, and adenosine triphosphate (ATP). ATP is a high energy molecule produced by the processes of cellular respiration and fermentation. In the phosphorus cycle, phosphorus is circulated mainly through soil, rocks, water, and living organisms. Phosphorus is found organically in the form of the phosphate ion (PO_4^{3-}). Phosphorus is added to soil and water by runoff resulting from the weathering of rocks that contain phosphates. PO_4^{3-} is absorbed from the soil by plants and obtained by consumers through the consumption of plants and other animals. Phosphates are added back to the soil through decomposition. Phosphates may also become trapped in sediments in aquatic environments. These phosphate containing sediments form new rocks over time.

Guidance on skills lab

Organize a field study in your school garden/school farm/ nearby farmer's activity; ask student-teachers to identify the plant species and animal species through observation of different plant and animal species, record the observation and interpret the recorded observation. Provide guiding questions to their observation. Then after make presentation and harmonize.

1.8 Answers for end unit assessment

Answer for multiple questions

- 1) c
- 2) b
- 3) b
- 4) c
- 5) d

Answers for Section B

- 6) It is the study of how living things interact with each other and with their environment. It is a major branch of biology, but has areas of overlap with geography, geology, climatology, and other sciences.
- 7) Individual, population, community, ecosystem, biome, and biosphere
- 8) The Sun is the major source of energy for organisms and the ecosystems of which they are a part. Producers such as plants, algae, and cyanobacteria use the energy from sunlight to make organic matter from simple inorganic substances of carbon dioxide and water. This establishes the beginning of energy flow through almost all food webs.
- 9) The answers are:
 - a) Ammonification
 - b) Nitrogen fixation
 - c) Nitrification
 - d) Denitrification
- 10) According to this law, during the transfer of energy from organic food, from one trophic level to the next, only about ten percent of the energy from organic matter is stored as flesh. The remaining is lost during transfer, broken down in respiration, or lost to incomplete digestion by higher trophic level.

Answers for Section C

- 11) Ecological pyramids are diagrams that represent each trophic level according to its energy, biomass or population. Three types of pyramids are used in ecology:

- Pyramids of numbers, based on counting the number of organisms at each trophic level;
 - Pyramids of biomass, which notes the weight (usually dry weight) of organisms at each trophic level;
 - Pyramids of energy, which monitors the energy content of the organisms at each trophic level.
- 12) The rate of energy flow decreases at each higher trophic level
- 13) Secondary succession usually occurs where soil, often containing seeds, is present
- 14) a) Tropical rainforest has higher or more consistent temperatures in all year; higher plant density; more light energy/ greater light; more water available/ higher rainfall; more evergreen plants/ fewer deciduous plants.
- b. Intensively cultivated land: crop varieties selected for high yield; monoculture/ crops all same type of plant; pests/ diseases all controlled; fertilizers used to maximize yield; irrigation; new crops planted immediately after harvest
- c. Use random numbers/ to place quadrat of given size; remove all plants from quadrat; repeat many times, each time placing quadrat randomly; remove soil / animals from plants; weigh to find fresh mass per known quadrat area; find mean value and multiply appropriately to find mass per area of grassland; or count number of plants in quadrat area; remove one plant; weigh and multiply by number of plants
- 15) a) Change or often an increase in species/ diversity of organisms presents; resulting in change to their environment, which benefits other species, for example addition for nutrients to the water in the lake
- b. Increase in number of species/ diversity; increase in numbers of organisms/ biomass; increase in complexity of organisms; increase in nutrients/ minerals/ soil available; decrease in space available for new species; more interspecific competition as conditions become less harsh
- c. Removing forest cover may increase soil erosion; more sediment deposited in lake may speed up succession; as more sediment for plants to grow in/ more minerals
- 16) a) All the biotic and abiotic components in a natural/ self-contained unit, through which energy flows and nutrients cycle

- b. Species present; numbers of each species or index of diversity; trophic level of each species; which are producers; herbivores; secondary consumers; tertiary consumers; top carnivores; decomposers; food chains/webs; biomass; energy input into system/amount of light available; amount of light absorbed/ gross primary productivity; net primary productivity; other climate details: temperature; humidity; availability of water/ rainfall; pH of water; salinity of water; type of soil/ geological material; mineral availability
 - c. Some solar energy is captured by photoautotrophs/producers; in photosynthesis; some is reflected/ not all is absorbed/ not all is of useful wavelengths; about 1% of incoming useful light is converted into gross primary productivity/GPP; cultivated crops may achieve higher levels of GPP and net primary productivity during growing season; amount of light falling on producers can be decreased by selective planting.
17. Ganza is missing the plant biomass eaten by herbivores and the production allocated to plant roots and belowground tissues.
18. A biogeochemical cycle is a closed loop through which a chemical element or water moves through ecosystems. In the term biogeochemical, bio- refers to biotic components and geo- to geological and other abiotic components. During biogeochemical cycle, chemicals cycle through both biotic and abiotic components of ecosystems. For example, an element might move from the atmosphere to the water of the ocean, from ocean water to ocean organisms, and then back to the atmosphere to repeat the cycle.

Elements or water may be held for various lengths of time by different components of a biogeochemical cycle. Components that hold elements or water for a relatively short period of time are called exchange pools. For example, the atmosphere is an exchange pool for water. It holds water for several days. This is a very short time compared with the thousands of years the deep ocean can hold water. The ocean is an example of a reservoir for water. A reservoir is a component of a geochemical cycle that holds elements or water for a relatively long period of time.

1.9 Additional activities

1.9.1 Remedial activities

Multiple questions and their answers

1) The natural place where the organism or communities live is known as:

- a) Niche
- b) Habit
- c) Habitat
- d) Biome

Answer: is c

2) Pyramid of numbers deals with the number of

- a) a) Species in area
- b) Subspecies in a community
- c) Individuals in a community
- d) Individuals in a trophic level

Answer: is d

3) Which statement is true in an ecosystem?

- a) Primary consumers are least dependent upon producers
- b) Primary consumers outnumber producers
- c) Producers are more than primary consumers
- d) Secondary consumers are the largest and most powerful

Answer: is c

4) In an ecosystem, which one shows one-way passage?

- a) Nitrogen
- b) Carbon
- c) Potassium
- d) Free energy

Answer: is d

Questions of True or False and their answers

Write true if the statement is correct or false if the statement is wrong.

5) Biotic factors include sunlight, soil, temperature, and water.

Answer: F

6) An ecosystem consists of all the biotic and abiotic factors in an area and their interactions

Answer: T

Questions with short answers

7) What do you understand by a trophic level?

Answer: The trophic level of an organism is its position in a food Chain, food web or pyramid of numbers or biomass

8) Distinguish between an ecological niche and a habitat

Answer: An ecological niche is a set of particular activities, resources and strategies that a species explores to survive and reproduce. A habitat is the place where the species lives to explore its ecological niche.

9) Where does the primary energy source of life on earth come from?

Answer: The primary energy source of life on earth is the sun. The sun plays the important role of keeping the planet warm and is the source of the light energy used in photosynthesis. This energy is converted into organic material by the photosynthetic autotrophic organisms and consumed by other living organisms.

10) In the ecological study of food interactions, what are autotrophic organisms called?

Answer: In ecology, autotrophic organisms are called producers because they synthesize the organic material consumed by the other living organisms of an ecosystem.

11) How are heterotrophic organisms divided in the ecological study of food interactions?

Answer: Heterotrophs are divided into consumers and decomposers. An ecosystem can exist without consumers but it cannot be sustained without decomposers. Without decomposers, organic material would accumulate, causing environmental degradation and later the death of living organisms.

12) Describe shortly in your own words the importance of water, carbon and nitrogen for living organisms?

Answer: Water is the main solvent for living organisms and it is necessary for almost all biochemical reactions, including as reagent of photosynthesis. Many properties of water are very important for life.

Carbon is the main chemical element of organic molecules; carbon dioxide is also reagent of photosynthesis and a product of the energy metabolism of living organisms.

Nitrogen is a fundamental chemical element of amino acids, the building blocks of proteins that are in turn the main functional molecules of living organisms; nitrogen is also part of nucleic acid molecules, which are the basis for reproduction, heredity and protein synthesis

13) Describe the reason why is the sun the “motor” of the water cycle?

Answer: The sun can be considered the motor of the water cycle because the transformation of liquid water into water vapour depends on its energy. Therefore, the sun is the energy source that causes water to circulate in nature.

14) Shortly, describe in your own words the water cycle?

Answer: The water cycle represents the circulation and recycling of water in nature.

Liquid water on the planet’s surface is heated by the sun and turns into water vapour, which enters the atmosphere. In the atmosphere, large volumes of water vapour form clouds that, when cooled, precipitate liquid water as rain. Therefore, water comes back to the planet surface and the cycle is complete.

15) Assume that producers in an ecosystem have 1,000,000 kilocalories of energy. How much energy is available to Primary consumers?

Answer: $100000 \times 10 = 1000000$ kilocalories: $100 = 10000$ kilocalories

1.9.1 Consolidation activities

Discuss the importance of an ecosystem for human being and for other living things

Answer:

- The ecosystem is impacted by humans.
- When human needs impact the ecosystem, the result can be beneficial or harmful.
- Humans use parts of other organisms for food and clothing. Some animals are used as pets for humans for enjoyment or protection.
- Animals can be used for assistance when compensating for disabilities and to perform work or provide activity.
- Plants and animals interact with each other in the environment. They also interact with the environment itself.
- The plants and animals depend on each other.
- Animals and humans depend on plants. Animals need food, protection and shelter. In human terms, food, clothing and shelter.
- Plants are used as sources of food and goods for humans.
- They can be used for shelter.
- They provide shade for protection from the hot sun.
- Humans use plants for fuel. We also use plants to make cloth, dyes and medicines.
- Some people use plants and plant material as decoration to make themselves attractive.
- Animals and humans depend on other animals. In the food chain, some animals eat other animals and use them for food. Humans also use animals as sources of food and clothing.

Plants benefit from animals.

- Animals are used by some plants to disperse seeds.
- Some animals can eat other plant-eating animals.
- Bees and other insects help pollinate flowers.
- Earthworms aerate the soil so that the roots of plants can better obtain oxygen.
- Relationships between animals and plants are complicated. The food chain begins with the Sun shining on plants. The plants use sunlight for energy to make food. The plants are at the base of the food chain.

- The plants are eaten by various types of animals. A particular type of plant may be eaten by more than one type of animal. In addition, a particular type of animal may be eaten by different types of animals. Some food chains share components. A given plant or animal may be found in more than one food chain. These interconnected food chains form

1.9.3 Extended activities

- 1) Do further research in textbooks or the internet about the ecosystem conservation. Write short notes then share with other class members

Answer: The learners should explain that conservation is the scientific study of nature, with the aim of protecting species, their habitats and ecosystems from extinction. The different types of ecosystem conservation include:

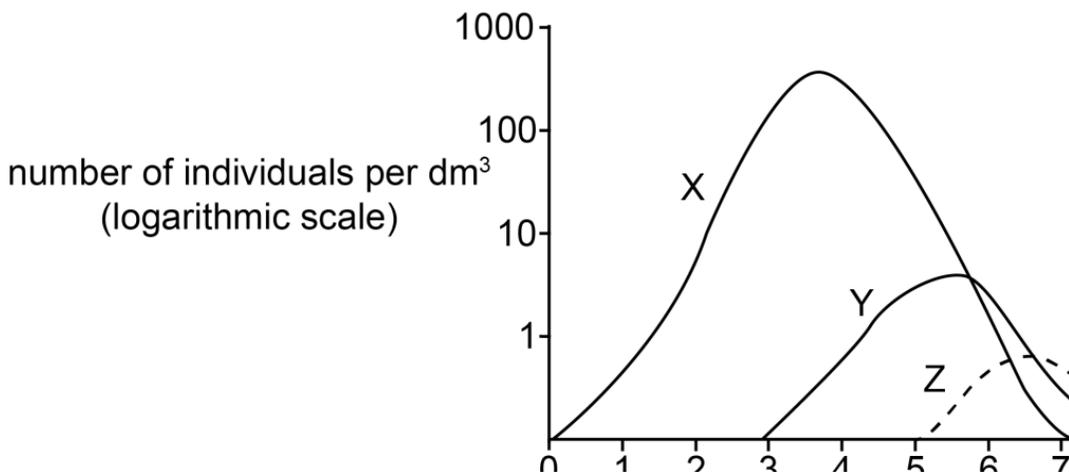
Ecosystem Conservation.

Animal and plants conservation.

Marine and freshwater Conservation. ...

Soil, water Conservation. ...

2. An experimental pond was set up by placing water containing a little plant fertilizer in a tank and leaving it outside. Various organisms, X, Y and Z, were subsequently found in the tank and their inter-relationships were observed.



Basing on what you have learned on ecosystem in your class, Identify the trophic levels indicated by X, Y and Z, make an interpretation of the graph.

Answer

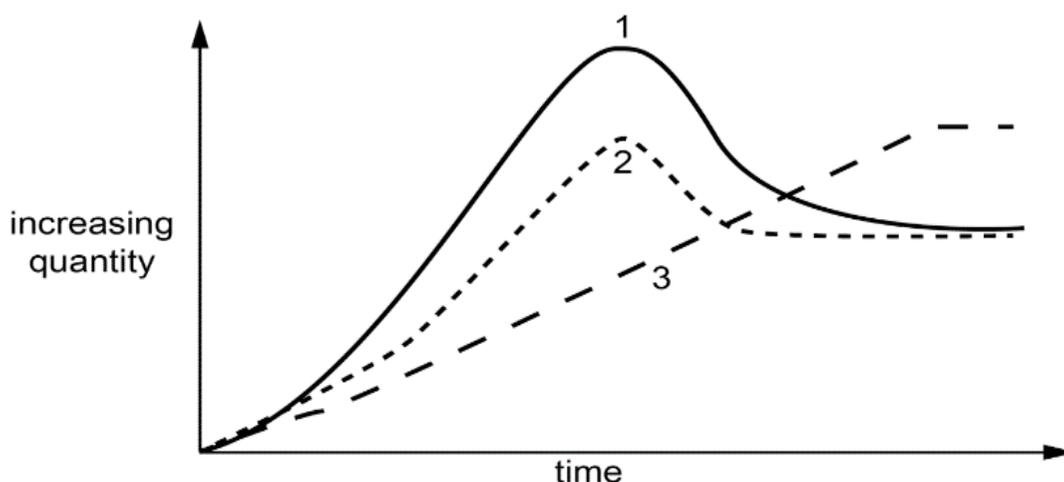
X: Primary producer

Y: Primary consumer

Z: Predator

The graph shows how their populations changed over time

3. The graph shows the changes in three quantities in a typical ecosystem as it goes through a succession to its climax. Analyse carefully the diagram below



What do the 1, 2, 3 lines represent?

Answer

1: Gross primary production of biomass

2: Biomass leaving as respiratory loss

3: Total biomass accumulated

UNIT 2

NERVOUS AND HORMONAL COORDINATION

2.1 Key unit competence:

Describe the structure of neurons, explain the mechanisms of impulse transmission and functions of endocrine glands in the body.

2.2 Prerequisites

To understand more this unit, make sure that the learners have learned and have understood well previous unit that is closely related to coordination particularly in animals. The previous unit that learners should know before studying is Unit 1 2, senior three, Response and coordination in animals in Ordinary level and make sure that the learners have learned and understood well the knowledge, skills, attitudes and values of response and coordination in animals in ordinary level

2.3 Cross cutting issues to be addressed

Inclusive education is one of the cross-cutting issue to be addressed in this unit since, there are many pictures within this unit; special attention arrangement should be paid for catering the students with special needs.

You should provide Braille/ tactile for experiment for example the mammalian eye dissection or using a scenario for visual impairment learners. There is also need to use sign languages for involving the learners in class activities with hearing difficulties.

If you may make the pictures by yourself or using projector, the attention should be made for the clarity as well as visibility.

Since some learning activities require taking students outside the school, students without disabilities should be sensitized to support their colleagues.

To seek for the information regarding the child from the parents about how they often communicate with children at home.

Comprehensive sexuality education

This issue will be addressed when students will understand how their body works for example secondary sexual characteristics in both boys and girls are influenced by hormones. Sexual responses are due to hormonal and nervous control. Student teachers will appreciate variations in humans related to voice, fear and physical appearances such as height

Gender education

This issue will be addressed when students will understand that the body differences are the results of hormonal system. Therefore, the body differences do not select whom to do a particular activity since all people being boys or girls can achieve. What is very necessary is the determination.

2.4 Guidance on introductory activity 2

Introduce the unit 2 by using the diagrams in introductory activity 2 and do the following:

- Invite the learners to think about the given diagrams of introductory activity
- Give time to think about the given questions and allows them to express their ideas:
 1. X= Brain, Y = spinal cord, A= Brain, B= Nerve trunk, F= Brain, G= Ganglia
 2. All have central nervous systems and peripheral nervous system
 3. Central and peripheral nervous system. Central (brain) and peripheral (spinal cord, nerve trunk and ganglia)
- Consider their ideas and then inform what they will learn in this unit

2.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1	Human nervous system	- Describe the subdivisions of human nervous system, their functions and the arrangement of neurons in a reflex arc.	1 period
2	Different types of neurons and reflex actions.	- Describe the functions of neurons in a reflex arc.	1 period

3	Nature, structure, function of synapse in the nervous system	<ul style="list-style-type: none"> - Relate the structure of a cholinergic synapse to its functions. - Explain how a resting potential is maintained. - Explain how an action potential is generated. 	1 period
4	Transmission of a nerve impulse	<ul style="list-style-type: none"> - Explain how a nerve impulse is transmitted along a neuron. - Explain the factors affecting the speed of impulse transmission. - Interpret graphs for all or nothing law and refractory period. 	2 periods
5	Structure and function of the endocrine system in humans	<ul style="list-style-type: none"> - Describe the structure and function of the endocrine system 	1 period
6	Principles of the negative feedback mechanism of Hormonal action	<ul style="list-style-type: none"> - Describe the principle of the negative feedback mechanism by which hormones produce their effects on target cells. - Explain why hormonal balance is necessary for coordinating the body. 	1 period
7	Effects of hormonal imbalances	<ul style="list-style-type: none"> - Explain the effects of hormonal imbalances 	1 period
8	Comparison of hormonal and nervous systems	<ul style="list-style-type: none"> - Compare and contrast the actions of the endocrine and nervous systems 	1 period
9	End unit Assessment		1 period

Lesson 1: Human nervous system

a) Learning objective

Describe the structure and functions of human nervous system.

b) Teaching resources

- Charts and illustrations indicating the coordination in animals
- Video/ movies of coordination in animals
- Projector
- Student books, pictures

c) Prerequisites/Revision/Introduction

Ask some questions to check students' understanding. The questions should focus on Human nervous system

d) Learning activities

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners in the flow of the activity.
- Learners in their groups present their findings.
- Ask some questions to check whether they agree with the findings from their colleagues.
- Harmonize students work and conclude the lesson by asking some questions related to the lesson.

Answers for activities 2.1

1. Nervous system
2. A= Brain, B= Nerves , C= Spinal cord
3. A and C are components of central nervous system while B is peripheral nervous system

e) Application activity 2.1

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.1.

Answers for application activities 2.1

1. A = Organs of central nervous system and organs of peripheral nervous system
2. Brain

Lesson 2: Different types of neurons and reflex actions

a) Learning objective

-Describe the functions of neurons in a reflex arc.

b) Teaching resources

Charts of neurones.

Video/ movies of types neurones downloaded from you tube

<https://www.youtube.com/watch?v=X4uuCgElK8>

Student textbooks, internet, pictures, Projector.

c) Prerequisites/Revision/Introduction

You should start this lesson by asking questions on the previous lesson and revise shortly the previous lesson “human nervous system”

d) Learning activities

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners in this activity
- Let learners to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson

Answers for activity 2.2

a. A= dendrite, B= cell body, C= axon, D = Schwann cell nucleus, E= Node of Ranvier, F= Myelin sheath, G= Motor end plates on muscle fibers

e) Application activity 2.2

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.2.

Answers for application activities 2.2

The neurons should be damaged/should not function/

Lesson 3: Nature, structure, function of synapse in the nervous system

a) Learning objective

- Relate the structure of a cholinergic synapse to its functions.
- Explain how a resting potential is maintained.
- Explain how an action potential is generated.

b) Teaching resources

- Charts illustrating the synapse
- Video/ movies of synapse.
- Student books, pictures, internet.
- Projector

c) Prerequisites/Revision/Introduction

Start this lesson by revising shortly the previous lesson of types of neurons and their functions.

d) Learning activities

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate students to do activity 2.3 by providing clear instructions
- Let learner in their pairs present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson through questions

Answers for activities 2.3

- a. A= Depolarization, B= Action potential, D= refractory, E= repolarization
- b. Action potential is the technical term for impulse. An action potential is rapid temporary reversal in the electrical potential difference of an excitable cell e.g. a neuron or a muscle cell. It is caused by changes in the permeability of the membrane following the application of a threshold stimulus. The action potential has a depolarization phase and a repolarization phase. There may be a short hyperpolarized phase after the repolarization phase. The time taken for an action potential is 2 to 3 milliseconds.

e) Application activity 2.3

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.3.

Answers for application activities 2.3

a. *The answers are:*

The voltage-gated sodium channels open faster in response to the given stimulus.

There is a rapid influx of Na⁺ ions into the axon during the depolarization phase

The sodium channels undergo inactivation near the peak of the action potential which causes the channels to close. The period of Na⁺ influx is brief, less than one millisecond.

Voltage-gated potassium channels open more slowly and also close more slowly than sodium channels.

K⁺ ions diffuse out of the axon during repolarisation phase

(b) The answer is:

The rate of diffusion of Na⁺ ions into the cell would be slower.

It would take a longer time to exceed the threshold level to generate an action potential

Lesson 4: Transmission of a nerve impulse

a) Learning objective

- Explain how a nerve impulse is transmitted along a neuron.
- Explain the factors affecting the speed of impulse transmission.
- Interpret graphs for all or nothing law and refractory period.

b) Teaching resources

- Charts illustrating transmission of nerve impulses
- Video/ movies showing the transmission of nerve impulse downloaded from you tube <https://www.youtube.com/watch?v=iBDX0tuHTQ>

- Student books, pictures, internet
- Projector

c) Prerequisites/Revision/Introduction

Introduce the lesson by asking to students to brainstorm what will happen to them when seeing a snake crawling very faster towards them while revising biology lesson sitting in school garden.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

Ask students to do activity 2.4 or write it on chalkboard or whiteboard

Facilitate the activity by supporting those who got stuck

Let groups of learners present their findings, harmonize and conclude

Answers for activity 2.4

1. Nervous system

1. Sympathetic nerves; 2. Cerebrum
3. Olfactory nerves; 4. Olfactory lobe
5. Optic nerves, 6. Optic lobe
7. Brachial plexus containing nerves (containing nerves 1-3)
8. Radial nerve; 9. Ulnar nerve
10. Abdominal nerve
11. Nerves 4-6 (leading to abdomen)
12. Sciatic plexus containing nerves 7-9
13. Sciatic nerve
14. Tibial nerve
15. Peroneal nerve
16. Filum terminale
17. Spinal cord

3. The sciatic nerve is a large and complex bundle of many nerve fibers.
4. The sciatic nerve supplies sensation to the skin of the foot, as well as the entire lower leg (except for its inner side). Sensation to skin to the sole of the foot is provided by the tibial nerve, and the lower leg and upper surface of the foot via the common fibular nerve. The sciatic nerve also innervates muscles.
5. Partial damage to the nerve may demonstrate weakness of knee flexion (bending), weakness of foot movements, difficulty bending of the foot inward (inversion), or bending the foot down (plantar flexion)

e) Application activity 2.4

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.4.

Answers for application activities 2.4

- 1) A decrease in permeability to K^+ an increase in permeability to Na^+ . Or both
- 2) Based on the figure:
- c) M – Represents the resting potential. The resting potential of the axon is $-70mV$. The inside of the axon is negatively charged with respect to the outside of the neurone. The resting potential is maintained by the sodium potassium pump and the relative permeability of axon membrane to K^+ and Na^+ ions.

N- The axon is stimulated, some voltage- gated sodium channels open and Na^+ ions diffuse into the axon down a concentration gradient and electro-chemical gradient. The axon membrane is polarized.

O- The threshold level is exceeded. More voltage- gated sodium channels open and more Na^+ ions diffuse rapidly into the axon. This is an example of positive feedback. The membrane potential reverses from $-70mV$ to $+40mV$. The inside of the axon membrane is positively charged with respect to the outside.

P- Repolarisation occurs. The sodium channels closed and the voltage gated potassium channels open. Potassium ions diffuse out of the axon down a concentration and electro-chemical gradient and the membrane potential decreases.

Q- Hyperpolarisation occurs. The potassium channels are slow to close. An excess of K^+ ions diffuse out from the axon. The inside of the axon become more negative slightly below $-70mV$.

R- Within a few milliseconds the K^+ channels close. There is a short period where membrane protein channels undergo conformational changes. During this period, the membrane becomes refractory and cannot respond to a normal stimulus.

Lesson 5: Structure and function of the endocrine system in humans

a) Learning objective

- Describe the structure and function of the endocrine system

b) Teaching resources

Student's books, chart showing different endocrine glands, a movie showing the location of endocrine glands computer aided materials such as animations and simulations.

c) Prerequisites/Revision/Introduction

Learners will learn better the endocrine glands if they know what are glands. The teacher can show different types of secretions such as saliva and tears and ask them where they are made. From the answers given by learners, the tutor will help the learners to understand the meaning of the endocrine glands and different secretions they produce.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

Ask students to do activity 2.5 or write it on chalkboard or whiteboard

Facilitate the activity by supporting those who got stuck

Let groups of learners present their findings, harmonize and conclude

Answers for activities 2.5

Endocrine glands secrete their products called hormones into the interstitial

fluid surrounding the secretory cells rather than into ducts. From the interstitial fluid, hormones diffuse into blood capillaries and blood carries them to target cells throughout the body. Because most hormones are required in very small amounts, the circulating levels of hormones are typically low.

The word endocrine means internal secretion and endocrine glands are therefore ductless glands of internal secretion. Since they shed their secretion into the bloodstream, they have no ducts once in the bloodstream, the hormones are carried around the body, bringing about responses in various places.

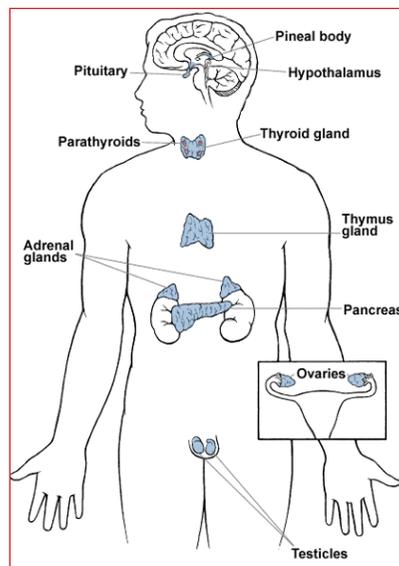
e) Application activity 2.5

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.5.

Answers for application activities 2.5

1.



2. It releases insulin and glucagon that involve in blood glucose regulation
3. you suffer from goiter, enlargement of the thyroid gland

Lesson 6: Principles of the negative feedback mechanism of Hormonal action

a) Learning objective

- Describe the principle of the negative feedback mechanism by which hormones produce their effects on target cells.
- Explain why hormonal balance is necessary for

b) Teaching resources

Different books of biology

c) Prerequisites/Revision/Introduction

Students will learn better the Principles of the negative feedback mechanism of hormonal action, if they have prior knowledge about the homeostasis and the functions of all hormones. The coordinating the body students can be given the model of the heating system in houses and compare it to the negative feedback in our body. The heating system keeps the temperature of the house within a given range. When the lower temperature is reached, the machine is automatically switched on and when the higher temperature is reached, the machine is automatically switched off.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

Ask students to do activity 2.6 or write it on chalkboard or whiteboard

Facilitate the activity by supporting those who got stuck

Let groups of learners present their findings, harmonize and conclude

Answers for activity 2.6

- a. The arrows that explain how the high concentration of hormone which inhibits the gland from releasing the same hormone in order to keep the concentration relatively stable are 6 and 7.
- b. If the event 6 and 7 were not there, there is no hormonal control.
- c. When the quantity of thyroid hormone increases, the hormonal message will reach the hypothalamus and pituitary glands, these glands will stop to send the message to thyroid gland and then thyroid gland will not continue to secrete thyroxine. When the quantity of thyroid hormone decreases,

the hormonal message will reach the hypothalamus and pituitary gland which will stimulate the thyroid gland to secrete thyroxine.

d. The name of the mechanism responsible for hormonal control is **feedback**

e) Application activity 2.6

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.6.

Answers for application activities 2.6

When the glucose levels in blood increases above normal levels, the following occur:

- Glucose levels in blood increase above normal level.
- The islets of langerhans of the the pancreas is stimulated
- to secrete insulin hormone into blood.
- insulin hormone is transported to the liver by blood.
- where it stimulates the conversion of excess glucose to glycogen stored in the liver.
- The glucose level now decreases in blood.
- Glucose level returns to normal.

When the glucose level in the blood increases above normal levels:	
Step 1	Glucose levels in the blood increases above normal levels
Step 2	The pancreas is stimulated
Step 3	to serve insulin into the blood
Step 4	Insulin travels in the blood to the liver
Step 5	Where it stimulates the convention of excess glucose to glycogen which is then stored
Step 6	The glucose level in the blood now decreases
Step 7	and return to normal

When the glucose level in the blood increases above normal levels:	
Step 1	Glucose levels in the blood decreases above normal levels:
Step 2	The pancreas is stimulated

Step 3	to serve glucagon into the blood
Step 4	Glucagon travels in the blood to the liver
Step 5	Where it stimulated the convention of stored glycogen to glucose
Step 6	The glucose level in the blood now increases
Step 7	and return to normal

Lesson 7: Effects of hormonal imbalances

a) Learning objective

Explain the effects of hormonal imbalances

b) Teaching resources

Books, internet, photos showing individuals with some disorders

c) Prerequisites/Revision/Introduction

Learners will learn better the effects of hormonal imbalances if they know the functions of different hormones seen in the previous units. In order to introduce the lesson, the learners will be given the photos showing different persons with endocrine disorders such as gigantism, goitre and dwarfism and will try to identify the causes of these disorders. If possible, a movie showing different endocrine disorders will be given.

d) Learning activities

The learners observe discuss on the questions set in the activity and observe the photo. After observation, the students will give the possible answers to the questions asked. The activity can be done in a group of three or four students.

Answers for activities with 2.7

A= Goitre B= dwarfism

e) Application activity 2.7

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.7.

Application activities

Blood glucose increases rapidly

Lesson 8: Comparison of hormonal and nervous systems

a) Learning objective

- Compare and contrast the actions of the endocrine and nervous systems

b) Teaching resources

Books, internet

c) Prerequisites/Revision/Introduction

This lesson requires the knowledge of the working of the nervous system and the endocrine system.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

Ask students to do activity 2.8 or write it on chalkboard or whiteboard

Facilitate the activity by supporting those who got stuck

Let groups of learners present their findings, harmonize and conclude

Answers for activities 2.8

- 1) The similarities between the structure and functioning of nervous and hormonal systems are:

Both systems provide means of communication within the body of an organism.

Both involve transmission of a message which is triggered by a stimulus and produces a response. Several chemicals function as both neurotransmitters and hormones including norepinephrine. Some hormones such as oxytocin are secreted by neuroendocrine cells; neurons that release their secretions into the blood.

- 2) The differences between the structure and functioning of nervous and hormonal systems

Nervous system	Endocrine system
Involves nervous impulses (electrical) and neurotransmitters (chemical)	Involves hormones (chemical substance)
Impulses transmitted by neurons	Hormones transported by blood
Quick response	Usually a slow response
Response short-lived	Response may be short-lived or long term
May be voluntary or involuntary	Always involuntary
Usually localized	May affect more than one target organ
Stops quickly when stimulus stops	May continue responding long after stimulus stop

e) Application activity 2.8

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 2.8.

Answers for application activities 2.8

- 1) The nervous system can be involved in the control of voluntary activities such as walking, touching an object and in involuntary activities such as the working of the heart, the movement of blood.
- 2) The endocrine system can have a long term effect such as growth which may take many years. It may also have a short term effect such as the release of adrenaline when someone has fear.

2.6 Summary of the unit

The nervous system of mammal is divided into central nervous system (CNS) and peripheral nervous system (PNS), which can be further divided into somatic nervous system and autonomic nervous system.

The autonomic nervous system has two main divisions: The parasympathetic nervous system which helps keep the body in a relaxed state, and the sympathetic nervous system which prepares the body for action.

The nervous system contains neurones which transmit nerve impulses rapidly from one specific location to another so that responses can be localized.

A neurone is the basic structural and functional unit of the nervous system,

A neurone not transmitting a nerve impulse has a resting potential. An above threshold stimulus causes depolarization and action potential.

An action potential (impulse) is a temporary reversal of the electrical difference maintained across the membrane of excitable cells. An action potential (a nerve impulse) is self-propagated along an axon. The action potential is regenerated repeatedly along the axon so that a wave of depolarization travels along the axon.

Information passes from one nerve to another or between nerve and an effector (e.g. muscle) via synapses which may be excitatory or inhibitory, depending on the type of neurotransmitters.

Endocrine glands are ductless glands that secrete hormones into the blood.

Hormones are chemical messengers, protein in nature and exert their effects on target organs or tissues. Hormones are secreted when there is a need for their effects. Each hormone has a specific stimulus for secretion.

The secretion of most hormones is regulated by negative feedback mechanisms: As the hormone exerts its effects, the stimulus for secretion is reversed, and secretion of the hormone decreases.

There are different endocrine glands: hypothalamus, pituitary gland, thyroid gland, four parathyroid glands, adrenal glands, pancreas and gonads (testis and the ovary)

2.7 Additional Information for teachers

Mode of action of hormones

A hormone affects cells that have receptors for it. Receptors are proteins that may be part of the cell membrane, or within the cytoplasm or nucleus of the target cell. Hormones can act in one of the two ways:

The two-messenger mechanism: a protein hormone (1st messenger) bonds to a membrane receptor; stimulates formation of cyclic AMP (2nd messenger), which activates the cell's enzymes to bring about the cell's characteristic response to the hormone.

Steroid hormones diffuse easily through cell membranes and bond to cytoplasmic receptors. Steroid-protein complex enters the nucleus and activates certain genes, which initiate protein synthesis.

Guidance on skills lab

1. Organize a laboratory study in your school laboratory ask student-teachers to dissect a fish by purpose of identifying the components of nervous system. Through dissection and observation. Ask student teacher to draw and label the brain and spinal cord of the fish. Provide guiding questions to their observation. Then after make presentation and harmonize.
2. Organize a laboratory study in your school laboratory ask student-teachers to Test for glucose level in blood by using a glucometer through observation, record the observation and interpret the recorded observation .Ask student teacher to write down their blood groups either A,B, AB or O Provide guiding questions to their observation. Then after make presentation and harmonize.

or

Organise a play, a song or a skit on how drug abuse affects mainly the human nervous system (include in your skit how you can maintain your nervous system and endocrine systems healthy.

2.8 End unit assessment (answers)

Multiple choice questions and their answers

- | | |
|------|------|
| 1.c | 2.b |
| 3.c | 4.c |
| 5.b | 6.d |
| 7. b | 8. a |
| 9.d | |

Answers for Section B

10.

a. Adrenal cortex	Aldosterone	Controls reabsorption of Na ⁺ in the kidney.
b. Produced in the hypothalamus, stored in the posterior pituitary	ADH	Increases the permeability of convoluted distal tubule and collecting duct.
c. Adrenal medulla	Adrenaline (epinephrine)	Increases heart rate.
d. Alpha cells in pancreas	Glucagon	Increases blood glucose level.
e. Beta cells in the pancreas	Insulin	Decreases blood glucose level.
f. Ovary	Oestrogen	Repair and growth of the endometrium.
g. Hypothalamus	Releasing hormone	Stimulates the anterior pituitary gland to release FSH.
h. Produced in the hypothalamus, stored in the posterior pituitary	Oxytocin	Stimulates contraction of the uterus.
i. Anterior pituitary	Prolactin	Stimulates the mammary glands to secrete milk.

11. The answer is summarized in the following table:

Name of abnormality	Caused by lack of (hormone)	From (gland)
Dwarfism	Growth hormone	Pituitary gland
Diabetes mellitus / sugar diabetes	Insulin	Pancreas
Water diabetes (diabetes insipidus)	Antidiuretic hormone (ADH)	Hypothalamus / Pituitary gland
Cretinism	Lack of thyroid hormones	Thyroid of baby

12. a) The omitted word is added in the text:

An action potential arrives at synaptic knob of presynaptic neurone. This causes Calcium ions to enter the synaptic knob. Vesicles move to the presynaptic membrane. A neurotransmitter called acetylcholine is

released into the synaptic cleft. This moves across the cleft by a process known as diffusion. The neurotransmitter combines with a receptor protein on the postsynaptic membrane.

Influx of sodium ions causes local depolarization and an action potential is set up in the postsynaptic neurone

b) Hydrolysed by enzyme; to choline and ethanoic acid; which are inactive as transmitters

c) Adrenergic

13. a) Sodium channels/ gates in cell surface membrane open, in response to a stimulus which causes a slight depolarization; sodium ions rapidly enter cytoplasm by diffusion; increased number of positive ions inside membrane; negative resting potential cancelled out; further depolarization makes potential difference across membrane positive (with respect to outside)

b) Potential difference rapidly returns to a negative value

c) Myelinated neurone has breaks called nodes of Ranvier, local circuits set up only at these nodes so action potential jumps from node to node/ salutatory conduction; faster than the series of smaller local currents in a non-myelinated axon

14. The answer is summarized in the following table:

Raises blood sugar	Increases blood sugar	Lowers blood sugar
Hormone's name	Glucagon	Insulin
Hormone's source	Pancreas / Alpha cells of the islets of Langerhans	Pancreas / Beta cells of the islets of Langerhans
Means of stimulating gland to secrete	The hormone is transported through blood to the liver when blood glucose is lowered	The hormone is transported through blood to the liver when blood glucose is increased
Main gland stimulated by the hormone	Liver	Liver

15. These are the answers:

a) Motor neurone

- b) X: axon; Y: dendrite
- c) Action potential set up / change in potential across axon membrane from negative inside value -70mV to positive $+40\text{mV}$; opening of sodium gates; channels in axon membrane; depolarization and the wave of depolarization along surface of nerve cell
- d) The answers are:
- (i) continuous muscle contraction/ paralysis
 - (ii) Acetylcholine accumulates, continues to depolarize postsynaptic membrane or produce action potential in sarcolemma of muscle cell leading to muscle contraction.

16. The complete table is the following:

Function	Region of brain
Osmoregulation	Hypothalamus
Control of posture	Cerebellum
Modification of heart rate	Medulla

17.

Based on the figure:

- a) A: myelin sheath; B: axon
- b) Acetylcholine/ noradrenaline
- c) Mitochondria; ATP produced in aerobic respiration within mitochondria required e.g for synthesis of neurotransmitter
- d) Hydrolysis and inactivation of neurotransmitter to prevent continuous firing of impulses in the postsynaptic nerve or muscle cell.

Section C:

18. The following are some of the elements of the answer:

A nerve impulse/ action potential arrives at the synaptic knob, then the voltage-gated calcium channels in the presynaptic membrane open, Ca^{2+} ions diffuse into synaptic knob. The influx of Ca^{2+} ions cause the synaptic vesicles to fuse with the presynaptic membrane and acetylcholine molecules are released into the synaptic cleft

Acetylcholine molecules diffuse across sites of protein channels. This causes the opening of sodium ligand-gated channels in the postsynaptic membrane. Na⁺ ions diffuse into the postsynaptic neurone; depolarization of the postsynaptic membrane occurs. When the threshold level is exceeded, an action potential is generated

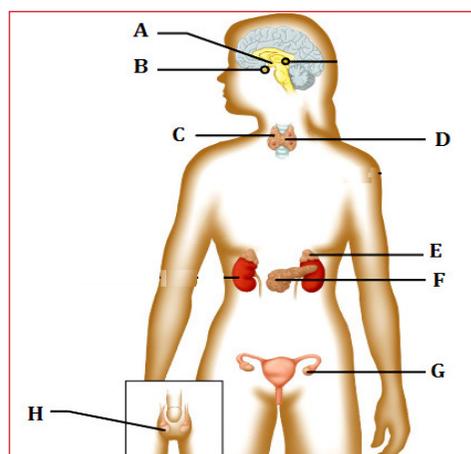
19. Diabetes insipidus and diabetes mellitus affect the kidneys in different ways. In diabetes insipidus, a deficiency of ADH or a lack of response by the kidneys to ADH affects the kidneys' ability to concentrate urine. A person with the disease produces large quantities of very dilute urine. In diabetes mellitus, there is too much glucose in the blood. The kidneys try to remove the excess glucose from the blood and excrete it through more frequent urination. If glucose levels remain high, capillaries in the glomerulus can be damaged. This may eventually lead to kidney failure.
20. For the production of thyroxin, the hypothalamus secretes TRH (TRH releasing hormone), which stimulates the anterior pituitary to secrete TSH (thyroid stimulating hormone). When TSH binds to specific receptors in the thyroid gland, this gland synthesizes thyroxin hormone. The system is balanced by negative feedback loops. High levels of thyroxin and TSH in the blood inhibit TRH secretion by the hypothalamus. There is also evidence that additional feedback loops are involved; for example, high levels of TSH may inhibit TRH secretion by the hypothalamus.
- 21.a) The similarities between the structure and functioning of nervous and hormonal systems are:
 - Both systems provide means of communication within the body of an organism.
 - Both involve transmission of a message which is triggered by a stimulus and produces a response.
 - Several chemicals function as both neurotransmitters and hormones including norepinephrine.
 - Some hormones such as oxytocin are secreted by neuroendocrine cells; neurons that release their secretions into the blood.
- b) The differences between the structure and functioning of nervous and hormonal systems

Nervous system	Endocrine system
Involves nervous impulses (electrical) and neurotransmitters (chemical)	Involves hormones (chemical substance)
Impulses transmitted by neurons	Hormones transported by blood
Quick response	Usually a slow response
Response short-lived	Response may be short-lived or long term
May be voluntary or involuntary	Always involuntary
Usually localized	May affect more than one target organ
Stops quickly when stimulus stops	May continue responding long after stimulus stops

2.9 Additional activities

2.9.1 Remedial activities

- 1) Classify and distinguish the neurones basing on their functions
- 2) Draw and label a typical motor neurone
- 3) Describe all or nothing law
- 4) What is an axon?
- 5) What are the main factors that determine the resting potential of a neurone?
- 6) Explain why synaptic knobs have a high density of mitochondria
- 7) Observe the figure below of the human endocrine system and answer to the questions that follow



- a) What are the endocrine glands represented by the letters A to H?
- b) Name any two hormones produced by the gland B.

Answers for remedial activities

- 1) Motor, sensory, and relay neurons
- 2) The drawing should indicate the cell body, dendrites, nucleus, organelles like mitochondria, golgi body, ribosomes, axon, axon terminals
- 3) All or nothing law: An action potential can only be generated after the threshold value is exceeded. After the threshold is reached, the size of the action potential produced remains constant and is independent of the intensity of the stimulus. All action potentials are of the same amplitude
- 4) It is a nerve fibre carrying nerve impulses away from the cell body
- 5) The resting potential is determined by an unequal distribution of charged ions inside and outside a neurone, making the inside negative relative to the outside
- 6) Mitochondria generate ATP required for the synthesis of neurotransmitters.
- 7) a. A : the hypothalamus, B: the pituitary gland, C: the parathyroid gland, D: the thyroid gland, E: the adrenal glands, F: the pancreas, G: the ovaries and H: the testis.
b. Any one from the following: GH, prolactin, TSH, ACTH, FSH, LH

2.9.2 Consolidation activities

- 1) State the effect of aldosterone on the kidneys. Describe the results of this effect on the composition of the blood.
- 2) Describe the antagonistic effects of PTH and calcitonin on bones and on blood calcium level. State the other functions of PTH.
- 3) Describe what happens after a new action potential is generated at postsynaptic neurone

Answers for consolidation activities

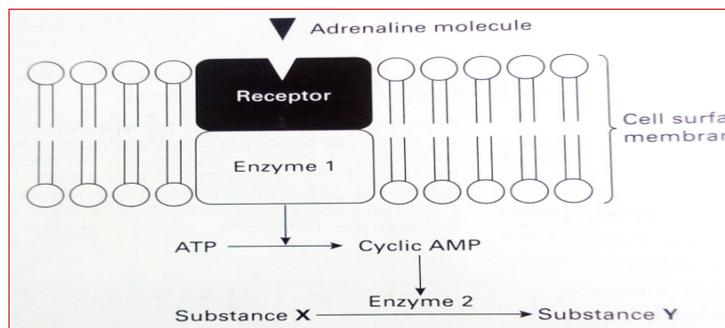
- 1) Aldosterone increases reabsorption of sodium and excretion of potassium by the kidneys. Results: hydrogen ions are excreted in exchange for sodium; chloride and bicarbonate ions and water follow sodium back to the blood; maintains normal blood pH, blood volume, and blood pressure.

- 2) The four parathyroid glands, embedded in the surface of the thyroid gland, function in the homeostasis of calcium ions. They secrete parathyroid hormone (PTH) which raises blood levels of calcium and thus has an effect opposite to that of the thyroid hormone calcitonin. Parathyroid hormone elevates blood calcium by stimulating calcium reabsorption in the kidneys and by inducing specialized bone cells called osteoclasts to decompose the bone and release calcium in the blood. It also increases calcium uptake in the small intestines. Calcitonin has just the opposite effects on the kidney and bone, thus decreasing blood calcium.
- 3) The acetylcholine is rapidly degraded by enzyme acetylcholinesterase to choline and acetate.

The sodium channels close again Choline diffuses back into synaptic knob, combine with acetyl coA to resynthesis acetylcholine. The energy for synthesis is produced by mitochondria

2.9.3 Extended activities

1. i. The diagram summarizes the way in which adrenaline can control a chemical reaction in a liver cell.



- a) Describe the function of cyclic AMP in this process
- b) Give one example of a chemical reaction in a liver cell which is controlled by adrenaline by naming
 - i) Substance X
 - ii) Substance Y
 - ii) Use the diagram to explain:
 - a) Why adrenaline may affect some cells and not others
 - b) How a single molecule of adrenaline may cause this cell to produce a large amount of substance Y ?

- 2) Describe the basic pathway of information flow through neurons that cause you to turn your head when someone calls your name
- 3) How would severing an axon affect the flow of information in a neuron? Explain

Answers to extended activities

- 1) i. The answers are
 - a) Activates enzyme systems within the cytoplasm in response to adrenaline being detected by cell membrane receptor.
 - b) The examples:
 - i) X: Glycogen / other correct molecule
 - ii) Y: glucose / other correct molecule
 - iii) The following are the answers:
 - a) Only target cells for adrenaline will have specific protein receptors that recognize / fit adrenaline
 - b) At each stage in the process / from adrenaline to receptor to enzyme 1 to cyclic AMP to substance Y amplification occurs; only a few molecules of enzyme 1 / adenylyl cyclase are needed to activate many molecules of substance Y / protein kinase / other named example; cascade effect.
- 2) Sensors in your ear transmit information to your brain. There the activity of interneuron in processing centre enables you to recognize your name. In response, signals transmitted via motor neurons cause contraction of muscles that turn your neck.
- 3) It would prevent information from being transmitted away from the cell body along the axon.

UNIT 3

NUCLEIC ACIDS, DNA REPLICATION AND PROTEIN SYNTHESIS

3.1 Key unit competence:

Explain nucleic acids, DNA replication, and the process of protein synthesis in eukaryotes.

3.2 Prerequisites

3.3 Cross cutting issues to be addressed

Within this unit, environment and sustainability in addition to inclusive education will be addressed by this unit.

a) Environment and sustainability will be addressed when students will acknowledge the interdependence between species living in the same area. They will understand it when they can express what will happen if one component in an area is missing or exist in a big number and suggest what can be done since there is relationship among the living things. Learners should be encouraged to maintain the environment and sustainability in proper way by avoiding the depletion or degradation of natural resources and thereby supporting long-term ecological balance. The learners should know that when one of the components of environment either biotic or abiotic component is damaged/ destroyed or removed; it affects automatically the life of all living things.

b) Inclusive education

Since, there are many pictures within this unit; special attention arrangement should be paid for catering the students with special needs. You should provide braille/ tactile or using a scenario for visual impairment learners. There is also need to use sign languages for involving the learners in class activities. If you may make the pictures by yourself or using projector, the attention should be made for the clarity as well as visibility. Since some learning activities require to take students outside the school, students without disabilities should be sensitized to support their colleagues. To seek for the information regarding the child from the parents about how they often communicate with children at home.

3.4 Guidance on introductory activity 3

Introduce the unit 3 by using a scenario of introductory activity and ask the students to do the following:

Teacher's activity

- Invite the learners to understand well the scenario and analyze it well
- Give time to think about the given questions
- Allow them to express their ideas
- Consider their ideas and then ask them to suggest a title of the next unit.

Learner's activity

In their groups, the learners are going to do an introductory activity 3

Answers for introductory activity

1. B
2. As it is seen on the table, the second father tested (B) seems to have more DNA in common with the child . Other fathers tested(A,C) do not have DNA in common with the child

3.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1	Structure of nucleic acids	<ul style="list-style-type: none">- Describe the structure of nucleotides- Describe the structure of DNA and RNA.- Explain that the structure of the DNA molecule is described as a ladder twisted into a spiral.	2 periods

2	Mechanism of DNA replication	<ul style="list-style-type: none"> - Explain semi-conservative replication - Describe how semi conservative replication of DNA takes place. - Explain how conservative and dispersive replications are other hypothesis for DNA replication. - Explain the importance of DNA replication in organisms. 	3 periods
3	Nature of gene ,Genetic code and the process transcription	<ul style="list-style-type: none"> - Describe the nature of genes - Describe the structure of a genetic code - Describe how the information in DNA is used during transcription 	3 periods
4	Process of translation	<ul style="list-style-type: none"> - Construct a flow chart, in proper sequence, for the stages of transcription and translation. - Using the evidence, predict the effect of change in genetic code on the structure of the protein manufactured during protein synthesis. 	3 periods
5	Effects of alteration of nucleotide sequence	<ul style="list-style-type: none"> - Describe the way in which the nucleotide sequence codes for the amino acid sequence with specific reference to HbA (normal) and HbsS (sickle cell) alleles for β globin poly peptides. - Explain how the gene mutation is a change in the sequence of nucleotides that may result in an altered polypeptide. 	2 periods
6	End unit assessment		2 periods

Lesson 1: Structure of nucleic acids

a) Learning objective

- Describe the structure of nucleotides
- Describe the structure of DNA and RNA.
- Explain that the structure of the DNA molecule is described as a ladder twisted into a spiral.

b) Teaching resources

- Charts and illustrations indicating the nucleic acids
- Video/ movies of nucleic acids downloaded from you-tube
- Projector, computer
- Student books, pictures

c) Prerequisites/Revision/Introduction

Start the unit by briefing the learners about structure of nucleic acids. DNA as the genetic material for heredity. Dwell further on structure of DNA and RNA, their similarities and dissimilarities. Teacher will clear the concepts of base pairing and nature of genes and genetic code.

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups
- Provide an activity 3.1 given in student textbook and ask learners to do the related questions, attribute to each group,
- Facilitate them in that activity
- Harmonize the lesson by using student findings and conclude the lesson by asking some questions related to the lesson
- Ask some questions to check whether they agree with the findings from their colleagues
- Learners in their groups present their findings. –

Answers for activity 3.1

Yes, both are twisted. Double helix of DNA is similar to twisted ladder of spiral stair case, the components of DNA are nucleotides which are made up of : Nitrogenous bases, sugars and phosphate groups.

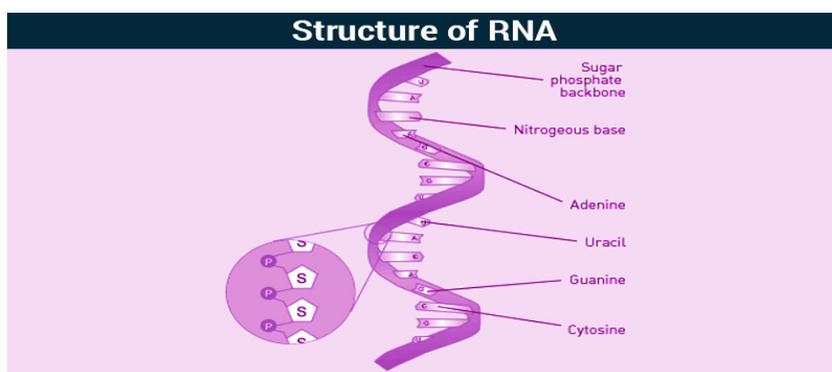
e) Application activity 3.1

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 3.1.

Answers for Application activities 3.1

1. DNA
2. A= Phosphate group, B= Sugar (deoxyribose), C= Nitrogenous bases



Lesson 2: Mechanism of DNA replication

a) Learning objective

- Explain semi-conservative replication
- Describe how semi conservative replication of DNA takes place.
- Explain how conservative and dispersive replications and are other hypothesis for DNA replication.
- Explain the importance of DNA replication in organisms

b) Teaching resources

- Charts and illustrations indicating the DNA replication
- Video/ movies of mechanism of DNA replication downloaded from you-tube
- Projector, computer
- Student books, pictures

c) Prerequisites/Revision/Introduction

Start the unit by briefing the learners about DNA replication as the process by which DNA makes a copy of itself during cell division. It produces two identical replicas. This process occurs in all organisms and is the basic for biological inheritance

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups
- Provide an activity 3.2 to the learners and ask them to do the related questions, attribute to each pair, the activity 3.2 given in student textbook
- In their groups, the learners are going to do an activity 3.2
- Facilitate them in that activity
- Let learner groups to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude

Answers for activity 3.2

Two new molecules of DNA are formed each with one of the strands of the parent. This form of replication is called semi-conservative replication because it conserves or preserves a half of the original strands of DNA in the new daughter strands of DNA formed.

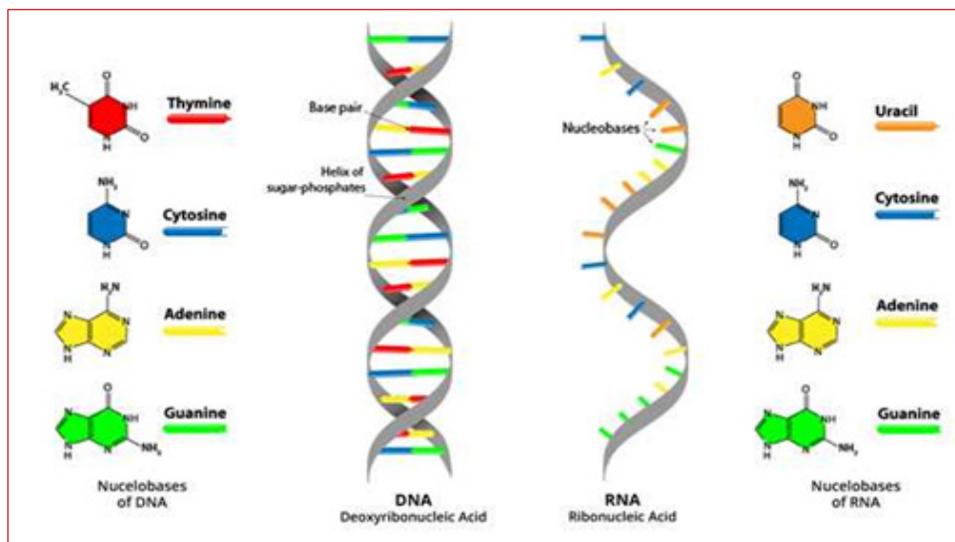
e) Application activity 3.2

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 3.2.

Answers for application activities 3.2

1.



2. The nitrogenous bases are different, purines and pyrimidines

3. Purines pair with pyrimidines and vice versa.

Lesson 3: Nature of gene , Genetic code and the process transcription

a) Learning objective

- Describe the nature of genes
- Describe the structure of a genetic code
- Describe how the information in DNA is used during transcription

b) Teaching resources

Books, charts, projector, computer

c) Prerequisites /Revision/Introduction

Teacher starts the unit by briefing the learners about genetic code and triplet codons. Teacher appreciates the importance of genetic code in determining the structure of a protein

d) Learning activities

Teacher initiates the topic by introducing genetic code. Ask the learners to research on the same. Teacher also discuss the transcription process. Start by asking the learners to explain the process using aids.

Answers for activity 3.3

- Genetic code is the nucleotide base sequence on DNA which determines the sequence of amino acids in the polypeptide chain.
- Transcription (from DNA to mRNA) this is the process by which information in DNA is used to code for the synthesis of messenger RNA (mRNA).

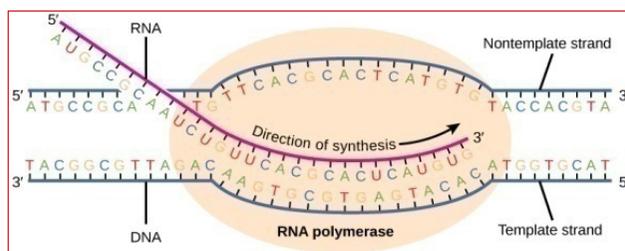
e) Application activity 3.3

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 3.3.

Application activities 3.3

1.



Lesson 4: Process of translation

a) Learning objective

- Construct a flow chart, in proper sequence, for the stages of transcription and translation.

- Using the evidence, predict the effect of change in genetic code on the structure of the protein manufactured during protein synthesis.

b) Teaching resources

Books, charts and videos illustrating the translation, computer aided materials such as animations and simulations.

c) Prerequisites/Revision/Introduction

Make a short revision on transcription before starting the translation

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups
- Provide activity 3.4 given in student textbook ask them to do the related questions
- Facilitate them in that activity
- Let learner groups to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize together with students and conclude

Answers for activity 3.4

Translation is the process by which the information of the sequence of bases in messenger RNA is converted into a sequence of amino acids in a polypeptide chain. The process of translation takes place on ribosomes in the cytoplasm. It involves another form of RNA called transfer RNA which is found in the cytoplasm

e) Application activity 3.4

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 3.4.

Answers for application activities 3.4

Val-Ala-His-Ser-Lys

Lesson 5: Effects of alteration of nucleotide sequence

a) Learning objective

- Describe the way in which the nucleotide sequence codes for the amino acid sequence with specific reference to HbA (normal) and Hb_s (sickle cell) alleles for β globin poly peptides.
- Explain how the gene mutation is a change in the sequence of nucleotides that may result in an altered polypeptide.

b) Teaching resources

- Charts
- Student books, pictures, internet
- Projector, computer

c) Prerequisites/Revision/Introduction

Introduce this lesson by asking the students to brainstorm if the single change in genetic code results in diseases .

d) Learning activities

Help the learners for developing competences related to the above lesson and do the following:

- Facilitate the learners to form groups
- Attribute the activity 3.5.
- Allow the learners to use the school library and the internet
- facilitate them in that activity
- Let learner groups to present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude

Answersfor activities 3.5

Any change in the nucleotide sequence of a gene can result into producing wrong or different polypeptide chain. In other words, gene mutation is a change in sequence of nucleotides that results in change in the synthesis of polypeptide chains

e) Application activity 3.5

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 3.5.

Answers for application activities 3.5

Cause

The mutation causing sickle cell anaemia is a single nucleotide substitution (A to T) in the DNA of haemoglobin coding gene. The change in a single nucleotide is transcribed as a codon for **valine amino acid (GUG)** on the m-RNA instead of **glutamic acid (GAG)**. Eventually, due to change in the codon, valine amino acid is translated instead of glutamic acid at the 6th position from N-terminus of the haemoglobin polypeptide chain. This defective form of haemoglobin in persons with sickle cell anaemia is referred to as **HbS**.

Symptoms

The sickled red blood cells are fragile and break easily, resulting in the anaemia. Normal red blood cells normally squeeze and pass through blood capillaries smoothly. However, sickled cells are not flexible and therefore have the tendency to get clogged in capillaries. As a result, blood circulation is impaired and tissues become deprived of oxygen. Oxygen deprivation occurs at the extremities, the heart, lungs, brain, kidneys, gastrointestinal tract, muscles, and joints.

3.6 Summary of the unit

Nucleotide is made up of pentose sugar, nitrogenous bases, and phosphate groups; whereas, nucleoside is made up of pentose sugar and nitrogenous bases. Phosphodiester bond connects the phosphate group, which is attached on 5' of one nucleotide, with the 3' carbon of another nucleotide. This bond is a strong bond. That is why DNA is a stable structure. Polynucleotide chains have polarity. On one end, there is a 5' carbon with a *phosphate group*. On the other end, there is a 3' carbon with a *hydroxyl group* on it. Chargaff's rules state that DNA of all organisms should have a 1:1 ratio of purine (A, G) and pyrimidine (T, C) bases. The specific base pairing of A-T bases and G-C bases is called complementary base pairs.

In 1953, Watson and Crick proposed the double helix structure of DNA. The two strands of DNA are anti-parallel; the bases on both strands are bonded by hydrogen bonds in line with Chargaff's rules. DNA has major and minor grooves. DNA replication is the process of producing two identical DNA replicates from one original DNA molecule. DNA replication plays an important role in reproduction, DNA repair and growth of organisms. DNA replicates semi-conservatively, where the two original strands act as template while the other two strands are newly synthesized. The other two models of replication are conservative and dispersive DNA replications.

Genetic Code is the set of rules by which information is encoded in genetic material (DNA or RNA sequences) is translated into proteins (amino acid sequences) by living cells. A codon is made up of three nucleotides or triplets. Out of 64 codons, 61 codons are sense codons and 3 codons are non-sense codons.

Genetic code is almost universal; it shows degeneracy. It is through genetic code that the genetic information found in m-RNA is translated to mature functional proteins. DNA molecule is a stable structure and replicates accurately in order to avoid any mutation or change in nucleotide sequences in DNA. Transcription is the process of copying information from one stand of DNA into a single stranded RNA (mRNA).

The process of transcription in eukaryotes involves:

- Initiation involves a complex of RNA polymerase II and general transcription factors.
- Elongation is similar to that of bacteria. But eukaryotic genes do not have terminator sequences.
- The newly formed pre-m-RNA has to undergo RNA processing.
- Translation is the production of protein molecules (polypeptides) by cellular ribosomes with the help of information present on the m-RNA

3.7 Additional Information for teachers: skills lab

Organize a laboratory study in your school ask student-teachers to extract the DNA from banana as experiment through observation of different steps of extraction of the DNA, ask them to record the observation and interpret the recorded observation. Provide guiding questions to their observation. Then after make presentation and harmonize.

3.8 Answers for end unit assessment 3

Section a: multiple choice questions

1. i. b
ii. b
iii. b
2. c
3. a
4. d

Section b: short answer type questions

5. a. X is mRNA; Y is the ribosome; Z is the (poly)peptide chain / chain of amino acids.
b. From left to right; increasing length of polypeptide chain.
6. a. Many amino acids have more than one triplet code; so sequence of amino acids is unchanged;
b. Adding or deleting three nucleotides may add or remove the coding for one amino acid; this may not affect the final shape of the protein; adding or deleting one nucleotide affects the arrangement of all subsequent triplets; this 'frameshift' may alter the coding of all amino acids following the addition or deletion; a triplet may be altered to a stop signal;
- 7.

mRNA codon	tRNA anticodon	DNA triplet from which mRNA was transcribed
UUA	AAU	AAT
UUG	AAC	AAC
CUU	GAA	GAA
CUC	GAG	GAG
CUA	GAU	GAT
CUG	GAC	GAC

8. a. 7

b. 7

c. TACCGG

d. Transcription.

e. mRNA is linear whereas tRNA is clover shaped; mRNA has codons whereas tRNA has anticodons

Section c: long answer type questions

9. a. The enzyme RNA polymerase moves along the template DNA strand causing the nucleotides on this strand to join with the individual complementary nucleotides from the pool which is present in the nucleus. The RNA polymerase adds the nucleotides one at a time, to build a strand of mRNA until it reaches a particular sequence of nucleotide bases on the DNA which it recognizes as a stop code.

b. DNA helicase: it acts on a specific region of the DNA molecule to break the hydrogen bonds between the bases, causing the two strands to separate and expose the nucleotide bases in that region.

c. Splicing is necessary because pre-mRNA has nucleotide derived from introns in DNA. These introns are non-functional and if left in the mRNA would lead to the production of non-functional polypeptides or no polypeptides at all. Splicing removes these non-functional introns from pre-mRNA.

d. i) UACGUUCAGGUC

ii) 4 amino acids (one amino acid is coded for by three bases; 12 bases code for 4 amino acids).

e. Some of the base pairs in the genes are introns/ non-functional DNA. These introns are spliced from mRNA so that the resulting mRNA has fewer nucleotides.

10. a. i. Universal because it is the same in all organisms.

ii. Degenerate because most amino acids have more than one codon.

iii. Non- overlapping because each nitrogen base in the sequence of mRNA is read once.

- b. RNA is smaller, DNA is larger; RNA is single stranded, DNA is double stranded; RNA has Uracil, DNA has thymine
11. a) AUG
e) Methionine-Glutamic acid-Proline-Alanine
f) CGA
g) AUC
h) The ribosome will make a bond between the polypeptide attached on the tRNA 1 and the amino acid brought by the tRNA 2, the ribosome will shift one codon to the right allowing the tRNA with an anticodon complementary to codon 6 to come to attach to the codon 6.
i) UCA, UCC, UCU, UCG
j) The protein synthesis would stop too early resulting in an abnormal protein that will have no function. This is called a nonsense mutation.

3.9 Additional activities

3.9.1 Remedial activities

Multiple choice questions

1. Gene codes for

- a) Polypeptides b) Blood
c) Specific trait d) Specific genome

Answer is **c**

2. Which of the following are the characteristics of genetic code?

- a) Triplet code b) Almost Universal
c) Non-overlapping d) All of these.

Answer is **d**

Answer by True or False

1. Genetic code is composed of A, C, G, and T nucleotides.
2. The main role of t-RNA is to decode the codons on m-RNA.

Answers 1.F

2.T

Questions with short answers

1. Complete the table below

	DNA replication	Transcription	Translation
Location in the cell			
Enzymes involved			
End products			

Answer

	DNA replication	Transcription	Translation
Location in the cell	Nucleus	Nucleus	In the cytoplasm on the ribosomes
Enzymes involved	DNA polymerase	RNA polymerase	Aminoacyl-tRNA synthetases
End products	Two identical copies of DNA	A strand of mRNA	A polypeptide chain of amino acids (a protein)

3.9.2 Consolidation activities

1. There are 20 different amino acids which cells use for making proteins.
 - a) How many different amino acids could be coded for by the triplet code? (Remember that there are 4 possible bases, and that the code is always read in just one direction on the DNA strand.)
 - b) Suggest how the 'spare' triplets might be used.
 - c) Explain why the code could not be a two-letter code.

Answer

- a) 64
- b) For 'punctuation marks' – that is, for starting or stopping the synthesis of a polypeptide chain. Also, some amino acids could be coded for by two or three different base triplets.
- c) A two-letter code could only code for 16 amino acids.

2. Copy and complete the following table to distinguish between the processes of transcription and translation.

	Transcription	Translation
Site in cell where process occurs		
Molecule used as a template in process		
Molecule produced by the process		
Component molecule (monomers) used in process		
One other molecule that is essential for the process to occur		

Answer

	Transcription	Translation
Site in cell where process occurs	<i>nucleus</i>	ribosome (in cytoplasm)
Molecule used as a template in process	DNA	(in cytoplasm) Molecule used as a template in the process is mRNA
Molecule produced by the process	mRNA	polypeptide / protein
Component molecule (monomers) used in process	RNA <i>Nucleotides</i>	Amino acids
One other molecule that is essential for the process to occur	RNA polymerase	tRNAs / enzymes / ribosomal RNA (rRNA) / ribosomal protein

3.9.3 Extended activities

1. In the 1940s, Chargaff and his co-workers analyzed the base composition of the DNA of various organisms. The relative numbers of the bases adenine (A), cytosine (C), guanine (G) and thymine (T) of three of these organisms are shown in the table.

	Relative numbers of bases			
	A	C	G	T
Ox (spleen)	27.9	20.8	22.7	27.3
Ox (thymus)	28.2	21.2	21.5	27.8
Yeast	31.3	17.1	18.7	32.9
Virus with single-stranded DNA	24.3	18.2	24.5	32.3

Explain why:

- The relative numbers of each base in ox spleen and thymus are the same, within experimental error.
- The relative numbers of each base in yeast are different from those in ox spleen or thymus.
- The relative numbers of each base A and T, or C and G, are similar in ox and yeast.
- In the virus, the relative numbers of each base A and T, or C and G, are not similar.

Answer

- The DNA in the spleen and thymus of the same organism is the same; the same genes are present in both organs;
- The DNA in different species is different; different genes are present;
- DNA has double helix / is double stranded; the numbers of A and T, and of C and G, are similar because A pairs with T and C pairs with G.
- The DNA is single stranded; no base pairing occurs.

UNIT 4

DIVERSITY OF SPECIALIZED TISSUES

4.1 Key unit competence:

Describe different specialized plant and animal tissues and their adaptation.

4.2 Prerequisites

In senior one students have learnt about animal and plant cells (unit 5), and levels of organization in multicellular organisms (Unit 6). Remind students some of none detailed concepts like specialized plant and animal cells and tissues that were seen in senior one. This unit deals with the specialized tissues. During the lessons in this unit, try to bring the awareness of students the fact that what you teach them will support to have knowledge on different types of animal and plant tissues as well as their adaptations and importance

4.3 Cross cutting issues to be addressed

a) Gender education

Engage girls and boys in all activities taking place in classroom and laboratory. Emphasize to students that everybody regardless to gender can do great things. You can also give some examples of exemplary girls and women who are successful teachers, doctors, local leaders in the society where students come from.

b) Inclusive education

Encourage students to participate during lessons, and group activities. Arrange your classroom in special way to take care for those students with special needs. For blind students, help them to learn by providing braille. For those ones who have sight problems you can print papers with large letters. Recognize and allocate the students with disabilities to others so that they can assist them during practical activities.

4.4 Guidance on introductory activity 4

This activity should provide guidance on how to conduct it, answers as well as a cross reference to the student's book. Learners may not be able to find the right solution but they are invited to predict possible solutions or answers. Solutions provided by learners gradually through discovery activities organized at the beginning of lessons or during the lesson.

Provide learners with student books and guide them to brainstorm the text in introductory activity on of unit 4. Ask learners in their respective groups to do the task below the text. Guide learners, to harmonize their presentation and evaluate their understanding.

Answers to the introductory activity:

Termites are specialized for particular task. Soldiers that protect the colony have mouth parts shaped like a pair of scissors building and a slightly larger abdomen for storing water. The queen is the largest of all and has a task of laying eggs. Workers have mouth parts for cutting and chewing food or soil particles. In an anthill, different termites are specialized to perform a particular task as tissues in the body are specialized to perform a particular function. Plants and animals have specialized tissues to increase the efficiency which the advantage of division of labor in multicellular organisms.

4.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1	Plant tissues	<ul style="list-style-type: none">- Explain a tissue as a group of cells with similar structure working together for a particular function.- Categorise the main types of plant tissues.- Observe and draw plant tissues under a light microscope.	2
2	Animal tissues	<ul style="list-style-type: none">- Observe and draw animal tissues under a light microscope.	2

3	Levels of organisation	- Explain an organ as a structure made up of a group of tissues with related functions working together to perform bodily functions	2
4	Advantages and disadvantages of being unicellular or multicellular	- State the advantages and disadvantages of being unicellular - Propose the advantages of being multicellular organism	2
	End of unit assessment		2

Lesson 1: Plant tissues

a) Learning objective

- Explain a tissue as a group of cells with similar structure working together for a particular function.
- Categorise the main types of plant tissues.
- Observe and draw plant tissues under a light microscope

b) Teaching resources

The laboratory experiments related to specialized plant tissues that require different materials as below,

- Staining reagents such as iodine solution
- Plant tissues
- Microscopes
- Slides
- Plastic ruler graduated in millimeters
- Prepared slides of cells and tissues
- Other resources like charts, printed papers, computer and projector
- Remember! If you find the materials are absent, do not think that it is the end.
- Do your best by improvisation or consult other schools that may have those materials.
- Books, computer

c) Prerequisites /Revision/Introduction

This is the first lesson of the fifth unit Diversity of specialized tissues. In this lesson you will be dealing with specialized plant tissues. The first thing to do

before starting teaching is to remind students that they have learnt about plant cells and tissues in senior one .During this lesson, make sure that you bring the awareness of the students the fact that what you teach them will support to have knowledge on different types of specialized plant tissues as well as their adaptations and importance. For good exploitation of students' knowledge about specialized tissues, try to remind the students about plant cells so that they can prepare themselves for this lesson.

d) Learning activities

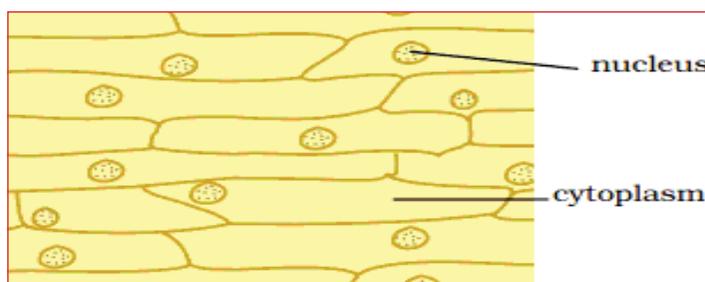
Before starting the activity 4.1ask your students to recall the unit 5 in senior one in which they have learnt plant and animal cells and tissues by asking them some questions on cells and tissues like what is a cell? What are two types of cells? What do you understand with term tissue? Opens short discussions to encourage learners to think about the previous learning experience and connect it with the current instructional objectives.

The teacher:

- Guide the students to form the groups of six members each.
- Remember to balance the groups basing on the capacity of students, gender and those with special needs to enhance the effective collaborative learning.
- Ask learners to do **activity 4.1** in their student book
- Provide the necessary materials.
- Provide the experiment activity protocol to guide the students
- Engage students in their respective groups to work collectively on activity.
- Relax a moment and move around in silence to monitor if they are having some problems, they are having enough materials; they are properly sharing ideas in English.
- Remember to assist those who are still behind but without giving them the knowledge.
- Invites representatives of groups to presents the group findings.
- Ask other students to follow carefully the representations
- Note on chalk board / manilla paper the students' ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage students then give the summary with tangible examples related to an activity.

Answers for activities 4.1

1.



2. The images seen under high power of objectives are more visible than the ones seen under low power of objective

e) Application activity 4.1

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 4.1.

Answers of application activities 4.1

• Building a house	• Building a plant
1. Foundation is laid	1. Meristems give rise to all tissues
2. Construction of the frame	2. Three tissue systems give rise to the major organs of a plant
3. Installation of plumbing (water), power (electricity)	3. Installation of the vascular tissue (plumbing)
4. Waterproof walls and roof	4. Installation of dermal tissues covering, skin
5. Food stored in appropriate places	5. Installation of ground tissue parenchyma

Lesson 2: Animal tissues

a) Learning objective

- Observe and draw animal tissues under a light microscope.

b) Teaching resources

- Microscopes
- Slides

- Plastic ruler graduated in millimeters
- Prepared slides of cells and tissues
- methylene blue
- Cheek cells
- Other resources like charts, printed papers, computer and projector

c) Prerequisites/Revision/Introduction

Lesson 4.2 deals with specialized animal tissues. Before you start teaching, remind students that they have learnt about animal cells and tissues in senior one (unit 5). During this lesson, make sure that you bring the awareness of the students the fact that what you teach them will support to have knowledge on different types of specialized animal and plant tissues as well as their adaptations and importance. For good exploitation of students' knowledge about cells and tissues, try to help them to remember the definition of animal tissue and to prepare themselves for this.

d) Learning activities

The teacher:

- Ask students to go in groups formed in previous lesson
- Ask learners to do activity 4.2 in their student book
- Provide the necessary materials.
- Provide the experiment activity protocol to guide the students
- Engage students in their respective groups to work collectively on activity.
- Tell other students to follow carefully the representations
- Write on chalk board / Manila paper the student's ideas.
- Confirm the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage students in making conclusion, then give the summary with tangible examples related to a lesson.

Answers

You are required to orient students in library with clear references. The opportunity they get must be exploited in your silence and monitoring to ensure the students competences.

Invite randomly four representative students to presents their results, and try to promise them to get clear result as the lesson will carry on.

e) Application activity 4.1

Guidance:

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 4.1.

Answers for application activities 4.2

1. **A=** Stratified Squamous Epithelium **B=**Simple Columnar epithelium **C=**Pseudostratified Ciliated Columnar Epithelium, **D=** Skeletal Muscle
2. **A=** Stratified squamous epithelium is a type of tissue found covering and lining parts of the body. In this tissue, cells are flattened, joined tightly together, and stacked. The major function of this tissue type is protection, as it is found in areas that undergo wear-and-tear
B= Simple columnar epithelia with microvilli secrete digestive enzymes and absorb digested food. Simple columnar epithelia with cilia aid in the movement of mucus and reproductive cells.
C= Ciliated pseudostratified columnar epithelium cells are found in places such as the trachea and upper respiratory tract, where their cilia and mucous secretions help collect foreign materials so you can cough or sneeze them out
D= Skeletal muscles move the body. Skeletal muscle contractions pull on tendons, which are attached to bones. If contraction of the **muscle causes the muscle to shorten, the bone and, thus, the body part will move. ... The energy from skeletal muscle** contractions produces heat and regulates body temperature.

Lesson 3: Levels of organization in multicellular organisms

a) Learning objective

- Explain an organ as a structure made up of a group of tissues with related functions working together to perform bodily functions

b) Teaching resources

Teaching aids like charts, printed papers, computer, projector, manila paper with diagrams for improvisation

c) Prerequisites/Revision/Introduction

Lesson 4.3 deals with the levels of organization. Before you start teaching, remind students that they have learnt about cells, tissue, organ, system and organization in senior one (unit 6).

During this lesson, make sure that your guidance and assistance will support students to have knowledge on different levels of organization. For good exploitation of students' knowledge about levels of organization, try to help them to remember the definition of cell, tissue, organ and system.

d) Learning activities

The teacher:

Ask learners to do individually activity 4.3 in their student books

Provide the necessary materials. Move around in silence to monitor if they are having some problems. Remember to assist those who are weak but without giving them the knowledge.

Answers for activities 4.3

Precaution:

Consider a building of which bricks are exposed (not plastered).

- 1) A brick.
- 2) One brick is joined with another one, and another to another to form a line of bricks, many lines of bricks form a wall.
- 3) Yes, it is made up of smallest particles of soil (sand or clay) or stones.
- 4) Very many, not easy to count.
- 5) They are formed by joining smallest components of a building block called bricks.
- 6) Brick, course, wall, room, block (use arrows to represent a sequence)
- 7) Relate the above arrangement of a building to levels of organization in multicellular organisms, beginning with a cell and ending with an organism.

Just as we seen that a building is made up smallest units called bricks, also our bodies also made up smallest units called cells. Cells in multicellular organisms are arranged in a sequence in levels of organization as follows: Cell, tissue, organ, system, and organism. This sequential arrangement is similar as the one

of a building above. A cell matches with a brick, course of bricks matches with a tissue; a wall matches with an organ and so on.

- Invites any three students to present their findings to the rest of students.
- Ask other students to follow carefully the representations
- Note on chalk board / Manila paper the students' ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage students in making that conclusion

e) Application activity 4.3

Guidance

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 4.3.

Lesson 4: Advantages and disadvantages of being unicellular or multicellular

a) Learning objective

- State the advantages and disadvantages of being unicellular
- Propose the advantages of being multicellular organism

b) Teaching resources

Some resources like charts, printed papers, computer and projector. Do your best by improvisation or consult other schools that may have other materials you may not have.

c) Prerequisites/Revision/Introduction

Lesson 4.4 deals with advantages and disadvantages of unicellular and multicellular organisms.

Before you start teaching, remind students that they have learnt about unicellular and multicellular organisms in senior one (unit 6)

During this lesson, make sure that your guidance and assistance will support students to have knowledge on Advantages and disadvantages of unicellular and multicellular organisms. For good exploitation of students' knowledge about unicellular and multicellular organisms, try to help them to remember the definition of unicellular and multicellular.

d) Learning activities

The Teacher:

- Ask learners to do in pair **activity 4.4**
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems
- Remember to assist those who are weak but without giving them the knowledge.
- Invites any three students to present their findings to the rest of students.
- Ask other students to follow carefully the presentations
- Note on chalk board / Manila paper the students' ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage students in making that conclusion

Answers for activity

1) Advantages and disadvantages of unicellular organism:

(i) Advantages:

- Unicellular organisms need fewer nutrients and can survive in bad conditions.
- Some of the organisms can generate energy through photosynthesis.
- Sometimes different bacteria work together to work to their advantages.
- Unicellular organisms can multiply quicker and have less energy/resource demands.

(ii) Disadvantages:

- Unicellular organisms only have one cell that is used to function their entire being. This is a disadvantage compared to multicellular organisms, which have many cells and function more easily and properly.

2) Organism being Multicellular

i) Advantages:

- Multicellular organism usually has a wider range of functions because of the aggregation of different types of cells.

- Multicellular organisms have many more necessities and can only survive in certain conditions.
- Multicellular organisms such as animals are unable to make their own food so
- they survive by eating living things such as vegetables, fruits, and meat. They can also eat things that are produced by other living things such as eggs, milk, and honey.
- Nutrients must be broken down for most multicellular organisms to be able to extract energy from them.

ii) Disadvantage:

Multicellular organisms such as animals are unable to make their own food and to get food is a tire some work. Their survival in critical condition is rare.

e) Application activity 4.4

Guidance

Ask student-teachers to work individually or in pair or in groups to answer the questions of application activity 4.4.

Answers for application activities 4.4

1. A = multicellular because it is made of many cells performing different functions (eg flight, digestion, respond to stimulus)
B = unicellular because it is made up of one cell, it microscopic
2. Organism, organsytem, organ, tissue, cell and mitochondrion.

4.6 Summary of the unit

This unit is based on the study of Diversity of specialized tissues. The study of animal and plant tissues is known as Histology. A tissue is a group of associated, similarly structured cells that perform specialized functions for the survival of the organism. In histology, differentiation is the process by which structures (cell, tissue, organ, and system) become modified and specialized to perform specific functions.

Plant tissues are is divided into two main groups: Meristematic tissues (apical, lateral, and intercalary meristems) and Permanent tissues (ground tissues and vascular tissues). **Meristem tissue** is a group of cells which retain the ability to divide by mitosis. It is specialized to carry out specific functions such

as reproduction, growth, photosynthesis and replacement of old or damage tissues. Permanent tissues consist of two groups of tissues such as: ground and vascular tissues in plants. The vascular tissue system consists of two kinds of conducting tissues: **the xylem** responsible for conduction of water and dissolved mineral nutrients, and **the phloem** responsible for conduction of elaborated food.

There are four basic types of tissues in the body of all animals, including the human body such as **epithelial tissue, muscle tissue, nervous tissue, and connective tissue**. The human body is organized into structural and functional levels. The simplest is the cells, organized into tissues, organs, and organ systems.

Guidance on skills Lab

Organize a laboratory activity; ask student-teachers to study plant cells by doing experiment, through observation under microscope, record the observation and interpret the recorded observation. Provide guiding questions to their observation. Suggest some questions to be asked as: draw and label what they have observed. Then after make presentation and harmonize.

4.7 Additional Information for tutors teachers

Remember to tell students to clean their materials before starting activity and make sure that all students are recognizing lab rules and regulations.

Do not forget to write the protocol on a chalkboard or to provide the protocol papers if possible. The activity protocol should have the procedures to follow during activity as indicated here under:

- Hold the glass slide on the edges.
- Place a drop of iodine solution on the centre of the glass slide.
- Peel off the thin inner layer of fleshy white storage leaves of the onion made up of a single layer of cells by using forceps.
- Gently, use a razor blade to cut off a small piece of the epidermis, about 1Cm²
- Place a small piece of the epidermis of onion in the drop of iodine, flatten it against the slide, by using the needle.
- Hold one side of the cover slip and slowly lower it on top of the iodine. Do this slowly and carefully to avoid air bubbles in specimen to be viewed.
- Using a tissue, clean away the iodine around the cover slip.

- Place the slide on the stage of the microscope.
- Adjust the microscope to view the specimen
- Make good drawing of what you see.
- Remember to move around to make sure weather all students are participating in activities
- Ask students to present their results them you help them to come up with good conclusion.
- Tell the students to leave the working place well-lit and clean.

4.8 End unit assessment

Section A multiple choice questions

- 1) Epithelial
- 2) Connective, Muscular, Epithelial, Nervous

Section B

- 3)

Growth tissues	Meristem , Cambium
Protective tissues	Cuticle, cork
Storage tissues	Parenchyma,
Support tissues	Sclerenchyma, collenchyma
Conducting tissues	Xylem, Phloem
Secretory tissues	Nectary gland, Fragrance glands

Section C: Long answer type questions

- 4) The answer includes:

Epithelium lining the respiratory air passages secretes mucus. This helps them to trap inhaled dust particles and microbes. Some epithelial tissues are made up of epithelium cells that have cilia. This helps them to propel the mucus and trapped particles to the throat. Some epithelial tissues are folded and form glandular tissues. This helps them to secrete the digestive enzymes, hormones, mucus, sweat and sebum. Some epithelial cells divide mitotically producing new cells. This helps them to replace damaged or dead cells. Some epithelial cells such as taste buds and retina cells are specialized to form sensory receptors.

- 5) Blood has a number of functions that are central to survival, including: supplying oxygen to cells and tissues. providing essential nutrients to cells, such as amino acids, fatty acids, and glucose, removing waste materials, such as carbon dioxide, urea, and lactic acid.

4.9 Additional activities

4.9.1 Remedial activities

- 1) Write any three functions of parenchyma tissues

Answer: In the leaves, they form the **mesophyll** and are sites for photosynthesis, gaseous exchange and transpiration. They store food substances such as starch, proteins and lipids. They can be modified to form specialized cells to carry out other function in epidermis, endodermis, pericycle, and secretory cells.

- 2) What do you understand by the term organ?

Answer: An organ is a group of tissues precisely arranged so as to accomplish specific functions.

- 3) Multicellular organisms are bigger than unicellular organisms. What does multicellular mean?

Answer: Multicellular means many cells

4.9.2 Consolidation activities

- 1) What are differences between apical meristematic tissue and intercalary meristematic tissue?

Answer

- a) Apical meristematic tissue

It is located in the root and shoot apex.

It is responsible for primary growth.

While,

- b) Lateral meristematic tissue

It is located in lateral parts of the plant,

It is responsible for secondary growth.

2) Draw the diagrams to differentiate Simple cuboidal epithelium and Simple squamous epithelium

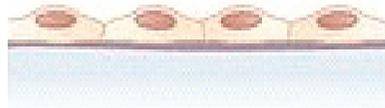
Answer:



Simple cuboidal epithelium

This is a tissue with cells that are cubical in shape

Cuboidal cells are specialized for secretion and they make up the epithelia of kidney tubules and many glands including salivary glands, and thyroid gland.



While,

Simple squamous epithelium

It is thin and leaky

It functions in the exchange of material by diffusion.

It lines blood vessels and the air sacs of lungs.

3) What do you think is relationship between organ systems in human body?

Answer:

The food is digested in alimentary canal and nutrients enter the blood then assimilated by the body and the waste products like carbon dioxide, urea...after metabolic activities, are released during urination, sweating and breathing, all under the control of nervous system.

4) Multicellular organisms such as animals are unable to make their own food but plants are able to make their own food. This helps us to think about two modes of nutrition in multicellular organisms. Write down the names and define those modes of nutrition.

Answer:

Autotrophic nutrition: mode of nutrition where green organisms like plants make their own food using carbon dioxide, water in the presence of sun light.

Heterotrophic nutrition: Mode of nutrition where living organisms like animals, fungi, get energy from the food made by plants or other organisms.

The organisms using this mode of nutrition are not able to make their own food due to lack of chlorophyll

4.9.3 Extended activities

- 1) Imagine what will happen to the flowering plants if the meristem tissue is removed.

Answer:

Inhibition of primary growth

increased lateral growth

No growth in length

- 2) Heat production is one of the functions of human muscle tissue. How do these tissues perform it?

Answer:

Most of the sugar molecules are stored in muscle tissue, these molecules are used during cell respiration where oxygen combine with them to produce energy which can be in heat form (thermal energy and in force form (mechanical energy)

Sugar+ oxygen to give Carbon dioxide+ water+ Energy

- 3) What is the origin of your entire body?

Answer:

The body originates from the cell, many similar cells form tissue, tissues make organ, organs make system and finally systems make entire body organism

- 4) Bacteria are unicellular organisms which do not have sexual organs for reproduction, but their rate of reproduction is extremely high.

Answer:

Answer of this question should base first on their advantages of being unicellular. These organisms do not need much nutrients for further body activities. They simply divide excessively and regenerate into new uncountable offspring. The mode of reproduction is known as Binary fission or Bipartition.

UNIT 5

TRANSPORT ACROSS THE CELL MEMBRANE

5.1 Key unit competence:

Explain the physiological processes by which materials move in and out of cells and the significance of these processes in the life of organisms.

5.2 Prerequisites

Student- teachers will learn better the transport across the cell membrane if they have understanding on solvent (water), solutes, concentration of a substance, hypotonic solution, hypertonic solution and isotonic solution. So, a tutor, introduce this unit asking them to brainstorm what they know about the terms.

5.3 Cross cutting issues to be addressed

The cross cutting issue addressed in this unit is the environment and sustainability. Student- teachers must be encouraged to protect the environment so that the transport of substances across the cell membrane continues. For example, osmosis in plants cannot occur if there is drought resulting from environmental pollution.

5.4 Guidance on introductory activity 5

As a tutor find or make four cubes of the side length of 1 cm, 2 cm, 3 cm and 4 cm. Then , ask 2 student- teachers sitting on the same desk to apply the formula found in student's book. Finally, request student- teachers to answer those questions.

Answers of introductory activity 5

- 1) - The K is simple diffusion in which molecules move freely from their high concentration to their low concentration without carrier proteins. So , K is down concentration gradient.
- The L is active transport in which molecules move from their low concentration to their high concentration through carrier proteins of cell membrane and ATP energy is used. So , L is against concentration gradient.

- 2) That is because K is down concentration gradient while L is against concentration gradient.

5.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1)	Types of transport of substances across the cell membrane	<ul style="list-style-type: none"> - Describe and explain the processes and significance of movement in and out of the cell mentioned in the content. - Appreciate the importance of movement of substances across cells. 	(2 Periods)
2)	Diffusion and factors affecting the process of diffusion.	<ul style="list-style-type: none"> - Increasing size of organisms is constrained by its ability to obtain resources through diffusion across the cell surface and its ability to move substances out of cells. Justify this statement. - Carry out an investigation on simple diffusion by using plant tissues and non-living materials. 	(2 Periods)
3)	Process of osmosis	<ul style="list-style-type: none"> - Apply the knowledge of hypertonic environments in food preservation by salting. - Show concern when exposing living organisms to concentrated media. 	(3 Periods)
4)	Water potential, osmotic potential, wall pressure	Explain the movement of water between cells and solutions with different water potentials and explain the effects on plant and animal cells.	(2 Periods)

5)	Process of active transport	Interpret and present data in graphic and table form on the effects of varying concentrations of: e.g. sugar, salt on plant and animal tissues	(3Periods)
6)	Endocytosis and exocytosis	- Distinguish between endocytosis and exocytosis in organisms.	(3 Periods)

Lesson 1: Types of transport of substances across the cell membrane

a) Learning objective

- 1) Describe and explain the processes and significance of movement in and out of the cell mentioned in the content.
- 2) Appreciate the importance of movement of substances across cells.

b) Teaching resources

As a tutor, find the following materials: Potato tubers, onion epidermis, slides and microscopes, visking tubing, knives, potassium permanganate, methylene blue, water, sucrose solutions of varying concentrations and animal tissues e.g. blood smear of a frog.

c) Prerequisites/Revision/Introduction

To understand this lesson, student- teachers must be aware of concentration gradient, electrochemical gradient .Ask them to differentiate those terms.

d) Learning activities

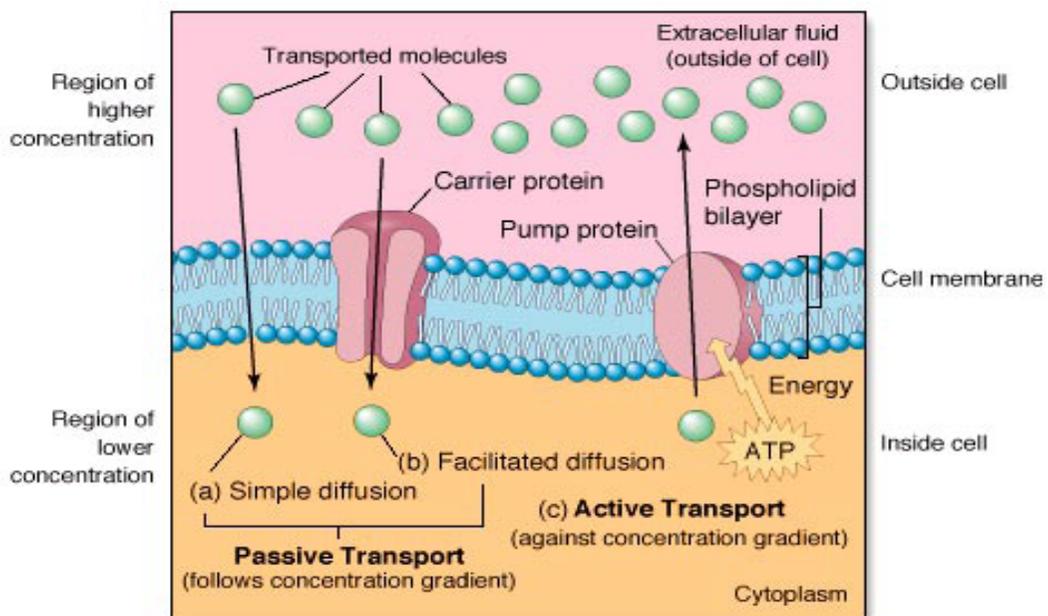
Guidance on activity 5.1

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Make copies / draw on a manila paper the image found in this activity 5.1 and write the questions related to this image on the blackboard.
- Give those copies to all groups or hang that manila paper in front of all student- teachers.
- Request the groups to do the activity 5.1.
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.

- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- During discussions, include the environment and sustainability as cross-cutting issue saying some human activities (such as deforestation) degrade the environment and lead to the lack of water that living organism should use in the transport of nutrients and other necessary substances in the body; so , they have to conserve the environment.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow students to note the summary in their notebooks.
- At the end, assess learners with application activity 5.1 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 5.1

The types of substances transported across the cell membrane.



d) Application activity 5.1

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually or in pairs or in groups, the application activity 5.1.

Answers of Application activity 5.1

- 1) i) Shrinks
 - ii) diffusion
 - iii) osmosis
 - iv) Turgor pressure
 - v) higher
- 2) This drying process is related to the transport of substances across the cell membrane because:
 - Water is lost from by a plant in the process of transpiration due to high sunshine.
 - High sunshine also causes the evaporation of some soil water molecules. So, plants have no water to absorb and mineral salts cannot be absorbed without water in the soil.

Lesson 2: Diffusion

a) Learning objective

- 1) Increasing size of organisms is constrained by its ability to obtain resources through diffusion across the cell surface and its ability to move substances out of cells. Justify this statement.
- 2) Carry out an investigation on simple diffusion by using plant tissues and non-living materials.

b) Teaching resources

To facilitate student- teachers, as a tutor, find the following materials: Visking tubing with capillary, Beaker with water, Sucrose solution (10%), pieces of beetroot.

c) Prerequisites/Revision/Introduction

Student- teachers must have prior information about why molecules move from one place to another. This was discussed in the first lesson. Ask them to

d) Learning activities

Guidance on activity 5.2

- Form new groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face. Each group must include talented or gifted student- teachers, middle student- teachers and less talented student- teachers.

- Give the materials and procedure to student- teachers.
- Request the groups to do the activity 5.2 using given materials.
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Assist student- teachers to write the lesson summary on the blackboard.
- Enable student- teachers to note the summary in their notebooks.
- Finally, assess learners with application activity 5.2 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 5.2

- 1) Simple diffusion
- 2) It is simple diffusion because red pigment of beetroot moves from a region of high concentration in the vacuoles to a region of low concentration in the solution outside the pieces of beetroot.
- 3) a) Factors affecting the rate of diffusion:
 1. The greater the concentration difference between the two sides of the membrane, the faster is the rate of diffusion.
 2. As the temperature increases, the rate of diffusion increases.
 3. Smaller molecules have faster rate of diffusion while the ones with larger mass, diffuse slowly.
 4. The larger the surface area of membrane available for diffusion, the higher is the rate of diffusion.
 5. The greater the distance across which diffusion is to occur, the longer it takes for molecules to pass through.

b) Significance of Diffusion:

Diffusion plays an important role in living systems. Below are a few examples where its diverse significance can be understood.

1. In the human body, nutrients (in the form of ions and small molecules) are absorbed from the food by the surrounding blood cells in the vessels by way of diffusion.
2. In the lungs, CO₂ diffuses out of blood in alveolar sacs whereas O₂ (present in high concentration in the inhaled air) diffuses into the cells in the blood vessels (with low O₂ concentration).

3. Cutaneous respiration (through skin) is the most common mode of respiration in lower non-chordates wherein gases directly diffuse through the air into the surface epithelium of the organisms.
4. The eyes lack a great number of blood vessels (which carry oxygen) and therefore, needs an extra supply of oxygen. The atmosphere provides this extra needed oxygen, which is taken up by the eye through direct diffusion of O_2 into the cornea, the hard outer covering on the eye. In absence of diffusion, the eyes would dry out.
5. For medicines taken orally as pills, the medicine must somehow find its way into the bloodstream. Once in the stomach, the medicine from the pill is absorbed into the lining of the stomach and then into the bloodstream, both by the process of diffusion.
6. Gaseous exchange during the process of respiration and photosynthesis takes place with the help of diffusion.
7. Transpiration or loss of water from the aerial parts of the plants involves the process of diffusion.
8. Diffusion is involved in passive uptake of mineral salts.
9. Scent present in molecules of the flowers to attract the pollinating animals, spreads in the air by diffusion.
10. Diffusion plays an important role in imbibition (special type of diffusion involving the absorption of water molecules by solids such as absorption of water by wood or seeds) and osmosis.

e) Application activity 5.2

Guidance

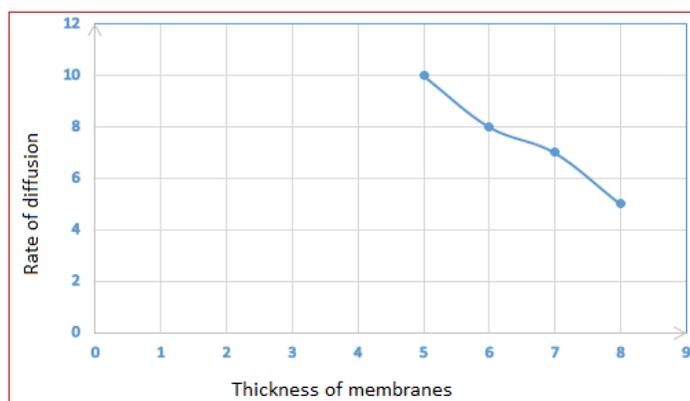
As a tutor, assess this lesson by asking the student-teachers to answer , individually or in pairs or in groups , the application activity 5.2.

Answers of Application activity 5.2

1) i) Diffusion

ii) Facilitated diffusion

2) a) Graph:



b) Graph interpretation:

Considering this graph, it is visible that, when the membranes thickness increases, the rate of diffusion decreases because the molecules travel a long distance.

- c) 1. The greater the concentration difference between the two sides of the membrane, the faster is the rate of diffusion.
2. As the temperature increases, the rate of diffusion increases.
3. Smaller molecules have faster rate of diffusion while the ones with larger mass, diffuse slowly.
4. The larger the surface area of membrane available for diffusion, the higher is the rate of diffusion.

Lesson 3: Osmosis

a) Learning objective

- 1) Apply the knowledge of hypertonic environments in food preservation by salting.
- 2) Show concern when exposing living organisms to concentrated media.

b) Teaching resources

The following resources are needed to understand this lesson: Irish or sweet potatoes, knife, water, salt or sugar, Petri dish or beaker.

c) Prerequisites/Revision/Introduction

Students must be aware of diffusion because it is related to osmosis by the fact that, in osmosis, water moves from hypotonic solution to hypertonic solution. So, ask students to describe orally the term diffusion, its factors and significance.

d) Learning activities

Guidance on activity 5.3

- Take your marks records list and form groups of 4 or 6 students based on their previous assessment marks and allow them to sit on 2 desks face-to-face.
- Provide students with required materials, procedure and questions.
- Request the groups to do the activity 5.3
- Move around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable learners to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- During discussions, include the environment and sustainability as cross-cutting issue saying some human activities (such as deforestation) degrade the environment and lead to the lack of water that living organism should use in the transport of nutrients and other necessary substances in the body; so, they have to conserve the environment by afforestation.
- Encourage the students to write the lesson summary on the blackboard.
- Allow students to note the summary in their notebooks.
- To finish this lesson, assess learners with application activity 5.3 or formulate your own assessment questions that must be answered by each learner.

Answers of activity 5.3

- 1) Osmosis.
- 2) Interpretation of observation :

Set- up A:

Water comes from the cells of Irish potato and Petri dish and enters the moist sugar in the made depression because the Irish potato and Petri dish are **hypotonic** media whereas the moist sugar is the **hypertonic** medium. So, Irish potato cells become **plasmolysed**.

Set up B:

Water comes from the cells of Irish potato and made depression and enters the 60% sugar solution in the Petri dish because the Irish potato and made cavity are **hypotonic** media whereas the 60% sugar

solution is the **hypertonic** medium. So, Irish potato cells become **initially turgid** as water moves from that to them ; but finally, those cells are plasmolysed because water continue towards the 60% sugar solution in the Petri dish B.

3) The factors affecting osmosis:

- i) Diffusion pressure deficit (D.P.D.)
- ii) Temperature.
- iii) Type of semi-permeable membrane.
- iv) Surface area to body volume ratio.
- v) Medium of osmosis.
- vi) Size and density.
- vii) Surface area.
- viii) Distance.
- ix) Concentration gradient.

4) **Significance of Osmosis:**

1. It influences the distribution of nutrients and the release of metabolic waste products. Living cells of both plants and animals are enclosed by a partially-permeable membrane called the cell membrane, which regulates the flow of liquids and of dissolved solids and gases into and out of the cell.
2. It helps to maintain the pressure on either side of the cell membrane thereby preventing the cells to become turgid and burst or to become flaccid.
3. Plant roots absorb water and minerals from soil and take it upwards to the leaves and other plant parts which are essential for plant growth.
4. Purification of blood by kidneys also involves osmosis. Osmosis maintains the balance of inter- and intracellular fluids.
5. Reverse osmosis is used to purify water.
6. Plants wilt when watered with salt water or provided too much of fertilizer as this makes the soil hypertonic than the plant roots and disrupts water uptake.

e) Application activity 5.3

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually, the application activity 5.3.

Answers of Application activity 5.3

1)

Column A	Column B
1. It occurs when a plant cell is placed in hypotonic solution	d. turgidity
2. It happens when a plant cell is placed in hypertonic solution	c. Plasmolysis
3. It takes place when animal cell is placed in hypotonic solution	b. lysis
4. It is undergone by an animal cell put in hypertonic solution	a. crenation

2) Plant roots absorb water (by osmosis) and minerals from soil and take it upwards to the leaves and other plant parts which are essential for plant growth.

Lesson 4: Water potential, osmotic potential, wall pressure

a) Learning objective

Explain the movement of water between cells and solutions with different water potentials and explain the effects on plant and animal cells.

b) Teaching resources

Potatoes (plant tissue), Cork borer, Measurement scale, Knife/Blade, Boiling tubes, Aluminium foil, Graph paper, Sucrose solution (0.0M, 0.2M, 0.4M, 0.6M, 0.8M and 1M), Water.

c) Prerequisites/Revision/Introduction

Student- teachers must have prior knowledge on diffusion and osmosis. Ask them to write their definitions on personal papers.

d) Learning activities

Guidance on activity 5.4

- Using your marks records, form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.

- Provide those groups with the materials mentioned above, the procedure and questions.
- Give those copies to all groups or hang that manila paper in front of all student- teachers.
- Request the groups to do the activity 5.4.
- Move around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Request other groups to add the missing information if they have it.
- Enable student- teachers to ask for explanation from what the groups have presented and explain what the groups have not highlighted.
- Aid the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- Finally, assess learners with application activity 5.4 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 5.4

- 1) – In solution whose sucrose concentration is 0.0 M ,potato tissue cylinders have swollen due to much water from that solution to those cylinders.
 - In solution, the tissue cylinders shrunk due to water exiting them by osmosis during plasmolysis.
- 2) Osmosis.

e) Application activity 5.4

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 5.4.

Answers of Application activity 5.4

- 1) The water potential decreases because as solute concentration increases, as water potential decreases. In fact, the Ψ of pure water is 0 and addition of solutes makes Ψ negative (-);those solute molecules can form bonds with water , preventing water from moving.
- 2)

$$\Psi_{\text{cell}} = \Psi_s + \Psi_p$$

Where:

Ψ_c or Ψ : water potential of the cell , Ψ_s : osmotic (solute) potential , Ψ_p , pressure potential.

$$\Psi_p = \Psi_c - \Psi_s = -950 \text{ kPa} - (-1400 \text{ kPa}) = 450 \text{ kPa}$$

Lesson 5: Process of active transport

a) Learning objective

Interpret and present data in graphic and table form on the effects of varying concentrations of: e.g. sugar, salt on plant and animal tissues

b) Teaching resources

These materials are required: Given data and the plotted graph. As a tutor, help student-teachers to get them.

c) Prerequisites/Revision/Introduction

Student- teachers must have studied the plotting and interpretation skills in mathematics. They must also know the types of transport of substances cross the cell membrane.

d) Learning activities

Guidance on activity 5.5

- Check on your marks records list and form new groups of 4 or 6 student-teachers based on their previous assessment results.
- Provide student-teachers with data in a table so that they plot them on a graph.
- Ask them to do the activity 5.5.
- Pass around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Request other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 5.5 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 5.5

- 1) Some potatoes placed in hypotonic media get water and their mass increase while other potatoes placed in hypertonic media lose water and their mass decreases.
- 2)

Hypotonic solutions with respect to potato tissue?	Hypertonic solutions with respect to potato tissue?
(0%, 0.2% NaCl	0.4%, 0.6%, 0.8% and 1% NaCl

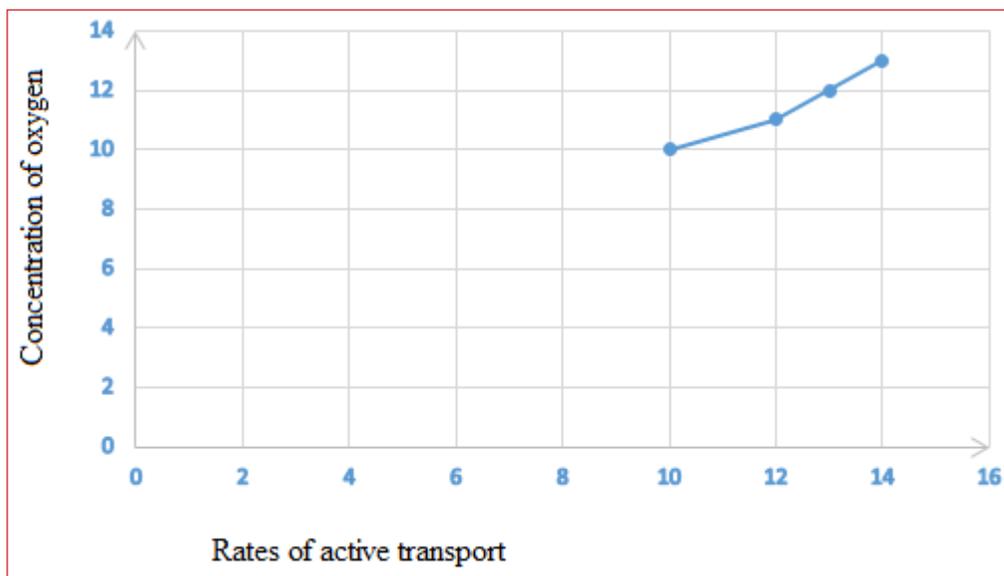
e) Application activity 5.5

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 5.5.

Answers of Application activity 5.5

- 1)



- 2) Graph interpretation: As the concentration of oxygen increases, the rate of active transport increases. In fact, oxygen is a reactant in aerobic cell respiration which produces much energy used in active transport.

3) Other factors of active transport :

i) Temperature : Increase in temperature up to *optimum* levels increases rate of chemical reactions that release energy in the cell. Increase in energy enhances the rate of active transport. Temperatures above optimum levels denature enzymes that speed up chemical reactions. This results in low energy production and therefore rate of active transport is slowed down. Low temperatures inactivate enzymes hence less energy is produced. This slows down active transport.

ii) Enzyme inhibitors: Enzyme inhibitors are substances that slow down the rate of enzyme activity. Presence of enzyme inhibitors slows down the rate of active transport. These block the enzyme active sites which makes it hard for the enzymes to bind and react with the substrates.

iii) Cofactors and coenzymes: Cofactors and coenzymes are substances that activate enzymes. Their presence increases the rate of chemical reactions leading to more energy production. This increases rate of active transport. A **cofactor** is nonprotein adjunct required by an enzyme in order to function; many cofactors are metal ions (such as Mg^{2+} , Magnesium ions), others are coenzymes. A **coenzyme** is a nonprotein **organic** molecule that aids the action of the enzyme to which it is loosely bound. Examples of coenzymes are Nicotinamide adenine dinucleotide(NAD), Flavine adenine dinucleotide(FAD).

iv) pH : This is the acidity or alkalinity of a solution. Some enzymes function best in acidic, alkaline or neutral pH. If the pH of a chemical reaction is altered, enzyme activity will be slowed down or stopped. This will slow down or stop energy production. Consequently, active transport will be slowed down or may stop.

Lesson 6: Endocytosis and exocytosis

a) Learning objective

Distinguish between endocytosis and exocytosis in organisms.

b) Teaching resources

As a tutor, provide student-teachers with internet connection and textbooks so that they provide accurate findings.

c) Prerequisites/Revision/Introduction

Student-teachers must have information about immunology and nutrition of unicellular organisms such as Amoeba. Ask them to comment about how the macrophages or neutrophils protect the body against pathogens and foreign antigens by phagocytosis.

d) Learning activities

Guidance on activity 5.6

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Ask them to do the activity 5.6.
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Assist the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 5.6 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 5.6

a) **Endocytosis** is an active transport in which cells take in substances by vesicle formation as plasma membrane pinches off by either phagocytosis, pinocytosis, or receptor-mediated endocytosis.

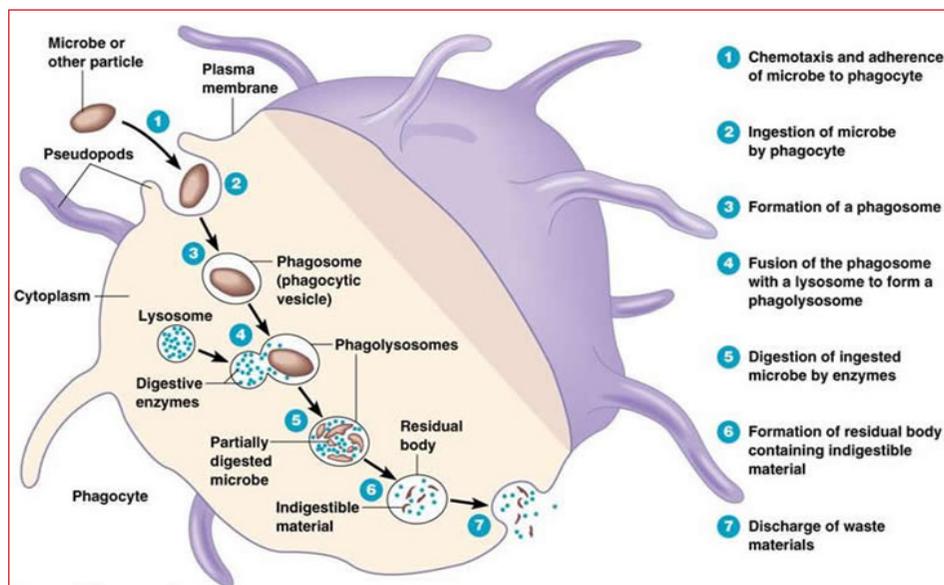


Figure : Phases of phagocytosis of microbes by a white blood cell

b) Exocytosis is an active transport in which a vesicle often formed by Golgi apparatus fuses with the plasma membrane and secretion occurs.

e.g. Insulin leaves insulin-secreting cells by this method.

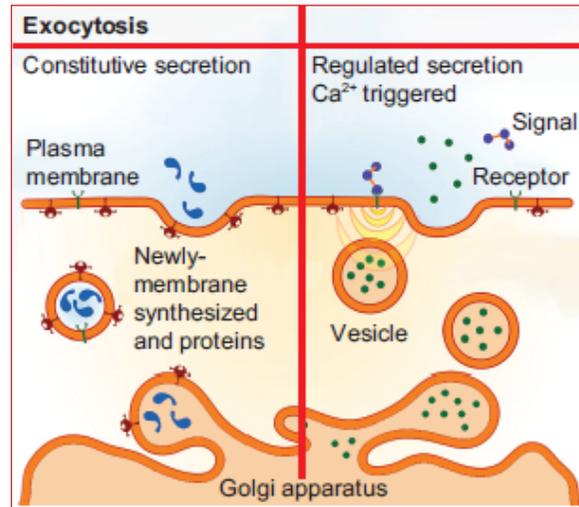


Figure : Exocytosis

e) Application activity 5.6

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 5.6.

Answers of Application activity 5.6

- 1) i) pinocytosis
- iii) active transport
- iv) antiport
- v) Phagocytosis
- vi) Christian de Duve

2)

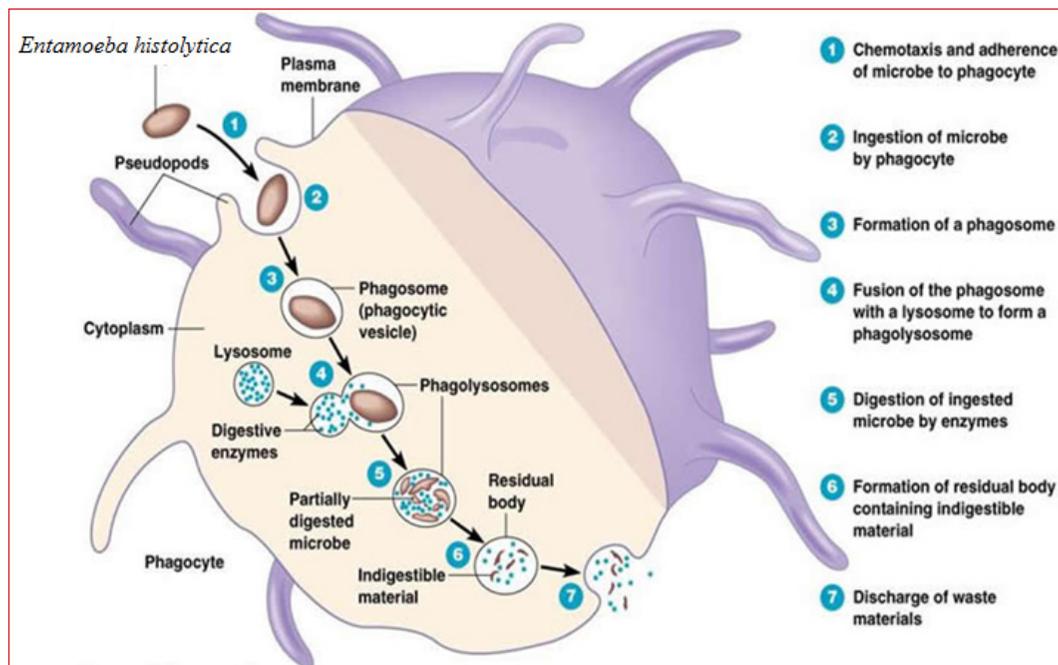


Figure : Phases of phagocytosis of microbes by a macrophage

5.6 Summary of the unit 5

Every cell is surrounded by cell or plasma membrane which regulates the movement or exchange of ions or molecules between the cell and its medium. This property of cell is called **cell permeability**. The presence of **concentration** and **membrane potential** (together called **electrochemical gradient**) helps in the movement of substances across the membrane.

Plasma membrane mediates transport of smaller molecules by **passive** and **active transport** whereas larger molecules are transported by **endocytosis**.

In **passive transport**, ions/molecules move from higher concentration to lower concentration which includes diffusion and osmosis and there is no utilization of energy.

Simple diffusion is the movement of small hydrophobic molecules from higher concentration to lower concentration by dissolving in phospholipid bilayer till equilibrium is reached.

Osmosis is a movement of water molecules from low solute concentration to high solute concentration side or from a region of a high water potential to the

region of a low water potential (or from higher solvent concentration to lower solvent concentration).

Active transport is the movement of ions/molecules from lower concentration to higher concentration.

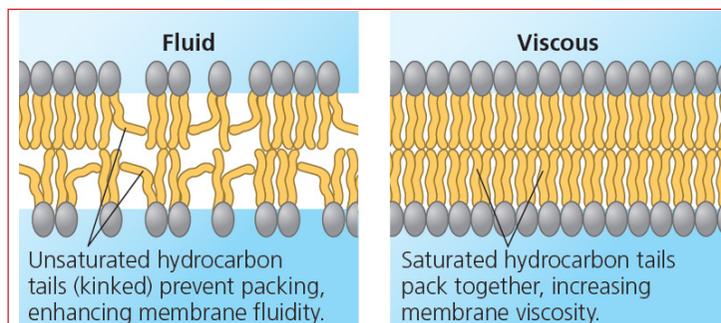
It is of two types: **Primary** and **Secondary active transport**. The former involves direct utilization of energy in the form of ATP hydrolysis while the later involves movement of molecules against concentration gradient but coupled with the movement of a second molecule in an energetically favourable direction without direct utilization of ATP. The movement may be **symport**, **uniport** or **antiport**.

Endocytosis is the ingestion of large particles such as bacteria, macromolecules and fluids into the cell in the form of small vesicles. It is further of two types, viz., **phagocytosis** (cell eating, engulfing of solid particles) and **pinocytosis** (cell drinking, uptake of liquid fluids).

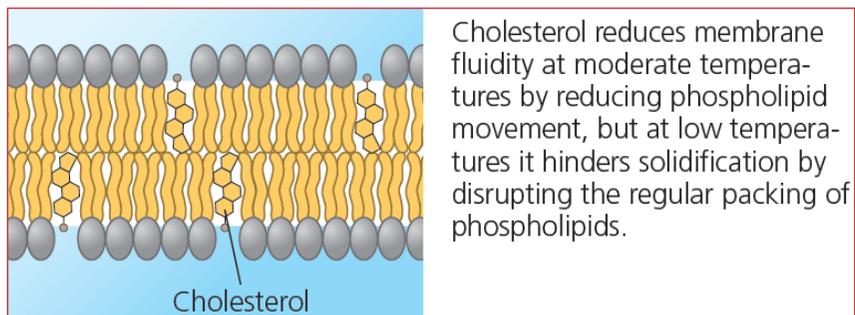
5.7 Additional Information for teachers

Factors that affect cell membrane fluidity:

a) Unsaturated versus saturated hydrocarbon tails.



b) Cholesterol within the animal cell membrane.



Guidance on skills Lab

- As a tutor, encourage student-teachers to practice what they have studied in this unit in order to get money and skills.
- To show them that it is possible, request those materials from your school leader.
- Then request students to implement that skill lab.
- Ask student-teachers to present their findings and conclude.

5.8 End unit assessment 5 (answers)

I. Choose whether the given statements are True (T) or False (F):

- | | | |
|----------|----------|----------|
| 1. True | 2. False | 3. False |
| 4. True | 5. False | 6. True |
| 7. False | 8. True | 9. False |
| 10. True | | |

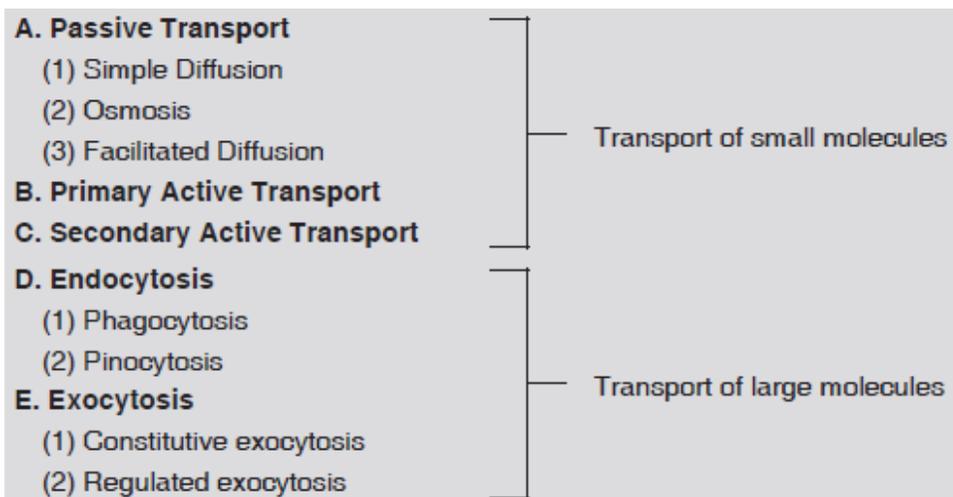
II. Multiple choice questions:

- 1) (a) 2. (b) 3. (b) 4. (b) 5. (a) 6. (c) 7. (c)

III. Long answer type questions:

1. Transport mechanisms can be broadly classified into two types:
Passive Transport: It involves the movement of molecules along the electrochemical gradient without the use of ATP (Downhill transport). Occurs by diffusion or osmosis. **Active Transport:** It drives the molecules against their electrochemical gradient by hydrolysis of ATP (Uphill transport).

Below is an account of different means of transport across the plasma membrane:



Passive Transport

Simple diffusion

It is the simplest mechanism in which a molecule dissolves in the phospholipid bilayer, diffuses across it and then dissolves in the aqueous solution present on the other side of the cell membrane. It neither requires ATP nor any protein. The direction of movement is determined by the concentration gradient (i.e., molecules flow from a region of higher concentration to a region of lower concentration) or electrical gradient. Therefore, any molecule that is soluble in the phospholipid layer is capable of crossing the plasma membrane. This is the reason why only small, relatively hydrophobic (water repelling) molecules (example–benzene), gases (O_2 , CO_2) and even small polar, uncharged molecules diffuse easily across the plasma membrane while other larger molecules are restricted.

Osmosis

In osmosis, the movement of water (solvent) occurs due to the difference of chemical potential (water potential in case of water) on the two sides. The kinetic energy or free energy possessed by the molecules of a substance is called chemical potential. The chemical potential of water is called water potential. The chemical potential of pure water (solvent) is higher than that of the same in a solution. Presence of solute particles decreases the chemical potential (free energy) of water. The lowering of chemical potential (free energy) is due to attraction and collision between solvent (water) and solute molecules.

Thus, in terms of thermodynamics, '*Osmosis is the movement of water or solvent molecules from the region of their higher chemical potential (free energy) to the region of their lower chemical potential (free energy) across a semipermeable membrane*'.

Active Transport

Active transport is the movement of ions or molecules from a region of lower concentration to higher concentration across the plasma membrane (Uphill transport). For this, the energy is provided either by another coupled reaction or by direct hydrolysis of ATP.

2. Diffusion plays an important role in living systems. Below are a few examples where its diverse significance can be understood.
 - i) In the human body, nutrients (in the form of ions and small molecules) are absorbed from the food by the surrounding blood cells in the vessels by way of diffusion.
 - ii) In the lungs, CO₂ diffuses out of blood in alveolar sacs whereas O₂ (present in high concentration in the inhaled air) diffuses into the cells in the blood vessels (with low O₂ concentration).
 - iii) Cutaneous respiration (through skin) is the most common mode of respiration in lower non-chordates wherein gases directly diffuse through the air into the surface epithelium of the organisms.
 - iv) The eyes lack a large number of blood vessels (which carry oxygen) and therefore needs an extra supply of oxygen. The atmosphere provides this extra needed oxygen, which is taken up by the eye through direct diffusion of O₂ into the cornea, the hard outer covering on the eye. In absence of diffusion, the eyes would dry out.
3. Listed below are a few examples that illustrate the importance of osmosis:
 - (i) Osmosis is of prime importance in living organism, where it influences the distribution of nutrients and the release of metabolic waste products. Living cells of both plants and animals are enclosed by a partially-permeable membrane called the cell membrane, which regulates the flow of liquids and of dissolved solids and gases into and out of the cell.
 - (ii) It helps maintain the pressure on either side of the cell membrane thereby preventing the cells to become turgid and burst or to become flaccid.
 - (iii) Plant roots absorb water and minerals from soil and take it upwards to the leaves and other plant parts which are essential for plant growth.
 - (iv) Purification of blood by kidneys also involves osmosis. Osmosis maintains the balance of inter-and intracellular fluids.

4. Significance of Active Transport in Organisms:

- i) In the intestinal lining, glucose is absorbed by active transport from a lower concentration to a higher concentration in the cells lining the intestine.
- ii) Na^+ and K^+ gradients established by the $\text{Na}^+ - \text{K}^+$ pump is required for the propagation of electric signals in nerves and muscles.
- iii) Ca^{2+} ions are actively transported by Ca^{2+} pump which is required for muscle contraction.
- iv) H^+ ions are actively pumped out of the cell lining the stomach which results in the acidity of gastric fluids which help in the digestion. H^+ ions are actively transported into the endosomes and lysosomes with the help of pumps.

Active transport is also important for the transport of nutrients, including ions, sugars, amino acids into the cells and transport of toxic substances out of the cell (e.g., ABC transporters in bacteria and eukaryotic cells).

5. When a cell is placed in a hypertonic solution, water actually flows out of the cell into the surrounding solution thereby causing the cells to shrink and lose its turgidity. Hypertonic solutions are used for antimicrobial control.

Salt and sugar are used to create hypertonic environment for microorganisms and are commonly used as food preservatives.

Salting is the preservation of food with dry edible salt. It is related to pickling (preparing food with brine, i.e., salty water). It is one of the oldest methods of preserving food, and two historically significant such foods are dried and salted cod (usually referred to as salt fish) and salt-cured meat. Salting is used because most bacteria, fungi and other potentially pathogenic organisms cannot survive in a highly salty environment, due to the hypertonic nature of salt. Any living cell in such an environment will become dehydrated through osmosis and die or become temporarily inactivated.

Salting Methods

Cut your vegetables up in pieces before you put them into the salt water to preserve food by salt-curing. As you chop a vegetable and put it into the salt water, it makes its own juice. Nowadays, you might want to use a smaller container. Just make sure the water has plenty of salt added. Let the vegetables stand in the salt water for at least 10 days in order to “pickle.” Pickle simply means preserved in brine. Then cover tightly with a lid.

Preserve meats by salt-curing. Rub meat completely with salt pellets and allow it to cure for 4 to 8 weeks. At the end of this time, the meat will be almost dry. It can be stored this way for a long time. This method is called “dry-curing.”

Soak meat in a solution of brine for a period of 3 to 4 weeks. It will be ready to eat, but it won't last long this way. You can also use a syringe to inject brine into the muscles of the meat in order to preserve the food by salt-curing. It will be ready to eat in 2 to 3 weeks. Just remember that these wet methods of salt-curing meat do not preserve it as long as the dry method does.

6. Plants in salty areas take up more salt from the soil resulting in an increase in salt concentration in the cells and thus maintaining a water potential that is more negative than that of the soil.

The difference in osmotic potential between plant cells and soil water leads to the movement of water into the cells through the cell membrane via osmosis. Water is evaporated from the leaves.

This also helps the movement of water from the roots up the stem to the leaves. Some plants restrict the opening of stomata to conserve their water in salty conditions and some turn down leaves to decrease the surface area of evaporation. Plants have glands to store the salt which burst when concentration of salt increases and cause the release of salt to the soil again. Some plants regulate salt levels by transporting sodium and chloride ions into the central vacuole. High salt concentration in the vacuole causes more water uptake and swelling. Some plants avoid salt stress by releasing leaves in which excess sodium chloride accumulates in petioles.

Animals adapt to the salty conditions very well as plants. For example, fishes in salt water intake a lot of water and reduce the loss of water by excreting less amount of urine by having a kidney with relatively few small glomeruli. Fishes also have chloride secretory cells on their gills which actively transport salts from the blood to the surroundings. Salt glands are also found in other animals inhabiting salty conditions.

Therefore, specially developed kidneys, gills, and body functions help equalizing salt concentrations across membranes through osmosis.

7. In the life of a cell, the plasma membrane fulfills a range of functions that go far beyond the shaping and maintenance of architectural features and the absorption of nutrients. The plasma membrane is a highly sophisticated structure whose phospholipidic backbone is loaded with proteins responsible for channelling the stream of information that continuously flows between a cell and its environment. The translation of genetic content of a cell is constantly modulated by signals triggered and often integrated at the level of the plasma membrane. The cell exposes on or releases from

its surface a wide variety of molecules that regulate its recognition by other cells and that sometimes influence the homeostasis of the whole organism.

The plasma membrane is also the site where intracellular pathogens first clash with their target and the place from which the immune system is subsequently called to the rescue. Correspondingly, the study of viruses has provided great strides in the comprehension of such fundamental processes as membrane fusion, protein transport, endocytosis, signal transduction, and antigen presentation, all phenomena that are intimately intertwined with the biology of membranes and their associated proteins.

Recent progress in the analysis of the HIV, probably by now the most extensively characterized of all human pathogens, provides a good illustration of this paradigm. Just as the composition of the plasma membrane influences viral infectivity, the virus in turn uses components of the plasma membrane that are to its advantage and modifies others to suit its purposes.

To infect a cell, a membrane-enveloped virus such as HIV must transfer its genome across both the viral and cellular membranes—not a trivial task given the inherent stability of biological membranes. Enveloped viruses accomplish this feat by encoding and expressing on their surface integral membrane proteins that, under the right conditions, undergo conformational changes that cause the viral and cellular membranes to fuse with one another, providing a portal of entry. The entry process is divided into three components: attachment of the virus to the cell surface, involving recognition and binding to specific cell surface receptors; a triggering event that causes the viral fusion protein to undergo conformational changes; and the membrane fusion reaction itself. The presence or absence of molecules on the cell surface necessary for attachment and triggering greatly influences viral tropism: the ability of a given virus to infect only specific cell types.

5.9 Additional activities (Questions and answers)

5.9.1 Remedial activities

Question 1: Enumerate the 2 main types of transport of substances across the cell membrane.

Answer1: The 2 main transport types are active and passive transport.

Question 2: State the type of transport used by a neutrophil to protect your body against a harmful pathogen

Answer 2: Phagocytosis.

5.9.2 Consolidation activities

Question 1: Explain the main factors of diffusion

Answer1:

1. The greater the concentration difference between the two sides of the membrane, the faster is the rate of diffusion.
2. As the temperature increases, the rate of diffusion increases.
3. Smaller molecules have faster rate of diffusion while the ones with larger mass, diffuse slowly.
4. The larger the surface area of membrane available for diffusion, the higher is the rate of diffusion.
5. The greater the distance across which diffusion is to occur, the longer it takes for molecules to pass through.

Question 2: Explain the role of active transport in nerve function and reabsorption of substances in kidney.

Answer2:

- a) Active transport is important for ions (K^+ and Na^+) when they move from their low concentration to their high concentration during the conduction of nerve impulse.
- b) The reabsorption of glucose and other solutes from the proximal convoluted tubule to the peritubular capillary network of a nephron of a kidney, occurs by active transport.

5.9.3 Extended activities

Question 1:

The potato strips (pieces) were left in various liquids. The percentage changes in mass, gain(+) or loss (-), are given below.

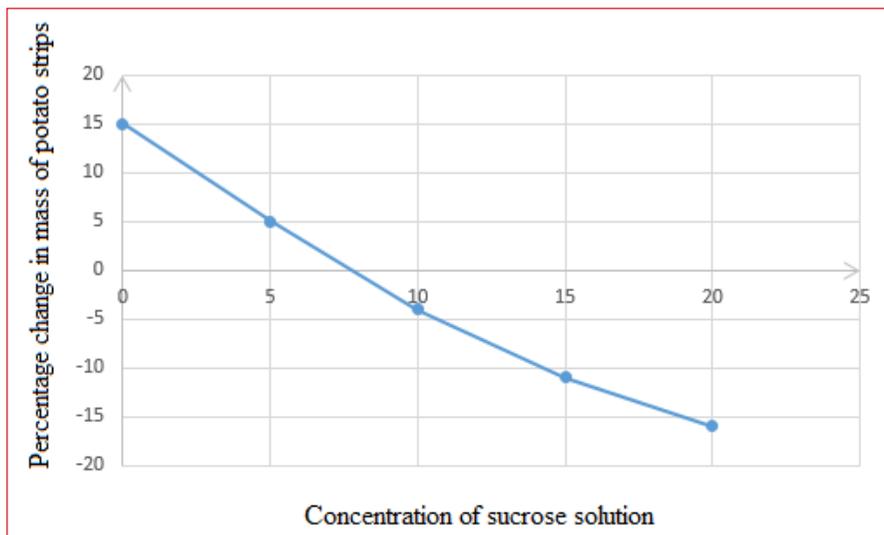
Potato strip	Concentration of sucrose solution % of liquid	Percentage change in mass of potato strips
A	0	+15
B	5	+5
C	10	-4

D	15	-11
E	20	-16

- Plot those data on a graph placing the sucrose concentration on abscissa axis and percentage change in mass on ordinate axis.
- Which potato strips have increased mass?
- Which potato strips have decreased mass?

Answer:

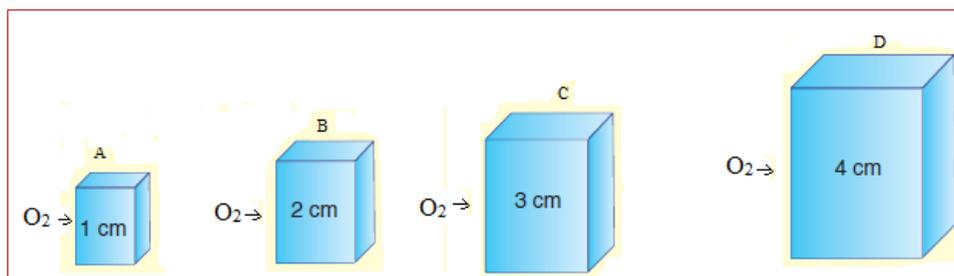
a)



- The potato strips having increased mass : A,B
- The potato strips having decreased mass : C,D,E

Question 2:

You are provided with the following cubes considered as the cells.



- Calculate the surface area to volume ratio (s/v) of each cube in a table.
- Based on your calculations, relate the size of the cell or body to the s/v.
- In which cell the rate of diffusion of oxygen is high? why?

Answer2:

- Calculated surface area to volume ratio(S/V) by applying the given formula:

No	Side size (cm)	total surface areas (S)	volume(V)	S/V
A	1	6	1	6
B	2	24	8	3
C	3	54	27	2
D	4	96	64	1.5

- It is noticeable that, as the size of the cell or organisms increases, the S/V decreases and the rate of passive transport decreases.
- The rate of diffusion of oxygen is high in cell A because it is small ,its S/V is high and the molecules have to travel a short distance in through it.

UNIT 6

SUPPORT, LOCOMOTION AND MUSCLES

6.1 Key unit competence:

Explain the modes of locomotion in protists, insects, fish, amphibians, birds and mammals and the structure of muscles in relation to movement.

6.2 Prerequisites

To understand this unit, student-teachers must have prior knowledge about the needs of living organisms. From this knowledge, they will understand why those animals move from one place to another and how movement is possible.

6.3 Cross cutting issues to be addressed.

In this unit the following cross cutting issues will be addressed: comprehensive sexuality education and standardization culture.

6.4 Guidance on introductory activity 6

As a tutor, facilitate student-teachers to do the introductory activity 6 by giving them those moving animals images and asking them to answer the related questions.

Answers of introductory activity 6:

- 1) Human and dog moving
- 2) Animals move due to the following reasons:
 - i) to find food, water and shelter.
 - ii) to find a mate
 - iii) to find a suitable microhabitat
 - iv) to escape dangerous fire or predator
 - v) to avoid competition with other animals of the same or different species
 - vi) to avoid overcrowding
 - vii) to avoid unfavourable condition.

- 3) Each organism has its locomotion adaptations. Example: A fish has fins, swim bladder and hydrodynamic shape as adaptations to swimming (locomotion in water).

6.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1.	Need for locomotion and non-muscular movements	1) Describe the main types of mammalian muscles. 2) Observe locomotion of animals and identify reasons for their movement. 3) Appreciate the need for locomotion in animals 4) Recognizes that the type of locomotion of animals depends on their habitat.	(1 Period)
2.	Movement and support of fish in water ,mammals and annelids.	1) Demonstrate the arrangement of muscles in fish. 2) Dissect a fish to observe its swim bladder.	(2 Periods)
3.	Movement through air by birds and insects.	Compare the flight of birds and insects.	(1 Period)
4.	Comparison of jumping movements of grasshoppers and toads	Compare the jumping movement of grasshoppers and toads/frogs.	(1 Period)
5.	Types of muscles	1) Explain the role of antagonistic muscles in a joint 2) Compare the structure of cardiac, smooth and skeletal muscle. 3) Adopt the practice of playing sport to develop healthy muscles and bones.	(1 Period)

6.	Ultrastructure and functioning of striated muscle	<ol style="list-style-type: none"> 1) Explain the sliding filament model of muscle contraction, including the roles of troponin, tropomyosin, calcium ions and ATP. 2) Explain the function of a motor unit/ neuromuscular junction/motor end plate. 3) Relate the structure of a motor end plate to its function. 4) Distinguish between slow twitch and fast twitch fibres 5) Demonstrate the structure and function of the sarcomere. 6) Demonstrate the laws of muscle contraction. 7) Illustrate the sliding filament model of muscular contraction. 8) Distinguish between temporal summation and muscle fibre recruitment. 	(1 Period)
7.	Types of joints	<ol style="list-style-type: none"> 1) Observe and explain the relationship between muscles, joints and musculoskeletal attachments in fish, birds, amphibians and mammals. 2) Develop research using internet through finding the relations between muscles, joints and musculoskeletal attachments in fish, birds, amphibians and mammals 3) Appreciate the role of joints and muscles in bringing about movement. 	(1 Period)

Lesson 1: Need for locomotion and non-muscular movements

a) Learning objective

- 1) Describe the main types of mammalian muscles.
- 2) Observe locomotion of animals and identify reasons for their movement.
- 3) Appreciate the need for locomotion in animals.
- 4) Recognizes that the type of locomotion of animals depends on their habitat.

b) Teaching resources

The following materials are needed for comprehending this lesson: internet connection ,books and computer. As a tutor , facilitate student-teachers to get and use them.

c) Prerequisites/Revision/Introduction

The prerequisite that the student-teachers must have include the types of animals and observed ways of locomotion.

d) Learning activities

Guidance on activity 6.1

- Form groups of 2 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Deliver computers, internet and books to groups.
- Request the groups to do the activity 6.1
- Move around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- During discussions, include the comprehensive sexuality education as cross-cutting issue telling to student-teachers that they have to avoid the movements aimed at mating before correct planned time. Show to them how to set a life vision (goal), general life actions plan including mating year and daily actions plan.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- Finally, assess learners with application activity 6.1 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 6.1

- i) Animals need a locomotion for a variety of reasons such as :
 - ii) to find food, water and shelter .
 - iii) to find a mate
 - iv) to find a suitable microhabitat
 - v) to escape dangerous fire or predator
 - vi) to avoid competition with other animals of the same or different species
 - vii) to avoid overcrowding
 - viii) to avoid unfavourable condition .
- 2) a) During Amoeba locomotion :
- i) The plasmagel is converted to plasmasol, which slides towards the front of the cell, forming a pseudopodium and propelling the cell forward.
 - ii) On reaching the tip of the pseudopodium, this plasmasol is reconverted into plasmagel; at the same time the plasmagel at the rear of the cell is converted into plasmasol and streams forward, thus maintaining continuous movement. This cytoplasmic streaming requires Ca^{2+} ions and ATP.
 - iii) Amoeboid locomotion is brought about by reversible changes in the actin filaments of the cell's cytoskeleton. Cross-linking of these filaments by other proteins creates a three-dimensional network with gel-like properties in the plasmagel region.
 - iv) Disassembly of this network causes reversion to the sol state of plasmasol.
- b) Ciliated locomotion of Paramecium: Cilia (singular : cilium) are numerous shorter hair-like appendages extending from the surface of a living cell. Some living organisms, such as Paramecium , move by beating cilia.

e) Application activity 6.1

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 6.1.

Answers of Application activity 6.1

- 1) a)
 - i) Non- muscular locomotion such as :
 - amoeboid locomotion .
 - ciliated locomotion
 - flagellar locomotion
 - ii) Muscular locomotion of animals having muscles like human.
- b) - aquatic locomotion (swimming),
 - terrestrial locomotion(walking, running and hopping)
 - aerial locomotion(flight).
- 2)

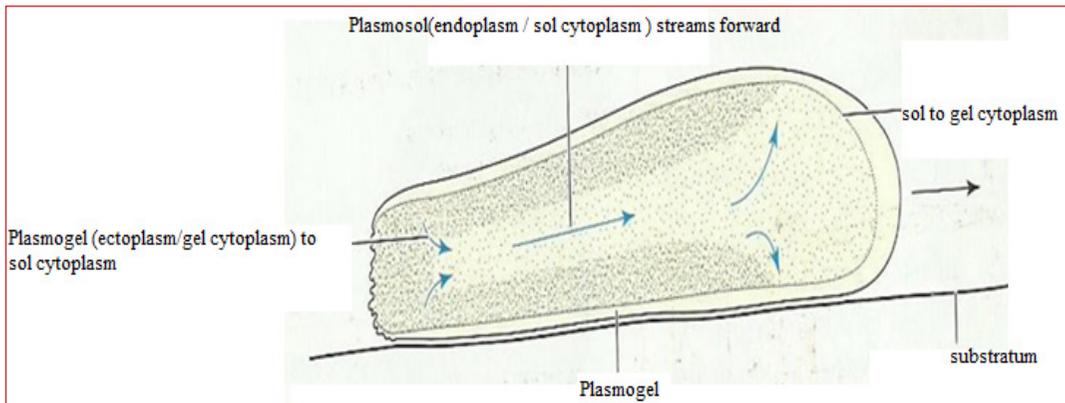


Figure : Drawing showing the amoeboid movement

- 3) i)a. Paramecium , b. Amoeba , c. Euglena ; d. Trypanosoma.
 - ii) - The Paramecium moves by ciliated locomotion.
 - Amoeba moves by amoeboid locomotion involving pseudopodium.
 - Euglena and Trypanosoma move by flagellar locomotion.

Lesson 2: Movement and support of fish in water ,mammals and annelids.

a) Learning objective

- 1) Demonstrate the arrangement of muscles in fish.
- 2) Dissect a fish to observe its swim bladder.

b) Teaching resources

As a tutor, provide the student-teacher with the following materials: freshly collected fishes or their figures, a mammal such as mouse and annelid such as Earthworm or their figures and dissecting kit.

c) Prerequisites/Revision/Introduction

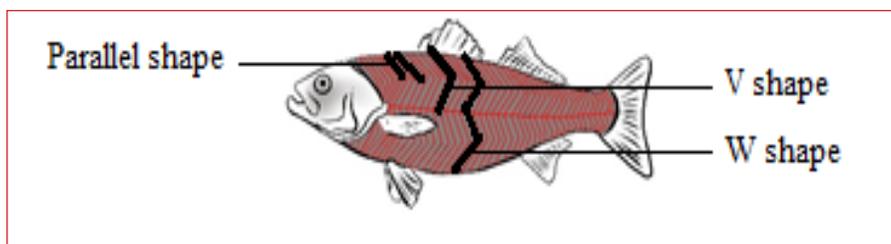
Student- teachers must have understood why animals move. Ask them to brainstorm the reasons of animal movement.

d) Learning activities

Guidance on activity 6.2

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Provide them with required materials.
- Request the groups to do the activity 6.2
- Move around groups, guiding and facilitating them.
- Prefer the groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- During discussions, include the environment and sustainability as cross-cutting issue saying Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 6.2 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 6.2



e) Application activity 6.2

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 6.2.

Answers of Application activity 6.2

- 1) The main muscles that contribute to locomotion in mammals and amphibians are flexor and extensor

A diagram showing circular and longitudinal muscles of Earthworm.

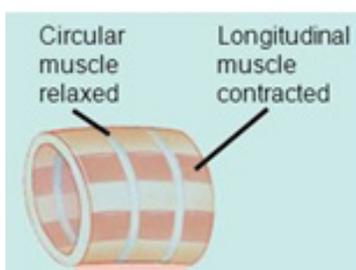


Figure :Drawing showing the circular and longitudinal muscles of Earthworm.

2) a) A: Pitching:

B: Yawing

C: Rolling

b) A. Pitching: this is the tendency of the front end of the fish to plunge vertically downwards. It is counteracted by the pectoral and pelvic fins.

B. Yawing: this is the side to side oscillation of the front part of the body resulting from the propulsive action of the tail. It is counteracted by the general massiveness of the head and the pressure of water against the side the body and the dorsal, anal and ventral fins.

C. Rolling: this is the rotation of the body about its longitudinal axis. It is counteracted by both the vertical and horizontal fins acting like the stabilizers on ships.

Lesson 3: Movement through air by birds and insects.

a) Learning objective

Compare the flight of birds and insects.

b) Teaching resources

Request student-teachers to bring different insects and birds as well as their images drawn on a manila paper.

c) Prerequisites/Revision/Introduction

The student-teachers must have prerequisites on movements of different things such as airplane studied in Physics. Ask them to compare those movements.

d) Learning activities

Guidance on activity 6.3

- Take your marks records , form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Provide students with all necessary materials.
- Request the groups to do the activity 6.3
- Pass around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- To complete this lesson , assess learners with application activity 6.3 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 6.3

1) A. Some adaptations of birds to flight :

- i) Modification of the forelimbs to form wings to provide a large surface area for movement in air.
- ii) Presence of large pectoral muscles, the pectoralis major and minor, which moves wings.

- iii) A light skeleton made up of hollow and mainly small bones which can be easily moved in the air.
- iv) A rigid skeleton made up of fused bones with a deep keel like extension of the sternum which provides a large surface area for the attachment of flight muscles.
- v) An efficient breathing system with air sacs attached to the lungs necessary to provide oxygen for respiration and to remove the resulting carbon dioxide.
- vi) A high metabolic rate for providing the high amount of energy required.
- vii) An efficient circulatory system necessary for transporting both the nutrients and respiratory gases at speed related with the body needs.
- viii) A high red blood cell count for efficient oxygen transport.
- ix) A keen eye sight to enable them to judge distances correctly especially on landing.
- x) A streamlined shape to reduce air resistance and allow smooth movement in the air.
- xi) Ability to fold the legs away during flight so as not to cause any unnecessary friction with the air.

B. Some adaptations of insect to flight:

- i) It has a tracheal gas exchange system in which spiracles are valve-like openings through which the atmospheric air passes when it enters the body. The 2 spiracles are found in thorax while 3 spiracles are found in abdomen .
- ii) Tracheae(air-filled tubes), which open at the surface of the thorax and abdomen through paired spiracles. The muscular valves of the spiracles, closed most of the time, open only to allow the uptake of oxygen and the escape of carbon dioxide. The tracheal walls are strengthened and maintained open by spiral rings of chitin , and they thus allow rapid flow of air into and out of them .
- iii) Tracheoles are thin-walled and highly permeable to gases. They are filled with tracheole fluid. They have some tracheole cells which enter body cells.
- iv) Air-sacs are thin-walled and act as air reservoirs .These sacs supply the extra volume of oxygen that is needed during higher cellular activity .The contractions and relaxations of the alary (flight) muscles during the flight cause the air-sacs to inflate and deflate and so supply the extra oxygen that is required in the tissues.
- v) It has wings used to move in downstroke or upstroke or forward.

2) Comparison of the flight of birds and flight of insects.

Criterion	flight of birds	flight of insects
Involved muscles	pectoralis major, pectoralis minor and keel of sternum.	dorsal-ventral muscles (also called tergo-sternal muscles)
Size of wing used in flight	Large	Small
Respiratory system carrying O ₂ for flight energy production	Pulmonary system	Tracheal system.
Alary muscles	Absent	Present

e) Application activity 6.3

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually, the application activity 6.3.

Answers of Application activity 6.3

- 1) - The insect can no longer fly as its wings are removed.
 - This insect will lack some of its needs such as food as it is not able to move
- 2) The downstroke of insect and birds is the downward movement of those animals.

Lesson 4: Comparison of jumping movements of grasshoppers and toads

a) Learning objective

Compare the jumping movement of grasshoppers and toads/frogs.

b) Teaching resources

As a facilitator, help students to collect the grasshoppers and toads/frogs, collecting net.

c) Prerequisites/Revision/Introduction

Students should be aware of reasons of the movements of living organisms.

d) Learning activities

Guidance on activity 6.4

- Considering the student-teachers' performance, form groups of 4 or 6 student- teachers and allow them to sit on 2 desks face-to-face.
- Deliver the materials to all groups.
- Request the groups to do the activity 6.4.
- Move around groups, guiding and facilitating them.
- Prefer groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 6.4 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 6.4

1. Those animals have extensor and flexor muscles which facilitate them to jump.
2. Their muscles behave as shown below:
 - a) **Grasshopper:** Being in resting or sitting position, the extensor muscle contracts which enable then the legs jerk or move very quickly backwards propelling the grasshopper.

Stages of jumping in a grasshopper:

- i) The hind legs are folded in the shape of Z in the position at rest (flexor muscles contract).
- ii) Extensor muscles contract. The legs of the grasshopper jerk backwards.
- iii) The grasshopper propel forward and upward into the air.



Figure :Stages of jumping in a grasshopper.

b) Frog:

When a frog is at rest, the hind legs are folded up in the shape of a letter Z; this means that its extensor muscles are relaxed while its flexor muscles are contracted as shown by the following figure:



Figure : Drawing showing a frog at rest.

The stages of hopping in a frog:



Figure : The stages of hopping in a frog

The following are the stages of jumping in a frog:

- i) Long hind legs are folded in the shape of Z when the frog prepares to jump.
- ii) Hind legs become straight when the frog jumps.
- iii) Forelimbs stretched to outside when the frog prepares to land.

e) Application activity 6.4

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 6.4.

Answers of Application activity 6.4

1.

Frog	Insect
i) Long hind legs are folded in the shape of Z when the frog prepares to jump.	i) The hind legs are folded in the shape of Z in the position at rest (flexor muscles contract).
ii) Hind legs become straight when the frog jumps.	ii) Extensor muscles contract. The legs of the grasshopper jerk backwards.
iii) Forelimbs stretched to outside when the frog prepares to land.	iii) The grasshopper propel forward and upward into the air.

2. A:Extensor ;B: tibia

3. A hind leg showing a Z shape which is different from the one formed when it is on resting.

Lesson 5: Types of muscles

a) Learning objective

- 1) Explain the role of antagonistic muscles in a joint
- 2) Compare the structure of cardiac, smooth and skeletal muscle.
- 3) Adopt the practice of playing sport to develop healthy muscles and bones.

b) Teaching resources

Dissection pan with 4 needles, 20 ml of physiological liquid (Ringer's solution), plastic eyedroppers, suture needle with thread attached, razor blade, magnifying hand lens, pins, chloroform, cotton wool, frog or toad, bell jar, forceps, glass beaker, gloves, and water.

c) Prerequisites/Revision/Introduction

Student-teachers must be aware of some muscles seen in lesson 4. Ask them to name those muscles.

d) Learning activities

Guidance on activity 6.5

- Based on their previous assessment results, form groups of 4 or 6 student-teachers and allow them to sit on 2 desks face-to-face.
- Provide students with all required materials, procedure and questions.
- Ask the groups to do the activity 6.5.
- Move around groups, guiding and facilitating them.
- Choose groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student-teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 6.5 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 6.5

Hints in the observations :

- The animal faints and does not react actively during the dissection due to the effect of chloroform (anesthesia)
- The blood flows as blood capillaries are cut
- The heart keeps on beating even when it has been removed from the body.

e) Application activity 6.5

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 6.5.

Answers of Application activity 6.5

- 1) X: Cardiac muscle; Z:skeletal muscle
- 2) Link between muscle contraction and its properties:

a) Responsiveness or excitability

Responsiveness is a property of all living cells, but muscle and nerve cells have developed this property to the highest degree. When stimulated by chemical signals (neurotransmitters), stretch, and other stimuli, muscle cells respond with electrical changes across the plasma membrane.

b) Conductivity

Stimulation of a muscle fiber produces more than a local effect. The local electric change triggers a wave of excitation that travels rapidly along the muscle fiber and initiates processes leading to muscle contraction.

c) Contractility

Muscle fibers are unique in their ability to shorten substantially when stimulated. This enables them to pull on bones and other tissues and create movement of the body and its parts.

d) Elasticity

When a muscle cell is stretched and the tension is then released, it recoils to its original resting length. Elasticity refers to the tendency of original length when tension is released.

e) Responsiveness or excitability

Responsiveness is a property of all living cells, but muscle and nerve cells have developed this property to the highest degree. When stimulated by chemical signals (neurotransmitters), stretch, and other stimuli, muscle cells respond with electrical changes across the plasma membrane.

f) Conductivity

Stimulation of a muscle fiber produces more than a local effect. The local electric change triggers a wave of excitation that travels rapidly along the muscle fiber and initiates processes leading to muscle contraction.

g) Contractility

Muscle fibers are unique in their ability to shorten substantially when stimulated. This enables them to pull on bones and other tissues and create movement of the body and its parts.

h) Elasticity

When a muscle cell is stretched and the tension is then released, it recoils to its original resting length. Elasticity refers to the tendency of a muscle cell (or other structures) to return to the original length when tension is released.

Lesson 6: Ultrastructure and functioning of striated muscle

a) Learning objective

- 1) Explain the sliding filament model of muscle contraction, including the roles of troponin, tropomyosin, calcium ions and ATP.
- 2) Explain the function of a motor unit/ neuromuscular junction/motor end plate.
- 3) Relate the structure of a motor end plate to its function.
- 4) Distinguish between slow twitch and fast twitch fibres
- 5) Demonstrate the structure and function of the sarcomere.
- 6) Demonstrate the laws of muscle contraction.
- 7) Illustrate the sliding filament model of muscular contraction.
- 8) Distinguish between temporal summation and muscle fibre recruitment.

b) Teaching resources

The following materials are required : Computers, books , internet connection. Help your student-teachers to find them.

c) Prerequisites/Revision/Introduction

Students must have prior knowledge about types of muscles and neurons as well as their functions. Request them to brainstorm about those prerequisites.

d) Learning activities

Guidance on activity 6.6.

- Form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Give materials to each group and questions to each group.
- Request students to the activity 6.6
- Pass around groups, guiding and facilitating them.

- Select 1 or 2 groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 6.6 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 6.6

All answers are in summary of this lesson 6.6 (It is not necessary to repeat them here)

e) Application activity 6.6

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , in pairs, the application activity 6.6.

Answers of Application activity 6.6

1)

a) A: Muscle fiber

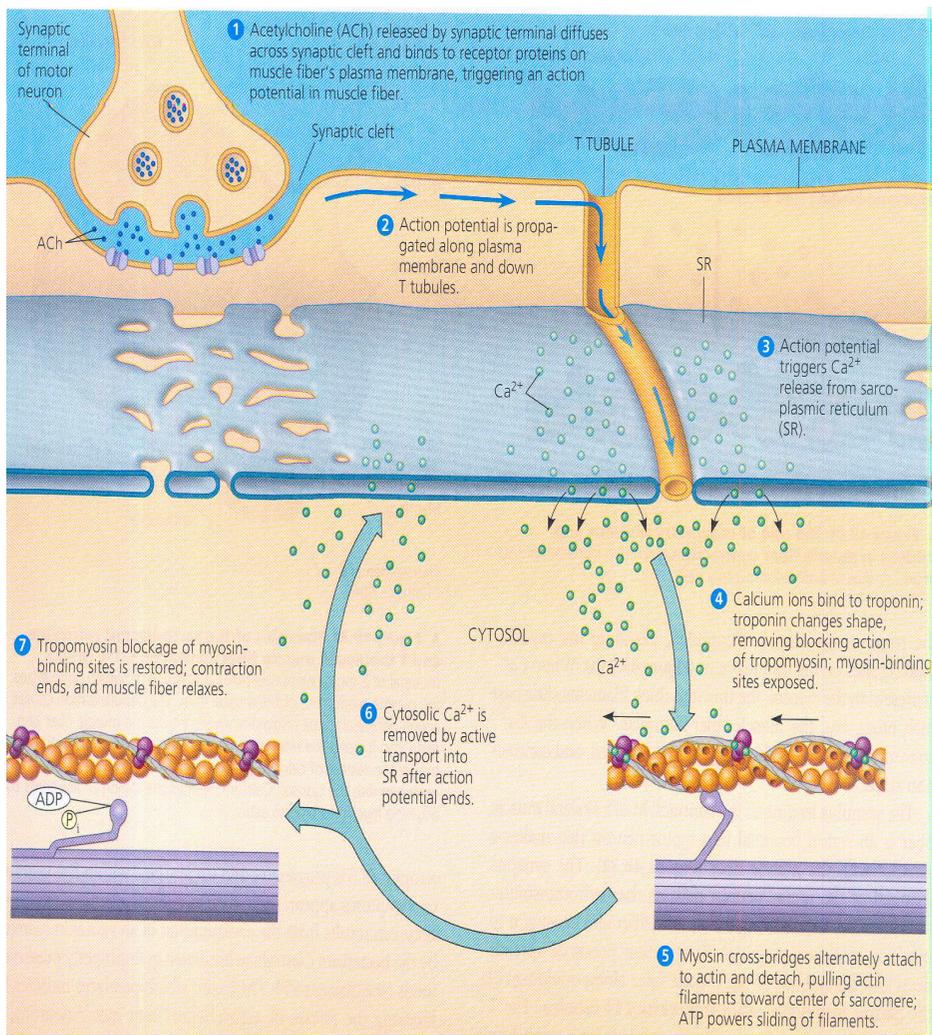
B: Mitochondrion

C:Axon of the motor neuron

b)- B(Mitochondrion) is the organelle in which most steps of aerobic cell respiration occur to produce energy used in the conduction of the nerve impulse during the muscle contraction process.

C(Axon of the motor neuron) conducts nerve impulse from the central nervous system to effector during the muscle contraction process.

2) Model of sliding filament theory of muscle contraction



Lesson 7: Types of joints

a) Learning objective

- 1) Observe and explain the relationship between muscles, joints and musculoskeletal attachments in fish, birds, amphibians and mammals.
- 2) Develop research using internet through finding the relations between muscles, joints and musculoskeletal attachments in fish, birds, amphibians and mammals
- 3) Appreciate the role of joints and muscles in bringing about movement.

b) Teaching resources

The following materials are needed: Models of joints, skeleton and muscles, computer, internet connection and books.

c) Prerequisites/Revision/Introduction

To understand this lesson, student-teachers must have got information about flexor and extensor muscles which contribute to movable joints functioning. As a tutor, ask them to explain orally what they know about those muscles.

d) Learning activities

Guidance on activity 6.7

- Form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Give the necessary materials to each group.
- Request the groups to do the activity 6.7
- Pass around groups, guiding and facilitating them.
- Select groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- To end this lesson, assess learners with application activity 6.7 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 6.7

Table 6.7: Summary of the types of joints

Type of joint	General characteristics	Examples	Function
1. immovable /suture joint/fixed/fused joint.	A thin layer of fibrous connective tissue exists between the bones ,holding them firmly in the position	<ul style="list-style-type: none"> - Between bones of skull; - between sacrum and ilia of the pelvic girdle - between bones of pelvic girdle. 	Provides strength and support for the body ,or protection of delicate structures (such as brain)which cannot withstand any kind of deformation.
2. partially movable joint :			
a) gliding joint	Bones are separated from each other by cartilaginous pads (pieces)	<ul style="list-style-type: none"> - Joints between vertebrae - wrist and ankle bones. 	<ul style="list-style-type: none"> - Bones glide/ slide over each other to a limited extent. - collectively,they provide a wide range of movement and confer strength on the limb.
b) swivel/rotating/ pivot joint	Bones are separated from each other by cartilaginous pads	Joint between atlas and axis vertebrae	Permits shaking of head from side to side.
3. Freely movable / synovial joint:			

a) hinge joint	<ul style="list-style-type: none"> - Articulating bone surfaces are covered with cartilage and separated from each other by a synovial cavity containing synovial fluid. - relatively few muscles operate this joint. 	Elbow, knee and finger joints	<ul style="list-style-type: none"> - Permits movements in one plane. - Capable of bearing heavy loads .
ball -and – sockets joint	<ul style="list-style-type: none"> - Articulating bone surfaces are covered with cartilage and separated from each other by a synovial cavity containing synovial fluid secreted by synovial membrane. - Variety of muscles attached to the bones of the joints 	Shoulder and hip joint	<ul style="list-style-type: none"> - Permits movement in all planes, and some rotation . - unable to bear very heavy loads.

e)Application activity 6.7

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 6.7.

Answers of Application activity 6.7

1) Associate the terms of column A and B

Column A	Column B
1. immovable/suture joint/fixed/fused joint.	a. Elbow, knee and finger joints
2. gliding joint	b. Between bones of skull
3. hinge joint	c. Joints between vertebrae

2) There are four classes of synovial joints:

- i) **Gliding** joints : The bones of these joints move across each other, back-and-forth and side-to-side. Examples are between the carpals of the wrist and tarsals of the ankle.
- ii) **Pivot** joints : These joints allow a turning movement. Examples are between the first and second vertebrae when turning the head, between the ulna and the radius of the lower arm when turning the palm of the hand up or down.
- iii) **Hinge** joints : These joints allow movement in one plane during flexion and extension. They act, as the name implies, like the hinge of a door. Examples are bending the elbow or knee.
- iv) **Ball and Socket**: This type of joint permits movement in three planes, i.e., in all directions. Examples are the shoulder and hip joints.

6.6 Summary of the unit

This unit consists of seven lessons. As described in student textbook, there are in the

following order: Need for locomotion and non-muscular movements, Movement and support of fish in water, mammals and annelids, Movement through air by birds and insects, Comparison of jumping movements of grasshoppers and toads, Types of muscles, Ultrastructure and functioning of striated muscle, and Types of joints.

In the first lesson, the concept of locomotion is described. In the same lesson, there are the requirements for locomotion and why locomotion is very necessary. In it, the locomotion in amoeba, paramecium and flagellate animals is also developed. The second lesson describes fish features that enable the

movement and support in water, mammals locomotion as well as annelids locomotion by longitudinal and circular muscles. Third lesson describes the movement through air by birds and insects. Involving wings and flight muscles. The fourth lesson compares the jumping movements of grasshoppers and toads. The fifth lesson explains the types of muscles which are cardiac muscles, skeletal muscles and smooth muscles. The sixth lesson explains the ultrastructure and functioning of striated muscle. The last lesson clarifies the types of joints. For each lesson, introduction, resources, learning activities and self-assessment questions have been provided. At the end of unit, end of unit assessment tasks are provided.

6.7 Additional Information for teachers

You are recommended to dissect frog and fish heart to observe myogenic contraction before you go in class for student-teachers to get deeper understanding of the unit.

Guidance on skills Lab

- As a tutor, reinforce student-teachers to practice what they have studied in this unit in order to get money and skills.
- To show them that it is possible, request them to practice this skill lab.
- Then, ask student-teachers to bring their own fish that they have bred in their ponds so that you help them get many biological skills about fish such as dissection.
- Ask student-teachers to present their findings and conclude.

6.8 End unit assessment (answers)

1) Animals move from a place to another:

- To capture food,
- To avoid predators
- To escape dangers
- To find their mates for the reproduction and
- To find new and favourable habitats.

Plants do not migrate because most are hermaphrodite and autotroph.

2) The answers are:

- a) **Bones:** provide hard anchorage point upon which muscles can act to bring about movement/act as lever when moving/support skeletal muscles/enable the body to make movement

b) **Joints:** provide a greater degree of flexibility and feasibility of movement/Absorb shocks in their synovial fluid.

c) **Muscles:** convert chemical energy into kinetic or mechanical energy.

3) The endoskeleton is the internal bony structure found in chordates (fish, amphibians, reptiles, birds and mammals). It is made of bones and cartilages, both of which are hard and tough tissue.

4) Functions of endoskeleton:

- It provides mechanical support to the body. The bones are hard and so provide a firm surface for attachment of muscles and ligaments.
- Parts of the endoskeleton enclose and therefore protect delicate organs. For example, the skull protects the brain; the rib cage protects the heart, the lungs and the major blood vessels, the vertebral column protects the spinal cord.
- Together with the skeletal muscles and cartilage, it permits movement of the body limbs.
- The expansion and contraction of the thorax permit gaseous exchange during breathing.
- The vertebral column gives the body flexibility during locomotion.
- Other functions include making blood cells and storing calcium and phosphate.

5) The main types of synovial joints include:

a) Ball and socket joints

- They are made of two bones; one with rounded head and the other one with a depression (cavity) into which the head of the first bone fits and moves freely.
- Movement is possible in all directions and usually allows rotation through 360° .
- They are unable to bear heavy loads
- Such joints are found in the shoulder where the head of the humerus fits into the glenoid cavity of the scapula.

b) Hinge joints

- They occur where the depression of bone allows the smooth condyle of another bone to fit and articulate to allow movement in one direction only.
- Only up and down movements are possible and hence a maximum stretch of 180° .
- Such joints are found in the elbow, the knee, and in the digits of the fingers and toes.

c) Gliding joints

- Such joints occur between the cervical, thoracic and lumbar vertebrae. The inter-vertebral discs not only permit the sliding movement of one vertebra over another, but also act as shock absorbers.
- These gliding joints make the vertebral column flexible, allowing the bending or curving of the back. They also permit adjustment of body posture.
- Gliding joint also occur among the metacarpals and metatarsals.

d) Pivot joints

- They occur where one bone forms a peg that enters in a cavity in the other bone.
- The peg acts as pivot over which rotates occur e.g. atlas and axis
- It permits rotational movement (side-to-side movement) of the head. This is facilitated by the odontoid process of the axis which fits into the neural canal of the atlas.

6) The triceps and biceps are antagonistic muscles of our hands.

During the upward movement (lifting)

- Triceps muscles relax and extends
- Biceps muscles contract and shorten
- The radius and ulna move upwards, causing the arm to bend.

During the downward movement (lowering)

- Triceps muscles contract hence shorten
- Biceps muscles relax and extend
- Radius and ulna move downwards, causing the arm to straighten.

7) Fused Joints have the following functions: provide strength, support and protection.

8) The muscles tissues are mainly responsible for movement of the body, posture maintenance, support of the joints, and heat production.

9) The MHAZI is it an abbreviation or acronym? is the M line is inside the H zone which is inside the A band, whilst the Z line is inside the I band.

10) The refractory period is the time after receiving a stimulus during which a nerve or muscle cell cannot respond to further stimuli.

11) When it happens sarcomere becomes stimulated and then causes the release of Ca^{2+} ions from the triad vesicles into the sarcoplasm. The Ca^{2+} ions bind to Troponin-C. This then interacts with Troponin-I, causing the myosin sites to be unlocked and activated.

12) A well labeled human skeleton as seen in student book.

13) Amoeba moves by means of pseudopodia/ cytoplasmic projections formed by its cell membrane.

Differently from amoeba, paramecium moves by cilia which are structures on its cell membrane.

Euglena and Trypanosoma move by their flagellum or flagella depending to number of flagella they possess.

14) A drawing /cartoon showing different fins, scales, and shape of fish as they enable fish to move from one place to another. Also the one showing swim-bladder and muscles arrangement is necessary. See student's book.

6.9 Additional activities (Questions and answers)

6.9.1 Remedial activities

1) Differentiate locomotion from movement

Answer:

Movement is the displacement of part of an organism

Locomotion is the displacement of the whole organism from one place to another.

Movement is common to all kind of living

Locomotion is specific to animals

2) What is the function of cilia, flagella and cytoplasmic invaginations, wings, hind limbs, feathers?

Answer:

They enable the animals that exhibit them to move

3) How do the following animals move about? Cow, kangaroo, dog, grasshopper, toad, butterfly, Trypanosoma sp., snails, snake, paramecium moves?

Answer:

Cow and dog walk by limbs; kangaroo, grasshopper, and toad hop or jump by hind legs; Butterfly and grasshopper are adapted to flying by wings; snail and snake crawl, trypanosoma and paramecium move by flagella and cilia respectively.

4) What are different fins that help a fish to swim?

Answer:

Tail, ventral, pectoral and dorsal fins

5) With examples of organism that exhibit particular type of skeleton, distinguish the three types of skeleton that supports animals.

Answer:

Hydrostatic skeleton is found in most invertebrates and in annelids. It consists of fluid filled body cavity surrounded by antagonistic sets of muscles.

Exoskeleton is particular to arthropods insects for example, is a hard cuticle made of chitin which lies outside the muscles which move parts of it.

Endoskeleton is characteristic to bony animals. Skeletal muscles are attached on skeleton bones.

7) The endoskeletons have stronger skeleton. What is its role?

Answer: It supports most of the body weight above ground which allows faster locomotion.

8) List and give an example for each type of Synovial Joints.

Answer:

- **Gliding: Examples are between the carpals of the wrist and tarsals of the ankle.**
- **Pivot: Examples are between the first and second vertebrae when turning the head, between the ulna and the radius of the lower arm when turning the palm of the hand up or down.**
- **Hinge: Examples are bending the elbow or knee.**
- **Ball and Socket: Examples are the shoulder and hip joints.**

9) Why are muscles twitching?

Answer:

Your **muscles** are made up of fibres that your nerves control. Stimulation or damage to a nerve may cause your **muscle** fibers to twitch. Most **muscle** twitches go unnoticed and aren't cause for concern. In some cases, they may indicate a nervous system condition and you should see your doctor.

10) Locate actin and myosin filaments in sarcomere.

Answer:

Myosin and actin are found in myofibrils which are located in muscle fibres.

11) What is sliding filament theory?

Answers:

The sliding filament theory explains the mechanism of muscle contraction based on muscle proteins that slide past each other to generate movement.

6.9.1. Consolidation activities

1) Based on different body structures, what does it cause the movement which may result in locomotion in animals with:

- a) Endoskeleton
- b) Exoskeleton
- c) Hydrostatic skeleton

Answer:

- a) Contraction of muscles bring about movement of their attached bones and finally to the locomotion.
 - b) Muscles attached to exoskeleton in part of legs enable the locomotion
 - c) For animals with hydro skeleton, the movement is brought as result from compressive contraction action.
- 2) Based on the table below, put the animals provided here into its respective way of locomotion: spider, rabbit, mosquito, snake, seahorse, bat, whale, penguin, worm, goose, and dragonfly.

Swim	Hop	Fly	Crawl
Answer			
Seahorse	Rabbit	Bat	Snake
Whale	Goose	Mosquito	Worm
Crocodile	Penguin	Dragonfly	Spider
Goose			
Penguin			

3) Describe the functions of the bones.

Answers: Some functions of bones are the following:

- **Structural Support of the Body:** The skeleton supports the body against the pull of gravity. The large bones of the lower limbs support the trunk when standing.
- **Protection of Internal Organs:** The skeleton provides a rigid frame work that supports and protects the soft organs of the body. The fused bones of the cranium surround the brain to make it less vulnerable to injury. Vertebrae surround and protect the spinal cord and bones of the rib cage help protect the heart and lungs.
- **Attachment of the Muscles:** The skeleton provides attachment surfaces for muscles and tendons which together enable movement of the body.
- **Movement of the Body:** Bones work together with muscles as simple mechanical lever systems to produce body movement.
- **Production of Blood Cells:** The formation of blood cells takes place mostly in the interior (marrow) of certain types of bones.
- **Storage of Minerals:** Bones contain more calcium than any other organ in the form of calcium salts such as calcium phosphate. Calcium is released by the bones when blood levels of calcium drop too low. Phosphorus is also stored in bones.

4) What is hinge joint and give examples?

Answers: Hinge: These joints allow movement in one plane during flexion and extension. They act, as the name implies, like the hinge of a door. Examples are bending the elbow or knee.

5) During the time that a muscle is in tetanic contraction, what are the motor neurons to the muscle doing?

Answers: During tetanic contraction, motor neurons are firing a continuous train of closely spaced nerve impulses.

6) What is the role of calcium in muscle contractions?

Answers: The calcium is a crucial part of muscle contraction. The ionic element is released from muscles during contraction and relaxation. The release of calcium helps propagate the muscle contraction and relaxation stages.

7) What role does ATP play in muscle contraction?

Answers: The breakdown of adenosine triphosphate (ATP) in a chemical reaction with water provides energy for skeletal muscles to contract. Since the amount of ATP stored in muscles is small, metabolic pathways that generate new ATP must be activated for continued muscle contraction.

6.9.3 Extended activities

1) Draw and label a fish diagram

Answer: a well labelled diagram showing fins, scales, shape (See student's book)

2) Describe how major muscles of locomotion contribute to locomotion on land

Answer:

- Description of flexor and extensor as well as circular and longitudinal muscles in earthworm.
- Flexor and extensor muscles work antagonistically to enable the locomotion on land, water and in air. One contracts (flexor) contracts and then bends a limb whereas extensor contracts for extending or straightening.
- There are also extensor tibiae muscle which contracts to extend the rear/back leg, and the flexor tibiae muscle which contracts to flex the leg.
- Frogs like grasshoppers hop by means of their hind limbs which are capable to be shortened and straightened as a result of its jumping muscles.
- Draw and illustrate how muscles are arranged in a fish

Answer:

3) A diagram showing muscles arranged in parallel, V, W shape (See student's book)

4) The hydrostatic skeleton is found in cold-blooded animals including invertebrates. Write in your own word what the cold-blooded animals mean.

Answers: It is an animal that does not have an internal mechanism for regulating its body temperature or Cold blooded animals cannot maintain their body temperature by themselves. Their body temperature depends on their environment. Some examples of cold blooded animals are snakes, fish, crocodiles, lizards, frogs and turtles. As a general rule, most amphibians, reptiles and fish are cold blooded.

5) Draw a well labelled diagram of cut section view of normal knee joint.

Answer: The expected answer is in student book

6) Why doesn't muscle relax between the arrivals of nerve impulses when it is in tetanic contraction?

Answers: A muscle doesn't relax between nerve impulses during tetanic contraction because each nerve impulse arrives before the muscle completes the sequence of chemical and mechanical events of contraction initiated by the previous impulses.

7) Describe the thick filament.

Answers: Description of the thick filament:

- Primarily composed of the protein myosin.
- Contains a tail region and globular head-looks like a golf club.
- Connected together by a hinge.
- Mammalian myosin dimerizes through inter twining of their tails.

8) Explain how do your muscle cells produce ATP during rapid exercise?

Answers: Muscle cells produce ATP anaerobically during periods of rapid exercise. ATP is the energy needed for cellular activity to occur.

UNIT 7

GAS EXCHANGE IN PLANTS, ANIMALS AND THE EFFECTS OF SMOKING

7.1 Key unit competence:

Describe structures of gaseous exchange organs in plants, respiratory organs in different groups of animals and the effects of tobacco smoking on the gas exchange system.

7.2 Prerequisites

To understand this unit, student-teacher must have prior knowledge about transport of substances across the cell membrane, especially diffusion. Ask them to brainstorm what they remember about diffusion.

7.3 Cross cutting issues to be addressed

In this unit, environment and sustainability, as cross cutting issue, will be addressed in terms of protecting the environment so that most plants producing oxygen continue to survive.

7.4 Guidance on introductory activity 7

- As a tutor, request student-teachers to do the introductory activity 7 as a group homework.
- As you teach this unit answer each question when you are on related lesson.

Answers of introductory activity 7:

- 1) - The plant (A) is receiving the sunlight energy and uses it to photosynthesize. By diffusion, carbon dioxide is entering the plant, reacts with water and there is production of oxygen and glucose. By diffusion, this oxygen leaves the plant and enters the atmosphere for living organisms respiration.
 - The process of ventilation (breathing i.e. inhalation and exhalation) is occurring in a person (B).
 - The last man (C) is smoking.

- 2) The smoking man will undergo different diseases (such as lung cancer and other respiratory diseases and cardiovascular diseases such as stroke, atherosclerosis etc) leading to death.
- 3) The plant adaptations include to those processes include stomata with guard cells, vascular tissues called xylem.
- 4) The transport of oxygen and carbon dioxide is described under the heading 7.4 of this unit in the student's book.

7.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1	Structure of stoma and theories used to explain the mechanism of opening and closure of stomata	<ol style="list-style-type: none"> 1) Describe the structure of stoma. 2) Explain the theories of opening and closure of stomata stating limitations of each. 	1 (Period)
2	Structural adaptation and function of stomata, lenticels , breathing roots and leaves.	<ol style="list-style-type: none"> 1) Explain how stomata, lenticels and breathing roots are adapted to their function. 2) Relate the differences between the structures of aquatic and terrestrial leaves to a habitat. 	(2Periods)
3	Gaseous exchanges in insects, fish and amphibians.	Explain the terms related to the lung capacities (tidal, reserve volume, vital capacity, residual volume, and dead air space).	(2Periods)

4	Mechanism of ventilation and gas exchange in the alveoli of humans	<ol style="list-style-type: none"> 1) Describe the structure of the human gas exchange system. 2) Describe the distribution of tissues within the trachea, bronchi, bronchioles and alveoli and relate each tissue to its function. 3) Explain the mechanism of ventilation in humans. 4) Explain the process of gas exchange in alveoli with emphasis on diffusion. 5) Describe the role of the brain in controlling gas exchange in humans. 	(2Periods)
5	Use of spirometer to measure ventilation rate and nervous control of breathing	Describe how a spirometer can be used to measure vital capacity, tidal volume, breathing rates, and oxygen uptake.	(2Periods)
6	Lung volume and capacities	Explain the terms related to the lung capacities (tidal, reserve volume, vital capacity, residual volume, and dead air space).	(2Periods)
7	Effects of tar and carcinogens in tobacco smoke on the gas exchange system, symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD)	Describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system.	(2Periods)

8	Effects of nicotine and carbon monoxide on the cardiovascular system, contribution of tobacco smoking to atherosclerosis and coronary heart disease related to early death.	1) Describe the signs and symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD). 2) Describe the effects of nicotine and carbon monoxide on the cardiovascular system. 3) Explain how tobacco smoking contributes to atherosclerosis and coronary heart disease.	(2Periods)
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Lesson 1: Structure of stoma and theories used to explain the mechanism of opening and closure of stomata.

a) Learning objective

- 1) Describe the structure of stoma.
- 2) Explain the theories of opening and closure of stomata stating limitations of each.

b) Teaching resources

To understand this lesson, the following resources are needed : Light microscope, glass slide, cover slip, *Commelina zebrine* leaves, razor blade, forceps, Pasteur dropper and iodine solution. As a tutor, assist student- teachers to find those materials.

c) Prerequisites/Revision/Introduction

The student- teachers will understand better this lesson, if they have prior knowledge on the structure and function of the plant leaves. As a tutor, stimulate the student-teacher to brainstorm what they remember about them.

d) Learning activities

Guidance on activity 7.1

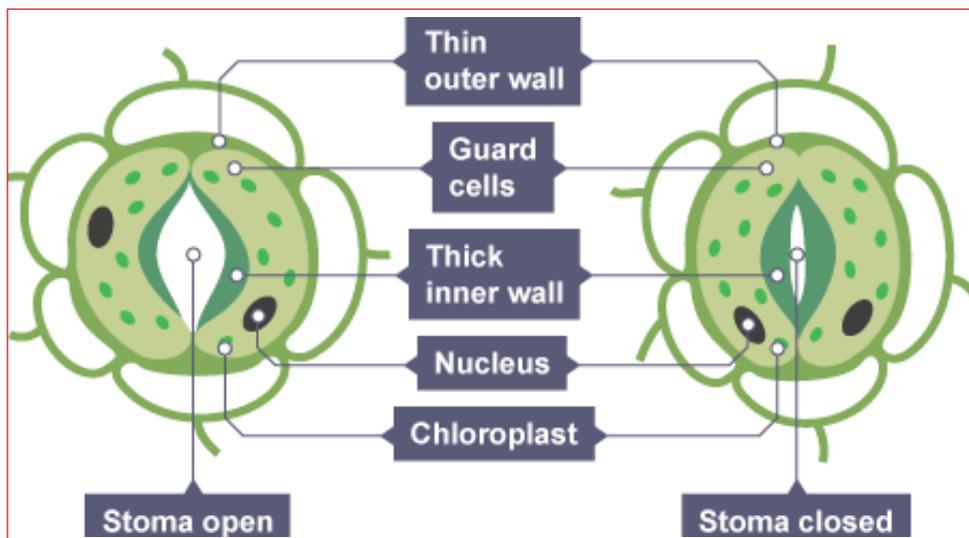
- Check on your marks records and form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.

- Provide each group with the needed materials, procedure and tasks.
- Request the groups to do the activity 7.1
- Move around groups, guiding and facilitating them.
- Select groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Allow student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 7.1 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 7.1

I. 1) To enable clear observation of the internal structures including stomata and neighboring cells.

2)A labelled diagram of stoma must be well drawn.



II. The theories used to explain the opening and closure of stomata are described in student's book.

e) Application activity 7.1

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.1.

Answers of Application activity 7.1

I. 1)D; 2) B; 3)A; 4)C; 5)A

II.

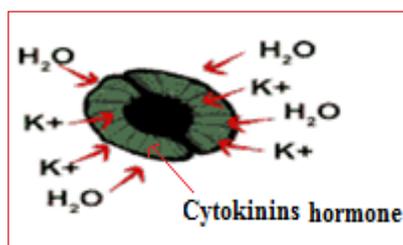


Figure: Drawing showing the process of opening of a stoma and involved hormone.

Lesson 2: Structural adaptation and function of stomata, lenticels, breathing roots and leaves.

a) Learning objective

- 1) Explain how stomata, lenticels and breathing roots are adapted to their function.
- 2) Relate the differences between the structures of aquatic and terrestrial leaves to a habitat.

b) Teaching resources

As a tutor, help students to get the following materials: microscope, prepared slides of leaves of aquatic and terrestrial plants, electrical current. You can also prepare your observation sample.

c) Prerequisites/Revision/Introduction

To understand this lesson , student-teachers must have understood the structure and function of the whole plant in different areas. Ask them to explain briefly the structure, function and adaptations of each plant part.

d) Learning activities

Guidance on activity 7.2

- Form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Deliver all materials and procedure to student- teachers.
- Give those copies to all groups or hang that manila paper in front of all student- teachers.
- Request the groups to do the activity **7.2**
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Facilitate the student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 7.2 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 7.2

Plants adaptations depends on where they live. In general, plants have specific stomata and particular leaves size and shape related to their habitat.

e) Application activity 7.2

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.2.

Answers of Application activity 7.2

1)

column A	column B
Lenticel	b. Porous tissue
Pneumatophores	c. Respiratory roots
Xerophytes	a. are adapted to dry conditions

- 2) Halophytes are adapted in the following ways;
- i. store water in succulent tissues which have high concentration of salt. They can thus take up water from the sea water by osmosis.
 - ii. extensive air spaces throughout the stem and roots making air available to all cells, and giving buoyancy to the stem and leaves at highest tides.
 - iii. they develop breathing roots called pneumatophores which grow upward and protrude out of the ground. e.g. mangrove tree.

Lesson 3: Gaseous exchanges in insects, fish and amphibians.

a) Learning objective

Explain the terms related to the lung capacities (tidal, reserve volume, vital capacity, residual volume, and dead air space).

b) Teaching resources

As a tutor, help the student-teachers to get the following materials: Cockroach, dissecting microscope, surgical scissors, chloroform, forceps, scalpels, pins, dissecting tray etc.

c) Prerequisites/Revision/Introduction

This lesson will be well understood if student-teachers have known before the general structure of insects, fish and amphibians.

d) Learning activities

Guidance on activity 7.3

- Refer to your marks record list and form groups of 6 student-teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Provide students with all needed materials and procedure.
- Request the groups to do the activity 7.3
- Move around groups, guiding and facilitating them.
- Choose groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Permit student-teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 7.3 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 7.3

I)

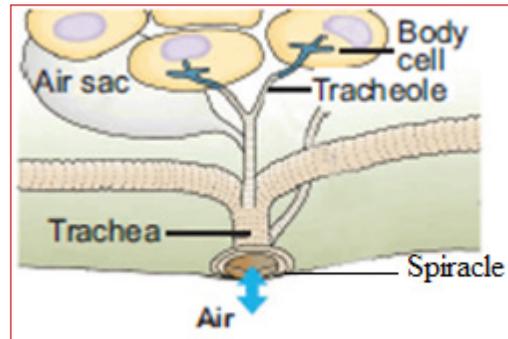


Figure: Drawing showing the parts of the tracheal system of an insect.

II.

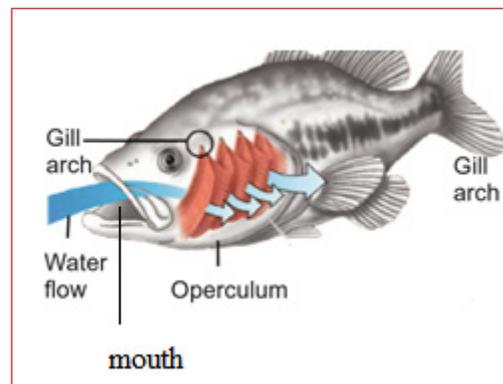


Figure: Drawing showing the parts (mouth, gill and operculum) of a fish involved in gas exchange.

e) Application activity 7.3

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.3.

Answers of Application activity 7.3

1) a) A:Lung; B:Buccal cavity; C: External nostril

b) Lung(A) labeled on the diagram

2)

Animal	Organ involved in gaseous exchange
Fish	gill , operculum
Insect	spiracle, tracheole

Lesson 4: Mechanism of ventilation and gas exchange in the alveoli of humans

a) Learning objective

- 1) Describe the structure of the human gas exchange system.
- 2) Describe the distribution of tissues within the trachea, bronchi, bronchioles and alveoli and relate each tissue to its function.
- 3) Explain the mechanism of ventilation in humans.
- 4) Explain the process of gas exchange in alveoli with emphasis on diffusion.
- 5) Describe the role of the brain in controlling gas exchange in humans.

b) Teaching resources

To comprehend this lesson, student-teacher must be provided with computer, internet connection, charts and books. Assist them to find those materials .

c) Prerequisites/Revision/Introduction

Student-teacher must have a prior knowledge about the structure of human respiratory system.

d) Learning activities

Guidance on activity 7.4.

- Take your marks record list and form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks .
- Give necessary materials to all groups.
- Request the groups to do the activity 7.4
- Move around groups, guiding and facilitating them.
- Prefer groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.

- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 7.4 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 7.4

1)

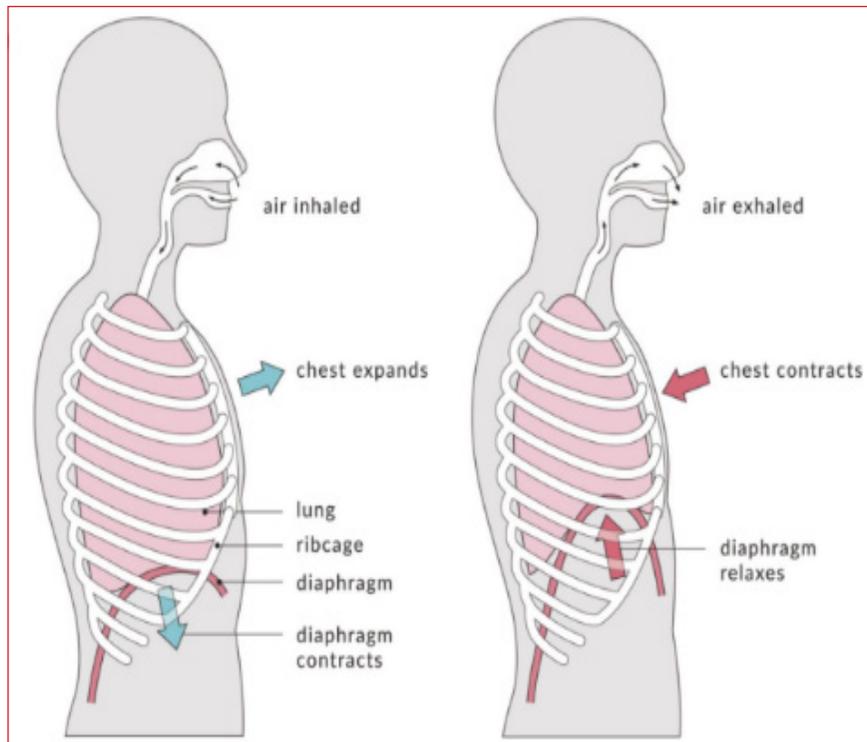


Figure: Drawing showing the mechanism of breathing.

2)

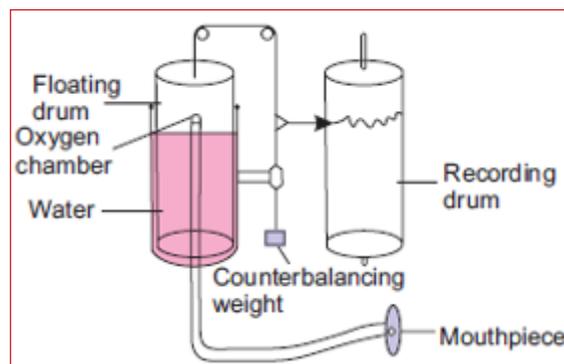


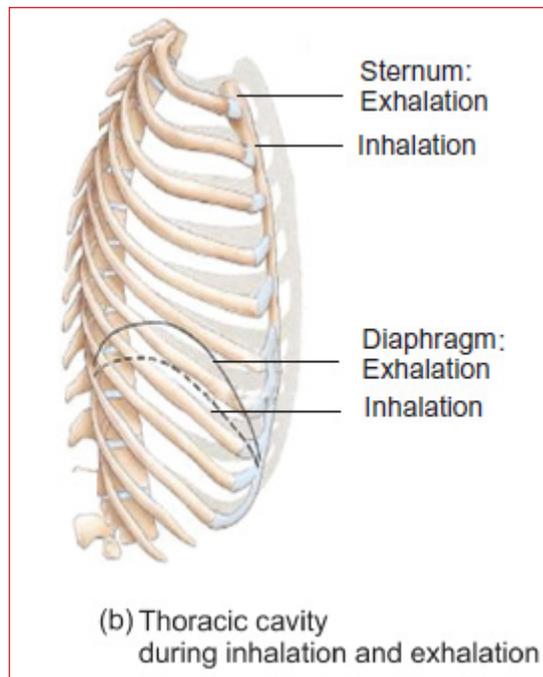
Figure: Drawing showing the model of a spirometer.

e) Application activity 7.4

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.4.

Answers of Application activity 7.4



2)

Column A	Column B
1. Nasal cavity	c. Filters ,warms and moistens the air.
2. Epiglottis	a. Stops food and liquids from going into the trachea during swallowing.
3. larynx(voice box)	b. Sound production

3) Diffusion

Lesson 5: Use of spirometer to measure ventilation rate and nervous control of breathing

a) Learning objective

Describe how a spirometer can be used to measure vital capacity, tidal volume, breathing rates, and oxygen uptake.

b) Teaching resources

As a tutor, provide student-teachers with the following resources: 2–3 litre empty soda/cold drink bottle with cap, One or two feet long piece of plastic tubing, One measuring cup with units in millilitres, One bucket or pan that can hold more than 3 litres of water, One permanent marker.

c) Prerequisites/Revision/Introduction

This lesson should be well understood if student-teachers have the prerequisite about the structure and function as well as those of the respiratory system of the nervous system. To be aware of this knowledge, ask those student-teachers to explain them by brainstorming.

d) Learning activities

Guidance on activity 7.5

- Form groups of 6 student-teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Deliver materials to groups.
- Request the groups to do the activity 7.5
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student-teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 7.5 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 7.5

- i) As a tutor, assist the learners to practice those practical steps on their own.
- ii) As a tutor, show this website to student –teachers so that they discover a video of nervous control of breathing: <https://www.youtube.com/watch?v=nfT0XRkMjC0>

e)Answers of Application activity 7.5

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.5.

Answers of Application activity 7.5

- 1)
 - i. Spirometer ,
 - ii. medulla oblongata,
 - iii. pons ,
 - iv. Apneustic area
- 2)M: expiratory area
N:Pons
O:Medulla oblongata.

Lesson 6: Lung volume and capacities

a) Learning objective

Explain the terms related to the lung capacities (tidal, reserve volume, vital capacity, residual volume, and dead air space).

b) Teaching resources

Assist student-teachers to buy the following materials : Notebook, pen, pencil etc.

c) Prerequisites/Revision/Introduction

Student-teacher should have previously known the structure and functions of the respiratory system. Ask them to tell what they know about it.

d) Learning activities

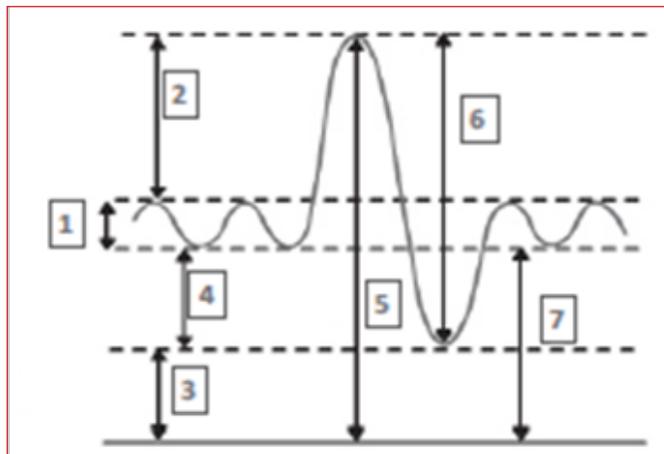
Guidance on activity 7.6

- Use previous assessment results to form groups of 4 or 6 student- teachers and allow them to sit on 2 desks.
- Request the groups to do the activity 7.6
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- Finally, assess learners with application activity 7.6 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 7.6

The tutor should assist the student-teachers to solve the following on their own.

Hint:



1 = Tidal Volume

2 = Inspiratory Reserve Volume

3 = Residual Volume

4 = Expiratory Reserve Volume

5 = Total Lung Capacity

6 = Vital Capacity

7 = Functional Residual Capacity

e) Application activity 7.6

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.6.

Answers of Application activity 7.6

1)

a. Pulmonary/ Lung volumes	W:Tidal volume (TV)	is a volume of air inhaled and exhaled without any noticeable effort (normal breathing).
	X:Inspiratory reserve volume (IRV)	is a volume of air that can be taken in by forced inspiration over and above the normal expiration.
B.Pulmonary/ Lung capacities .	Y:Vital capacity (VC)	is a volume of air that can be maximally breathed out(exhaled) after a maximum inspiration (VC = IRV+TV+ERV).
	Z:Inspiratory Capacity (IC)	is the sum of tidal volume(TV) and inspiratory reserve volume(IRV)

2)Alveolar ventilation (ml/min) = (Tidal volume – Dead space) ×
Respiratory rate

(ml/breath) (ml/breath) (breath/min)

= (500 – 150) ml/breath × 12 breath/min =
350 × 12 = 4200 ml/min.

Lesson 7: Effects of tar and carcinogens in tobacco smoke on the gas exchange system, symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD)

a) Learning objective

Describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system.

b) Teaching resources

The tobacco leaves or cigarette butts , water , heat source/Bunsen burner , plant with aphids and pan are needed. As a tutor, provide student- teachers with them.

c) Prerequisites/Revision/Introduction

Student-teachers should have prior knowledge on types of diseases and their causes. Incite them to brainstorm what they know about diseases.

d) Learning activities

Guidance on activity 7.7

- Form groups of student- teachers based on their previous assessment results .
- Deliver the materials and procedures to them.
- Deliver those materials and procedure to each group.
- Request the groups to do the activity 7.7
- Move around groups, guiding and facilitating them.
- Choose 1 or 2 groups which will present answers to the whole class.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 7.7 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 7.7

1) The teacher should assist the learners in performing the activity.

Hint:

1. Boil tobacco leaves in water to get the extract
2. Cool down the water
3. Spray the obtained extract on the infested plants
4. Observe the effect of extract on Aphids
5. Make observation table

Observation: Aphid will die because of toxic effect of tobacco.

Conclusion: Tobacco is really harmful for every living organism. Not only humans, it's even harmful for tiny insects.

As tobacco chemicals affect negatively the aphids, it can also cause different human diseases such as COPD, cancer, atherosclerosis, Coronary heart diseases and stroke.

II) The teacher should guide the learners to perform activity on their own.

Hint:

1. Take a plastic bottle
2. Make a hole near its base and close it with a pen with its lid.
3. Fill the tap water in the water bottle to 3/4.
4. Make a hole in the cap of the water bottle and put the tip of the cigarette in the hole.
5. Screw up the cap back to the bottle.
6. Light up the cigarette with match stick.
7. Slowly open lid of the pen and let the water come out through the hole.
8. As the water comes out, it sucks the smoke in which results filling of the bottle completely with smoke.
9. Remove the cap and close the bottle mouth with tissue paper and put rubber band over it.
10. Blow up the smoke through bottom opening to expel the smoke out leaving only tar inside.
11. When smoke passes through the tissue paper, tar sticks to it.
12. Observe the tissue paper which contains the dangerous chemical nicotine and sticky brown chemical tar.

Observation: you will see a sticky brown compound 'tar' on the tissue paper. Tar makes coatings on the lung, and hinders the oxygen exchange that makes person's breathing difficult. It leads to cancer also in the alveoli.

e) Application activity 7.7

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 7.7.

Answers of Application activity 7.7

- 5) Lung cancer
- 1) Due to passive smoking, the fumes or smokes chemicals such as acetaldehyde and arsenic released from her parents enter her respiratory system and cause cancer.

Lesson 8: Effects of nicotine and carbon monoxide on the cardiovascular system, contribution of tobacco smoking to atherosclerosis and coronary heart disease related to early death.

a) Learning objective

- 1) Describe the signs and symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD).
- 2) Describe the effects of nicotine and carbon monoxide on the cardiovascular system.
- 3) Explain how tobacco smoking contributes to atherosclerosis and coronary heart disease.

b) Teaching resources

As a tutor deliver the computers of the mart classroom, internet connection and books to your student- teachers.

c) Prerequisites/Revision/Introduction

The student- teachers should be aware of all harmful chemicals or drugs of the nervous system. Ask them to explain what they know about those drugs effects.

d) Learning activities

Guidance on activity 7.8

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.

- Give the computers of the mart classroom, internet connection and books to your student- teachers.
- Request the groups to do the activity 7.8
- Move around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- To finish this lesson, assess learners with application activity 7.8 or formulate your own assessment questions that must be answered by each student- teacher.

Answers of activity 7.8.

- The carbon monoxide in tobacco smoke reduces the amount of oxygen in blood. This means the heart has to pump harder to supply the body with the oxygen it needs.
- The nicotine in cigarettes stimulates body to produce adrenaline, which makes heartbeat faster and raises the blood pressure, making heart work harder.
- The chemicals found in tobacco cause atherosclerosis and coronary heart disease.

e)Answers of Application activity 7.8

I. 1)Figure :Drawing showing plaque formation around the artery wall in atherosclerosis

2)C:endothelium

D:Lipids,calcium,cellular debris.

3) Plaque formation around the artery wall in atherosclerosis is due to tobacco/cigarette smoking or high consumption of lipids. The harmful chemicals found in tobacco kill smokers early.

II) a)As years advance, the number of smokers increases and many peoples are killed by the disease related to smoking.

b) Other disease associated with smoking include stroke, atherosclerosis and coronary heart disease .

7.6 Summary of the unit

The unit 7 comprises eight lessons :Structure of stoma and theories used to explain the mechanism of opening and closure of stomata ;Structural adaptation and function of stomata, lenticels , breathing roots and leaves ;Gaseous exchanges in insects, fish and amphibians; Mechanism of ventilation and gas exchange in the alveoli of humans ;Use of spirometer to measure ventilation rate and nervous control of breathing ;Lung volume and capacities ;Effects of tar and carcinogens in tobacco smoke on the gas exchange system, symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD) ; andEffects of nicotine and carbon monoxide on the cardiovascular system, contribution of tobacco smoking to atherosclerosis and coronary heart disease related to early death.

The first lesson explain how the stomata open and close involving the guard cells, Potassium ions, Abscisic acid (ABA) and cytokinins. It also highlights the theories of this stomatal mechanisms. The second lesson shows how stomata, lenticels , breathing roots and leaves are adapted to their functions. It also explains the characteristics of hydrophytes and terrestrial plants. The third lesson describes the gaseous exchanges in insects, fish and amphibians. Insects use tracheal system, fishes use gills while amphibians use lungs and skin in gaseous exchange. The fourth lesson clarifies the mechanism of ventilation and gas exchange in the alveoli of humans .In this lesson , the respiratory system is involved. The respiratory gases diffuse through the alveoli , capillary walls and cells membranes.The fifth lesson describes the use of spirometer to measure ventilation rate and nervous control of breathing . The medulla oblongata and pons are mainly involved in the control of breathing.

In the sixth lesson, the lung volume and capacities are explained. The pulmonary capacities tests are useful diagnostic tools. The seventh lesson talks about effects of tar and carcinogens in tobacco smoke on the gas exchange system and symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD). Based on this lesson, it is noticeable that smoking has many negative effects including diseases such as cancer. The last lesson shows the effects of nicotine and carbon monoxide on the cardiovascular system, contribution of tobacco smoking to atherosclerosis and coronary heart disease related to early death. This lesson indicates that early death can results from smoking.

7.7 Additional Information for teachers

Theories of opening and closing of stomata are summarized in student textbook. The detailed is given to you so that you may be equipped with knowledge and understanding about them while using this guide. These theories are also followed by further information related to the adaption of plants in gas exchange. The four theories of opening and closing of stomata are highlighted as follow:

1) Theory of Photosynthesis in Guard Cells:

Von Mohl (1856) observes that stomata open in light and close in the night. He then proposed that chloroplasts present in the guard cells photosynthesize in the presence of light resulting in the production of carbohydrate due to which osmotic pressure of guard cells increases.

Its explanation is based on following sequence:

Light Photosynthesis in guard cells Formation of sugar Increase of osmotic pressure of cell sap Endosmosis takes place from subsidiary cell to guard cell

Increase of TP in guard cells Stomata open.

Demerits:

- Increasing the CO₂ concentration around the leaves should lead to wide opening of stomata but here occurs their partial closure.
- Chloroplast of guard cells are poorly developed and incapable of performing active photosynthesis.

1) Starch Sugar Inter-Conversion Theory:

According to Lloyd (1908) turgidity of guard cell depends on inter-conversion of starch and sugar. It was supported by Loft-field (1921). He found out that guard cells contain sugar during day time when they are open and starch during night when they are closed.

Sugar Inter-Conversion Part 1:

Sayre (1926) observed that stomata open in neutral or alkaline pH, which prevails during day time due to constant removal of carbon-dioxide by photosynthesis. Stomata remain closed during night when there is no photosynthesis and due to accumulation of carbon-dioxide, carbonic acid is formed that causes the pH to be acidic. Thus, stomatal movement is regulated by pH due to inter-conversion of starch and sugar.

Sayre concept was supported by Scarth (1932) and Small et. al. (1942).

Yin and Tung (1948) isolated for the first time phosphorylase enzyme from the guard cells. According to them starch is converted into glucose-1, phosphate in the presence of this enzyme. During the process, inorganic phosphate is also used and light and dark phases (changing CO₂ concentration) control the changes in pH. The reaction may be represented as follows:

Starch Sugar Interconversion Part 2:

Steward (1964) proposed another modified scheme of inter-conversion of starch and sugar for stomatal movement. He believes that conversion of starch to Glucose

- 1 phosphate is not sufficient. It should be converted to glucose in order to increase sufficient osmotic pressure. For this, ATP is also required which means that the process should be through respiration in presence of oxygen. Guard cell carries enzymes like Phosphorylase, Phosphoglucomutase, Phosphatase and Phosphorylase. These enzymes help in opening and closing of the stomata.

Starch Sugar Interconversion Part 3:

Based on the above mentioned theory, process of opening and closing of stomata may be summarized as given below. In light:

Photosynthesis (1) → Decreased CO₂ Concentration in leaf cells (2) → Increase in p_H

of guard cells (3) → Hydrolysis of starch to sugar by enzymes (4) → Increase of O.P.

of guard cells (5) → Endosmosis of water in guard cells (6) → Increase in T.R of guard cells (7) → Aperture.

2) Theory of Glycolate Metabolism:

Zelitch (1963) proposed that production of glycolic acid in the guard cells is an important factor in stomatal opening. Glycolate is produced under low concentration of CO₂. He suggested that glycolate gives rise to carbohydrate, thus raising the osmotic pressure and also that it could participate in the production of ATP. Which might provide energy? required for the opening of stomata?

Demerits:

- It fails to explain the opening of stomata in dark (e.g. – in succulent plants).
- In some plants stomata have been found to remain closed even during daytime.
- It fails to explain the effect of blue light on stomatal opening.

3)Active Potassium Pump Theory:

The concept of K^+ ion transport was given by Fujino. It was supported and elaborated by Levitt & Rashke in 1975. It appears to be an active mechanism which needs ATP. It is based on recent observations and (explains the mechanism as follows.

A. Opening of Stomata during Daytime (in presence of light):

Opening of stomata depends upon following conditions:

- Presence of light.
- Decrease in starch contents of guard cells.
- Increased concentration of malic acid in guard cells.
- Influx of K^+ ions in guard cells.
- Efflux of H^+ ions from guard cells.
- Intake of Cl^- ions by guard cells.
- Low CO_2 concentration in an around guard cells.
- High pH (more than 7) in guard cells (hence, alkaline medium of the cell sap in guard cells).
- High T.P. in guard cells due to endosmosis, (turgidity of cells).
- TP more towards thin wall of guard cell & stomata open.

According to Levitt, in the guard cells, starch is converted into malic acid in presence of light (during day time).

Guidance on skills Lab

- As a tutor, motivate student-teachers to practice what they have studied in this unit in order to get money and skills.
- To show them that it is possible, request needed materials from your school leader.
- Then request students to implement that skill lab.
- Request student-teachers to present their report and conclude.

7.8 End unit assessment (answers)

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

6. During the day, K⁺ pumps of guard cells open and K⁺ ions flow in guard cells by active transport. This makes guard cells permeable to carbon dioxide which is used in the chloroplast of guard cells to make glucose by photosynthesis. High amount of sugar (malate) increases the osmotic pressure in the guard cells. Water moves from the neighbouring cells into the guard cells which become turgid. The guard cells stretch backwards and the aperture of stoma opens wider. Water vapour and Oxygen are released.

7. Insects have a specialised system of 'tubes' called the tracheal system for exchange of gases. This system consists of a vast network of cuticular (*i.e.*, made of chitin, a long-chain polymer of an n-acetyl glucosamine) tubes penetrating to almost each individual cells of the body. This system serves two functions: it brings air into the body, and also distributes it to the cells. This pattern of tracheal system is very much similar to the system of blood vessels in higher animals.

Air enters the tracheal system of the animal through special openings called spiracles. These are present mostly on the lateral side of the animal. These are usually guarded by valves, operated by muscles and sometimes provided with filters. Tracheal tubes are invaginations (infoldings) of the body surface. Thus, their walls are similar in structure and composition to the general body surface (integuments) of the animals. Sometimes larger tracheas have thickenings called taenidia. These are spiral cuticular layers which give strength and elasticity. The tubes become progressively smaller and thinner to form tracheoles or air capillaries. The smaller tubes may have incomplete taenidial support.

8. Gills are typical respiratory organs of aquatic animals, including fishes. Gills range in shape and size. It may be finger like projections or simple epithelial extensions. Gills are more developed in fishes. Fish gills consist of thousands of highly specialised gill lamellae enclosed in a gill cavity. The gill cavity is covered by an operculum and continuously ventilated by flowing water. Respiration through gills is also known as branchial respiration. All gill surfaces are provided with a dense network of thin capillary vessels and supported by skeletal elements called the branchial arches.

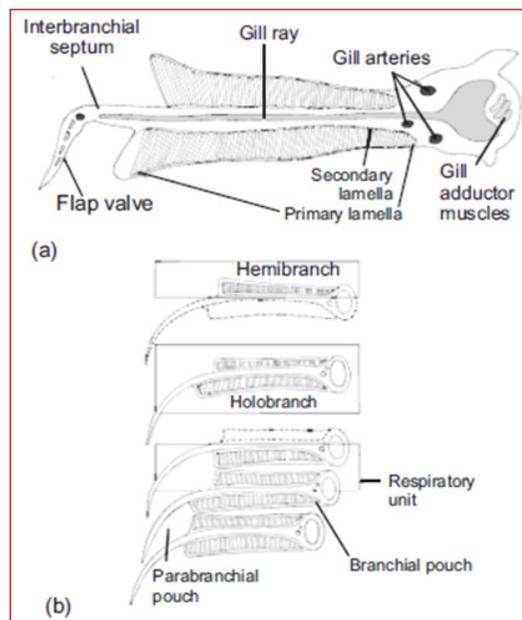
Types of Gills

Gills can be of two types:

External gills: These gills are exposed to the environment and not enclosed within a pouch or cavity. They are found in the larvae of many vertebrates, including lungfishes, actinopterygians, and amphibians.

Internal gills: Gills are covered and protected laterally by soft skin folds, like the interbranchial septum in cartilaginous fishes, or by a firm operculum in many bony fishes. They are found within pharyngeal gills slits or pouches of most cartilaginous and bony fishes. In cartilaginous fishes, the gills are found on the lateral side of the branchial arch. Gills are usually five pairs in number. They are located in vertical, anterioposteriorly compressed branchial chambers or gill pouches. Each branchial pouch is separated from each other by a stout interbranchial septum. This septum is made up of fibro-muscular tissue with blood vessels.

A branchial pouch communicates to exterior with the help of narrow external branchial aperture or gill slits. Each gill has a central partition called the interbranchial septum. Within this septum, a stiff structure called gill ray gives support to the gills. This septum is covered on each face by primary lamellae or gill filaments. Gill filaments are series of raised thin, highly vascular horizontal lamellar folds of the interbranchial septum. The primary lamellae are again made up of standing rows of secondary lamellae. Water flows across their sides to irrigate the gills.



When gill lamellae are present on both anterior and posterior sides of a septum, it is called a holobranch or complete gill. However, when lamellae is present on only one face, it is called a hemibranch. Facing plates of lamellae on adjacent gills constitute a respiratory unit. A branchial pouch therefore consists of posterior hemibranch of one gill and anterior hemibranch of the succeeding gill.

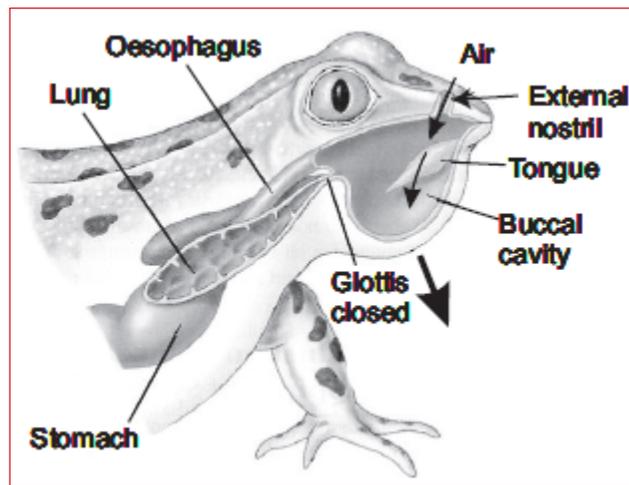
The pharyngeal structural region in bony fishes is almost similar to that of cartilaginous fishes. The gill/branchial chamber on each side is covered by a fold of integument called the operculum (gill covering). It is supported by four opercular bones. The operculum protects the branchial arches and its gill lamellae and also helps in gill ventilation. There are five pairs of gill pouches and four pairs of holobranchs or complete gills. In cross section, each gill is V-shaped and composed of primary lamellae (gill filaments) that are subdivided into secondary lamellae and supported on a branchial arch.

9. Amphibians use the moist skin, gills or the lungs for gas exchange (Figure 9.8). Gas exchange occurring through the skin is known as cutaneous respiration. In some larval Salamanders and adult, external gills are also used for respiration. Modern amphibians rely heavily on cutaneous respiration. Sometimes, they develop accessory skin structures to increase the surface area available for gas exchange.

The amphibian skin is thin, moist, and rich supplied with capillaries making it best suited for gas exchange by diffusion.

In aquatic amphibians, pharyngeal slits often persist with internal gills. Feathery external gills are often present especially among larval amphibians.

Most adult amphibians have lungs for breathing air. Normally, the respiratory surface within the lungs on the anterior region is more developed than the posterior along the inner walls. The inner surface of lungs forms partitions and divide to increase the surface area for gas exchange. Such a surface is called septal. The interconnecting septa divide the internal wall into compartments called faveoli. This faveoli open into the central chamber within each lung. Faveoli differ from the alveoli of mammalian lungs. Alveoli are found at the end of a highly branched tracheal system but faveoli are not. Faveoli are internal subdivisions of the lung wall that open into a common central chamber. Inspired air travels along the trachea into the central lumen of the lung and from here diffuses into the surrounding faveoli. Capillaries located within the thin septal walls of the faveoli take up oxygen and give up carbon dioxide.



10. Vital capacity = inspiratory reserve volume + tidal volume + expiratory reserve volume

$$= 2500 \text{ ml} + 550 \text{ ml} + 1450 \text{ ml} = 4500 \text{ ml}$$

- Alveolar ventilation (ml/min) = (Tidal volume - Dead space) × Respiratory rate

$$(\text{ml/breath}) (\text{ml/breath}) (\text{breath/min})$$

$$= (550 - 185) \times 17 \text{ ml/min} = 365 \times 17 \text{ ml/min} = 6205 \text{ ml/min}$$

11. Smoking harms nearly every bodily organ and organ system in the body and diminishes a person's health and smokers are more likely than non-smokers to develop heart disease, stroke, and lung cancer. 'Smoke-free' campaigns are run to encourage people to change their behaviour.

The campaigns are aimed at:

- Making people aware of the health dangers of smoking
- Stopping young people from taking up smoking
- Encouraging smokers to try and quit, and to do so in the most effective way
- Encouraging people to stop smoking in their homes and family cars—emphasizing how it affects children.

7.9 Additional activities (Questions and answers)

7.9.1 Remedial activities

- 1) What do you understand by the following terms: (a) Stoma - (b) pneumatophores - (c) Lenticels

- 2) Identify the structures involved in gaseous exchange in plants
- 3) State the adaptations for gaseous exchange in mangroves.

Answers:

- 1) (a) Stoma is the aperture between two guard cells that opens and closes to control water transpiration and gaseous exchange in plant leaves and stems (b) Pneumatophores are breathing roots of plants (c) Lenticels are any of pores in the stems of woody plants that allow gas exchange between the atmosphere and the internal tissues.
- 2) Structures involves in gaseous exchange in plants are stomata, cuticles, lenticels and pneumatophores.
- 3) Adaptation of gas exchange in mangroves:
 - Presence of stomata on leaves
 - Presence of lenticels
 - Presence of pneumatophores

7.9.2 Consolidation activities

- 1) Why do plants living at high altitudes need xeromorphic adaptations?
- 2) Why do halophytes have very little lignified tissues?
- 3) Glassworts are edible, salty tasting plants. Why do they accumulate salt in their tissues?

Answers:

- 1) Plants at high altitudes have xeromorphic adaptations to reduce transpiration losses when soil is frozen and free water is unavailable
- 2) Hydrophytes are supported by water
- 3) Salt is actively absorbed in tissues of glassworts to create a concentration gradient for the uptake of water by osmosis.

7.9.3 Extended activities

- 1) Have a Commelina leaf. Remove its upper epidermis and its lower epidermis. Use 2mmx 2mm portion from each epidermis. Mount each portion on a drop of dilute iodine solution. Observe each preparation under the lower magnification. Count the number of stomata from each side. Repeat the same procedure using the leaf of mango leaf.

a) Fill the table below:

Plant leaf	Number of stomata on lower Epidermis	Number of stomata at upper epidermis.
Commelina		
Mango		

b) What conclusion can you draw from the data in table above?

Answers:

- a) The answer can vary from one student to another
- b) The leaves of monocotyledonous plants have stomata on both upper and lower epidermis but the leaves of dicotyledonous plants do not have stomata on the upper epidermis.

2) Why the fish cannot survive longer out of water at yet the atmosphere has plenty oxygen than water?

Answer

Because the gills are adapted to fix little amount of oxygen dissolved in water. The flow of water in parallel current or countercurrent direction allows the efficient gas exchange. But the open air does not match with such an adaptation in fish.

3) Suggest why each cubic centimeter volume of a frog lung has a total gaseous exchange surface of 20 Cm², whereas a cubic centimeter volume of a mouse lung has a gaseous exchange surface of about 800 cm².

Answer

The shape of the respiratory surface areas of both frog and mouse are not the same.

4) How does tar in cigarette smoke contribute to the development of emphysema?

Answer: Tars irritate and damage lung tissue both mechanically and chemically.

UNIT 8

TRANSPORT IN PLANTS AND ANIMALS

8.1 Key unit competence:

Describe the structure of the transport tissues in plants, the mechanisms by which substances are moved within the plant and relate the structures of the circulatory and lymphatic systems to their functions in human.

8.2 Prerequisites

To understand this unit, student-teachers should have got, in ordinary level, the prior knowledge, skills, attitudes and values concerning the components of each system in the body. They should have got information about the interaction between the systems of the body, especially how the nervous and hormonal (endocrine) systems coordinate the body functions. Focus on transport systems to test whether they have those information by asking some oral questions.

8.3 Cross cutting issues to be addressed

In this unit, the following cross cutting issues will be addressed: Environment and sustainability, comprehensive sexuality education and standardization culture.

8.4 Guidance on introductory activity

8.5 List of lessons

	Lesson title	Learning objectives	Number of Periods
1)	Need for a transport system and the structure of transport tissues	1) Explain the need for a transport system in animals.	(1 Period)

	<p>Need for a transport system and the structure of transport tissues</p>	<ol style="list-style-type: none"> 2) Observe, draw and label, from prepared slides, plan diagrams of transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants to show tissues in correct proportion. 3) Draw and label, from prepared slides, the cells in roots, stems and leaves using transverse and longitudinal sections. 4) Recognise, from prepared slides, using the light microscope to draw and label the structure of xylem vessel elements, phloem sieve tube elements and companion cells. 5) Carry out an investigation to demonstrate mass flow hypothesis. 6) Appreciate the importance of transport systems in plants. Acknowledge that plants do not have systems for transporting oxygen and carbon dioxide. Instead these gases diffuse through air spaces within stems, roots and leaves. 7) Appreciate the importance of the need for transport systems when animals become larger, more complex and more active, to supply nutrients to, and remove waste from, individual cells. 	
2)	<p>Transport mechanisms of plants and the process of transpiration</p>	<ol style="list-style-type: none"> 1) Explain the movement of water between plant cells, and between them and their environment, in terms of water potential. 	<p>(2Periods)</p>

		<p>2) Transpiration is an inevitable consequence of gas exchange in plants. Justify this statement</p> <p>3) Explain how hydrogen bonding is involved with the movement of water in the xylem by cohesion tension in transpiration pull and adhesion to cellulose cell walls.</p> <p>4) Describe how sucrose and amino acids move between sources and sinks in phloem sieve tubes.</p> <p>5) Explain how transport systems in plants move substances from where they are absorbed or produced to where they are stored or used.</p> <p>6) Explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the cotransporter mechanism in the cell surface membranes.</p> <p>7) Explain mass flows in phloem sap down a hydrostatic pressure gradient from source to sink.</p> <p>8) Relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions</p> <p>9) Show concern when selecting crop plants to reflect adaptations to environments e.g. where they grow well, and when under water or not under water stress.</p>	
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		<p>10) Experimentally investigate and explain the factors that affect transpiration rate using simple potometers, leaf impressions, epidermal peels, and grids for determining surface area.</p> <p>11) Make annotated drawings, using prepared slides of cross sections, to show how leaves of xerophytes are adapted to reduce water loss by transpiration.</p>	
3)	The blood circulatory system in insects, annelids, fish and mammals	<p>1) Explain the advantages and disadvantages of different types of circulatory systems.</p> <p>2) Distinguish between open and closed, single and double circulation with reference to insects, earthworm, fish and mammals.</p>	(3Periods)
4)	Structure of the mammalian heart	<p>1) Describe the external and internal structure of a mammalian heart.</p> <p>2) Show resilience when setting apparatus and making observations using microscopes and solutions of different concentration to ensure improved reliability .</p>	(2Periods)
5)	The heartbeat and the mammalian cardiac cycle	<p>1) Explain how a heartbeat is initiated.</p> <p>2) Describe the main events of the cardiac cycle.</p>	(2Periods)

6)	Control of the heart rate and the factors controlling heart rate	<ol style="list-style-type: none"> 1) Explain how blood circulation is controlled. 2) Describe the effects of exercise on respiration and on circulation. 3) Carry out an investigation on the effects of exercise on the pulse rate and blood pressure. 	(2Periods)
7)	Structure of blood vessels	<ol style="list-style-type: none"> 1) -Explain the relationship between the structure and function of blood vessels. 2) Recognise blood vessels from their structures using a light microscope. 3) Relate the structure of blood vessels to their functions. 	(1Period)
8)	Blood composition, its functions and cardiovascular diseases.	<ol style="list-style-type: none"> 1) Differentiate between blood, tissue fluid, and lymph. 2) Relate blood as a tissue to its functions. 3) Recognise possible risk factors as diet, stress, smoking, genetic predisposition, age and gender in relation to cardio vascular diseases. 	(2Periods)
9)	Transport of respiratory gases	<ol style="list-style-type: none"> 1) Describe the structure of haemoglobin and explain how haemoglobin transports oxygen. 2) - Interpret oxygen dissociation curves for haemoglobin and other respiratory pigments. 	(2Periods)

10)	Blood clotting and common cardiovascular diseases	1) Describe the process of blood clotting. 2) Describe the risk factors associated with cardiovascular diseases.	(2Periods)
11)	Lymphatic system .	Explain how tissue fluid and lymph are formed.	(1Period)

Lesson 1: Need for a transport system and the structure of transport tissues

a) Learning objective

- 1) Explain the need for a transport system in animals.
- 2) Observe, draw and label, from prepared slides, plan diagrams of transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants to show tissues in correct proportion.
- 3) Draw and label, from prepared slides, the cells in roots, stems and leaves using transverse and longitudinal sections.
- 4) Recognise, from prepared slides, using the light microscope to draw and label the structure of xylem vessel elements, phloem sieve tube elements and companion cells.
- 5) Carry out an investigation to demonstrate mass flow hypothesis.
- 6) Appreciate the importance of transport systems in plants.
- 7) Acknowledge that plants do not have systems for transporting oxygen and carbon dioxide. Instead these gases diffuse through air spaces within stems, roots and leaves.
- 8) Appreciate the importance of the need for transport systems when animals become larger, more complex and more active, to supply nutrients to, and remove waste from, individual cells.

b) Teaching resources

Student-teachers will use the following materials: Computer, internet connection, Electrical source, Microscope, Prepared slides of transport structures in stem, roots and leaves. You can prepare your sample to be observed using the onion or *Commelina*

c) Prerequisites/Revision/Introduction

This lesson will be understood if student-teachers have prior knowledge about the role of soil to the plant. Ask them to describe orally what they know about it.

d) Learning activities

Guidance on activity 8.1

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Deliver materials to each group
- Request the groups to do the activity 8.1
- Move around groups, guiding and facilitating them to achieve efficiently the activity.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- In this lesson talk about environment and sustainability as cross cutting issue. Tell to student-teachers that if they do not protect the environment, the plants will die and people will lack oxygen for respiration.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.1 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.1

- 1). No heart, no blood and no circulatory system, but **plants** do **need a transport system** to move food, water and minerals around.

They use two different systems :

- a) **xylem** moves crude /inorganic/mineral sap (water and solutes) from the soil to roots to other parts of the plants.
- b) **phloem** moves elaborated / organic sap (organic substances such as carbohydrates, proteins and lipids made during photosynthesis) from leaves to other parts of the plants.

2) As a tutor, help your student-teachers to observe carefully the transport structures

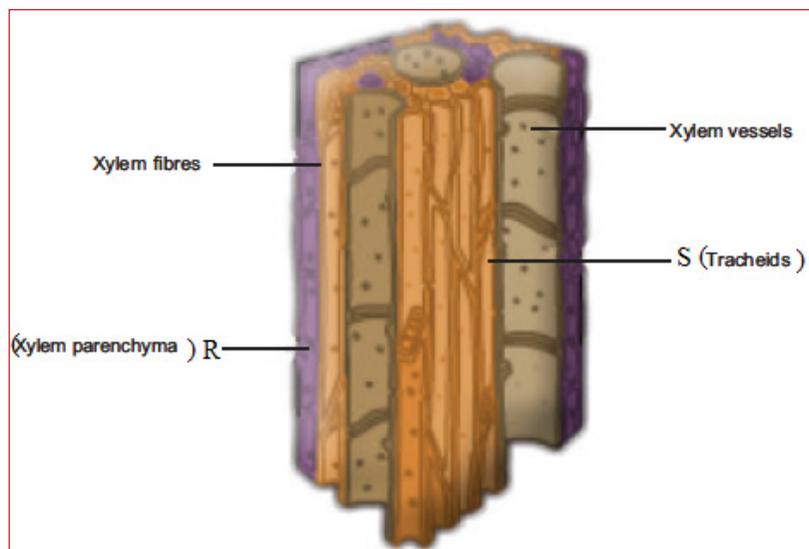
e) Application activities 8.1

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually, the application activity 8.1.

Answers of Application activity 8.1

- 1)
 - i) tracheids, vessels, parenchyma and fibres
 - ii) absorb, transport
 - iii) active and passive
- 2)
 - a) Xylem
 - b)



c) The **xylem** moves crude/inorganic/mineral sap (water and solutes) from the soil to roots to other parts of the plants.

Lesson 2: Transport mechanisms of plants and the process of transpiration

a) Learning objective

- 1) Explain the movement of water between plant cells, and between them and their environment, in terms of water potential.
- 2) Transpiration is an inevitable consequence of gas exchange in plants. Justify this statement
- 3) Explain how hydrogen bonding is involved with the movement of water in the xylem by cohesion tension in transpiration pull and adhesion to cellulose cell walls.
- 4) Describe how sucrose and amino acids move between sources and sinks in phloem sieve tubes.
- 5) Explain how transport systems in plants move substances from where they are absorbed or produced to where they are stored or used.
- 6) Explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the cotransporter mechanism in the cell surface membranes.
- 7) Explain mass flows in phloem sap down a hydrostatic pressure gradient from source to sink.
- 8) Relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions.
- 9) Show concern when selecting crop plants to reflect adaptations to environments e.g. where they grow well, and when under water or not under water stress.
- 10) Experimentally investigate and explain the factors that affect transpiration rate using simple potometers, leaf impressions, epidermal peels, and grids for determining surface area.
- 11) Make annotated drawings, using prepared slides of cross sections, to show how leaves of xerophytes are adapted to reduce water loss by transpiration.

b) Teaching resources

As a tutor, provide your student-teachers with the following materials :a fresh green plant, a glass of water, natural food colour, a razor, slide and a microscope; a potted plant, glass plate, Twig of *Dracaena*. Potometer, Luxmeter, table lamp.. bell jar, oilcloth, grease and thread.

c) Prerequisites/Revision/Introduction

To understand these mechanisms, student-teachers should have prior knowledge about the types of transport of substances across the cell membrane as discussed in unit 5. Ask them to brainstorm what they remember about it.

d) Learning activities

Guidance on activity 8.2

- Referring to marks records lists, form groups of student-teachers based on their previous assessment results and allow them to sit face-to-face.
- Deliver materials to each group
- Request the groups to do the activity 8.2.
- Move around groups, guiding and facilitating them to practice this activity.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Allow student-teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.2 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.2

1) As a tutor facilitate the student-teachers to practice each step.

Hint:

1. Take a fresh green plant.
2. Give a cut at the basal end.
3. Put the cut segment in water with natural food colours.
4. Cut a transverse section of the stem and observe under the microscope.

Results

We observe that some parts of the stem appear coloured.

This is because the water is rising through the specialized conducting tissues called the xylem.

II) As a tutor, assist student –teachers to perform well this activity step by step.

Hint:

Take a watered healthy plant. Cover the soil by cloth to avoid evaporation. Place the pot on a glass plate and cover with a bell jar. Leave the apparatus for some time and observe.

Results: Small drops of water start appearing on the inner side of bell jar due condensation of water vapour transpired from the plant.

The experiment demonstrates the phenomenon of transpiration.

III) The teacher should introduce the learners to transpiration and perform the following activity.

Hint:

A twig of the plant is filled and sealed in one end of the photometer. The entire apparatus is filled with water so that there are no air spaces in between. The plant is exposed to different light intensities.

The drop in the level of the tube at other end is measured at different light intensities.

Results

With the increase in light intensity, the level of the water drops indicating increase in the rate of transpiration.

e)Application activity 8.2

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.2.

Answers of Application activity 8.2

- | | | |
|----|-------------------|-------------|
| 1) | (i) Transpiration | (ii) sunken |
| | (ii) Potometer | (iv) CAM |

2)

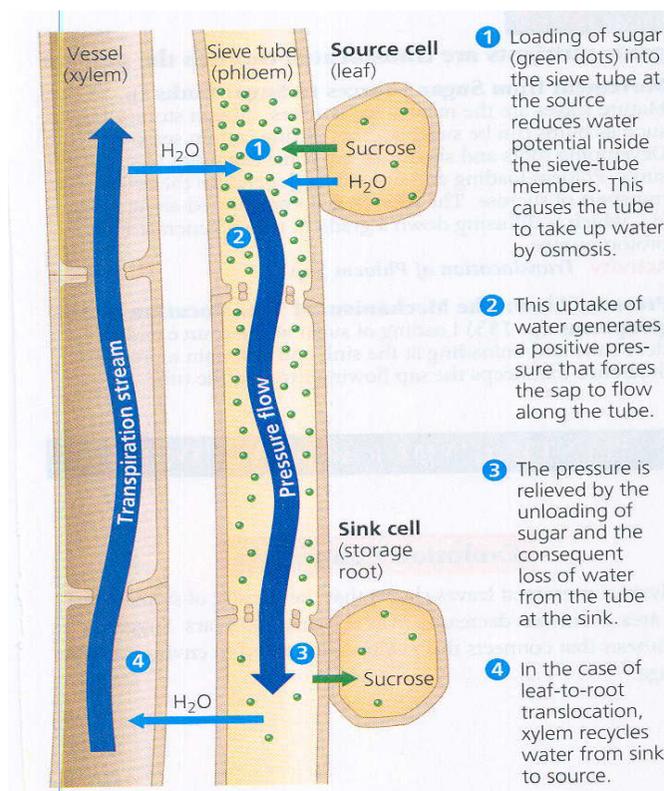


Figure : Transport (mass flow) of organic matter in phloem of a plant .

Lesson 3: The blood circulatory system in insects, annelids, fish and mammals

a) Learning objective

- 1) Explain the advantages and disadvantages of different types of circulatory systems.
- 2) Distinguish between open and closed, single and double circulation with reference to insects, earthworm, fish and mammals.

b) Teaching resources

Real animals or their images on manila papers .Example: Earthworm, fish , grasshopper are needed. As a tutor, request students to bring them.

c) Prerequisites/Revision/Introduction

This lesson will be understood if students have prior knowledge on digestion ,on how nutrients absorbed from the small intestine enter the circulatory system in order to move via the blood vessels. Test whether they have this prerequisite by asking the questions related to it.

d) Learning activities

Guidance on activity 8.3

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Ask each student- teacher to show the killed animal that she/he has brought.
- Request the groups to do the activity 8.3
- Pass around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.3 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.3

No, these animals do not have the same circulatory system. Their circulatory system vary as follows:

- Lion has closed double circulatory system
- Fish has closed single circulatory system
- Grasshopper has open circulatory system
- Earthworm has closed circulatory system

e) Application activity 8.3

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.3.

Answers of Application activity 8.3

- 1) e) It contains neurons that conduct the nerve impulses.

2) These are differences between open and closed circulation

Closed circulation	Open circulation
Present in annelids and vertebrates	In invertebrates (arthropods)
Blood does not bath the cells	Blood directly bathes the cells
Blood flows in vessels	Blood flows in haemocoel
There is a muscular heart	There is not heart but nodes as simple heart
Higher blood pressure	Lower blood pressure
Blood contains haemoglobin	There is no haemoglobin
e.g. Earthworms, fish, frog, human	e.g. insect, arachnids

3)

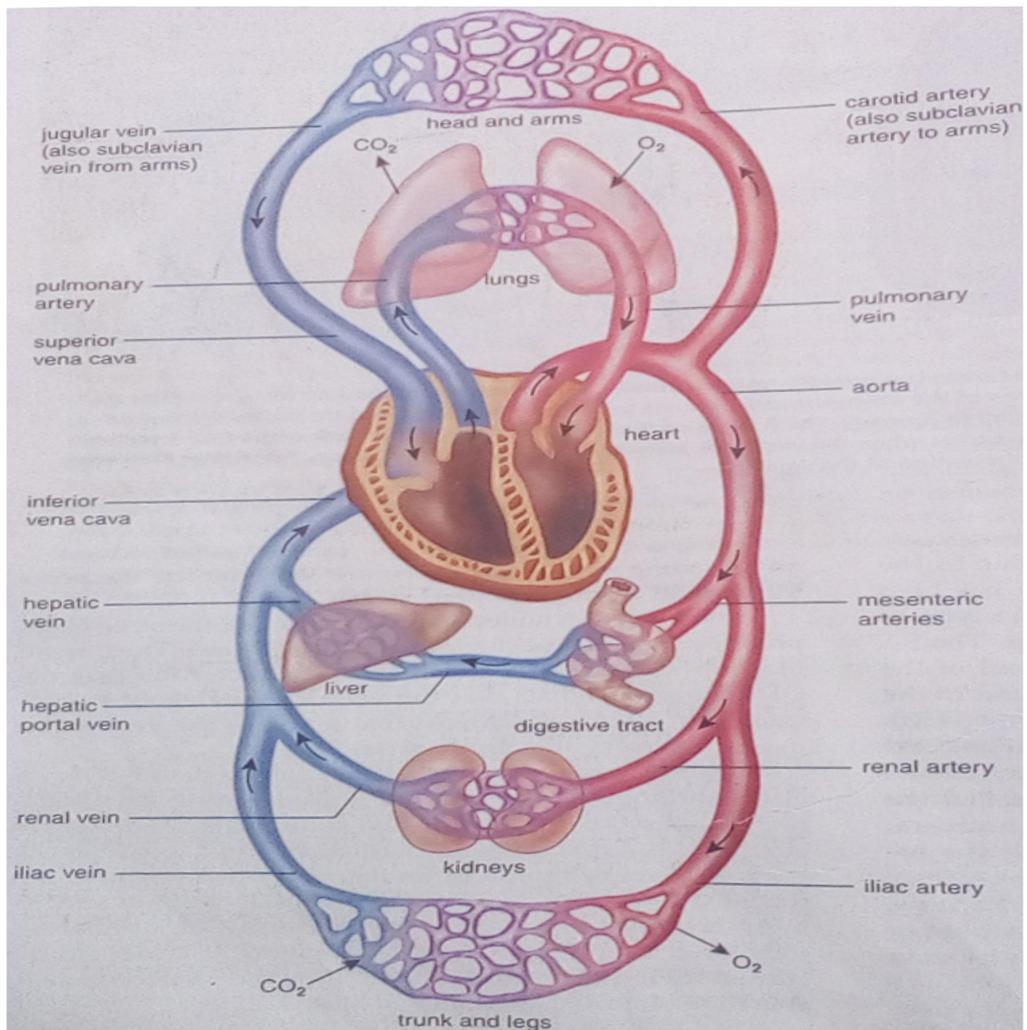


Figure : Drawing showing the closed double circulation in mammals and birds

Lesson 4: Structure of the mammalian heart

a) Learning objective

- 1) Describe the external and internal structure of a mammalian heart.
- 2) Show resilience when setting apparatus and making observations using microscopes and solutions of different concentration to ensure improved reliability .

b) Teaching resources

As a tutor , provide your student-teachers with these materials:mammalian heart , dissecting kit.

c) Prerequisites/Revision/Introduction

To understand this lesson, student-teachers should know the general structure of the circulatory system.

d) Learning activities

Guidance on activity 8.4

- Form groups of 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Deliver all needed materials to each group.
- Request the groups to do the activity 8.4.
- Pass around groups, guiding and facilitating them to practice this activity step by step..
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.4 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.4

- 1) Student-teachers have to identify the following: Left and right atrium, aorta, vena cava, septum.

- 2) Left ventricle is thicker compared to right ventricle.
- 3) Blood flow in human heart

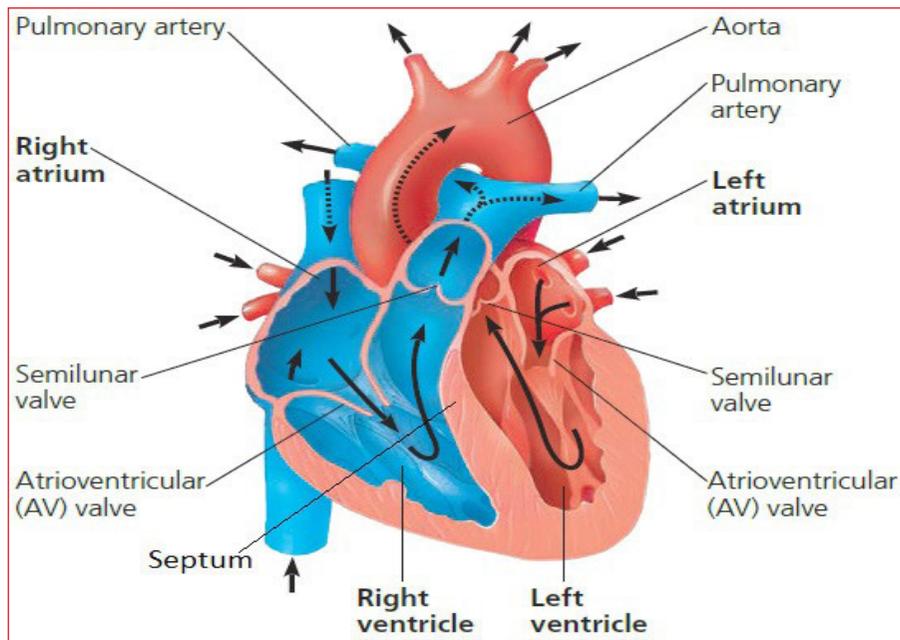


Figure : Drawing showing the blood flow in human heart (From Campbell 11th Edition)

e) Application activity 8.4

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.4.

Answers of Application activity 8.4

- 1) The reasons are: The left part of the heart is larger than right part of the heart because it has large muscle size which is needed to generate the force necessary to pump the blood to the whole body.
- 2)

column A	column B
1.The valve located between right atrium and right ventricle	b. Tricuspid valve
2. Sac surrounding the heart	c. Pericardium
3. Artery linked to lungs	a. Pulmonary artery

Lesson 5: The heartbeat and the mammalian cardiac cycle

a) Learning objective

- 1) Explain how a heartbeat is initiated.
- 2) Describe the main events of the cardiac cycle.

b) Teaching resources

The computer, internet connection and circulatory system chart are materials needed by student- teachers to understand this lesson.

c) Prerequisites/Revision/Introduction

As a tutor, test whether student-teachers have prior knowledge to the heart structure and function.

d) Learning activities

Guidance on activity 8.5

- Use your marks records list to form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Provide each group with necessary materials.
- Request the groups to do the activity 8.5
- Pass around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachersto ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.5 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.5

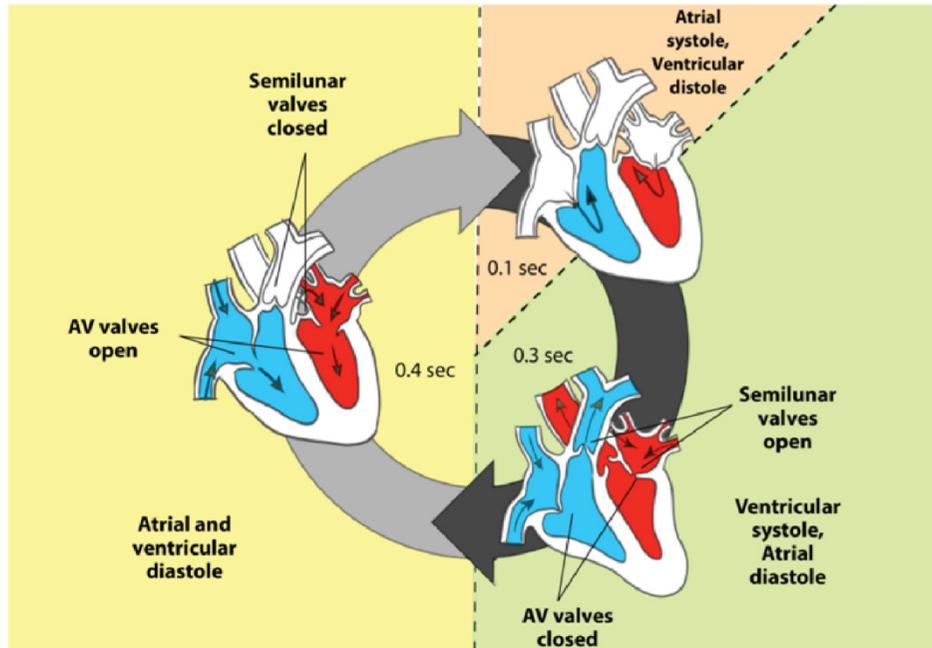


Figure: Drawing showing the cardiac cycle

e) Application activity 8.5

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually, the application activity 8.5.

Answers of Application activity 8.5

- 1) The answers are:
 - a) The participant C has cardiovascular problem he is below normal standard of heartbeat, systolic pressure and diastolic pressure.
 - b) Systolic pressure this is the pressure generated when ventricles contract whereas diastolic pressure is the pressure generated when ventricles relax.
- 2) The answers are:
 - a) The electrocardiogram trace consists of a series of waves that are labelled P, Q, R and T. Wave P shows the excitation of the atria, QRS indicates the excitation of the ventricles and T shows diastole.

- b) The *P wave* represents atrial depolarization, which is when the impulse spreads through the atria. The *QRS complex* corresponds with ventricular depolarization. The *P wave* is smaller *than* the *QRS complex* because the atria *have* a smaller muscle mass *than* the ventricles.

Lesson 6: Control of the heart rate and the factors controlling heart rate

a) Learning objective

- 1) Explain how blood circulation is controlled.
- 2) Describe the effects of exercise on respiration and on circulation.
- 3) Carry out an investigation on the effects of exercise on the pulse rate and blood pressure.

b) Teaching resources

Provide the student-teachers with a watch.

c) Prerequisites/Revision/Introduction

Student-teachers can understand easily this lesson if they have understood that coordination is brought about by the nervous and hormonal systems. Ask them some oral questions related to this prerequisite.

d) Learning activities

Guidance on activity 8.6

- Based on their previous assessment results, form groups of 4 or 6 student-teachers.
- Provide each group with at least one watch.
- Order the groups to do the activity 8.6
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Permit student-teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- Finally, assess learners with application activity 8.6 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.6

- i) The heart beat increases after physical exercise compared to the heart beat during resting time.
- ii) During physical exercise heart beat quickly in order to distribute O₂ in different tissues which is needed during aerobic respiration and also to eliminate metabolic waste products produced.

e) Application activity 8.6

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.6.

Answers of Application activity 8.6

- 1) i) Adrenaline (epinephrine)
 - ii) Adrenaline (epinephrine) increases the heartbeat rate.
- 2) Caffeine found in coffee, tea and soda is a stimulant drug that influences the nervous system to increase heart rate. It mimics the effect of adrenaline, a natural hormone in the body responsible for elevating heart rate. Other stimulants such as cocaine and ephedrine work in a similar manner.

There are specific drugs used in lowering heart rate such as beta- and calcium channel blockers. Beta-blockers work by interfering with the receptors that adrenaline binds to, subsequently decreasing hormonal influence on heart rate. Calcium channel blockers reduce the amount of calcium that enters the heart muscle. Because calcium is needed for muscle to contract, the heart beats at a slower rate when this drug is taken.

Lesson 7: Structure of blood vessels

a) Learning objective

- 1) Explain the relationship between the structure and function of blood vessels.
- 2) Recognize blood vessels from their structures using a light microscope.
- 3) Relate the structure of blood vessels to their functions.

b) Teaching resources

These are need resources : Microscope, prepared slides of blood vessels and electrical current.

c) Prerequisites/Revision/Introduction

Student –teachers should be aware of the components of the circulatory system including the blood vessels, heart and blood. Ask them to test whether they have this prerequisite.

d) Learning activities

Guidance on activity 8.7

- Form groups of 4 or 6 student- teachers based on their previous assessment results and allow them to sit on 2 desks face-to-face.
- Deliver the materials to each group.
- Request the groups to do the activity 8.7
- Pass around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.7 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.7

The diagrams, comparison and relationships are well shown in the student's book. Find them there.

e) Application activity 8.7

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.7.

Answers of Application activity 8.7

1)

Vessels	Functions
Blood artery	Carries oxygenated blood from heart to organs.
Blood capillary	Is the site of exchange of materials between blood and tissue cells.
Blood veins	Carry carbonated blood from organs to heart.

2) Those adaptations are shown in the table 8.4 in student's book.

Lesson 8: Blood composition, its functions and cardiovascular diseases.

a) Learning objectives

- 1) Differentiate between blood, tissue fluid, and lymph.
- 2) Relate blood as a tissue to its functions.
- 3) Recognize possible risk factors as diet, stress, smoking, genetic predisposition, age and gender in relation to cardiovascular diseases.

b) Teaching resources

As a tutor, help student-teachers to find these teaching resources: Animal such as a small mammal like mouse, sharp material such as blade or knife, test tube or other container, microscope, slide, coverslip, stain (such as methylene blue) and cleaning tissue.

c) Prerequisites/Revision/Introduction

Before learning this lesson, student-teachers should have known the relationship between the digestive system, circulatory system and skeletal system. Nutrients from the digestive system enter the circulatory system; the blood cells (formed elements) are made in bone marrow of skeletal system. They should also be aware of the relationship between some digestive diseases (such as malnutrition diseases like obesity related to high lipid consumption) to cardiovascular diseases (such as hypertension, atherosclerosis). Test whether they have such a prerequisite by asking them some questions related to it.

d) Learning activities

Guidance on activity 8.8

- Use your marks records list to form groups of 4 or 6 student- teachers based on their previous assessment.
- Deliver the materials to each group.
- Show to all groups the activity 8.8 and request them to do it.
- Move around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Allow student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Enable the student- teachers to note the summary in their notebooks.
- Finally , assess learners with application activity 8.8 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.8

All answers are in student's book under the subheading 8.8.

e) Application activity 8.8

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.8.

Answers of Application activity 8.8

- 1) The cells contributing to phagocytosis of pathogens :
 - a) Macrophage.
 - b) T-lymphocytes.
- 2) Blood is composed of plasma and different types of cells including red blood cells (erythrocytes), white blood cells (leukocytes), and thrombocytes (platelets); the tissue fluid (interstitial fluid) is plasma minus most proteins. So, tissue fluid can be got from blood.

3) The answers are summarized in the following table:

Blood component. Answer 3.a.	Function (Answer 3.b)	Origin (Answer 3.c)
I. Formed elements	Different functions	bone marrow
1.1.Red blood cells (D and G)	Transport of oxygen. Transport of some carbon dioxide.	bone marrow
1.2. white blood cells(leukocytes)	Fight infection	bone marrow
1.2.1. granulocytes (granular leukocytes)	Different functions related to fighting infection	bone marrow
a)Neutrophils (A)	Phagocytize pathogens	bone marrow
b) Eosinophils (B)	Phagocytize antigen- antibody complexes and allergens	bone marrow
c) Basophils (H)	- Release histamine which promotes blood flow to injured tissues. - Produce heparin(anticoagulant)	Red bone marrow
1.2.2. Agranulocytes (agranular leukocytes)	Different functions related to fighting infection	bone marrow
a) Lymphocytes(C)	1. B-lymphocytes are responsible for humoral immunity, i.e. antibody secretion (substances that recognize and bind to bacteria and allow their phagocytosis and destruction). Granulocytes and monocytes can better recognize and destroy bacteria when antibodies are attached to them (opsonisation). Cells are also responsible for the production of some components of blood serum, called immunoglobulin.	bone marrow, lymphoid tissue and spleen

	2. T-lymphocytes recognize the infected cells and destroy virus using macrophages. These cells amplify or suppress the overall immune response by regulating the other components of the immune system, and secrete many cytokines.	
b) Monocytes (F)	Become macrophages that phagocytize pathogens and cellular debris.	bone marrow
1.3. Platelets (I)	Blood clotting (coagulation)	bone marrow
II. Plasma (E)	Different functions	Different sources such as transport of molecules, maintaining the blood volume, pressure and pH as well as fighting infection.
2.1. water	Maintains blood volume. Transports molecules.	Absorbed from small intestine
2.2. Plasma proteins	Maintain blood osmotic pressure and pH.	Liver
a) Albumin	Maintain blood volume and pressure	Liver
b) Globulins	Transport. Fight infection.	Liver
c) Fibrinogen	Blood clotting	Liver
2.3. Salts	Maintain blood osmotic pressure and pH. Aid metabolism	Absorbed from small intestine

Gases	Different functions	Different sources
a) Oxygen	Cellular respiration	Lungs
b) Carbon dioxide	End product of metabolism	Tissues

Lesson 9: Transport of respiratory gases

a) Learning objectives

- 1) Describe the structure of haemoglobin and explain how haemoglobin transports oxygen.
- 2) Interpret oxygen dissociation curves for haemoglobin and other respiratory pigments.

b) Teaching resources

The student –teachers will use computer, internet connection, books, images drawn on manila paper. As a tutor, facilitate them to get these materials.

c) Prerequisites/Revision/Introduction

The student –teachers should have understood ,in lesson 8.8, the function of each blood cell, especially the red blood cells whose hemoglobin transports the respiratory gases.

d) Learning activities

Guidance on activity 8.9

- Based on previous assessment results, form groups of student- teachers and allow them to sit on 2 desks face-to-face.
- Provide each group with required materials.
- Request the groups to do the activity 8.9
- Pass around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Enable student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.9 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.9

All answers are in student's book under the subheading 8.9.

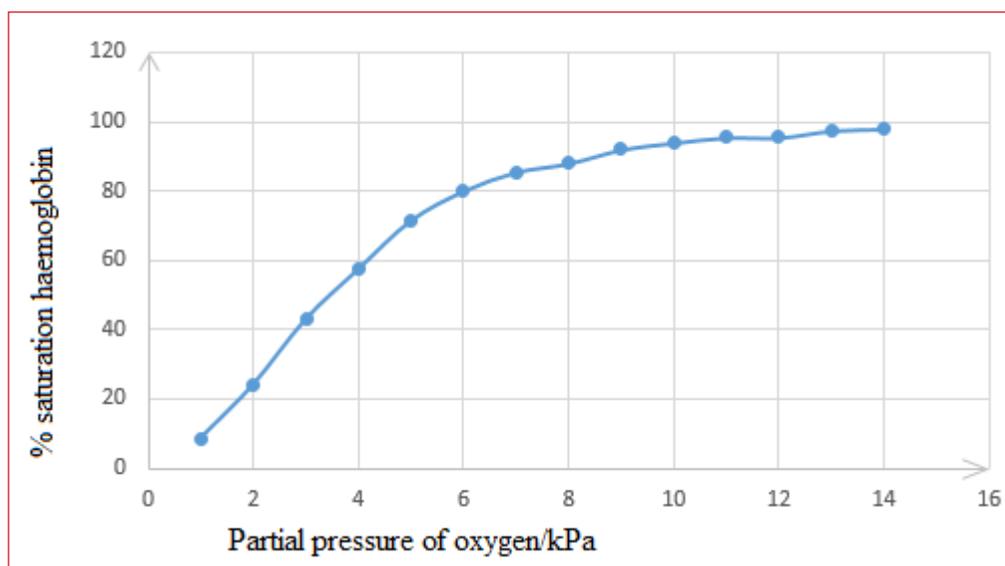
e) Application activity 8.9

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually, the application activity 8.9.

Answers of Application activity 8.9

1)a)



This graph shows the relationship between the oxygen partial pressure and saturation of haemoglobin with oxygen. Based on this curve, it is visible that, as oxygen partial pressure increases, also the saturation of haemoglobin with oxygen increases until all iron atoms are linked to oxygen. When all iron atoms of haemoglobin are linked to oxygen, no other oxygen is linked to haemoglobin. Hence this curve plateaus.

b) This is oxygen dissociation curve for haemoglobin.

2)The answer is:

150g of Hb → 1dm³ of blood.

1g of Hb → 1.3cm³ of O₂

150g of Hb → 1.3 x 150cm³ of O₂ = 195cm³ of O₂

Lesson 10: Blood clotting and common cardiovascular diseases

a) Learning objective

- 1) Describe the process of blood clotting.
- 2) Describe the risk factors associated with cardiovascular diseases.

b) Teaching resources

The student –teachers will use computer, internet connection, books. As a tutor, facilitate them to get these materials.

c) Prerequisites/Revision/Introduction

This lesson will be well understood if student-teachers have understood previously the role of platelets in the body. This is explained in lesson 8.8. Ask them to brainstorm it.

d) Learning activities

Guidance on activity 8.10

- Form groups of student- teachers based on their previous assessment results.
- Give materials to all groups.
- Show to all groups the activity 8.10 and request them to do it.
- Move around groups, guiding and facilitating them.
- Attribute to each group the part of the activity that it will present.
- Ask other groups to add the missing information if they have it.
- Allow student- teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student- teachers to write the lesson summary on the blackboard.
- Allow student- teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.10 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.10

All answers are in student's book under the subheading 8.10.

e) Application activity 8.10

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer , individually , the application activity 8.10.

Answers of Application activity 8.10

- 1) The smoking and much lipids consumption cause the cardiovascular system diseases such as atherosclerosis, stroke, coronary heart diseases.
- 2) a) The 2 suspected cardiovascular diseases associated with his death are atherosclerosis, stroke, coronary heart diseases.
b) Let us consider the example of atherosclerosis :Atherosclerosis is a cardiovascular disease characterized by the progressive narrowing and hardening of the arteries over time. Atherosclerosis normally begins in later childhood, and is usually found in most major arteries. It does not usually have any early symptoms. Causes of atherosclerosis include a high-fat diet, high cholesterol, smoking, obesity, and diabetes.

Lesson 11: Lymphatic system

a) Learning objective

Explain how tissue fluid and lymph are formed.

b) Teaching resources

As a tutor, facilitate student –teachers to get these materials: computer, internet connection, books.

c) Prerequisites/Revision/Introduction

The student –teachers should have prior knowledge about the structure and functioning of all components of the circulatory system. Ask them to brainstorm the structure and function of each part.

d) Learning activities

Guidance on activity 8.11

- Refer to previous assessment results and form groups of 4 or 6 student-teachers
- Deliver materials to all groups.
- Show to all groups the activity 8.11 and request them to do it.
- Move around groups, guiding and facilitating them.
- Assign to each group the part of the activity that it will present.
- Request other groups to add the missing information if they have it.
- Enable student-teachers to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Help the student-teachers to write the lesson summary on the blackboard.
- Allow student-teachers to note the summary in their notebooks.
- At the end, assess learners with application activity 8.11 or formulate your own assessment questions that must be answered by each student-teacher.

Answers of activity 8.11

All answers are in student's book under the subheading 8.11.

e) Application activity 8.11

Guidance

As a tutor, assess this lesson by asking the student-teachers to answer, individually, the application activity 8.11.

Answers of Application activity 8.11

The answers are given in the following table:

Organ	Name / identity (Answer 1)	Function (Answer 2)
W	Thymus gland	Secretes thyroxin, a hormone that contributes to the maturation of T- lymphocytes from bone marrow. Generates T- lymphocytes

X	Lymph nodes	Filters lymph Fight infection
Y	Spleen	Filters blood and removes cellular debris
Z	Bone marrow	Generates blood formed elements such as B-lymphocytes which mature in it.

8.6 Summary of the unit

Water is an important solvent and acts as a reagent in various chemical reactions in the plants.

It helps to maintain turgidity of cells and is important for growth of plants as it serves as a raw material for photosynthesis. Transport of water is an important process in plants and has been well understood. Several physical phenomena such as imbibition, diffusion, osmosis, turgor and water potential facilitate uptake of water in plants. Forces of cohesion and adhesion also play an important role in transport of the water upstream. Water enters the plants through active or passive absorption process. The upward movement of water through stem is called ascent of sap.

Practically, most of the water absorbed by plants is lost into the atmosphere through the process of transpiration.

A variety of internal and external stimuli govern the rate of transpiration in plants.

Atmospheric humidity, temperature, light, wind velocity, leaf area, leaf structure and availability of water affect the process.

Plants also take up inorganic nutrients from the soil with water. The sugars synthesized in leaves are translocated downwards, upwards and to lateral organs mostly through phloem.

Experiments have been conducted to demonstrate the movement of food through phloem. Besides sugars that are end products of photosynthesis, amino acids are also transported through phloem.

The circulatory systems are needed as they play various roles such as transport of nutrients to all organs of the body. Different circulatory systems exist in animals. They include open circulatory system of organisms like insects and closed circulatory system of animals such as cows. Single circulation occurs in some animals such as fish while double circulation occurs in organisms such

as human. In single circulation, the blood passes once via the heart but, during double circulation, the blood passes twice through the heart. The heart, blood vessels and blood constitute the human circulatory system. The heart is a striated muscle situated between the two lungs and behind the sternum in the thorax and contracts in order to propel blood throughout the body. The heart of both mammals and birds is composed of 4 chambers: 2 upper atria and 2 lower ventricles. Heart beat is a rhythmic sequence of contractions of the heart. It is controlled by the nervous system and hormonal system; the factors such as carbon dioxide, temperature, sport or physical exercises, drugs and pH also affect the heartbeat.

They are three types of blood vessels are veins, capillaries and arteries. The blood has two main components which are formed elements and plasma. Generally, the blood and the circulatory system have three main functions including transport of substances in the body, regulation such as thermoregulation and protection against infections that ensured by leukocytes.

There are different cardiovascular diseases among them include stroke, atherosclerosis and coronary heart disease. A lymphatic system is system composed of tissues and organs, including the bone marrow, spleen, thymus and lymph nodes that produce and store cells which fight infections and diseases. The channels that carry lymph are also part of this lymphatic system.

8.7 Additional Information for teachers

These are factors involved in blood clotting:

- Factor I - fibrinogen
- Factor II - prothrombin
- Factor III - tissue thromboplastin (tissue factor)
- Factor IV - ionized calcium (Ca^{++})
- Factor V - labile factor or proaccelerin
- Factor VI – activated factor V
- Factor VII - stable factor or proconvertin
- Factor VIII - antihemophilic factor
- Factor IX - plasma thromboplastin component, Christmas factor
- Factor X - Stuart-Prower factor
- Factor XI - plasma thromboplastin antecedent
- Factor XII - Hageman factor
- Factor XIII - fibrin-stabilizing factor

Guidance on skills Lab 8

- As a tutor, request student-teachers to practice what they have studied in this unit in order to get money and skills.
- To show them that it is possible, request needed materials from your school leader.
- Then request students to implement that skill lab.
- Request student-teachers to present, in detail, their report and conclude.

8.8 End unit assessment (answers)

- 1) d
- 2) d
- 3) Complete the following paragraph by filling in the blank spaces: Blood is **oxygenated** in the lungs. The red pigment **haemoglobin** has a high affinity for oxygen. The pumping action of the **heart** creates pressure which pushes the blood around the body. In the tissues the partial pressure of **oxygen** is low. This causes the **dissociation** of the oxyhaemoglobin. In the tissues, the oxygen is used in the process of **respiration**. Most of the carbon dioxide produced in this process enters the cells. Here it is converted to carbonic acid by the action of the enzyme carbonic anhydrase the carbon dioxide is transported as **carbonic acid** back to the lungs.
- 4) Each haemoglobin molecule can transport 4 molecules of oxygen.
- 5) Fibrinogen is involved in blood clotting as it is converted into fibrin threads that prevent continuous bleeding.
- 6) The plasma is the yellowish portion of blood including proteins whereas serum is the plasma from which proteins (especially fibrinogen) have been removed
- 7) Answers are
 - i) Haemoglobin is called conjugated protein because it has a non-protein part (haeme) and polypeptide chains (globin).
 - ii) High carbon dioxide concentrations shift the oxygen dissociation curve to the right (Bohr effect)
- 8) The answers are:
 - a) Ultrafiltration (pressure filtration)
 - b) Erythrocytes, platelets and proteins.

9) The answers are:

a) A=Aorta, B=Pulmonary semilunar valve, C=atrio ventricular valve,
D=right ventricle

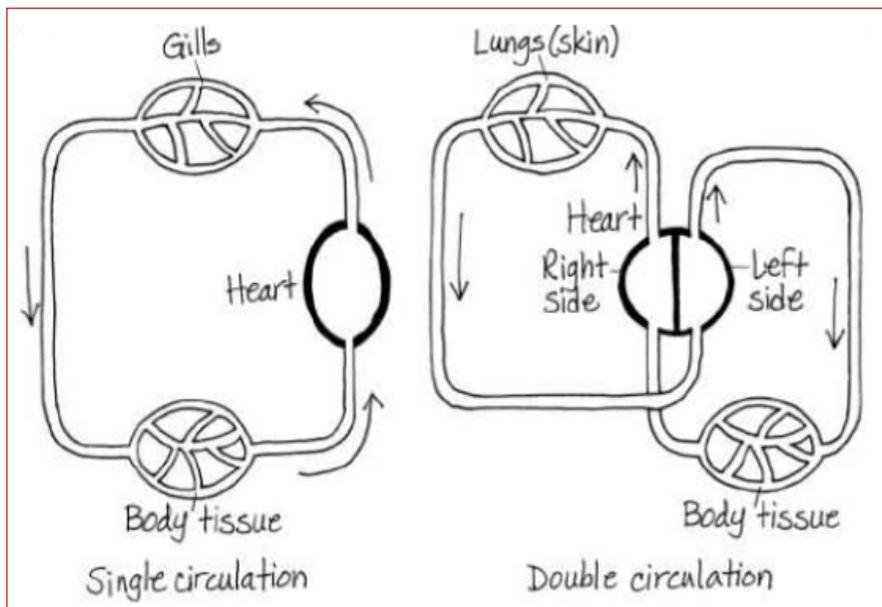
E=Inferior vena cava

b) A transports blood from left ventricle leading to the different part of
the body while

B-prevent backflow of the blood when the right ventricle is relaxed.

10) Because the delay allows the atria to empty completely, filling ventricles
fully before they contract.

11) The following is the drawing:



12) The following are the answers:

a) A - Atrio-ventricular valve closes when pressure in ventricle rises above
pressure in the atrium.

B-Semi-lunar/aortic valve opens when pressure in the ventricle exceeds
pressure in the aorta/artery.

C- Semi-lunar/aortic valve closes when pressure in aorta exceeds pressure
in the ventricle.

D - Atrio-ventricular valves open when ventricular pressure falls below
that of the atrium.

b) The cardiac circle in one minute = $\frac{60}{0.8}$ = 75 beats per minute

13) The advantages of closed double circulatory systems include:

- Relatively high blood pressures, which enable the effective delivery of O₂ and nutrients to the cells of larger and more active.
- Closed double systems are also particularly well suited to regulating the distribution of blood to different organs.
- Disadvantages of open circulatory system are little fine control over distribution of the hemolymph to body regions and mechanism for reducing flow to a specific part of an organ.

14) The following are the answers:

- a) The radial pulse is taken from radial artery found on the arm near the wrist
- b) The vagus is responsible for the parasympathetic stimulation on the heart resulting in a decrease in heart rate. If it was cut, the parasympathetic tone on the heart will decrease and the heart rate will go up.

15) The following are the answers:

- a) A- sinoatrial node/pacemaker
- b) The answers are:
 - i. Ventricles contract after atria allowing time for ventricles to fill before contracting. In other words the delay allows the atria to empty completely, filling ventricles fully before they contract.
 - ii. Blood is squeezed out of the ventricles more efficiently in other words more blood is expelled at each contraction because contraction starts at the base of ventricles.
- c) When excitatory part of cardiovascular Centre is stimulated the sympathetic nerves, from medulla stimulate pacemaker which result in an increase in heart rate.

16) The answer includes:

- a) The human heart is a double pump adapted to forcing blood, at the same rate but at different pressures, along the two systems of double circulation. High pressure in the systemic (body) circulation has evolved with lower pressure in the pulmonary (lung) circulation and low pressure lymphatic circulation. Each heart beat is controlled by a wave of electrical excitation. In turn, the cardiac output of the

heart adapts to meet the bodies needs and is influenced by nervous and hormonal control. The human heart is a double pump adapted to forcing blood, at the same rate but at different pressures, along the two systems of double circulation. Explain how the mechanism that controls each heartbeat, and the structure of the heart, enable it to do this. Pacemaker initiates heartbeat. Wave of excitation spreads across both atria causing simultaneous contraction, it reaches to atrioventricular node where bundle of his and Purkynje fibres spread down to both ventricles at the same time up to the base, from where it radiate upwards. Ventricles contract simultaneously from the base upwards by contracting at the same rate. Nerves act on SA node to alter the rate. Pressure produced by contraction of cardiac muscle where left ventricle has thicker muscle and the blood ejected from left ventricle has higher pressure compared to one of right ventricle.

- b) Adrenaline from adrenal gland and noradrenaline increase heart rate. Sympathetic nerve from medulla increase heart rate and it takes nerve impulses from excitatory centre. Parasympathetic or vagus nerves decrease heart rate, it carries inhibitory impulses from the centre to SA node.

8.9 Additional activities

8.9.1 Remedial Activities

- 1) Identify 3 main functions of the circulatory system of human.

Answer: The 3 main functions of the circulatory system are:

- Transport of chemicals in the body. E.g. Haemoglobin of red blood cells transports oxygen and carbon dioxide.
- Regulation such as thermoregulation
- Protection against infections achieved by leukocytes.

- 2) Explain the function of each type of blood vessel

Answer

- The arteries carry blood away from the heart at high pressure. They transport oxygenated blood (except pulmonary artery).
- The capillaries supply all cells with their requirements. So, they provide large area for exchange of materials between blood and body cells. They take away waste products.

- Veins return blood to the heart at low pressure. They transport deoxygenated blood (except pulmonary vein).
- 3) Describe what can happen to the body if:
- a) It has low concentration of fibrinogen.
 - b) Low concentration of hemoglobin.

Answer

- a) If the body has low concentration of fibrinogen, it would be difficult for blood to clot when a person is injured.
 - b) If there is low concentration of hemoglobin, few oxygen molecules will be carried and most cells do not realize aerobic cell respiration; it is also difficult to excrete CO₂ because hemoglobin transports oxygen and few CO₂ at different time.
- 4) Distinguish between thrombus and embolus.

Answer: Thrombus is a stationary blood clot whereas embolus is a moving blood clot.

5) Complete the following statement

- a) The cardiovascular disease associated with the fact that oxygen does not reach brain is.....

Answer: stroke.

- b)is the process whereby tissue fluid is formed.

Answer: Ultrafiltration (pressure filtration)

- c) The lymph passes via vessels called.....

Answer: lymphatic vessels

- 6) The concentration of oxygenated hemoglobin of UWINEZA is 13 g/dl. Her concentration of deoxygenated hemoglobin 12 g/dl. Calculate her oxygen saturation.

Answer:

Data:

$$C(\text{HbO}_2) = 13\text{g/dl}$$

$$\text{Recombination frequency} = \frac{\text{Number of individuals showing recombination} \times 100}{\text{Number of offspring}}$$

- 7) Describe briefly one difference between a single circulation and double circulation.

Answer: In single circulation, the blood passes once via the heart during one complete circuit of the body while, in double circulation, the blood passes twice through the heart during one complete circuit of the body.

- 8) Explain the role of valves in the circulatory system.

Answer: The valves prevent the backflow of blood.

- 9) Discuss the effect of caffeine on the cardiovascular system of a human.

Answer: Caffeine found in coffee, tea and sodas is a stimulant drug that influences the nervous system to increase heart rate. It mimics the effect of adrenaline, a natural hormone in the body responsible for elevating heart rate.

- 10) Describe the tracheids and vessels of the xylem.

Answer:

- a) **Tracheids:** Tracheids are elongated cells with blunt ends, present along the long axis of the plant system. Tracheids are imperforate cells with bordered pits on their end walls. They are arranged one above the other. These have broader lumen and lignified walls that offer mechanical support to the plants. Sometimes an intermediate type of cell element is also found in vascular system known as fibre- tracheids.
- b) **Vessels:** Vessels are main transporting elements in xylem. These are long cylindrical tube like structures made up of many cells called vessel members. These vessels are joined end to end forming a continuous column. Sides of xylem vessels are lignified. These do not have protoplasm and have perforations in their end walls.

8.9.2 Consolidation activities

- 1) Explain why blood in the pulmonary veins has a higher O₂ concentration than blood in the venae cavae, which are also veins.

Answer: In general, all veins bring blood to the heart. Pulmonary vein carries blood from the lungs which is oxygenated whereas venae cavae carries blood from different parts of the body which is deoxygenated.

- 2) After exercising regularly for several months, you find that your resting heart rate has decreased. Given that your body now requires fewer cardiac cycles in a given time, what other change in the function of your heart at rest would you expect to find? Explain.

Answer: The heart, like any other muscle, becomes stronger through regular exercise. You would expect a stronger heart to have a greater stroke volume, which would allow for the decrease in heart rate.

- 3) If you had additional hearts distributed throughout your body, what would be one likely advantage and one likely disadvantage?

Answers: Additional hearts could be used to improve blood return from the legs. However, it might be difficult to coordinate the activity of multiple hearts and to maintain adequate blood flow to hearts far from the gas exchange organs.

- 4) How does the Bohr shift help deliver O₂ to very active tissues?

Answer: The Bohr shift causes hemoglobin to release more O₂ at a lower pH, such as found in the vicinity of tissues with high rates of cellular respiration and CO₂ release.

- 5) The table below shows the cell composition of three samples of blood.

	Sample from		
Cells number per mm ³	Peter	John	Joseph
Red blood cells	6.000.000	5.000.000	2.000.000
White blood cells	500	6.000	5.000
Platelets	200.000	220.000	500

- a) Identify a person who is most likely to have lived at high altitude recently. Explain your answer.

Answer: Peter. That is because he has a large number of red blood cells (RBCs)/erythrocytes to attach a lot of oxygen used in aerobic cell respiration which produces energy, a part of which becomes heat that increases temperature as high altitude is cold.

- b) Which person would be the most likely to become ill if exposed to a virus? Justify your answer.

Answer:

Peter. That is because he has little /few white blood cells which could fight against virus infections or diseases.

- c) Which person's blood is least likely to clot efficiently if injured? Justify your answer.

Answer:

- d) Joseph. That is because he has little /few platelets (thrombocytes) that enable blood clotting (coagulation).

- 6) Mount Everest is nearly 9000 m high. The partial pressure of oxygen in the alveoli at this height is only about 2.5 kPa. Explain what effect this would have on the supply of oxygen to body cells if a person climbed to the top of Mount Everest without a supplementary oxygen supply.

Answer2: Less oxygen would enter the blood by diffusion, and therefore less oxygen would be carried to the body cells. The percentage saturation of haemoglobin will be only about 30 % (as shown on the oxygen dissociation curve in student's book)

- 7) Explain how an increase in the number of red blood cells can help to compensate for the lack of oxygen in the air at high altitude.

Answer3: At high altitude, the percentage saturation of the haemoglobin is relatively low. If the number of red blood cells is increased, then the number of haemoglobin molecules is also increased. Even though the percentage saturation of the haemoglobin is low, the fact that there is more of it can increase the actual quantity of oxygen carried in the blood.

- 8) Explain the factors affecting the uptake of water from the soil to plant parts.

Answer:

Those factors include the :

- i. **root pressure:** is the transverse osmotic pressure within the cells of a root system that causes sap to rise through a plant stem to the leaves. Root pressure occurs in the xylem of some vascular plants when the soil moisture level is high either at night or when transpiration is low during the day. When transpiration is high, xylem sap is usually under tension, rather than under pressure, due to transpirational pull. At night in some plants, root pressure causes guttation or exudation of drops of xylem sap

from the tips or edges of leaves. Root pressure is studied by removing the shoot of a plant near the soil level. Xylem sap will exude from the cut stem for hours or days due to root pressure. If a pressure gauge is attached to the cut stem, the root pressure can be measured. Root pressure is caused by active distribution of mineral nutrient ions into the root xylem. Without transpiration to carry the ions up the stem, they accumulate in the root xylem and lower the water potential. Water then diffuses from the soil into the root xylem due to osmosis. Root pressure is caused by this accumulation of water in the xylem pushing on the rigid cells. Root pressure provides a force, which pushes water up the stem, but it is not enough to account for the movement of water to leaves at the top of the tallest trees. The maximum root pressure measured in some plants can raise water only to 6.87 meters, and the tallest trees are over 100 meters tall.

ii. transpiration pull: In botany, transpiration pull refers to the suction, force, or pull that draws water up through a plant. It is a biological process where the water molecules and ions are absorbed up from the roots, and then evaporation occurs within the leaves, spreading water throughout the plant.

iii. Cohesion : ability of water molecules to be linked to one another .

iv. adhesion: ability of water molecules to be attached to a surface of an objet.

v. capillarity action :the ability of a liquid to flow in narrow spaces without the assistance of, or even in opposition to, external forces like gravity.

8.9.3 Extended activities:

- 1) Suggestion of Questions and Answers for gifted and talented students. Why does pumping blood to the whole body require more force than pumping blood to the lungs?

Answer: The vessels of the *whole* body (systemic circulation) provide a much higher resistance to flow than the vessels in the lungs (pulmonary circulation). Therefore, the left ventricle requires more force to overcome this resistance.

- 2) Answer the following questions:

- a) What happen to the ventricular walls of someone who has hypertrophic cardiomyopathy?
- b) How would the ability of the heart to efficiently pump blood be affected?

Answer:

- a) In this case ventricular walls of someone who has hypertrophic cardiomyopathy are thicker than normal leaving little room in the chamber for blood to accumulate.
 - b) Because of little rooms that accumulate blood cause the heart to pump less blood.
- 3) Think of an analogy for capillaries. Remember they are small blood vessels with very thin walls and facilitates their ability to perform exchanges with body cells. What are the similarities between capillaries and the object you have chosen to compare them to?

Answer: For example, capillaries can be considered as small side streets. Side Street do not carry a lot of traffic, which is similar to the small volume of blood that travels through the capillary.

- 4) Explain how the functions of cardiovascular system contribute to homeostasis.

Answer: Cardiovascular system contribute in regulation of internal environment by delivering oxygen from the lungs, nutrient from digestive system and removes metabolic wastes.

- 5) Why do pregnant women (especially those who are in their third trimester of pregnancy) experience and complain about their swollen and ankles.

Answer: In this case, these pregnant women that experience this condition have a greater volume of blood and more blood results in more interstitial or tissue fluid

- 6) Athletes who abuse erythropoietin have many more red blood cell than usual.
- a) Explain why an athlete might die from having too many blood cells.
 - b) Why is death more likely at night when an athlete is sleeping than during the day when they are active? Base your explanation on the heart beat rate.

Answer:

- a) Too much red blood cells may clog capillaries and decrease the rate of gas exchange.
- b) At night the heart beat decreases and the red blood cells move more slowly through capillaries and gas exchange rate is even lower.
- 7) Clots in arteries can cause heart attacks and strokes. Why, then, does it make sense to treat hemophiliacs by introducing clotting factors into their blood?

Answer: Clotting factors do not initiate clotting but are essential in the clotting process. Also, the clots that form a thrombus typically result from an inflammatory response to an atherosclerotic plaque, not from clotting at a wound site.

- 8) A doctor might use bicarbonate (HCO_3^-) to treat a patient who is breathing very rapidly. What assumption is the doctor making about the blood chemistry of the patient?

Answer The doctor is assuming that the rapid breathing is the body's response to low blood pH. Metabolic acidosis, the lowering of blood pH, can have many causes, including complications of certain types of diabetes, shock (extremely low blood pressure) and poisoning.

- 9) Explain how the plants living in dry conditions are adapted to reduction of water loss by transpiration:

Answer :

- i) Xerophytes have thick waxy cuticle which reduces evaporation as it acts as a barrier. The shiny surface also reflects heat and so lowers temperatures reducing water loss.
- ii) They have rolled leaves or leaves reduced to spines to reduce water loss.
- iii) Stomata are present in pits. They are sunken. They open at night to reduce the amount of water lost by transpiration.
- iv) Roots are deep and/or spreading to maximize the absorption of underground water.
- v) They exhibit crassulacean acid metabolism, i.e., CAM Physiology.
- vi) They have fleshy stems or leaves—some cells in stems or leaves have very large vacuoles that acts as water storage areas. These stems are also called succulent stems.

UNIT 9

GENERAL PRINCIPLES OF HOMEOSTASIS, EXCRETION AND OSMOREGULATION

9.1 Key unit competence:

Explain general principles of homeostatic mechanisms, excretion and osmoregulation.

9.2 Prerequisites

The students will understand very well the general principles of homeostasis if the learners have well understood the cell and its functions, the body fluids (intercellular and extracellular fluids) and if they still remember the organs of the excretory system and their functions as seen in the ordinary level.

9.3 Cross cutting issues to be addressed

Gender

Inspire active participation of boys and girls in activities, not only boys. Make sure that all learners are actively involved.

Comprehensive sexuality education

This unit will involve the dissection of animals in order to study male reproductive systems and female reproductive systems. The learners should be told to be able to take right decisions about their sexuality.

Inclusive education

This unit will have some practical activities such dissecting animals in order to study the urinary system. All learners should be given the opportunity to make dissection. The teacher should engage all learners in all practical activities.

Environment and sustainability

As a facilitator, emphasise to the learners that environment must be sustainably protected for different reasons such as:

Excretory products should be kept in specific places as to avoid contaminating our environment and to avoid the transmission of diseases which could harm the community and the economy of the country.

9.4 Guidance on introductory activity

The introductory activity shows a water treatment plant. The teacher forms groups of four or five students and discuss on the questions found in the introductory activity 9.1. The teacher will help learners to know the working of the water treatment plant and help them to be able to compare the working of the water treatment plant with the process of removing metabolic waste products.

Answers of the introductory activity

- a) The urinary system
- b) The kidneys, the ureters, the bladder and the urethra.
- c) Urine
- d) They are similar in the fact that the two systems remove the waste products and the remaining fluid is useful to the body or the population. They have some steps in common such as filtration.

9.5 List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Significance of constant internal environment and factors that must be kept constant in the body	<ul style="list-style-type: none">- State the factors that must be kept constant in the internal environment of the body.- Explain the significance of a constant internal environment.	1 period
2	Feedback mechanisms	<ul style="list-style-type: none">- Discuss the role of the negative feedback mechanism.	1 period

3	Negative feedback mechanisms related to the endocrine and nervous systems in homeostatic activities.	- Explain the feedback mechanism in relation to the endocrine and nervous system.	1 period
4	Causes of changes in the internal environment	- Identify the main internal and external causes of change in the internal environment.	1 period
5	Formation, composition and movement of tissue fluid and its relationship to the blood and lymph.	- Describe the formation, composition and movement of tissue fluid in relation to blood and lymphs.	1 period
6	Structure and functions of excretory organs in mammals	- Describe the structure and role of excretory organs in mammals. - Describe how the process of ultrafiltration and selective reabsorption are involved in the formation of urine in the nephron.	1 period
7	Formation of urea and urine	- Describe the ornithine cycle and its role in the conversion of ammonia to urea.	1 period
8	Adaptations of organisms to different environmental conditions	- Relate adaptations of different organisms to their habitat in terms of osmoregulation.	1 period
9	Role of the hypothalamus, pituitary gland, adrenal gland and nephron in varying the osmotic pressure of blood	- Describe the role of hypothalamus, posterior pituitary, ADH and collecting ducts in osmoregulation.	1 period

10	Kidney transplants and dialysis machines.	<ul style="list-style-type: none"> - Describe the use of dialysis in kidney machines. - Describe how kidney transplants are performed. - Explain dialysis in terms of salt balance, the maintenance of glucose concentration and the removal of urea. 	1 period
11	Excretion and osmoregulation in protocista, insects, fish, amphibians and		1 period
12	Principles of osmoregulation in marine, freshwater and terrestrial organisms.	<ul style="list-style-type: none"> - Explain the principles of osmoregulation in organisms living in marine, freshwater and terrestrial habitats. 	1 period
13	The excretion in plants.	<ul style="list-style-type: none"> - Explain why plants do not have specialized excretory organs. - Classify excretory products of plants and how they are eliminated. 	1 period
14	End unit assessment & Remedial		2 periods

Lesson 1: Significance of constant internal environment and factors kept constant in the body

a) Learning objectives

- State the factors that must be kept constant in the internal environment of the body.
- Explain the significance of a constant internal environment.

b) Teaching resources: A computer, books

c) Prerequisites/Revision/Introduction

Ask students about their previous knowledge about the cell and the body fluids. The teacher helps them to state the functions of different body fluids.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 9.1 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 9.1.

1. **a) Homeostasis:** is the process of maintaining constant the internal environment.
b) Internal environment is the immediate surrounding of cell.
2. Temperature, blood glucose level, blood calcium level...
3. The body temperature is kept constant independently of the external environment because our enzymes work at an optimal temperature. If our body temperature becomes too high or too low, our enzymes would be denatured.

e) Application activities 9.1

Guidance: Ask student-teachers to work individually to answer the questions of application activity 9.1.

Answers for application activities 9.1

- a) The significance of a constant internal environment is necessary to maintain homeostasis and to allow metabolic reactions to function very well.
- b) Water balance, concentration of glucose, pH, concentration of respiratory gases...
- c) External causes: change in temperature,
Internal causes: metabolic reactions,

Lesson 2: Feedback mechanisms

a) Learning objective

- Discuss the role of the negative feedback mechanism.

b) Teaching resources: books, computer, flowchart showing a case of negative feedback.

c) Prerequisites/Revision/Introduction

The students need to know what is homeostasis and different factors that are kept constant in the human body seen in the previous lesson.

d) Learning activities

The teacher will form groups of 5 or 5 students depending on the size of the class. The students in their groups will be discussing on the negative feedback by comparing the working of the house heating system with the negative feedback. If students don't have any information about the heating system which is usually used in very cold countries such as Europe, a movie on this may be shown. The students will then present their findings on the activity 9.2 in the student's book.

Answers of activity 9.2.

1. The thermostat works as a negative feedback mechanism because it helps to maintain constant the temperature in the house. When the external temperature is lowered to a critical temperature set in the thermostat, it will switch on automatically and increase the house temperature. If the house temperature is increased above the temperature set in the thermostat, it will automatically switch off. This is the same as the negative feedback of our body.

e) Application activity 9.2

Guidance:

Ask student-teachers to work in pairs to answer the questions of application activity 9.2. The work in pairs will help them to understand very well the negative feedback mechanism.

Answers for application activities 9.2.

- a) Two examples of a negative feedback: blood sugar regulation, body temperature, blood calcium level... Two examples of positive feedback in our body: lactation, blood clotting, child birth
- b) See the answers in the student's book in the table 9.1.
- c) A positive feedback cannot be effective in homeostatic regulation because it keeps the values out of range.

Lesson 3: Negative feedback mechanisms related to the endocrine and nervous systems in homeostatic activities.

a) Learning objectives

Explain the feedback mechanism in relation to the endocrine and nervous system.

b) Teaching resources:

A computer, flowchart showing the homeostatic regulation of blood calcium level...

c) Prerequisites/Revision/Introduction

To understand this lesson, students need to know what is a negative feedback mechanism and the hormones that have antagonistic functions especially insulin and glucagon, calcitonin and parathyroid hormone and their functions.

d) Learning activities

The teacher asks student's to sit in a group of two or three students and provides them a printed flowchart showing the regulation of blood calcium level. If possible, a projector can be used in order to help all the students to see clearly at the same time, students will answer the questions in the activity 9.3 in the student's book.

Answers of activity 9.3.

1. The body is involved in the regulation of blood calcium level by a negative feedback mechanism by using two antagonistic hormones called calcitonin and parathyroid hormone.

Homeostasis is the constancy of the internal environment. Homeostasis is required to help our cells to work efficiently as our enzymes have a narrow range of pH and temperature at which they can work correctly; otherwise our enzymes will be denatured.

When the blood calcium is more than the set point, the thyroid gland produces calcitonin hormone which decreases the blood calcium level by the following processes: it decreases the absorption of calcium by the intestines, it decreases the reabsorption of calcium by the kidneys, it stimulates the bone cells called osteocytes to take up calcium from the blood and to store it in the bones. When the blood calcium is lower than the set point, the parathyroid glands produce parathyroid hormone which decreases the blood calcium level by the following processes:

it decreases the absorption of calcium by the intestines, it decreases the reabsorption of calcium by the kidneys, it stimulates the bone cells called osteocytes to take up calcium from the blood and to store it in the bones.

e) Application activities 9.3.

Guidance

Ask student-teachers to work individually to answer the questions of application activity 9.3.

Answers for application activities 9.3.

- a) Hypothalamus.
- b) Calcitonin and parathyroid hormone.
- c) The nervous and the hormonal systems are involved in the control and in the production of hormones which regulate the negative feedback activities.

Lesson 4: Causes of changes in the internal environment

a) Learning objectives

- Identify the main internal and external causes of change in the internal environment.

b) Teaching resources: books, computer

c) Prerequisites/Revision/Introduction

This lesson requires the knowledge of homeostasis in general and the hormones that regulate different activities.

d) Learning activities

The teacher helps students to form groups of three or four in order to do the activity 9.4. Every student will have time to say what he knows about the external and internal causes of the change in the external environment.

Answers of activity 9.4.

1. Diabetes mellitus is caused by the lack of insulin in our body or by the body being able to use properly the insulin produced (insulin not recognized the target cells). Diabetes insipidus is caused by the lack of ADH (Anti diuretic hormone).

e) Application activities 9.4

Guidance

Ask student-teachers to work individually to answer the questions of application activity 9.4.

Answers for application activities 9.4

a) Genetic causes: nutrition: the amount of food you eat, Environmental causes: pollutants, pesticides and toxins.

Physical Activity: Physical activity is essential for proper functioning of our cells and bodies. Adequate rest and exercise are examples of activities that influence homeostasis.

Mental Health: Both the physical and mental health is inseparable. Negative stress (also called distress) leads to thoughts and emotions harmful for homeostatic mechanisms in the body.

Lesson 5: Formation, composition and movement of tissue fluid and its relationship to the blood and lymph.

a) Learning objective

- Describe the formation, composition and movement of tissue fluid in relation to blood and lymphs.

b) Teaching resources

books, computer, flowchart showing the process of formation of the lymph.

c) Prerequisites/Revision/Introduction

The students need to know what is homeostasis and different factors that are kept constant in the human body seen in the previous lesson.

d) Learning activities

The teacher will give time to the students in order to say what they think about the body fluids. The teacher will start by asking to the students to show the main parts of the blood and their functions. After that, he will provide a flowchart showing the formation of the lymph and he will ask the students to say what they know about the lymph or if someone has seen the flow of the lymph after having an injury. Using the activity **9.4.** in the student's book, the students will make a table comparing blood and lymph.

Answers of activity 9.5.

It the lymph.

This fluid has the same composition as blood plasma except that it has a big number of lymphocytes.

Differences between blood circulatory system and the lymphatic system

The lymphatic system	Blood circulatory system
Has no pumping organs	Has a pumping organ called heart
Composed of one type of vessels	Composed of three types of vessels
Has nodes called lymph nodes	Has no nodes
The transporting fluid within vessels is lymph	The transporting fluid within its vessels is blood
Lymph has only one type of cells called lymphocytes	Blood has three major types of blood cells namely: red blood cells, leucocytes and platelets
Lymph flows relatively slowly	Blood flows faster
Contain valves throughout lymphatic vessels	Contain valves throughout the veins and at bases of arteries

e) Application activities 9.5

Guidance

Ask student-teachers to work individually to answer the questions of application activity 9.5.

Answers for application activities 9.5.

- a) Lymph contains water, amino acids, glucose, minerals, antibodies.... And white blood cells.
- b) See on the table above.
- c) Lymph has the same composition as tissue fluid / extracellular fluid. Lymph is considered to be extracellular fluid until it enters the lymphatic vessels where it is then considered to be lymph.

Lesson 6: Structure and functions of excretory organs in mammals

a) Learning objectives

- Describe the structure and role of excretory organs in mammals.
- Describe how the process of ultrafiltration and selective reabsorption are involved in the formation of urine in the nephron.

b) Teaching resources:

A computer, books, projector, chart showing the urinary system and a chart showing the nephron.

c) Prerequisites/Revision/Introduction

Ask students about their previous knowledge about the urinary system, the formation of urine and the structure of the nephron.

d) Learning activities

The teacher will form groups of five or six students and each group will be given a chart of the urinary system and that of the nephron. The students will discuss about the parts of the urinary system and the formation of urine in the nephron. If a projector is available, the students will watch a movie on the working of nephrons and their groups they will discuss what they have understood about the functioning of the urinary system and they will present their findings.

They will answer the activity 9.6 in the student's book.

Answers of activity 9.6.

1. The main excretory organs of the human are the kidneys (which excretes urine), the lungs (which excretes carbon dioxide), the skin (which excretes excess of salts) and the liver (which excretes the bile).
2. The main excretory waste products of mammals are urea, uric acid and ammonia.
3. The organs of the human excretory are the kidneys which produce urine, regulate blood pH... the ureters which carry urine from the kidneys to the urinary bladder, the urinary bladder which stores urine and the urethra which eliminates urine to the outside.

e) Application activities 9.6

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 9.6.

Answers for application activities

- 1) The nephron has the following parts: the afferent vessel, the efferent vessel, the glomerulus, the Bowman's capsule, the proximal convoluted tubule, the loop of Henle, the distal convoluted tubule and the collecting duct.
- 2)
 - a) Ultrafiltration: glomerulus
 - b) Reabsorption: proximal convoluted tubule. Some reabsorption also takes place in the loop of Henle and in the collecting duct.
 - c) Secretion: distal convoluted tubule
- 3) The main function of the collecting duct is the reabsorption of water.

Lesson 7: Formation of urea and urine

a) Learning objectives

- Describe the ornithine cycle and its role in the conversion of ammonia to urea.

b) Teaching resources

A computer, books, projector and flowchart showing the ornithine cycle.

c) Prerequisites/Revision/Introduction

This unit involves the knowledge of the parts of the urinary system and the nephron and their functions as seen previously.

d) Learning activities

The teacher will start the lesson by asking students what they remember about the parts of the urinary system and their functions. He will ask individually what they remember on the parts of the nephron and their functions. Then he will provide to them a chart of the ornithine cycle and they will discuss the importance of the ornithine cycle and the reason for our body of excreting urea rather than ammonia. From the discussion, they will provide the answers to the activity 9.5 found in the student's book.

Answers of the activity 9.7.

1. Liver
2. Kidney
3. Ultrafiltration, reabsorption and secretion.
4. The importance of the ornithine cycle is to convert ammonia which is toxic into urea which is not much toxic. Ammonia is very toxic even in very low concentration and would require a high amount of urine to excrete.

e) Application activities 9.7 (answers)

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 9.7. They will have to discuss on the process of excretion in order to understand very well the formation of urine.

Answers for application activities 9.7.

1. The main components of urine are water and metabolic waste products such as urea and very small amounts of ammonia and excess of sodium and chloride ions.
2.
 - a. The proteins are too big to pass through the glomerulus.
 - b. Urea.
 - c. Because it is a metabolic waste that must be removed from the body. Urea is toxic when in high concentration.
 - d. Diabetes mellitus. Because glucose is present in urine.

Lesson 8: Adaptations of organisms to different environmental conditions

a) Learning objectives

- Relate adaptations of different organisms to their habitat in terms of osmoregulation.

b) Teaching resources

A computer, books, and a projector.

c) Prerequisites/Revision/Introduction

Asking the students to make a list of animals adapted to live in different areas such in ice (polar areas) and in deserts and ask them what are their adaptations. They may recall the adaptations of xerophytes seen in the previous lessons.

d) Learning activities

The teacher will help students to form groups and in their groups the teacher will provide a movie downloaded on youtube.com which shows the adaptations of animals in different climates. The teacher may download a movie on the adaptations of the camels that helps it to survive in the deserts. The students will then discuss and answer the questions on the activity 9.7 in the student' book.

Answers of activity 9.8.

- a) Polar bears, penguins, dolphins and seals
- b) They have a thick layer of fats in their skin, a thicker and warmer fur or feathers, they usually have larger bodies and smaller extremities.
- c) Some of the adaptations of these animals are:

The tissues of a camel have the ability to tolerate dehydration.

- The camel is unable to store water in advance of conditions of water shortage. It gains water from the metabolism of fats stored in the humps.
- The camel can tolerate temperature fluctuations ranging from 34°C to 41°C without evaporation of water but by being able to store up heat during the day. The heat is lost during the night by evaporation, conduction and convection during the night.
- The camel is able to drink a vast volume of water in a short time to rehydrate the body tissues after a period of severe dehydration. For example, a 325 kg camel is known to have drunk 30 dm^3 of water in less than 10 minutes.
- It can survive long periods of drought without the supply of water by conserving the water in its body.

e) Application activities 9.8.

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 9.8.

Answers for application activities 9.8.

Two structural adaptations such as the **white appearance** to camouflage from prey on the snow and ice. Polar bear have **thick layers of fat and fur**, for insulation against the cold and a greasy coat which sheds water after swimming. Two physiological adaptations such as **changes of colour** or **body markings** in order to blend into its surroundings. Marine mammals such as whales are **endothermic/warm blooded** (able to maintain a constant body temperature).

Two behavioural adaptations such as whales **producing sounds that allow them to communicate**, navigate and hunt prey (**echolocation**). Bears **hibernate** or 'sleep' through the coldest part of the year.

Lesson 9: Role of the hypothalamus, pituitary gland, adrenal gland and nephron in varying the osmotic pressure of blood.

a) Learning objectives

- Describe the role of hypothalamus, posterior pituitary, ADH and collecting ducts in osmoregulation.

b) Teaching resources: A computer, books, chart showing the location of the hypothalamus, the pituitary gland and the adrenal glands.

c) Prerequisites/Revision/Introduction

To understand this lesson, the students need to know locations of some endocrine glands such as the hypothalamus, the pituitary gland and the adrenal glands and their secretions (hormones) involved in the regulation of water balance and salt balance.

d) Learning activities

The teacher will help students in their groups to recall the endocrine glands involved in the regulation of water and salts that they have studied in the previous lessons and their functions. They will then answer the questions from the activity 9.9 in the student's book.

d) Learning activities

- ADH, aldosterone and other mineralocorticoids, angiotensinogen and angiotensin.
- ADH produced by the hypothalamus, released by the posterior pituitary gland. Aldosterone produced by the adrenal cortex.

- c) ADH: reabsorption of water in the kidney; aldosterone: reabsorption of sodium ions and excretion of salts.

e) Application activities 9.9.

Guidance

Ask student-teachers to work individually to answer the questions of application activity 9.9.

Answers for application activities 9.9.

- a) **ADH:** the production of ADH decreases and the production of urine increases.
- b) **Aldosterone:** the production of aldosterone increases and the production of urine also increases.

Lesson 10: Kidney transplants and dialysis machines

a) Learning objectives

- Describe the use of dialysis in kidney machines.
- Describe how kidney transplants are performed.
- Explain dialysis in terms of salt balance, the maintenance of glucose concentration and the removal of urea.

b) Teaching resources

A computer, books, projector, a movie downloaded from youtube.com showing the process of dialysis.

c) Prerequisites/Revision/Introduction

The teacher will introduce the lesson by asking them to recall the process of urine formation and by asking whether they know if such process can be done artificially by using a machine.

d) Learning activities

The teacher will form groups and their respective books, the students will watch a movie on the process of dialysis and they discuss on how the process takes place and they will present their findings. They be able to answer the questions from the activity 7.10.

Answers of activity 9.10.

- a) Because their kidneys are not able to remove the metabolic waste products from the blood.
- b) They help in removing the metabolic waste products from the blood. They function as an artificial kidney.

e) Application activities 9.10

Guidance

Ask student-teachers to work individually to answer the questions of application activity 9.10.

Answers for application activities 9.10.

Dialysis is the process of removing the metabolic waste products by using a dialyzing machine. A kidney transplantation is the process of giving a kidney to someone who has a diseased kidney.

Lesson 11: Excretion and osmoregulation in protocista, insects, fish, amphibians and birds

a) Learning objectives

- Explain the principles of osmoregulation in protocista, insects, fish and amphibians.

b) Teaching resources: A computer, books

c) Prerequisites/Revision/Introduction

Ask students about the osmoregulation in protists and from this, they will be able to understand the process of osmoregulation in other aquatic animals.

d) Learning activities 9.11.

1. a) Cell membrane
 - b) Malpighian tubules
 - c) Kidney
- 5) Fresh water fishes live in a hypotonic medium. Water enters into them through their gills. To compensate this entry of water, fresh water fishes never drink water and excrete a large amount of diluted urine.

e) Application activities 9.11.

Guidance: Ask student-teachers to work individually to answer the questions of application activity 9.11.

Answers for application activities 9.11.

Unicellular organisms such as amoeba use their cell membrane and the contractile vacuole as their excretory organ whereas the insects use the Malpighian tubules.

Lesson 12: Principles of osmoregulation in marine, freshwater and terrestrial organisms.

a) Learning objectives

- Explain the principles of osmoregulation in organisms living in marine, freshwater and terrestrial habitats.

b) Teaching resources: Books, bucket, water, salt, a living fish or a young tadpole

c) Prerequisites/Revision/Introduction

To understand this lesson, the students are required to know the principles of excretion in general.

d) Learning activities

The will make group of 4 or 5 students and will be told to do the activity 9.12. Each group will be given a bucket, water, salt, a living fish or tadpole and they will do the activity as it is described in the student's book.

Answers of the activity 9.12.

The fish will die because it loses water to the external environment. The salt medium is a hypotonic solution and water will move from the hypotonic solution to the hypertonic solution.

e) Application activities 9.12

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 9.12.

Answers for application activities 9.12.

Fresh water fishes live in a hypotonic environment. They gain water by osmosis through their gills. To compensate this, they never drink water and excrete a large volume of urine. Salt water fishes lose water to the external environment by osmosis through their gills. To compensate this, salt water fishes drink a large volume of water and excrete salts through their gills. They also produce a small amount of urine.

Lesson 13: The excretion in plants

a) Learning objectives

- Explain why plants do not have specialized excretory organs.
- Classify excretory products of plants and how they are eliminated.

b) Teaching resources: books

c) Prerequisites/Revision/Introduction

To understand this unit, the students need to know the structure of stomata and the exchanges of gases that place in the stomata.

d) Learning activities

In a group of two, ask students to discuss about the excretion in plants. The students will be asked to compare the excretion in plants and the excretion in animals.

Answers of the activity 9.13.

a) Resins, rubber, quinine...

b) Plants do not have complex excretory organs. State three reasons.

- There is very little accumulation of toxic wastes. Often the plant wastes are utilized by the plant. For example, carbon dioxide is used for photosynthesis and oxygen for respiration.
- The extra gaseous waste is removed from the plant by simple diffusion through the stomata and the lenticels.
- Most of the waste substances formed in plants are not harmful and can be stored in the plant tissues.
- Some plants store other waste such as resins in their tissues in a non-toxic form. These tissues or organs later fall off the plant.
- Excess water and dissolved gases are removed by the process of transpiration through the stomata.

- Some plants remove waste products by exudation, for example gums, resins, latex and rubber.
- In some plants water with dissolved salts oozes out through hydathodes. This is called guttation.
- c) Hydathodes are specialized structures and they are mainly responsible for secreting water in liquid form. They are generally restricted to the apex or the serrated edges of the margins of leaves. They help in the excretion of excess of water from the plant.

e) Application activities 9.13

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 9.13.

Answers for application activities

Chloroquine, quinine, rubber

9.6 Summary of the unit

- Homeostasis is the ability of a living body to maintain a relatively stable internal environment.
- Homeostasis is an important characteristic of living things requiring continuous adjustments due to the changes occurring in internal and external environment.
- Variables that must be kept constant and regulated to the normal level (set points) in a body are temperature, glucose, pH, water, ions, respiratory gases and osmotic pressure of body fluids.
- Homeostatic control mechanisms have three interdependent components: receptor, integration centre and effectors.
- Negative feedback occurs when the response to a stimulus reduces the original stimulus.
- Positive feedback occurs when the response to a stimulus increases the original stimulus.
- The nervous system controls the activities of body parts quickly to external and internal stimuli.
- The endocrine system regulates body activities slowly with long lasting effects.
- The hypothalamus is a part of brain and link the nervous system and endocrine system.

- The homeostatic mechanisms are altered or interrupted based on internal (genetic) and external (lifestyle choices and environmental exposures) factors.
- Interstitial/tissue fluid is formed from blood plasma and it surrounds and bathes the cells in tissue spaces.
- Tissue fluid provides nutrients and removes waste products from the cells of the body.
- Tissue fluid is formed due to the pressure difference in flow of the blood through the blood capillaries.
- Tissue fluid contains sugars, salts, fatty acids, amino acids, coenzymes, ions, hormones, neurotransmitters, as well as metabolic waste products from the cells in a water medium.
- Tissue fluid moves from tissue spaces to lymph vessels (lymph), to lymph nodes and finally returns to the blood.
- Adaptation is a feature/characteristic of an animal which enables it to survive in its habitat.
- Different organisms have adapted to distinct habitats and environmental conditions. Three categories of adaptations are structural, physiological and behavioural. Each type of adaptation has its own survival value.
- The urinary system consists of two kidneys, two ureters, the urinary bladder, and the urethra. The kidneys form urine to excrete waste products and to regulate the volume, electrolytes, and pH of blood and tissue fluid. The Nephron is the functional unit of the kidney. There are 1 million nephrons per kidney
- The formation of urine involves three steps: filtration, reabsorption and secretion.
- Glomerular filtration: takes place from the glomerulus to Bowman's capsule. High blood pressure in the glomerulus forces plasma, dissolved materials, and small proteins out of the blood and into Bowman's capsule. The fluid is now called filtrate. Filtration is selective only in terms of size; blood cells and large proteins remain in the blood.
- Tubular reabsorption: takes place from the filtrate in the renal tubule to the blood in the peritubular capillaries; 99% of the filtrate is reabsorbed; only 1% becomes urine.
- Tubular secretion: takes place from the blood in the peritubular capillaries to the filtrate in the renal tubule; creatinine and other waste products may be secreted into the filtrate to be excreted in urine; secretion of H⁺ ions helps maintain pH of blood.

- Hormones that affect reabsorption: aldosterone, antidiuretic hormone, and parathyroid hormone.
- Insects use Malpighian tubules as their excretory organs. Malpighian tubules function in osmoregulation and removal of nitrogenous wastes from the haemolymph. Insects produce a relatively dry waste matter, an important adaptation to terrestrial life. Kidneys, the excretory organs of vertebrates, function in both excretion and osmoregulation.

9.7 Additional Information for teachers

The Renin-Angiotensin-Aldosterone System

When blood pressure or blood volume in the afferent arteriole drops, renin released from the juxtaglomerular apparatus (JGA) initiates conversion of angiotensinogen to angiotensin II. Functioning as a hormone angiotensin II raises blood pressure by constricting arterioles and triggering release of the hormone aldosterone. The rise in blood pressure and volume in turn reduces the release of renin.

Another hormone, atrial natriuretic peptide (ANP), opposes the Renin-Angiotensin-Aldosterone System (RAAS). The walls of the atria of the heart release ANP in response to an increase in blood volume and pressure. ANP inhibits the release of renin from the JGA, inhibits NaCl reabsorption by the collecting ducts, and reduces aldosterone release from the adrenal glands. These actions lower blood volume and pressure. Thus, ADH, the RAAS, and ANP provide an elaborate system of checks and balances that regulate the kidney's ability to control the osmolality, salt concentration, volume, and pressure of blood.

9.8 Guidance on skills Lab

For the smooth running of activity, you need to do:

- **Provide to learners the materials which are required to do the dissection of the rabbit.**
- Advised to follow the laboratory safety rules in order to avoid the accidents.
- **Help students to make groups of 5 to 6 students.**
- Ask each group to get a rabbit and the materials which are required to make the dissection.
- Facilitate them while dissecting and doing observation through instructions and questions.
- Ask students or some groups of students to show the parts of the urinary system of a rabbit and explain the functions of every part.

- You can expand their explanations and also ask questions for deep understanding.

9.9 End unit assessment (answers)

1. (d)
2. (b)
3. (d)
4.
 - a) Urea
 - b) Because they are toxic in high concentration.
5.
 - a) Kidney
 - b) Ureter
 - c) Renal artery
 - d) Urinary bladder
6.
 - a) The answers are:
 - (i) 4
 - (ii) 1
 - b) The U shaped part.
 - c) Glomerulus.
 - d) The pressure is higher in the efferent vessel than in the afferent vessel. This is because the afferent vessel has wide lumen while that of the efferent vessel is narrow.
 - e) Proteins are too big to pass through the wall of the glomerulus. Amino acids are able to pass because they are small.
 - f) The renal artery has a higher concentration of urea than the renal vein.
 - g) Kidneys and the liver.

9.10 Additional activities (Questions)

Excretion is one process that is used to maintain homeostasis.

- a) What is excretion?

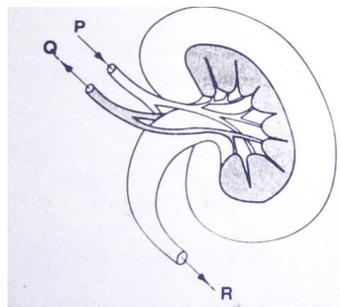
- b) What are the nitrogenous wastes of a fish and an insect?
- c) What is the significance of the difference in diameter between the afferent and efferent arteriole?
- d) Where does most of the water resorbed after glomerular filtration go? What are the other substances resorbed by the nephron tubules?

Answers to additional activities

- a) Excretion is the process of elimination of metabolic wastes and other toxic substances from the body.
- b) The nitrogenous waste product of a fish is ammonia while that of an insect is uric acid.
- c) Narrower diameter increases pressure inside capillary and forces plasma out of the blood into the Bowman's capsule.
- d) Only 0.5 to 1% of the glomerular filtrate is eliminated as urine. The remaining volume, containing mainly metabolic ions, glucose, amino acids and water, is reabsorbed through the nephron tubules (by means of active or passive transport) and gains the blood circulation again. The convoluted tubules of the nephron are responsible for the reabsorption of substances.

9.10.1 Remedial activities

The figure below illustrates an internal section of a kidney



- a) State the differences in the composition of fluids passing through vessels P and Q.
- b) State two similarities between vessels P and Q in terms of composition of fluids passing through them.
- c) State the substances that would be in high concentration as fluids that pass through vessel R in individuals suffering from diabetes mellitus and suffering from nephritis
- d) Name the organ where R empties its contents.

Answers to remedial activities

a) The following are differences:

P	Q
More oxygen	Less oxygen
More urea	Less urea
More water	Balanced water

b) Both contain blood cells; both carry nutrients such as glucose and amino acids

c) Glucose and Proteins

d) Urinary bladder

9.10.2 Consolidation activities (Questions)

1. The control of blood glucose concentration involves a negative feedback mechanism.
 - a) What are the stimuli, receptors and effectors in this control mechanism?
 - b) Explain how negative feedback is involved in this homeostatic mechanism.

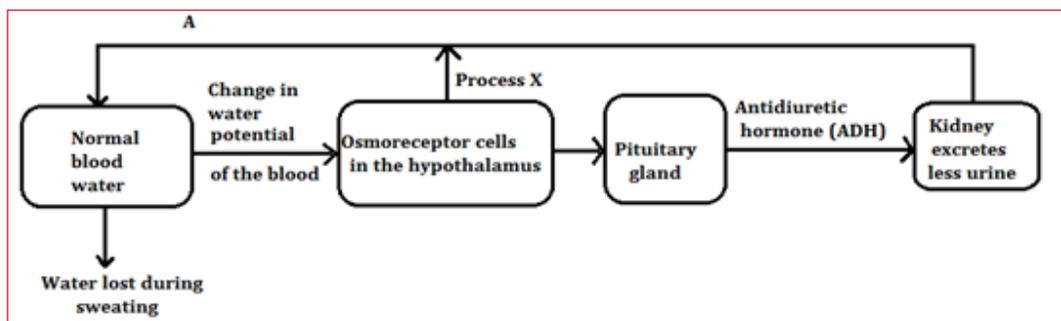
Consolidation activities (Answers)

1. a) Stimuli: changes in concentration of blood glucose above and below the set point; receptors: the α and β cells in the islets of Langerhans in the pancreas; effectors: the cells that change the glucose concentration in the blood by absorbing it from the blood or release it into the blood; these are liver and muscle cells.
b) The blood glucose concentration fluctuates about a set point. In negative feedback, a change stimulates a response that brings things back to normal. In the homeostatic control of blood glucose, an increase in the concentration stimulates mechanisms that reduce the concentration, and a decrease in the concentration stimulates mechanisms that increase it. These corrective actions restore the blood glucose concentration to its set point.

9.10.3 Extended activities (Questions)

- 1) Explain why drinking alcohol causes a sensation of thirst.

The figure below shows some of the homeostatic changes that occur as a result of water being lost from the blood due to sweating



- a) Describe the changes in water potential that occurs in the blood as a result of sweating.
- b) Which of the structures shown acts as?
 - i. A receptor
 - ii. An effector
- 2) Describe how ADH gets from the pituitary gland to the kidney
- 3) The kidney conserves the water that is already in the blood. Given that the water potential of the blood remains in its normal level prior to sweating, suggest what is happening in process X. State as precisely as possible what mechanism is shown by the line labelled A.

Answers to extended questions

- 1) Drinking alcohol causes diuresis because alcohol inhibits the release of the ADH by the posterior pituitary gland. Less ADH production decreases the permeability of the walls of the collecting duct and the distal convoluted tubule to water. This increases urine production.
- 2) The following are the answers:
 - a) As sweating involves a loss of water from the blood, its water potential will decrease/ be lower/ more negative.
 - b) The answers:
 - i. Osmoreceptor cells in the hypothalamus
 - ii. Kidney
- 3) As it is a hormone, it is transported in the blood.
- 4) Absorption/ taking in/ drinking the water. Because water has been lost during sweating. As the water potential of the blood returns to normal, the lost water must have been replaced. However, the kidney excretes less water, it does not replace it. Therefore, process X must be the way that water is replaced. Mechanisms shown by the line labelled A is the negative feedback.

UNIT 10

CHARACTERISTICS OF DIFFERENT GROUPS OF MICROORGANISMS, CULTURING AND FACTORS AFFECTING THEIR POPULATION GROWTH

10.1 Key unit competence:

Describe the structure, characteristics of microorganisms and explain the process of culturing microorganisms and the factors affecting their population growth.

10.2 Prerequisites

The students will understand very well the **Characteristics of different groups of microorganisms, culturing and factors affecting their population growth** if the learners have well understood the importance of microorganisms and the cell and the functions of cell organelles.

10.3 Cross cutting issues to be addressed

Environment and sustainability

Show to the learners the importance of microbes because they more beneficial effects than the harms that they may cause to the humans. Bacteria and fungi are involved in the recycling matter. The teacher should focus on the recycling and show to the learners the importance of using non-biodegradable objects as they can be easily decomposed by microbes.

Comprehensive sexuality education

This unit will involve the dissection of animals in order to study male reproductive systems and female reproductive systems. The learners should be told to be able to take right decisions about their sexuality.

Inclusive education

Emphasize to learners that anybody irrespective of their gender can present and reports during group activities. Give a role model who are successful in real life without considering their gender, make sure that during experiments both boys and girls shares and participates equally the works.

10.4 Guidance on introductory activity

The teacher will introduce the lesson by forming groups that will be used in this activity. The teacher will provide to each group two bread: a normal bread and a bread which has been deteriorated. The students in their groups will discuss on the reason that caused the bread to deteriorate. The students will discuss and find different reasons and will present their findings to the class.

Answers of the introductory activity 10.1.

- a) The bread has deteriorated. Microbes which are involved in the recycling matter are using the bread as their food to transform it into inorganic nutrients to be used by producers.
- b) These are molds.
- c) If Gakwaya eats such a bread, he may become ill because some microorganisms may be dangerous and cause diseases.

10.5 List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Types of microorganisms (Archaeobacteria, bacteria, fungi, protozoa and Viruses)	<ul style="list-style-type: none">- Distinguish between the structure and function of viruses and prokaryotic organisms.- Describe the basic structure of viruses.	2 periods
2	Viruses as living or non-living and the structure and life cycle of viruses.	<ul style="list-style-type: none">- Describe the basic structure of viruses.- Identify the effects of viruses on organisms.	2 periods
3	Protozoans, algae (microscopic algae), molds (microscopic fungi) and eubacteria.	<ul style="list-style-type: none">- Describe the main structural forms of eubacteria.- Describe the structure and life cycle of pathogenic protozoa limited to <i>Entamoeba histolytica</i>, <i>Plasmodium</i> and <i>Trypanosoma</i>.	2 periods

4	<i>E. coli</i> , food poisoning and evolution of harmful strains	- Describe the process of food poisoning and the evolution of harmful strains.	1 period
5	Food conservation and water purification.	- Describe different methods of food conservation and their uses	2 periods
6	Fermentation.	- Describe the role of anaerobic respiration in yeast during bread-making.	1 period
7	Measuring population growth of bacteria and fungi	- Describe the roles of microorganisms and their requirements for growth.	1 period
8	Culturing microorganisms	- Explain the role of environmental variables in culturing microorganisms. - Describe the main features of aseptic techniques.	2 periods
9	Staining bacteria and staining bacteria.	- Distinguish between gram negative and gram positive bacteria. - Carry out an experiment to stain bacteria for examination with a light microscope.	2 periods
14	End unit assessment & Remedial		2 periods

Lesson 1: Types of microorganisms (Archaeobacteria, bacteria, fungi, protozoa and Viruses)

a) Learning objectives

- Distinguish between the structure and function of viruses and prokaryotic organisms.
- Describe the basic structure of viruses.

b) Teaching resources

Computer simulations, books, charts showing different microorganisms.

c) Prerequisites/Revision/Introduction

The students are required to know the importance of microbes and some examples of microbes which have been described in the previous chapters.

d) Learning activities

The teacher will introduce the lesson by asking to the learners what they know on the cell and the types of cells. From their answers, the teacher will ask them to identify the types of organisms which are prokaryotic and they will give examples. The teacher will ask them again to make a search on other living organisms which cannot be seen with a naked eye and they identify different types of microorganisms. The teacher may use a downloaded video from youtube.com which shows various microorganisms, their structure and their importance.

Answers to the activity 10.1.

1. a) Microbiology: study of small organisms which cannot be seen with a naked eye.
b) Prokaryotic: a cell without a nucleus and other membrane-bound organelles.
2. Beneficial effects of microbes:
They are involved in recycling matter;
They are involved in fermentation
They are involved in nitrogen fixation...
3. Archaeobacteria live in unusual situations (extreme conditions) whereas eubacteria live in usual situations. Eubacteria have a cell wall made of peptidoglycan whereas archaeobacteria have a cell wall not made of peptidoglycan.

e) Application activity 10.1

Guidance

Ask student-teachers to work in pairs to answer the questions of application activity 10.1.

Answers for application activities 10.1

- 1) There are three basic shapes of bacteria: spherical shapes called cocci, rod shaped bacteria called bacilli and spiral shaped bacteria called spirilla.
- 2) Methanogens and thermophilic acidophiles.

- 3) Protozoa are heterotrophic as animals. They are also eukaryotic as animals.

Lesson 2: Viruses as living or non-living and the structure and life cycle of viruses.

a) Learning objectives

- Describe the basic structure of viruses.
- Identify the effects of viruses on organisms.

b) Teaching resources: Computer simulations, books, charts showing the lytic cycle and the lysogenic cycle.

c) Prerequisites/Revision/Introduction

The students are required to know structure of viruses

d) Learning activities

The teacher will form groups of 4 to 6 students depending on the size of the classroom. In their groups, the teacher will show them charts showing a bacteriophage and another one showing HIV virus. A simulation showing the replication of viruses may also be used if possible. After watching the movie, they will answer to the questions of the activity 10.2.

Answers to the activity 10.2.

- 1) A nucleic acid (DNA or RNA), a protein coat called capsid and an envelope.
- 2) A virus has no nucleus and other organelles such as the mitochondria, the ribosomes, the ER, the Golgi apparatus...
- 3) It helps the virus to make a copy of DNA from RNA.

e) Application activity 10.2

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 10.2.

Answers for application activities 10.2.

- 1) Viruses are called obligate intracellular parasites because they only reproduce inside their host cells. Outside the cell, the virus is unable to reproduce; it is like a lifeless particle.

- 2) Viruses do not contain organelles while cells possess organelles; Viruses do not have the characteristics of living things while cells possess the characteristics of living cells.
- 3) It is a virus that replicates by using the lysogenic cycle.

Lesson 3: Protozoans, algae (microscopic algae), molds (microscopic fungi) and eubacteria.

a) Learning objectives

- Describe the main structural forms of eubacteria.
- Describe the structure and life cycle of pathogenic protozoa limited to *Entamoeba histolytica*, *Plasmodium* and *Trypanosoma*.

b) Teaching resources: Computer simulations, books, charts showing the life cycle of microbes.

c) Prerequisites/Revision/Introduction

The students are required to know structure of viruses

d) Learning activities

The teacher will form groups of 4 to 6 students depending on the size of the classroom and he will provide to the students a simulation showing the life cycle of *Plasmodium*. After watching the movie, they will answer to the questions of the activity 10.3.

Answers to the activity 10.3.

1. i) **Protozoa:** are unicellular, are heterotrophic, most of them are able to move, most of them cause different diseases...
 - ii) **Molds:** most of them are unicellular, they reproduce by means of spores, are eukaryotic...
 - iii) **Eubacteria:** are prokaryotic, some are autotrophic whereas others are heterotrophic...
- 2) **The life cycle of Plasmodium:** When an infected mosquito bites a person, *Plasmodium* sporozoites enter the bloodstream and travel to liver cells, where they divide repeatedly. New spores called merozoites emerge and infect red blood cells, where they reproduce asexually. At regular intervals, the merozoites burst out of the red blood cells and the release of toxins in the blood cause fever, anemia and other symptoms of malaria. The merozoites infect other red blood cells and again reproduce asexually. This asexual reproduction can happen many times over a long

period of time. Merozoites of some species remain in the liver and do not come out for months or years. Thus, an infected person could take antimalaria drugs and cure the infection in the blood, only to become ill again when the merozoites leave the liver cells. Some of the merozoites in the blood develop into specialized cells called gametocytes. When a female anopheles bites the infected person, it ingests these gametocytes. In the mosquito's digestive system, the sperm and eggs combine to form a zygote. The nucleus of the zygote divides repeatedly to form more sporozoites. When the zygote bursts, the sporozoites migrate to the body cavity and salivary glands of the mosquito. When the insect bites another person, the life cycle begins again.

e) Application activities 10.3

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 10.3.

Answers for application activities 10.3.

1)

Disease	Causative agent	Vector
Malaria	Plasmodium	Female Anopheles mosquito
Trypanosomiasis	Trypanosoma	Tsetse flies

2) Mild abdominal cramps

Flatulence

Bloody stools

3) Anemia is caused by the destruction of red blood cells by the merozoites.

Lesson 4: Types of microorganisms (Archaeobacteria, bacteria, fungi, protozoa and Viruses)

a) Learning objectives

- Distinguish between the structure and function of viruses and prokaryotic organisms.
- Describe the basic structure of viruses.

b) Teaching resources: Computer simulations, books, charts showing different microorganisms.

c) Prerequisites/Revision/Introduction

The students are required to know the importance of microbes and some examples of microbes which have been described in the previous chapters.

d) Learning activities

The teacher will form groups of 5 students and in their groups they discuss a scenario where a group of persons in a hotel have been intoxicated after eating the food from the restaurant. They will discuss in order to find possible reasons for this problem. After the discussion

Answers to the activity 10.4.

The reason for the intoxication is food poisoning. Most cases of food poisoning are caused by bacteria called Salmonella. Salmonellosis is transmitted in different cases of poor hygiene. This is why hygienic measures should be applied everywhere.

e) Answers for application activities 10.4.

The drugs used nowadays are not treating the diseases that they used to treat because of resistance of different pathogens. For example the antibiotic resistance may be caused by the overuse of antibiotics; people taking antibiotics unnecessarily; people taking drugs and stop after ending the correct dose...

Lesson 5: Food conservation and water purification

a) Learning objectives

- Describe different methods of food conservation and their uses.

b) Teaching resources: Computer simulations, books, charts showing different microorganisms.

c) Prerequisites/Revision/Introduction

The students are required to know the importance of microbes and some examples of microbes which have been described in the previous chapters.

d) Learning activities

The teacher will begin by forming groups of 5 or 6 students. The teacher will provide to the students different charts containing different conservation methods and the students will identify the possible food substances which can be used to conserve them.

Answers to the activity 10.5.

- a) Meat, milk, fish, vegetables, fruits...
- b) Fish

e) Application activities 10.5

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 10.5.

Answers for application activities 10.5.

This is an activity that can be home or in a school laboratory. If possible, the students can perform the activity in the school lab and after they identify the reason why meat can remain conserved after such period of time. The salt prevents the growth of microorganisms.

Lesson 10.6: Fermentation

a) Learning objectives

- Describe the role of anaerobic respiration in yeast during bread-making.

b) Teaching resources: Computer simulations, books, charts showing different microorganisms.

c) Prerequisites/Revision/Introduction

The students are required to know the importance of microbes and some examples of microbes which have been described in the previous chapters.

d) Learning activities

The teacher will make groups of 4 students and will guide them on the activity 10.5 in the student's book. They will discuss on the production of beer and all the ingredients needed to produce beer.

Answers to the activity 10.6.

Banana beer can be produced from banana juice.

- a) Banana juice be converted into beer by a process of fermentation which converts glucose into ethanol and carbon dioxide.
- b) The ingredients necessary to produce banana juice are banana juice and yeasts. Flavoring substances such as yeasts can be added.

e) Application activities 10.6

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 10.6.

Answers for application activities 10.6

In bakery products, fermentation is a complex series of biological reactions that allow dough to leaven. It is carried out by strains of *Saccharomyces cerevisiae* yeast, wild yeast and lactic acid bacteria. These microorganisms start by consuming simple sugars in the flour and generated by amylase. This produces CO₂ and other compounds, which are responsible for the unique flavour and texture of bread. The process starts once yeast/LAB is added to the flour and water, either as individual ingredients or preferments. It continues through early stages of baking where the yeast is inactivated by heat. The fastest fermentation rate occurs during proofing and oven spring stages.

Lesson 7: Measuring population growth of bacteria and fungi

a) Learning objectives

- Describe the roles of microorganisms and their requirements for growth.

b) Teaching resources: Computer simulations, books, charts showing different microorganisms.

c) Prerequisites/Revision/Introduction

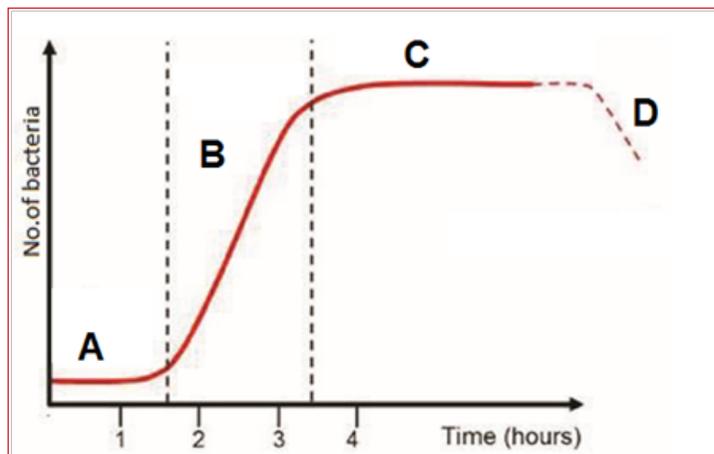
The students are required to know the importance of microbes and some requirements for the growth of microbes.

d) Learning activities

The teacher will make groups and in their groups they will do the activity 10.7. They will analyze the activity and they will provide the possible answers for the activity.

Answers to the activity 10.7.

The figure below shows the growth curve of bacteria. Observe it and answer the questions that follow:



Indicate on the figure the letter that shows when

- a) B
- b) D
- c) C
- d) . Plentiful of resources such as food, space or light.
 - Little or no competition from other inhabitants.
 - Favourable abiotic factors such as temperature or oxygen. Little or no predation or diseases.

e) Application activities 10.7

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 10.6.

Answers for application activities 10.7.

1. a) The stationary phase: C and which the lag phase is A
- b) D
- c) Factors that could affect the rate of population growth during phase **C: competition for food, space**, increase of predators and diseases, build-up of waste such as excrement or excess carbon dioxide

Lesson 9: Culturing microorganisms

a) Learning objectives

- Explain the role of environmental variables in culturing microorganisms.
- Describe the main features of aseptic techniques.

b) Teaching resources: Computer simulations, books, charts showing different microorganisms.

c) Prerequisites/Revision/Introduction

The students are required to know the importance of microbes and some examples of microbes which have been described in the previous chapters.

d) Learning activities

The teacher forms groups of four or five students and they will be given the activity 10.9 in the student's book. They will be given a task of finding different ingredient and apparatus necessary to make a culture medium. They may use books or the internet.

Answers to the activity 10.1.

- A culture medium is a solid or liquid preparation containing nutrients for the culture of microorganisms.
- Culturing microorganisms can help to find out which nutrients they need to survive and which chemicals will kill them. We can also discover which microorganisms can be useful to us and which cause deadly disease.
- The ingredients necessary to make a culture medium: Source of energy such as glucose, maltose, juice; a source of other nutrients (minerals such as potassium, sodium, iron, magnesium and calcium, vitamins, proteins; air for aerobic microbes or complete absence of air for anaerobic microorganisms.
- Incubator, petri dish, inoculating loop, autoclave

e) Application activities 10.8

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 10.8.

Answers for application activities 10.8.

Materials and products necessary to make a culture medium and the importance of each one.

Instrument	Uses
Autoclave	Used for sterilization of glass ware and media
Incubator	Used for bacterial or fungal cultures
Inoculation loop	Used to inoculate test samples into culture media for bacterial or fungal cultures. They are sterilized by passing through a blue flame.
Petri dish / agar plate	To act as a supporting container to hold the culture medium in
Microscope	To observe microscopic specimens that cannot be seen by the naked eye.
Tissue culture bottles	To grow or keep alive cells or tissue from a living organism.
Platine wire loop	Used to inoculate test samples into culture media for bacterial or fungal cultures... sterilized by flaming to red hot before use

Lesson 10: Staining bacteria and staining bacteria

a) Learning objectives

- Distinguish between gram negative and gram positive bacteria.
- Carry out an experiment to stain bacteria for examination with a light microscope.

b) Teaching resources: Computer simulations, books, movie showing the culture medium technique

c) Prerequisites/Revision/Introduction

The students are required to know the main types of bacteria and their characteristics.

d) Learning activities

The teacher provide a movie to the students where they will follow the process of gram staining. The students will watch the movie and each one will write the steps in the Gram stain technique and the observation of bacteria after the Gram stain.

Answers to the activity 10.9.

Use books and other sources and answer the following

- a) The Gram stain helps to distinguish bacteria and to know which type of antibiotics can be used to cure a bacterial infection.
- b) Cfr student's book
- c) Bacteria without a lipid layer along with their peptidoglycan cell wall take the gram stain and appear **violet** (purple) and are therefore called **gram positive**. Example streptococcus and staphylococcus. Bacteria having a lipid layer along with their peptidoglycan cell wall do not take up the gram stain and are therefore called **gram negative**.

e) Application activities 10.9

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 10.9.

Answers for application activities 10.9.

The students will perform the gram stain with the help of the teacher if the materials are available. After the end of the activity, the students will have to make comparison between gram positive and gram negative bacteria.

Some major differences between gram positive and gram negative bacteria:

Gram positive bacteria	Gram positive bacteria
Take a purple color after the Gram stain	Take a pink color after the Gram stain
They have a thick layer of peptidoglycan	They have a thin layer of peptidoglycan
Easy to treat with antibiotics	Not easy to treat with antibiotics

10.6 Summary of the unit

- **Microorganisms** are organisms that are too small to be seen with the naked eye, and usually require a microscope to be seen. Microbiology is the study of microorganisms.
- Many microorganisms can be grown in the laboratory. Microorganisms include bacteria, viruses, some fungi and protists. Taxonomists used to classify all prokaryotes in kingdom monera, yet they slightly differ in

characteristics.

- Archaeobacteria were first discovered in extreme environments such as swamps, salt lakes, hot springs. Most Eubacteria have one of the three basic shapes. Eubacteria that are rod-shaped are called **bacilli**, sphere-shaped are called **cocci** (sing. Coccus) and spiral shaped are called **spirilla** (sing. Spirillum). E. coli is a rod-shaped bacterium measuring about $2.5\mu\text{m}$ by $0.5\mu\text{m}$. It is mainly found in guts of vertebrates. It is chemoheterotroph, capable of thriving on a variety of the organic molecules. Its presence in water indicates contamination by faeces. In 1996, an outbreak of E. coli food poisoning was traced to drinking fresh apple juice. The existence of viruses was established in 1892, when Russian biologist **Dmitry Ivanovsky** discovered microscopic particles later known as the tobacco mosaic virus.
- Viruses consist of either **ribonucleic acid (RNA)** or **deoxyribonucleic acid (DNA)**-never both-plus a protective coat called **capsomere** made of protein or of protein combined with lipid or carbohydrate components. DNA and RNA viruses differ in the way they use the host cell's machinery to produce new viruses. Bacteriophages are viruses that infect bacteria. Their discovery has increased biologist's understanding of virus replication.
- Viruses replicate by using either the **lytic cycle** or the **lysogenic cycle**. Many microorganisms can be grown in the laboratory. Source nutrients include: minerals such as potassium, sodium, iron, magnesium and calcium, vitamins, proteins. Temperature, pH and oxygen concentration are all important for bacterial growth. A medium is a solid or liquid preparation containing nutrients for the culture growth of microorganisms, animals. A culture is a collection of microbial cells growing on or, in a medium.
- A **medium** is a solid or liquid preparation containing cells or plant tissue culture medium. A microbial culture undergoes four steps namely: Choice of the culture medium cells or plant tissue cultures, Sterilization of the culture medium and streaking, carrying out a pure culture.
- Pure culture technique is a method of culturing microorganisms in which all of the individuals in a culture have descended from a simple individual. Sterilization, inoculation, and incubation are all required during culturing. When bacteria or any other germs are incubated in a suitable culturing medium, they reproduce by binary fission and the number of individuals increases.

- In positive staining, cells structures take in the stain e.g. methylene blue while in negative staining. The purpose of staining bacteria is to see, for example, how thick of a layer of peptidoglycans their cell wall has. The culture of viruses is made more difficult than the culture of bacteria or fungi because viruses can only grow and multiply inside living cells.

10.7 Additional Information for teachers

- Help students to develop observation skill by practicing many experiments on microbiology.
- Points out those bacteria are almost everywhere in nature, but some few cause diseases. Make students carry out an experiment to find out where on the human body are the most bacteria.
- Ask pairs of students to prepare six Petri dishes of sterile nutrient agar. Have learners choose one of the pair for investigation. The other learner should use a separate sterile cotton swab to rub a 2cm area at five different places on the first learner's body: forehead, side of nose, cheek, and palm of the hand and on ankle. For each rubbing the learner should roll the cotton swab over the agar in one of the dishes and slow the swab away. Have learners, cover the dishes, label them, and place in an incubator or a warm spot in the room for 48hours. Then have learner pairs observe and compare the growth on each of the dishes.
- Ask learners to present their findings to the class. Help learners to develop writing skills especially scientific articles for example "viruses in the biosphere".
- Viruses can be used in the production of vaccines that could eradicate specific diseases such as measles and polio: genetic engineers can correct genetic defects by using viruses to carry desirable genes from one cell to another.
- Harmful aspects: viruses are pathogens and resistant to antibiotics. Viral diseases that affect humans are described in the students' book.

Guidance on skills Lab

The production of alcohol using banana juice is an easy practical that can be easily done in a school laboratory. The teacher will help the students to make the banana juice to be used in the manufacture of beer.

10.8 End unit assessment (answers)

- 1) Diseases caused by:
 - a) Bacteria: Tuberculosis, typhoid, cholera, tetanus, etc...

- b) Protozoa: Malaria, trichomoniasis, sleeping sickness, etc...
- c) Microscopic fungi: Ring worms, Candidiasis, athlete's foot, etc...

2) The main feature of moulds is:

Moulds contain cells arranged in long thread-like filaments known as the hyphae that form a mass called Mycelium.

3) Viruses are not generally considered to be living things because:

They cannot metabolize

They crystallize when in isolation.

They cannot reproduce outside of host.

They are not made of cells. This means that they have a relatively simple non cellular organisation.

They cannot respond to stimuli

They have one type of nucleic acid, either DNA or RNA. But living cells contain both DNA and RNA.

4) a) A: RNA

B: Reverse transcriptase enzyme

C: Protein coats

D: Glycoprotein

b) **Retrovirus** is RNA viruses that contain an enzyme called **reverse transcriptase** in addition to RNA. Reverse transcriptase uses RNA as a template to make DNA. The DNA then makes an RNA transcript of itself. This RNA is then translated into proteins that become part of new viruses. Reverse transcriptase is so given this name because it reverses the normal process of transcription, in which DNA serves as a template for producing RNA.

c) White blood cells mainly destroyed by HIV/AIDS are called **Helper T cells**.

5) The main types of media are: Cultural media, minimal media, selective media, differential media, indicator media and enriched media.

6) Gram-positive bacteria have a single cell wall layer absorb only the violet primary stain while Gram-negative bacteria have a thin layer of peptidoglycans which the red stain that the bacteria appear red.

- 7) Methods of preventing bacterial growth in food are: sterilization, use of disinfectants, food storage and food processing.
- 8) Optimum temperature promotes bacterial growth, raising the temperature higher may reduce the growth of bacteria and very low temperatures inhibit bacterial growth.
- 9) It would not be a good idea because vaccinations prevent infections rather than attacking and destroying bacteria. The best way would be treating the infection with strong antibiotics.
- 10) Bacteria are essential to maintaining life on earth. Some are important producers, decomposers, nitrogen fixers and others are useful to humans in various ways.
- 11) Groups of bacteria
 - a. Bacillus
 - b. Coccus
 - c. Spirillum
 - d. Spirochete
 - e. Vibrios
 - f. Streptococcus
 - g. Staphylococcus
 - h. Diplococci
 - i. Chain of bacilli

10.9 Additional activities (Questions and answers)

10.9.1 Remedial activities

- 1) What do you understand with prokaryote?
- 2) Most Eubacteria have one of the three basic shapes. What are those three shapes of Eubacteria?
- 3) Answer the following by true or false

The following is feature that makes viruses non-living things:

- a) Viruses crystallize when in isolation.
 - b) They cause diseases to other living things
 - c) They are not made of cells.
 - d) They cannot respond to stimuli
 - e) They evolve as a result of mutation and natural selection.
- 4) Who has discovered the antibiotic Penicillin?
 - 5) Why do we culture microorganisms in the lab?
 - 6) Why are bacteria used in yoghurt making?

Answers to remedial activities

Expected answers

1. Prokaryote is a unicellular organism that lacks a membrane –bound nucleus, mitochondria and other membrane-bound organelle.
2. Shapes of Eubacteria are:
 - a) Bacilli: rod-shaped
 - b) Cocci (sing. Coccus): Sphere-shaped
 - c) Spirilla: (sing. Spirillum): Spiral-shaped
3. Answers
 - a) True b) False c) True d) True e) False
4. Penicillin has been discovered by a scientist Sir Alexander Fleming
5. For study purpose.
6. They multiply so fast and change milk to yoghurt.

10.9.2 Consolidation activities

- 1) Suggest any three characteristics of prokaryotes
- 2) Suggest where Archaeobacteria are found in environment.
- 3) Explain how scientist Sir Alexander Fleming discovered antibiotics Penicillin.
- 4) What symptoms can help you to know that a person is suffering from *Entamoeba histolytica*?

Expected answers:

- 1) Characteristics of prokaryotes are:
 - The absence of a membrane around the nuclear materials
 - The absence of clearly defined membrane-limited organelles like mitochondria, Golgi complex and lysosomes.
 - The genetic material is located on a single chromosome which consists of circular double strand of DNA
 - The absence of nucleolus and mitotic apparatus etc.
- 2) Archaeobacteria were first discovered in extreme environments such as swamps, salt lakes, hot springs

3) Discovery of *Penicillium*

Penicillin, the first antibiotic has been discovered in 1928 by a scientist Sir **Alexander Fleming** when he was culturing some *Staphylococcus* bacteria during his medical research. He left some Petri dishes for many days, and after he found a mouldy growth of *Penicillium notatum* contaminating a corner of one of dishes. Then Fleming realised that *Staphylococcus* next to the mould has been destroyed. After studying *Staphylococcus* closely, Fleming concluded that the *Penicillium* mould was producing a substance that killed the *Staphylococcus*. He carried on with finding out if the broth of *Penicillium* mould contained penicillin which could destroy pathogenic bacteria.

4) The symptoms of *Entamoeba histolytica* are:

- Gas (flatulence) intermittent
- Constipation loose stools
- Stomach ache
- Stomach cramping.

10.9.3 Extended activities

1) The passage below describes how a student grows a culture of microorganisms on an agar plate. Petri-dishes and culture medium containing agar, carbohydrate, protein and mineral ions are heated to 120°C for 15 minutes. The culture medium is poured into the Petri dishes and left to set. An inoculating wire loop is passed through a flame until red hot, allowed to cool and then dipped into a container of microorganisms. The loop is then streaked across the medium in the Petri dish.

The Petri dish is sealed with adhesive tape and incubated at a temperature not exceeding 25°C. Use the passage to answer the questions that follow:

In each case, give one reason why the following procedures were carried out.

- a) Carbohydrate was used in the culture medium.
- b) The culture medium and Petri dishes were heated to 120°C for 15 minutes.
- c) The inoculating wire loop was cooled before being used to transfer microorganisms.
- d) The Petri dish was sealed with adhesive tape.
- e) The temperature at which the microorganisms are grown was not allowed to exceed 25°C.

2) Suggest measures you can use to prevent food spoilage by microorganism.

Expected answers

1. a) To provide the necessary energy.
 - b) To sterilize the medium
 - c) To prevent the destruction of bacteria
 - d) To prevent microorganisms in air from contaminating the culture
 - e) This greatly reduces chances of pathogens growing which might be harmful to humans.
- 2) In order to prevent food spoilage by bacteria at home, we can treat food in the following ways;

Cooking- the heat denatures enzymes and other proteins. This kills bacteria. Pasteurising- this involves heating to 72 degrees Celcius for 15seconds and then cooling. Drying, salting and coating in sugar – these methods dehydrate any bacteria as water leaves them by osmosis. Smoking- the food develops a hardened, dry outer surface and smoke contains antibacterial chemicals.

UNIT 11

BIOTECHNOLOGY AND ITS APPLICATIONS

11.1 Key unit competence

Explain the biotechnology involved in the production of ethanol, biogas and bread making.

11.2 Prerequisites

Introduce the unit by asking learners identify different groups of microorganisms studied in the previous unit. It is also necessary for the teacher, to ask learners about what they recall about how microorganisms reproduce. Ask learners the significance of microorganisms, what do microorganisms need in order to grow, how do we grow microorganisms in a lab?

Learners have knowledge of classification of living organisms, basically the prokaryotes like bacteria as well as eukaryotes such as protists and some microscopic fungi like yeasts, and knowledge of microorganisms will enable learners to discover a lot about culturing.

11.3 Cross cutting issues to be addressed

a) Environment and sustainability

Take precautions during culturing to avoid microorganisms harming the form of life including humans. The attack of such harmful microorganisms can result into death of living organisms which degrades the environment. As a teacher, you are required to be creative and innovative enough, in integrating this cross cutting issue since it is applicable in all lessons of this unit for example in the lessons of the role of microbes in plant and animals. Learners must recognise the significance of plants and animals in environmental protection. Learners also need to understand their positive roles in environment and sustainability.

b) Gender

In all lessons of this unit, this cross cutting issue can be integrated. As a teacher your role is to ensure gender equality in activities you conduct inside and outside the classroom. Gender can be integrated, for example by mix boys and girls in group work, while setting tasks and when presenting.

c) Comprehensive sexuality education (HIV/AIDS, STI, Family planning, Gender equality and reproductive health)

When facilitating a lesson of common bacterial diseases, learners need to be aware that syphilis and gonorrhoea are STIs and at the same time caused by bacteria. Lesson of the structure and classification of viruses, integrate in this cross cutting issue. Link the cause of AIDS which is HIV to this issue and emphasise on preventative measures. Learners are required to put into practice the preventative measures of HIV/AIDS and STIs.

d) Peace and values education

The role of a teacher is to create and promote peace in a learning environment. This cross cutting issue can be integrated at any time in classroom, outside classroom, in school environment and anywhere in life. Teacher should not be a source of conflicts. Learners need to appreciate peace and values and advocate for positive behaviour among them.

11.4 Guidance on introductory activity

This activity is very essential since it captures the attention of learners: As a teacher, you are required to give such activity because it has the following benefits:

It creates curiosity among learners and enhances active learning through doing.

It promotes critical thinking and allows learners to predict the next lesson / unit. Plants can be modified genetically to produce genetically modified organisms. This is genetic engineering. The teacher will help learners to know the wide range of applications of biotechnology nowadays.

Answers of the introductory activity

- a) The figure A shows DNA. It stores the genetic information of the cell.
- b) GMO. It means in full genetically modified organism.
- c) The figure C shows two types of rice: the normal rice and the GMO rice. The genetically modified rice contains a gene from the maize that helps the manufacture of beta carotene which is metabolized by our body into vitamin A.
- d) The GMO has been modified. It has a gene from an organism of another species.
- e) The tomato such as the one shown of the figure B is produced through a technique called genetic engineering. **GM is a technology that involves inserting DNA into the genome of an organism. To produce a GM plant,**

new DNA is transferred into plant cells. Usually, the cells are then grown in tissue culture where they develop into **plants**. The seeds **produced** by these **plants** will inherit the new DNA.

11.5 List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Role of bacteria in biotechnology and genetic engineering	<ul style="list-style-type: none"> - Explain that bacteria are useful in biotechnology and genetic engineering. - Discuss why bacteria are useful in biotechnology and genetic engineering. 	1 period
2	Immobilization of enzymes	<ul style="list-style-type: none"> - Investigate and describe the use of lactase to produce lactose-free milk. 	2 periods
3	Application of enzyme technology	<ul style="list-style-type: none"> - Investigate and describe the use of pectinase in fruit juice production 	1 period
4	Fermentation, fermenters and the production of penicillin.	<ul style="list-style-type: none"> - Interpret and explain graphs showing how the pH and the concentration of penicillin in a culture changes over time when the pH is controlled and not controlled. - Compare leavened and unleavened bread. 	1 period
5	Antibiotics	<ul style="list-style-type: none"> - Describe the role played by antibiotics in treatment of bacterial diseases. 	2 periods
6	Biogas production	<ul style="list-style-type: none"> - Apply the knowledge of bioreactors, using cow dung, agricultural waste and domestic waste to prepare and produce biogas 	1 period
14	End unit assessment & Remedial		2 periods

Lesson 1: Role of bacteria in biotechnology and genetic engineering

a) Learning objectives

- Explain that bacteria are useful in biotechnology and genetic engineering.
- Discuss why bacteria are useful in biotechnology and genetic engineering.

b) Teaching resources: A computer, books, simulations, charts

c) Prerequisites/Revision/Introduction

The learners learnt about culturing microorganisms such as Bacteria in the previous lessons. This will help students to develop competences (knowledge, skills and attitudes) taught in this lesson.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 11.1 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 11.1.

Bacterial cells can be genetically modified so that they have the gene for producing human insulin. As these modified bacteria grow, they produce human insulin. This protein can be purified and supplied to diabetics. The process of producing genetically engineered bacterial cells will be seen later.

e) Application activities 11.1

Guidance

Ask student-teachers to work in pairs to answer the questions of application activity 11.1.

Answers for application activities 11.1

Bacteria were the first organisms to be genetically modified in the laboratory, due to the relative ease of modifying their chromosomes. This ease made them important tools for the creation of other GMOs. Genes and other genetic information from a wide range of organisms can be added to a plasmid and inserted into bacteria for storage and modification. Bacteria are cheap, easy to grow, clonal, multiply quickly, are relatively easy to transform, and can be stored at -80 °C almost indefinitely. Once a gene is isolated it can be stored inside

the bacteria, providing an unlimited supply for research. The large number of custom plasmids make manipulating DNA excised from bacteria relatively easy.

Lesson 2: Immobilization of enzymes

a) Learning objectives

- Investigate and describe the use of lactase to produce lactose-free milk.

b) Teaching resources: A computer, books, simulations, charts

c) Prerequisites/Revision/Introduction

The learners learnt about culturing microorganisms such as Bacteria in the previous lessons. This will help students to develop competences (knowledge, skills and attitudes) taught in this lesson.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 11.2 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 11.2.

The students will perform the experiment with the help of the teacher and will record the observations and will be able to explain clearly how lactase can be used to produce lactose-free milk.

e) Application activities 11.2

Guidance

Ask student-teachers to work in pairs to answer the questions of application activity 11.2.

Answers for application activities 11.2

Pectinase is an enzyme that breaks down pectin. Pectin is one of the compounds found in plant cell walls; it is in the plate (middle lamella) that is the first part of the wall to be formed during cytokinesis, following cell division. Pectinase therefore helps to break down the cell walls. This increases the volume of juice obtained (increases the yield) lowers the viscosity of the juice (makes it more runny) reduces the cloudiness of the juice.

Lesson 3: Application of enzyme technology

a) Learning objectives

- Investigate and describe the use of pectinase in fruit juice production

b) Teaching resources: A computer, books, simulations on the production of beer

c) Prerequisites/Revision/Introduction

The learners learnt about culturing microorganisms such as Bacteria in the previous lessons. This will help students to develop competences (knowledge, skills and attitudes) taught in this lesson.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 11.3 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 11.3.

- Mix the flour, salt and yeast in a large bowl. Make a well in the centre, add the oil and water, and mix well. If the dough seems a little stiff, add water.
- Tip the dough onto a lightly floured work surface and knead it until the dough becomes satin-smooth.
- Place it in a lightly oiled bowl to prove. Leave to prove for 1 hour until doubled in size or place in the fridge overnight.
- Knock back the dough, then gently mould it into a ball. Place it on a baking tray lined with parchment to prove for a further hour until doubled in size.
- Dust the loaf with flour and cut a cross, about 6cm wide, into the top of the loaf.
- Preheat the oven to 220°C/fan 200°C/gas 7 and bake for 25-30 minutes.
- Bake until golden brown and the loaf sounds hollow when tapped underneath.
- Cool on a wire rack.

(<https://www.bbcgoodfood.com/videos/techniques/how-make-bread>)

e) Application activities 11.3

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 11.3.

Answers for application activities 11.3

1. Amylases

The most commonly used enzyme in baking is amylase. Amylase converts starch to dextrins, oligosaccharides, and the sugar maltose. Maltose provides a fermentable sugar for the yeast, a critical function before adding sugar to bread became common. Other benefits are improved loaf volume and symmetry, darker crust colour, better flavour, and shelf life extension.

2. Proteases

Protease breaks down proteins such as gluten. This reduces mix times, increases dough extensibility and flow, improves gas retention, and produces a darker crust as well as a better crumb grain and texture.

3. Lipases

Lipase breaks down lipids into monoglycerides, diglycerides, and free fatty acids. This increases dough tolerance, improves loaf volume, and allows for a reduction in the use of shortening.

4. Pentosanases and cellulases

These enzymes work on pentosans and cellulose, fibers that are naturally present in wheat and rye. The result is a softening of the dough and a reduced water absorption capacity, which can allow for a shorter bake time in certain baked goods like crackers.

Other enzymes are available for baking such as phospholipases, oxidases, and xylanases and, in fact, it's very common to use blends. This helps achieve the best finished product for the current processing conditions. Opportunities exist for enzyme use in other baked goods as well such as cakes, muffins, pizza crusts, and tortillas.

(<https://blog.watson-inc.com/baking/the-role-of-enzyme-based-dough-improvers-in-bakery-products>)

Lesson 4: Fermentation, fermenters and the production of penicillin

a) Learning objectives

- Interpret and explain graphs showing how the pH and the concentration of penicillin in a culture changes over time when the pH is controlled and not controlled.
- Compare leavened and unleavened bread.

b) Teaching resources: A computer, books, simulations, charts

c) Prerequisites/Revision/Introduction

The learners learnt about culturing microorganisms such as Bacteria in the previous lessons. This will help students to develop competences (knowledge, skills and attitudes) taught in this lesson.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 11.4 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 11.4.

The teacher will introduce the lesson by asking to the students the meaning of fermentation and fermenter. The students will be given time to present their findings on the production of beer using banana juice.

e) Application activities 11.4

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 11.4.

Answers for application activities 11.4

The *Penicillium* cells are grown using a technique called fed-batch culture, in which the cells are constantly subject to stress, which is required for induction of penicillin production. The available carbon sources are also important: glucose inhibits penicillin production, whereas lactose does not. The pH and the levels of nitrogen, lysine, phosphate, and oxygen of the batches must also be carefully controlled.

Lesson 5: Antibiotics

a) Learning objectives

- Describe the role played by antibiotics in treatment of bacterial diseases.

b) Teaching resources: A computer, books, simulations, charts

c) Prerequisites/Revision/Introduction

The learners learnt about culturing microorganisms such as Bacteria in the previous lessons. This will help students to develop competences (knowledge, skills and attitudes) taught in this lesson.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 11.5 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 11.5.

- a) Antibiotics are chemicals which kill or inhibit the growth of bacteria.
- b) The uses of penicillin: penicillin is used to cure bacterial infections diseases such gonorrhea, syphilis...

Penicillin is a widely used antibiotic prescribed to **treat** staphylococci and streptococci **bacterial** infections. **Penicillin** belongs to the beta-lactam family of antibiotics, the members of which use a similar mechanism of action to inhibit **bacterial** cell growth that eventually kills the **bacteria**.

Penicillin is an antibiotic in the penicillin group of drugs. It fights bacteria in your body.

Penicillin is used to treat many different types of infections caused by bacteria, such as ear infections.

e) Application activities 11.5

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 11.5.

Answers for application activities 11.5

Some resistance occurs without human action, as bacteria can produce and use antibiotics against other bacteria, leading to a low-level of natural selection for resistance to antibiotics. However, the current higher-levels of antibiotic-resistant bacteria are attributed to the overuse and abuse of antibiotics. In some countries and over the Internet, antibiotics can be purchased without a doctor's prescription. Patients sometimes take antibiotics unnecessarily, to treat viral illnesses like the common cold.

Lesson 6: Biogas production

a) Learning objectives

- Apply the knowledge of bioreactors, using cow dung, agricultural waste and domestic waste to prepare and produce biogas

b) Teaching resources: A computer, books, simulations, charts

c) Prerequisites/Revision/Introduction

To understand this lesson, the students need to know some information from chemistry such as the uses of alkanes. Alkanes such as methane gas and others are used to produce the energy. They also need to know the process of fermentation seen previously and anaerobic respiration.

d) Learning activities

Ask students to form groups of two or three students and ask them to do the activity 11.6 in the student's book. Tell them to write their findings that they will have to present to the class.

Answers of activity 11.6.

- a) Biogas production is an eco-friendly strategy for energy production from biomass and the residue can be used as a soil conditioner. Biogas is produced by the anaerobic biological breakdown of organic matter. It primarily consists of methane and carbon dioxide. Flammable methane is the main component of biomass (50%–85%), representing the main energy source. It can be used in boilers for heat generation.
- b) Biogas is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes.
- c) The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy released allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking.

e) Application activities 11.6

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 11.6.

Answers for application activities 11.6

Fossil fuels are limited and contribute to the greenhouse effect. **Biogas is renewable and can help to reduce the climate change as well as support the protection and conservation of limited resources. Gases as fuels have one big advantage in comparison to other fuels.**

Biogas is a renewable, as well as a clean, source of energy. Gas generated through bio digestion is non-polluting; it actually reduces greenhouse emissions (i.e. reduces the greenhouse effect). No combustion takes place in the process, meaning there is zero emission of greenhouse gasses to the atmosphere; therefore, using gas from waste as a form of energy is actually a great way to combat global warming.

11.6 Summary of the unit

- Biotechnology is a broad discipline in which biological processes, organisms, cells or cellular components are exploited to develop new technologies. New tools and products developed by biotechnologists are useful in research, agriculture, industry and the clinic.
- The term “immobilized enzymes” refers to “enzymes physically confined or localized in a certain defined region of space with retention of their catalytic activities, and which can be used repeatedly and continuously. Immobilized enzymes are attached to or located within an unreactive support such as nylon that protects it from denaturation.
- There are some disadvantages: immobilization requires extra time, equipment and work; there may be a reduction in reaction rates if enzymes cannot mix freely with the substrate; and immobilized enzymes cannot be used if one of the substrates is insoluble.
- There are several advantages of using immobilized enzymes as the following: (i) reuse (ii) continuous use (iii) less labor intensive (iv) saving in capital cost (v) minimum reaction time (vi) less chance of contamination in products, (vii) more stability (viii) improved process control and (ix) high enzyme: substrate ratio. Enzymes are applied in Brewing, medical, baking, cheese, yoghurt and in bread making.

- Fermentation is anaerobic breakdown of organic compounds by living cells that produces ethanol and carbon dioxide or lactate. *Antibiotics are* powerful medicines that fight certain infections by either stopping bacteria from reproducing or by destroying them.
- Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen.
- There are three stages of biogas production which are the following: **anaerobic fermentation** by eubacteria including *lactobacillus*, which converts the organic waste into a mixture of organic acids and alcohol, with some Hydrogen, Carbon dioxide, and acetate, **acetogenic reaction** by *bacteria* such as *acetobacterium* which, in addition to acetate, produce hydrogen and Carbon dioxide from the organic acid and alcohol and **methanogenic reactions** by archaeobacteria, including *Methanobacterium*, *Metanococcus*, and *Methanospirillum*.

11.7 Additional Information for teachers

There are numerous sub-fields of biotechnology. While the three main forms of biotechnology are medical, agricultural and industrial (sometimes called «red,» «green» and «white» biotechnologies, respectively), there are many different types of biotechnology, some of which fall outside the scope of these three main fields and some of which combine multiple types.

1. **Red biotechnology** is biotechnology applied to medical processes. Some examples are the designing of organisms to produce antibiotics, and the engineering of genetic cures to cure diseases through genomic manipulation.
2. **White biotechnology**, also known as **grey biotechnology**, is biotechnology applied to industrial processes. An example is the designing of an organism to produce a useful chemical. White biotechnology tends to consume less in resources than traditional processes when used to produce industrial goods.
3. **Green biotechnology** is biotechnology applied to agricultural processes. An example is the designing of an organism to grow under specific environmental conditions or in the presence (or absence) of certain agricultural chemicals. One hope is that green biotechnology might produce more environmentally friendly solutions than traditional industrial agriculture. An example of this is the engineering of a plant to express a pesticide, thereby eliminating the need for external application of pesticides. Whether or not green biotechnology products such as this are ultimately more environmentally friendly is a topic of considerable debate.

4. The term **blue biotechnology** has also been used to describe the marine and aquatic applications of biotechnology, but its use is relatively rare.

Biotechnology in Production of Antibiotics

Plants are used to develop antibiotics for **Humans** as well as for **Animal** use. It helps in production of antibiotics, vaccines and artificial hormones for hormone therapies.

Edible Vaccines are mucosal-targeted vaccines, which cause stimulation of both systematic and mucosal immune response. Edible vaccines hold great promise as a cost-effective, easy-to-administer, easy-to-store and fail-safe readily acceptable vaccine delivery system, especially for the poor developing countries. It involves introduction of selected desired genes into plants and then inducing these altered plants to manufacture the encoded proteins. Edible vaccines are being developed for various diseases, such as Measles, Cholera and Hepatitis B, and many more are in the process of development.

Guidance on skills Lab

The skill lab presented in the student's book is a practical work. The teacher will help the learners to find the appropriate materials required to make the filtration of water.

11.8 End unit assessment (answers)

1. There are five different techniques of immobilizing enzymes: (i) adsorption, (ii) covalent bonding, (iii) entrapment, (iv) copolymerization or cross-linking, and (v) encapsulation. (More explanations can be seen in the student's book).
2. Biogas is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.
3. Even if antibiotics play a major role in actual medicine, the excessive use of antibiotics continues to generate unwanted side effects, and continues to have severe health consequences around the world.
4. Bacteria become resistant through a gene mutation or by acquiring a resistance from other bacteria. Bacteria can exchange the plasmids through conjugation.

5. The production of biogas involves three stages and three communities of microorganisms namely
 - a) **Anaerobic fermentation** by eubacteria including *Lactobacillus*, which converts the organic waste into a mixture of organic acids and alcohol, with some Hydrogen, Carbon dioxide, and acetate.
 - b) **Acetogenic (acetate-producing) reaction** by bacteria such as acetobacterium which, in addition to acetate, produce hydrogen and Carbon dioxide from the organic acid and alcohol.
 - c) **Methanogenic (methane-producing) reactions** by *archaebacteria*, including *Methanobacterium*, *Metanococcus*, and *Methanospirillum*.
6. The main ingredients include: bread-flour, dry yeast ('rapid rise'), levain (sourdough), salt, water, sugar, and eggs.

11.9 Additional activities (Questions and answers)

11.9.1 Remedial activities

- 1) What do you understand with biotechnology?
- 2) Why are enzymes added to washing powder?
- 3) Describe the role of the fungus *Penicillium* in the production of the antibiotic penicillin.
- 4) Explain why the biological washing-powder should not be used in boiling water.

Answers for remedial activities

- 1) Biotechnology is a controlled and deliberate manipulation of biological systems (whether living cells or cell components) for the efficient manufacture or processing of useful products.
- 2) The biological *washing powders contain* enzymes like protease and lipase to remove protein stains and fat/grease from clothes. The *enzymes* break down proteins or fats on the fabric, forming water-soluble substances that can be washed away.
- 3) Penicillin is produced commercially by growing the fungus *Penicillium chrysogenum* in large stirred fermenters.
- 4) Enzymes are denatured at high temperature, and will not wash properly.

11.9.2 Consolidation activities

- 1) State the advantages of using immobilized enzymes.
- 2) Silk is a material made from protein. Explain why the biological washing powder should not be used to wash silk clothes.
- 3) Justify why specialized biologists should minimize the build-up of end-products during scaling-up.
- 4) Explain why antibiotics affect bacteria and not viruses.

Answers of consolidated activities

1. The advantages of using immobilized enzymes are: (i) reuse (ii) continuous use (iii) less labor intensive (iv) saving in capital cost (v) minimum reaction time (vi) less chance of contamination in products, (vii) more stability (viii) improved process control and (ix) high enzyme: substrate ratio.
2. There is protease in the biological washing powder. This would digest the protein in the silk so the clothes would get spoiled.
3. Specialized biologists should minimize the build-up of end-products during scaling up production, because the build-up of end products acts as inhibitors which may reduce production.
4. Penicillin as an antibiotic affects bacterium which are biotic and not viruses which are abiotic.

11.9.3 Extended activities

- 1) Defend the role played by antibiotics in treatment of bacterial diseases.
- 2) Compare leavened and unleavened bread.
- 3) Draw a well labelled diagram of a fermenter.
- 4) Identify three communities of microorganisms that are involved in each stage of biogas production.

Answers for extended activities

- 1) Expected answers are in the student book.
- 2) Expected answers are in the student book.
- 3) Expected answer is in students' text books
- 4) The three communities of microorganisms that are involved in each stage of biogas production include:

- Eubacteria including *Lactobacillus*, which converts the organic waste into a mixture of organic acids and alcohol, with some Hydrogen, Carbon dioxide and acetate.
- *Bacteria* such as acetobacterium which, in addition to acetate, produce hydrogen and Carbon dioxide from the organic acid and alcohol.

Archaeobacteria including *Methanobacterium*, *Metanococcus*, and *Methanospirillum*

UNIT 12

HUMAN REPRODUCTIVE SYSTEM, GAMETOGENESIS, PREGNANCY AND METHODS OF BIRTH CONTROL

12.1 Key unit competence

Relate the structures of the human reproductive system to their functions and describe gamete formation and explain the role of hormones in human reproduction, stages of pregnancy, contraceptive methods and fetal development.

12.2 Prerequisites

Students are equipped with knowledge, skills and attitudes that they have developed from the study of cells, specialized tissues and human reproductive system.

12.3 Cross cutting issues to be addressed

Comprehensive sexuality

Comprehensive sexuality will be addressed through questions that will be asked to students and to the knowledge and skills that will be developed by the unit. The questions should be like: What are the consequences of non-planned pregnancy? Is non-planned an issue in Rwanda? How young people should behave in relation to sexuality?

Gender

Gender will be addressed when students will understand that the biological differences in humans are the results of hormonal system. Therefore, they will be sensitised that the biological differences should not be considered in job determination for individuals since all people can achieve.

Inclusive education

This unit involves a number of activities on research from different sources and experiments that require the listening and vision. This may be challenging to students with special educational needs especially children with visual impairment. However, the teacher can do the following:

- Grouping students with special educational needs with others and assigned roles basing on individual student's abilities.
- Providing procedure earlier before the experiment so that students get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts.
- Every important point is written and spoken. The written points help students with hearing impairment. Speaking aloud helps students with visual impairment
- Remember to repeat the main points of the lessons.

12.4 Guidance on introductory activity

Ask students to observe and do analysis of pictures given in student textbook and discuss about them. After discussion, they will answer to the questions from the activity 12.1 and some students may present their findings to the class.

Answers to the introductory activity

- a) The origin of the fetus is the fusion of the male and female gametes during fertilization. The first cell formed is called the zygote. The zygote develops into an embryo and later a fetus.
- b) Use the student's book to find more details on the embryonic development.
- c) Use the student's book to find more details on the parts of the female reproductive system and their functions.
- d) Use the student's book to find more details on the parts of the male reproductive system and their functions.
- e) Increase in size of the breasts, uterus, Breast may become large and more tender because of increased level of estrogen hormone progesterone thus breast gets even bigger to prepare for breast feeding.
Nipples may stick out more.

12.5 List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	The male and female human reproductive systems.	<ul style="list-style-type: none"> - Describe the structure of human male and female reproductive systems. - Relate the histology of the testis and ovary to their functions. 	2 periods
2	Gametogenesis	<ul style="list-style-type: none"> - Describe how female and male gametes are produced. - Analyze and interpret chart diagrams of spermatogenesis and oogenesis. 	2 periods
3	The menstrual cycle in humans	<ul style="list-style-type: none"> - Describe the main events of the menstrual cycle and explain how hormones interact to regulate the menstrual cycle. - Distinguish between an estrous and menstrual cycle. 	1 period
4	Copulation, fertilization and fetal development	<ul style="list-style-type: none"> - Explain how a sperm enters and fertilises an ovum and how only one sperm fertilises an ovum. 	2 periods
5	The role of placenta in the development of an embryo.	<ul style="list-style-type: none"> - Describe how a human embryo develops and the role of the extra embryonic membranes in pregnancy. - Explain how the placenta forms and discuss its functions. 	1 period
6	Physiological changes in females during pregnancy, gestation period, birth and Parental care.	<ul style="list-style-type: none"> - Discuss the significance of parental care in mammals. 	1 period
7	Twins and multiple births.	<ul style="list-style-type: none"> - Explain how twins and multiple births arise. 	
8	Infertility and in-vitro fertilization.	<ul style="list-style-type: none"> - Identify the technique of in vitro fertilisation (IVF). 	

9	Family planning and contraceptive methods.	- Discuss the advantages and disadvantages of different birth control methods.	2 periods
10	End unit assessment & Remedial		2 periods

Lesson 1: The male and female human reproductive systems

a) Learning objective

- Describe the structure of human male and female reproductive systems.
- Relate the histology of the testis and ovary to their functions.

b) Teaching resources

A computer, a projector, simulations, books, charts showing the male and female reproductive systems.

c) Prerequisites/Revision/Introduction

To understand this lesson, students are required to know the tissues of the human body and the secretions produced by the gonads: testes and ovaries.

d) Learning activities

This is a practical activity that requires great attention of the teacher and the students

Materials required:

Dissecting kit

Scissors

Razor blades

Goggles

Gloves

1 rat per group. Each group will have enough material to make their own dissection. The teacher will be moving around to see if there is any problem in the group while doing the dissections. The students will analyze the parts of the male and female reproductive system and their functions.

e) Application activities 12.1

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 12.1.

Answers to application activities 12.2.

- a) 1: epididymis, 2: vas deferens, 3: urinary bladder, 4: ureter, 5: seminal vesicles, 6: prostate gland, 7: penis, 8: urethra.
- b) 1: Maturation of sperm
- 2: Carries sperm from the epididymis to the ejaculatory duct.
- 5: Produce secretions that contain nutrients to nourish the sperm.
- 8: Carries urine from the urinary bladder to the bladder.

Lesson 2: Gametogenesis

a) Learning objective

- Describe how female and male gametes are produced.
- Analyze and interpret chart diagrams of spermatogenesis and oogenesis.

b) Teaching resources: a computer, books, simulations and charts showing the process of spermatogenesis.

c) Prerequisites/Revision/Introduction

Students need to know the male and female reproductive system and their functions.

d) Learning activities

The students will put in groups of five to six children and will watch the movie on the gametogenesis process. They may also be given charts showing spermatogenesis and oogenesis. In their groups, students will make the activity 12.2.

Answers to the learning activity 12.2.

The number of chromosomes before meiosis is equal to 46 ($2n = 46$). The number of chromosomes following meiosis is equal to 23 ($2n = 23$).

e) Application activities 12.2

Guidance

Ask student-teachers to work individually to answer the questions of application activity 12.2.

Answers: check for the figure of a sperm and that of an egg to identify the parts in the question.

Lesson 3: The menstrual cycle in humans

a) Learning objective

- Describe the main events of the menstrual cycle and explain how hormones interact to regulate the menstrual cycle.
- Distinguish between an estrous and menstrual cycle.

b) Teaching resources: a computer, books, simulations and charts showing the menstrual cycles.

c) Prerequisites/Revision/Introduction

Students need to know the male and female reproductive system and their functions.

d) Learning activities

The students will put in groups of five to six children and will watch the movie on the menstrual cycles. After watching a movie, they will discuss on what they have seen and will identify the hormones involved in menstrual cycles and their functions. In their groups, students will make the activity 12.3.

Answers to the learning activity 12.3.

- 1) Before menstruation to occur, hypothalamus releases gonadotrophin releasing hormone (GnRH) which stimulates anterior pituitary gland to secrete follicle stimulating hormone (FSH) which stimulates the development of a primary follicle. It also stimulates production of estrogen hormone (steroid hormone) by uterine cells (theca cells). Estrogen promotes healing, repair and growth of uterine lining. It also inhibits secretion of FSH. And Stimulates secretion of luteinizing hormone (LH) by pituitary gland. The surge of LH brings about ovulation, LH also stimulates secretes of progesterone hormone, Progesterone hormone maintains corpus luteum **and** Progesterone hormone also inhibits secretion of FSH and LH.

- 2) Their function is to coordinate the timing of each phase of the menstrual cycle.
- 3) Check in the student's book.
- 4) On the 14th day of the cycle.

e) Application activities 12.3

Guidance: Ask student-teachers to work in pairs to answer the questions of application activity 12.3.

Answers for application activities 12.3.

1.
 - i. Corpus luteum / yellow body
 - ii. The follicles that remain in the ovary after ovulation.
 - iii. To produce progesterone that maintains the endometrium.
 - iv. It degenerates
 - v. FSH.

Lesson 4: Copulation, fertilization and fetal development

a) Learning objective

- Explain how a sperm enters and fertilises an ovum and how only one sperm fertilises an ovum.

b) Teaching resources

A computer, books, simulations and charts showing the process of fertilization and the embryonic development.

c) Prerequisites/Revision/Introduction

Students need to know the male and female reproductive system and their functions, the hormones produced and their functions.

d) Learning activities

The students will put in groups of five to six children and will watch the movie on the gametogenesis process. They may also be given charts showing the embryonic development. In their groups, students will make the activity 12.4.

Answers to the learning activity 12.4.

See more details on the embryonic development in the student's book.

e) Application activities 12.4

Guidance

Ask student-teachers to work in pairs to answer the questions of application activity 12.4.

Answers for application activities 12.4.

- a. i. Ovulation
 - ii. Mitosis
 - iii. Corpus luteum
 - iv. Progesterone
- d) The letter should be on the oviduct.

Lesson 5: The role of placenta in the development of an embryo

a) Learning objective

- Describe how a human embryo develops and the role of the extra embryonic membranes in pregnancy.
- Explain how the placenta forms and discuss its functions.

b) Teaching resources

A computer, a projector, simulations, books, charts showing the embryonic development of a human.

c) Prerequisites/Revision/Introduction

To understand this lesson, students are required to know the tissues of the human body and the secretions produced by the gonads: testes and ovaries.

d) Learning activities

1. a) A: amniotic fluid, B: uterus, C: umbilical cord, D: placenta.
- b) Substances which pass from the mother to the embryo: oxygen, glucose, amino acids and vitamins.
- c) One substance which passes from the embryo to the mother: carbon dioxide,

d) A: absorbs shocks, protects the fetus. B: where the embryo or fetus develops. C: links the fetus to the mother; D: makes hormones, exchange of substances between the fetus and the mother

e) Transfers nutrients from the mother to the fetus; makes hormones...

Guidance: Ask student-teachers to work in pairs to answer the questions of application activity 12.4.

Answers to application activities 12.5.

1. a)

Circulatory system	Blood vessels that carry oxygenated blood
Maternal	V
Fetal	Y

The structure **T** is the umbilical cord. After birth, the umbilical cord is cut and tied off.

a) The placenta transfers nutrients such as glucose, amino acids, vitamins, minerals, oxygen... which are used in different metabolic reactions of the fetus. It also removes the metabolic waste products such as urea and carbon dioxide.

Lesson 6: Physiological changes in females during pregnancy, gestation period, birth and Parental care.

a) Learning objective

- Discuss the significance of parental care in mammals.

b) Teaching resources: a computer, a projector, simulations, books.

c) Prerequisites/Revision/Introduction

To understand this lesson, students are required to know the effects of different hormones produced during pregnancy and their functions.

d) Learning activities 12.6

The physiological changes that can be observed to the pregnant woman can be read from the student's book.

e) Application activities 12.6

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 12.6.

Answers to application activities 12.6.

1.

Hormone	Site of secretion	Effect(s) of hormone	
		Ovary	Endometrium
FSH	Pituitary gland	Stimulates the growth of follicles in the ovary	None
LH	Pituitary gland	Stimulates the process of ovulation.	None
Estrogens	Ovary	None	Stimulates the thickening of the endometrium wall.
Progesterone	Ovary	None	Stimulates the maintenance of the endometrium wall.

2. Cleavage, differentiation and organogenesis.
3. The embryo is more susceptible to damage because the organs are being made (organogenesis) whereas in the fetus the organs have been formed. In the fetus, the organs are increasing in size so not more susceptible to damage.
4. The umbilical cord is cut before the fetus has started to breathe on its own as it stimulates the process of breathing in the fetus.

Lesson 7: Twins and multiple births

a) Learning objective

- Describe the structure of human male and female reproductive systems.
- Relate the histology of the testis and ovary to their functions.

b) Teaching resources: a computer, a projector, simulations, books, charts showing the formation of twins.

c) Prerequisites/Revision/Introduction

To understand this lesson, students are required to know the embryonic development seen previously.

d) Learning activities

The teacher forms groups of 3 to four students and do the activity 10.7 in the student's book. They provide possible answers and make short notes that they can present in the classroom.

Answers of activity 12.7.

For the answers of this activity, check in the student's book.

e) Application activities 12.7

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 12.6.

Answers to application activities 12.7.

1. a) Type A: asexual reproduction. Type B: sexual reproduction.
- b) It is quick, it requires only one parent
- c) The reproduction type A differs from the formation of twins in that it originates from one parent whereas the identical twins arise from the fertilization of an egg with a sperm which gives a zygote. The two sperm come from two parents. In type A the gametes are not used whereas in the identical twins the gametes are used.

Lesson 8: Infertility and in-vitro fertilization

a) Learning objective

- Identify the technique of in vitro fertilization (IVF).

b) Teaching resources: a computer, a projector, simulations, books and a chart showing the process of in vitro fertilization.

c) Prerequisites/Revision/Introduction

To understand this lesson, students are required to know normal process of fertilization and the embryonic development.

d) Learning activities

The teacher forms groups of 4 or 5 students. In their groups, the students watch a movie on the process of in vitro fertilization and outline how in vitro fertilization takes place and how it differs from the normal fertilization.

Answers to the activity 12.8.

For this activity, check the answers in the student's book.

e) Application activities 12.8

e) Application activities 12.8

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 12.8.

Answers to application activities 12.8.

For the answers of this activity, check in the student's book.

Lesson 9: Family planning and contraceptive methods

a) Learning objective

- Discuss the advantages and disadvantages of different birth control methods.

b) Teaching resources: a computer, a projector, simulations, books and a movie showing the different contraceptive methods.

c) Prerequisites/Revision/Introduction

To understand this lesson, students are required to know the parts of the reproductive system and their functions.

d) Learning activities

The teacher forms groups of 4 or 5 students. In their groups, the students watch a movie on the process of in vitro fertilization and outline how in vitro fertilization takes place and how it differs from the normal fertilization.

Answers to the activity 12.8.

A: Intra uterine device; B: male condoms; C: tubal ligation; D: diaphragm; E: pills; F: vasectomy

The more effective are: IUD and the pills because they have a low rate of failure and can be used for a long time. Vasectomy and tubal ligation have a very low failure rate but they are irreversible.

e) Application activities 12.9

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 12.9.

Answers to application activities 12.9.

1. Abstinence and condoms
 - a. Estrogens
 - b. A and E.
 - c. A: the follicles are not growing because during pregnancy, the FSH hormone secretion is inhibited to prevent the growth of another follicle.
E: During the early stages of pregnancy, the corpus luteum continue to produce progesterone which maintains the endometrium wall.
 - d. Stage
 - e. A: the high levels of estrogens prevents the secretion of FSH which also prevents the growth of another ovarian follicle.

12.6 Summary of the unit

- Menstrual cycle monthly cycle occurs after 28 days unless interrupted by pregnancy. It is monthly discharge of blood a process called menstruation. This cycle is controlled by four hormones such FSH, LH, oestrogen and progesterone secreted by anterior pituitary gland and ovary respectively. The natural cycle repeats until there is either a pregnancy or the woman reaches menopause (the end of the reproductive phase of a woman's life). It undergoes three phases such as; follicular phase, ovulatory phase and lacteal phase.
- Oestrus cycle. Is derived from Latin oestrus meaning sexual desire. The female animal is sexually and receptive to the male.
- Fertilization is the union of sperm and egg nuclei to form zygote. It takes place in upper part of oviduct (fallopian tube) after fertilization, Zygote traveling down the oviduct (Fallopian tube)) by peristaltic contraction and by beatings of the cilia in wall of the oviduct toward the uterus. As it travels, it divides by mitosis several times to form a ball of cells called a morula. The cell divisions, which are called cleavage, increase the number of cells but not their overall size. More cell divisions occur, and soon a fluid-filled cavity forms inside the ball of cells. At this stage, the ball of

cells is called a blastocyst. The blastocyst reaches the uterus and becomes embedded in the endometrium at roughly the 5th – 10th day.

- Once in the uterus the blastocyst burrows into the uterine wall a process called implantation. When mother's blood gets contacts with fetal blood vessels, Oxygen and nutrients enters fetus and carbon dioxide from the fetus's blood by diffusion, active transport, and selective absorption between the fetal blood and maternal blood.
- There are some birth control methods such as Intrauterine device, Cap (diaphragm), condom, Tubal ligation, vasectomy and Abstinence it ends with sexual transmitted infections such as: AIDS, Syphilis, Herpes and Gonorrhoea.

12.7 Additional Information for teachers

- At birth, and usually until sexual intercourse or vigorous physical activity ruptures it, a vascularized membrane called the **hymen** partially covers the vaginal opening in humans. The vaginal opening and the separate urethral opening are located within a region called the vestibule, bordered by a pair of slender skin folds, the labia minora. A pair of thick, fatty ridges, the labia majora, enclose and protects the labia minora and vestibule. During sexual arousal, the clitoris, vagina and labia minora all engorge with blood and enlarge. The clitoris consists largely of erectile tissue. Richly supplied with nerve endings, it is one of the most sensitive points of sexual stimulation.
- G – Spot is a sensitive area of the anterior wall of the vagina believed by some to be highly erogenous and capable of female ejaculation. The G-spot, also called the Gräfenberg spot is characterized as an erogenous area of the vagina that, when stimulated, may lead to strong sexual arousal, powerful orgasms and potential female ejaculation. It is typically reported to be located 5–8 cm (2–3 in) up the front (anterior) vaginal wall between the vaginal opening and the urethra and is a sensitive area of a female.

Guidance on Lab skills

This skill lab has two end goals: to help all learners to know their fertile period for girls or women with irregular menstrual cycle and to know the use of pregnancy test. It is important that everyone knows how to calculate the fertile period as it can help to avoid unintended pregnancy and also to help in family planning. This skill lab will also help students to know the working and use of pregnancy test.

12.8 End unit assessment (answers)

1. a)
2. c)
3. a) a: estrogens, b: FSH, c: progesterone, d: LH
b) On the 12th day
4. Check the answers in the student's book.
5. a) Puberty
b) Testosterone
c) Check in the student's book
d) i. Mitosis
ii. Check in the student's book
iii. Breaking of the amniotic sac, powerful contractions of the uterus.

12.9 Additional activities (Questions and answers)

12.9.1 Remedial activities

- 1) From which body layer in embryo does brain develop?
- 2) List the extraembryonic membranes.
- 3) Which membrane form the foetal side of the placenta.
- 4) What is the role of: i) relaxin and ii) oxytocin during pregnancy?
- 5) What is the name given to an embryo when it reaches 8 old weeks?
- 6) Name the birth control method that is used after sexual intercourse.
- 7) Which type of birth control method offers some protection against sexually transmitted disease?

Remedial activities (Answers)

- 1) Ectoderm
- 2) Amnion, York sac, chorion and allantois.
- 3) Chorion
- 4) i) relaxes connective tissue in bones of pelvic girdle,
ii) Stimulates uterine contraction
- 5) Foetus
- 6) Morning after pills,
- 7) Abstinence and condoms

12.9.2 Consolidation activities

- 1) Describe various hormones secreted by placenta during pregnancy.
- 2) Some lactating mothers have plenty of milk but it does not flow freely to nipple. They therefore have difficulty in breast feeding their babies. Suggest which hormone might lack.
- 3) What are the functions of?
 - (i) The acrosome reaction and
 - (ii) The cortical reaction.
- 4) Describe features that aid of placenta to transfer materials

Answers to consolidation activities

- 1) There are three hormones: Human chorionic gonadotrophic hormone, progesterone hormone and oestrogen hormone.
- 2) Oxytocin.
- 3) (i) Acrosome reaction enables sperm to penetrate an oocyte.
(ii) Cortical reaction. To form fertilization membrane, preventing further entry of sperm into ovum.
4. - It provides a large surface area for the exchange
 - Maternal blood flows closer to the foetal blood
 - Provides a minimal barrier for diffusion and active transport of materials

12.9.3 Extended activities

- 1) Explain why are sperms unable to fertilize an oocyte until they have spent some time in female reproductive tract.
- 2) Name two substances that enter the umbilical vein and two substances that leave from the umbilical artery.
- 3) Explain why does maternal blood never come into direct contact with foetal blood?
- 4) What is the role of amniotic fluid?
- 5) Study the diagram of the male reproductive system below

UNIT 13

INHERITANCE AND MUTATIONS

13.1 Key unit competence

Explain the role of genes in inheritance, how genetic disorders occur and describe the types, causes and effects of mutation in organisms.

13.2 Prerequisites

Student-teachers will learn better this unit if they know the following:

- Sexual reproduction.
- Chromosomes
- Introduction to genetics

As tutor, you start this unit by asking questions related to the above topics studied in ordinary level to ensure that student-teachers have good foundation to this new unit.

13.3 Cross cutting issues to be addressed

a) Inclusive education

The tutor should organize the activities that involve fully participation of all student-teachers.

Special arrangements should be made to take care of student-teachers with special needs. For example, large print text for those with visual problems and allocate physically challenged student-teachers to others to assist them during field trips and practical activities. Further, this category should be given tasks that they can manage during the practical sessions.

b) Standardization culture

Bring to the student-teachers' attention the need to appreciate inheritance of sex-linked traits. Also emphasize the need to seek medical healthcare in standard and quality hospitals whenever they have signs and symptoms of haemophilia to avoid being given fake or substandard drugs.

c) Gender education

Emphasize to learners that inheritance of sex in human beings follows the Mendelian fashion and that couples have a 50% chance of getting either boy or girl who are equally important.

d) Financial education

Emphasize the need for going through genetic counseling before partners proceed to getting married to avoid transmitting genetic disorders whose treatment could have financial implications.

13.4 Guidance on introductory activity

Make groups of four or five and ask them to observe the images in the introductory activity 13. Print or write the guiding questions on chalkboard. Ask student-teachers to answer questions of **introductory activity 13** as designed in Student's Book on observed diagram.

Notes: This activity is very essential since it captures the attention of student-teachers. As a tutor, you are required to give such activity because it has the following benefits:

- It creates curiosity among student-teachers and enhances active learning through practice.
- It promotes critical thinking and allows student-teachers to predict the next lessons.

The tutor is encouraged to set clear introductory activity which can give a general picture of the whole unit if possible.

13.5 List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Concept of inheritance and monohybrid inheritance	<ul style="list-style-type: none">- Describe an example of inheritance involving multiple alleles.- Analyze various patterns of inheritance.	3 periods
2	Co-dominance, multiple alleles and lethal alleles.	<ul style="list-style-type: none">- Explain the effect of lethal genes on phenotype ratios.- Give a genetic explanation of Mendelian dihybrid inheritance.	2 periods
3	Dihybrid inheritance	<ul style="list-style-type: none">- Explain the use of test crosses to determine unknown genotypes in studies of dihybrid inheritance.- Use genetic diagrams to solve problems involving dihybrid crosses	3 periods
4	Linkage and crossing over	<ul style="list-style-type: none">- Explain why linked genes do not show independent assortment.	2 periods
5	Sex determination and sex linkage.	<ul style="list-style-type: none">- Explain how sex is determined in humans and the role of sex related Y genes in determining sex.- Describe how non-disjunction can affect the distribution of sex chromosomes in gametes and offspring.	2 periods
6	Mutations and genetic disorders	<ul style="list-style-type: none">- Describe mutation, types of mutation and causes of mutations.- Explain the significance of mutations.	3 periods

7	Types of mutations	- Explain that gene mutation occurs by substitution, deletion, inversion and insertion of base pairs in DNA and discuss how such mutations may affect the phenotype.	2 periods
8	Causes, effects and significance of mutations	- - Explain how a change in the base sequence of the gene for haemoglobin results in abnormal haemoglobin and sickle-shaped red blood cells.	3 periods
	End assessment unit		2 periods

Lesson 1: Concept of inheritance and monohybrid inheritance

a) Learning objective

- Describe an example of inheritance involving multiple alleles.
- Analyze various patterns of inheritance.

b) Teaching resources

Computer, projector, simulation, etc.

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Sexual reproduction
- Chromosome
- Meiosis

Let student-teachers remember what they have learnt about meiosis and sexual reproduction in animals and plants studied in previous level. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups.
- Tell them to answer the questions in the activity 13.1.
- Provide questions to answer which are related to genetic terminologies.

- Invite any groups to present their findings to the rest of student-teachers.
- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student-teacher's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and engage student-teachers while making conclusion.

Answer to learning activities 13.1

- a) Skin color, size of the cat, sex, shape of the ears...
- b) Through genes or genetic information transmitted from the parents to their offspring.
- c) 19. It receives half of the chromosomes from its father and half of the chromosomes from its mother.

e) Application activity 13.1

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 13.1.

Answers to application activities 13.1

1. a) 24
b) 1
c) 50
d) 23 (change rat by gorilla)

2. a) Axial flower

b) A: axial; a: terminal

Parents	Female	X	Male
Phenotype	Axial flower (A)		terminal flower (a)
Genotype	AA		aa
Gametes	A, A		a, a

F1:

♂		
♀	a	a
A	Aa	Aa
A	Aa	Aa

F1 Genotype: Aa (Heterozygous): 100%

F1 Phenotype: All with axial flowers

F2: F1 X F1

Parents Female X Male

Phenotype Axial flowers X Axial flowers

Genotype Aa Aa

Gametes A, a A, a

F2:

♂		
♀	A	a
A	AA	Aa
a	Aa	aa

F2 Genotypes: AA: 1/4: 25%

Aa: 2/4: 50%

aa: 1/4: 25%

F2 Phenotypes = Axial flowers; 3/4 (75 %)

Terminal flowers = 1/4 (25 %)

3 Axial: 1 terminal

d) The ratio of phenotypes in F2: 3 Axial : 1 terminal

The number of plants with terminal flowers is $360 / 3 = 120$ plants.

Lesson 2: Co-dominance, multiple alleles and lethal alleles

a) Learning objective

- Explain the effect of lethal genes on phenotype ratios.
- Give a genetic explanation of Mendelian dihybrid inheritance.

b) Teaching resources

Photo of roan coat cattle, computer, projector, simulation of incomplete dominance

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Genetic terminologies.
- Monohybrid inheritance seen in the previous lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of activity 13.2 in Student's Book.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.
- Ask student-teachers to demonstrate working procedure on chalk board.
- Provide another exercise for fixing working procedures. Fixation exercise should be done on monohybrid inheritance (dominance and incomplete dominance).
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and engage student-teachers while making conclusion

Answer to learning activities 13.2

This is an example of codominance. In codominance, the phenotype of the offspring is the same as that of both parents.

e) Application activity 13.2

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 13.2.

Answers to application activities 13.2

1. a) Key: R is red flower, W is white

Parents RR x WW

Gametes R x W

F₁ RW all pink

b) F1 parents RW x RW

Gametes R or W and R or W

F₂ genotypes: RR, RW, RW, WW

F₂ Phenotypes: 1 red: 2 pink: 1 white

2. The man has blood group B so he can have 2 genotypes: BB or BO

The woman of blood group AB has only one genotype AB

Possible crossings

First case: Parents BO x AB

Gametes B, O and A, B

Offspring

Gametes	A	B
B	AB	BB
O	AO	BO

The possible groups of their offspring are A, B and AB

Second case: Parents BB x AB

Gametes B and A, B

Offspring:

Gametes	A	B
B	AB	BB
B	AB	BB

The possible groups of their offspring are AB and B

The blood group their children will not have is blood group O.

Lesson 3: Dihybrid inheritance

a) Learning objectives

- Explain the use of test crosses to determine unknown genotypes in studies of dihybrid inheritance.
- Use genetic diagrams to solve problems involving dihybrid crosses.

b) Teaching resources

Computer, projector, books

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Monohybrid crosses.

Let student-teachers remember what they have learnt about transmission of characters (traits) in animals and plants studied in previous lesson. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of make a research on dihybrid inheritance.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.

Answer to learning activities 13.3.

Check information about the dihybrid inheritance in the student's book.

e) Application activity 13.3

Guidance

Ask student-teachers to work individually or in pair to answer the questions of **application activity 13.3** as designed in Student's book.

Answer to application activities 13.3

1. The F_1 phenotypes show that purple flower and short stem are dominant and red flower and long stem are recessive.

The approximate ratio of 1:1:1:1 in a dihybrid cross suggests that the two genes controlling the characteristics of flower color and stem length are not linked and the four alleles are situated on different pairs of chromosomes.

Let P represents purple flower

p represents red flower

S represents short stem

s represents long stem

Since the parental stocks were both homozygous for both characters, the F_1 genotypes must be PpSs

Test cross: PpSs x ppss

Gametes	PS	Ps	pS	ps
ps	PpSs	Ppss	ppSs	ppss

Offspring genotype: PpSs, Ppss, ppSs and ppss.

Offspring phenotype: 1 purple flower short stem, 1 purple flower long stem, 1 red flower short stem and one red flower long stem

2. a) i). One copy, as only one chromosome is present from each pair as the chromosome number is halved at meiosis, i.e haploid number.
ii). Two copies, as in a leaf cell the chromosomes are in pairs, i.e diploid
- b) i. RrTt
ii. Yellow fruit, tall

iii.

	rT	rt
RT	RrTT	RrTt

50% have red fruits

Lesson 4: Sex determination and sex linkage

a) Learning objectives

- Explain why linked genes do not show independent assortment.

b) Teaching resources

Textbooks, computer, projector, simulation, internet, etc.

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Monohybrid and test cross.
- Chromosomes

Let student-teachers remember what they have learnt about transmission of characters (traits) in animals and plants studied in previous lesson. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of activity 13.4 in Student's Book.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.
- Ask student-teachers to demonstrate working procedure on chalk board.
- Provide another exercise for fixing working procedures. Fixation exercise should be done on sex linked diseases.
- Tick the correct findings and engage student-teachers while making conclusion.

- Harmonize the student-teachers' findings.

Answer to learning activities 13.4

The answer is discussed in **Unit 13 of student's Book.**

e) Application activity 13.4

1. a) 1 : 1 : 1 : 1

- b) Linkage; that is the two loci are on the same chromosome. The alleles for grey body and straight wings are on one homologous chromosome in the heterozygote and the alleles for ebony body and curled wings are on the other homologous chromosome. There is linkage with crossing over.

$$c) \text{ Crossover frequency} = \frac{30+29}{113+30+29+115} \times 100\% = 20.6\%$$

Lesson 5: Sex determination and sex linkage

a) Learning objectives

- Explain how sex is determined in humans and the role of sex related Y genes in determining sex.
- Describe how non-disjunction can affect the distribution of sex chromosomes in gametes and offspring.

b) Teaching resources

Textbooks, computer, projector, internet, etc.

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Sex linked disorders
- Chromosomes

Let student-teachers remember what they have learnt about transmission of characters (traits) in animals and plants studied in previous lesson. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of activity 13.5 in Student's Book.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.
- Ask student-teachers to demonstrate working procedure on chalk board.
- Provide an exercise on sex determination for fixing working procedures.
- Tick the correct findings and engage student-teachers while making conclusion.
- Harmonize the student-teachers' findings.

Answer to learning activities 13.5

The answer is discussed in **Unit 13 of student's Book.**

e) Application activity 13.5

1. a) A gene / trait / allele carried on a sex chromosome / X or Y.
b) Recessive. Evidence from the pedigree (e.g. 2nd generation-2 and -3 do not have the condition but have one child who does).
c) X^aY (where a = condition)
d) X^AX^a or X^AX^A where A = normal and a = condition.

Lesson 6: Mutations and genetic disorders

a) Learning objectives

- Describe mutation, types of mutation and causes of mutations.
- Explain the significance of mutations.

b) Teaching resources

Textbooks, computer and projector

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- The genetic code
- Protein synthesis
- Chromosomes

Let student-teachers remember what they have learnt about transmission of characters (traits) in animals and plants studied in previous lesson and the genetic code and the protein synthesis. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of activity 13.6 in Student's Book.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.
- Ask student-teachers to demonstrate working procedure on chalk board.
- Provide an exercise on sex determination for fixing working procedures.
- Tick the correct findings and engage student-teachers while making conclusion.
- Harmonize the student-teachers' findings.

Answer to learning activities 13.6

- a) The meaning of the sentence would be changed
- b) The meaning of the sentence would be changed
- c) The meaning of the sentence would be not be changed but there will be repetition of unnecessary elements.
- d) Removing one element would have a bigger effect than adding one letter. Removing one letter can cause a change to the whole sentence. The same in our body, removing one nitrogen base can change the reading frame of the genetic information.

e) Application activity 13.6

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 13.6.

Answers to application activities 13.6

1. H: huntington's disease; h: normal allele

Genotype of the man: Hh; genotype of the woman: hh

♂	H	h
♀	h	h
h	Hh	hh
h	Hh	hh

50 % of their children will have the disorder and 50 % will be normal.

2. a) Polydactyly is caused by a dominant allele

b) Because 2 person with polydactyly can produce a child without polydactyly.

c) Genotypes of the parents are Hh and Hh

♂	H	h
♀	H	h
H	Hh	Hh
h	Hh	hh

There 25 % chances of having the disorder.

Lesson 7: Types of mutations

a) Learning objectives

- Explain that gene mutation occurs by substitution, deletion, inversion and insertion of base pairs in DNA and discuss how such mutations may affect the phenotype.

b) Teaching resources

Textbooks, computer and projector

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- The genetic code
- Protein synthesis
- Chromosomes

Let student-teachers remember what they have learnt about transmission of characters (traits) in animals and plants studied in previous lesson and the genetic code and the protein synthesis. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of activity 13.7 in Student's Book.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.
- Provide an exercise on the types of mutations for fixing working procedures.
- Tick the correct findings and engage student-teachers while making conclusion.
- Harmonize the student-teachers' findings.

Answer to learning activities 13.7

For more information on this activity, check in the student's book unit 13

e) Application activity 13.7

Guidance

Ask student-teachers to work in groups to answer the questions of application activity 13.7.

Answers to application activities 13.7

1. a) Many amino acids have more than one triplet code; so sequence of amino acids is unchanged.

- b) Adding or deleting three nucleotides may add or remove the coding for one amino acid; this may not affect the final shape of the protein; adding or deleting one nucleotide affects the arrangement of all subsequent triplets; this 'frameshift' may alter the coding of all amino acids following the addition or deletion; a triplet may be altered to a stop signal.

Lesson 8: Causes, effects and significance of mutations

a) Learning objectives

- Explain how a change in the base sequence of the gene for hemoglobin results in abnormal hemoglobin and sickle-shaped red blood cells.

b) Teaching resources

Textbooks, computer, charts showing different types of mutations and projector

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Mutations and its types
- Genetic code
- Protein synthesis

Let student-teachers remember what they have learnt about transmission of characters (traits) in animals and plants studied in previous lesson and the genetic code and the protein synthesis. This will help student-teachers to pay attention during this lesson.

d) Learning activities

Guidance

- Organize student-teachers in groups or in pairs. Ask them to do the questions of activity 13.8 in Student's Book.
- Monitor the activity and guide student-teachers with learning difficulties to reach the answer.
- Verify the achievement of each student-teacher.
- Provide an exercise on the types of mutations for fixing working procedures.
- Tick the correct findings and engage student-teachers while making conclusion.
- Harmonize the student-teachers' findings.

Answer to learning activities 13.8

For more information on this activity, check in the student's book unit 13

e) Application activity 13.8

Guidance: Ask student-teachers to work in groups to answer the questions of application activity 13.8.

Answers to application activities 13.8.

- a) gene mutation / substitution
- b) Val / valine;
- c) Sickle cell anemia.

13.6 Summary of the unit 13

- **Inheritance/heredity** is the phenomenon of transmission of traits from parents to offspring.
- **Mendel** conducted breeding experiments in garden pea to study inheritance pattern of several traits. He found that first generation progeny always exhibited one of the parental traits (**dominant**) while second generation progeny exhibited both the forms of trait dominant and recessive in 3: 1 ratio, popularly known as phenotypic monohybrid ratio. He postulated that there are two alleles for each trait, the alleles segregate (**principle of segregation**) at the time of gamete formation and reunite in zygote.
- Mendel's factors are now known as gene, two alternate forms are known as alleles. Mendel also devised the test cross which helps us differentiate pure dominant form from the **hybrid dominant** form.
- In population, there can be more than two alleles (multiple allele), although a particular individual will have two alleles. Sometimes both the alleles are equally expressed (co-dominance) as in **ABO** blood type. There can be incomplete dominance where one form is not completely dominant. Also, sometimes allele is lethal which leads to the death of the individual. Also, one gene may influence the expression of another gene. It leads to variation in Mendelian ratio.
- **Sex determination** in humans is determined by the presence of Y chromosome. The "Y" chromosome plays an important role in determining maleness. It has gene testis determining factor (TDF) which initiates the sequence of events required to differentiate primordial gonadal tissue into testis.

- The genes located on sex chromosome (X and Y chromosome), demonstrates **sex linkage**. The inheritance of such traits depends on the sex of the individual.
- The genetic diseases may happen due to changes in genes or chromosomes on which genes are located. The inheritance of genetic disease caused by genes can be traced by **pedigree analysis** which involves collection of information about the expression of particular genetic trait in the family's history.

13.7 Additional Information for the teacher

Origin of genetics

The history of genetics started with the work of the Augustinian friar George Johann Mendel. His work on pea plants, published in 1866, described what came to be known as Mendelian inheritance. Many theories of heredity proliferated in the centuries before and for several decades after Mendel's work.

The year 1900 marked the "rediscovery of Mendel" by Hugo de Vries, Carl Correns and Erich von Tschermak, and by 1915 the basic principles of Mendelian genetics had been applied to a wide variety of organisms most notably the fruit fly *Drosophila melanogaster*.

Led by Thomas Hunt Morgan and his fellow "drosophilists", geneticists developed the Mendelian model, which was widely accepted by 1925. Alongside experimental work, mathematicians developed the statistical framework of population genetics, bringing genetic explanations into the study of evolution.

Gene, DNA and cell

Every cell in the body with a nucleus (a compartment in most cells) has the same complete set of genes. A gene is made of DNA (deoxyribonucleic acid) and is basically a type of genetic instruction.

Those instructions can be used for making molecules and controlling the chemical reaction of life. Genes can also be passed from parent to offspring; this is inheritance.

Some genes are active ('on') in some tissues and organs but not in others. This is what makes the difference between a liver cell and a lung cell. Genes are turned on and off during development and in response to environmental changes, such as metabolism and infection.

Gene stability

Genes can change or mutate, although this happens only rarely. A mutation is a permanent change in DNA. Given our trillions of cells, some mutation is occurring all the time. While certain mutations are harmful, in many cases there is no effect on traits. Some mutations are even beneficial. Only mutations in sperm or egg can be passed from parent to child.

Our bodies can sometimes recognize and destroy cells with harmful mutations, but not always. This is how cancer starts. In general, the genome (all the DNA in your body) is quite stable, and the genetic makeup we are born with remains throughout our lives. It is this stability that makes genetic testing a little different from other medical testing. For example, your cholesterol level or your blood count may change with time, but your genes do not change.

Pedigree Analysis: Studies of Inheritance of Genetic Diseases in Humans

The inheritance pattern of different genetic diseases can be studied by pedigree analysis. It involves collection of information about the family's history for a particular genetic trait.

Hypothetical Pedigree for Different Genetic Traits

Based on the transmission of genetic trait, the different pedigree can be made.

- a) Recessive pedigree:** if an affected person has unaffected parents, it indicates that nature of affected gene is recessive. It can be autosomal or sex-linked.

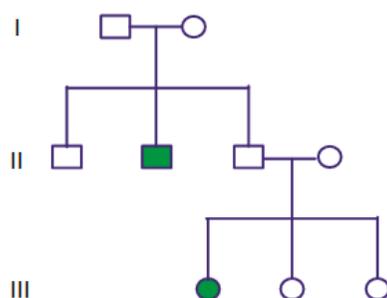
If it appears randomly in male and female, then it is autosomal (Figure (a)).

If affected person is mostly males, then it might be sex-linked recessive genetic trait

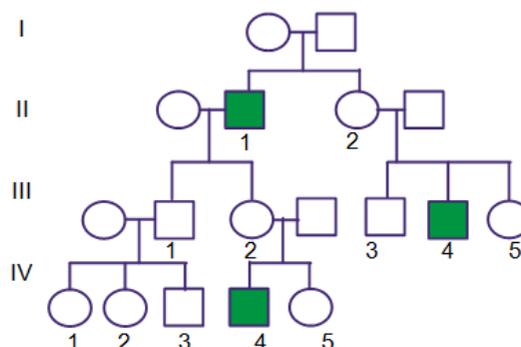
(Figure (b))

(a) Autosomal recessive pedigree

(b) X-linked recessive pedigree



Autosomal recessive pedigree



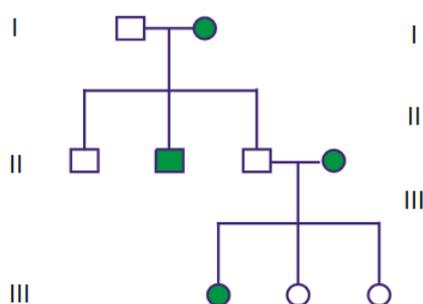
X-linked recessive pedigree

b) Dominant pedigree: if an affected person has affected parents and traits appears almost in every generation, it indicates that nature of affected gene is dominant. It can be autosomal or sex-linked.

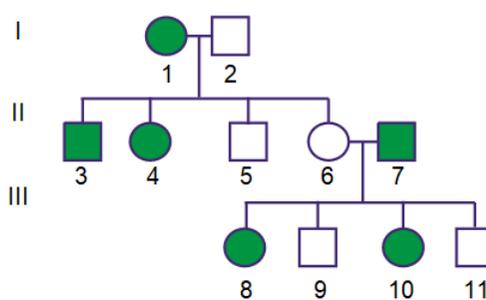
If it appears randomly in male and female, then it is autosomal (Figure (a)) below.

If trait is passed on every generation but differentially transmitted based on sex of the affected person, then trait is X-linked dominant (Figure (b)) below.

An affected father will pass the disease to all of his daughters. An affected mother will pass the trait equally to her sons and daughters.



(a) Autosomal dominant pedigree



(b) X-linked dominant pedigree

Significance of Pedigree Analysis

- Pedigree analysis is very useful to find out nature of genetic trait in family.
- It is useful to study the inheritance pattern of traits in organisms in which there is long generation time, especially in humans.

- c) Pedigree analysis is used by genetic counsellors to advise couples about the possibility of having genetically defective children when a defect runs in their family Pedigree analysis is very useful to find out nature of genetic trait in family.
- d) It is useful to study the inheritance pattern of traits in organisms in which there is long generation time, especially in humans.
- e) Pedigree analysis is used by genetic counsellors to advise couples about the possibility of having genetically defective children when a defect runs in their family

Guidance on skills Lab

The determination of blood groups requires the presence of antibodies against type A and B blood, and the sample is checked to see whether or not the blood cells stick together (agglutinate). If blood cells stick together, it means the blood reacted with one of the antibodies.

Materials and products to be used in this skill lab

- Anti A
- Anti B
- Glass slides
- Sterilized
- Ethanol
- Cotton wool

13.8 End unit assessment

I. Choose whether the given statements are True (T) or False (F)

- | | |
|----------|----------|
| 1. True | 6. False |
| 2. False | 7. False |
| 3. True | 8. False |
| 4. True | 9. False |
| 5. True | 10. True |

II. Multiple Choice Questions

1. (b) nonsense mutation
2. (c) substitution mutation
3. (c) environment and genotype

III. Long Answer Type Questions

1. Describe the types of mutation and causes of mutations. **Check for answers in the student's book**
2. Explain the significance of mutations. **Check for answers in the student's book**
3. Explain that gene mutation occurs by substitution, deletion, inversion and insertion of base pairs in DNA. Outline how such mutations may affect the phenotype. **Check for answers in the student's book**
4. a) i. **ALLELES:** different forms of the same gene.
ii. **LOCUS:** position of a gene on a chromosome.
iii. **AUTOSOME:** Any chromosome except the sex chromosomes. Genes on the autosomes are inherited without regard to the sex of the individual.
b) Mendel's first law: the law of segregation: the characteristics of a diploid organism are controlled by alleles occurring in pairs of such alleles. Only one can be carried in a single gamete.
Mendel's second law: the law of independent assortment: any one of a pair of characteristics may combine with either one of another pair.
c) Key: B is black and G is ginger
 $X^B X^B \times X^G Y$
Gametes $X^B \times X^G$ or Y
F1 cats $X^B X^G, X^B Y$;
Phenotypes: tortoiseshell female and black male
5. a) 10 purple/hairy: 3.2 purple/hairless: 1 green/hairy: 1 green/hairless.
b) 9:3:3:1; as it is a dihybrid cross/two genes are involved.
c) Too few plants; some of the seeds did not germinate; some plants died before their characteristics become apparent; incorrect interpretation of results; some plants did not express their characteristics.
d) 3 purple/hairy and 1 green / hairless.

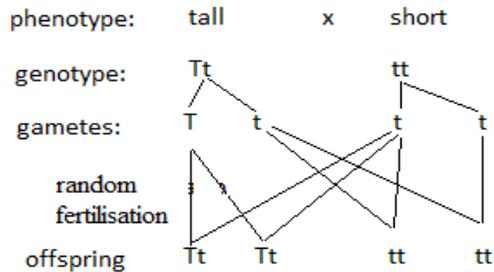
13.9 Additional activities

13.9.1. Remedial activities

1. In pea plants, the allele for tallness (T) is dominant over the allele for shortness (t). Using a Punnett square:
a) Determine the genotype of offspring of a cross between a hybrid and short plant.

b) State the genotypic and phenotypic ratios.

Answer to remedial activities



Phenotype: tall = 50% short = 50%

Genotype: Tt = 50 % tt = 50%

Phenotypic ratio = 2:2 Genotypic ratio = 2:2

13.9.2 Consolidation activities

1. Distinguish between the following pairs of terms.
 - a) genotype and phenotype
 - b) homozygous and heterozygous
2. A species of poppy may have plain petals or petals with a large black spot near the base. If two plants with spotted petals are crossed, the offspring always have spotted petals. A cross between unspotted and spotted plants sometimes produces offspring that all have unspotted petals, and sometimes produces half spotted and half unspotted offspring. Explain these results.

Answer to consolidation activities

1. **Genotype:** the genetic constitution of an organism with respect to a gene or genes;
Phenotype: the physical, detectable expression of the particular alleles of a gene or genes present in an individual;
Homozygous: describes a diploid organism that has the same allele of a gene at the gene's locus on both copies of the homologous chromosomes;
Heterozygous: describes a diploid organism that has different alleles of a gene at the gene's locus on the homologous chromosomes;
2. If a cross between an unspotted and a spotted plant can sometimes produce offspring that are all unspotted, then unspotted must be the dominant allele.

Suitable symbols could be:

A to represent the dominant unspotted allele; **a** to represent the recessive spotted allele. (U and u or S and s are not good choices, as they are difficult to distinguish.)

An unspotted plant could therefore have either the genotype **AA** or **Aa**. A spotted plant could only have the genotype **aa**. Therefore, a cross between spotted and unspotted could either be:

Parents: **AA** × **aa**

Offspring: **Aa** or it could be:

Parents: **Aa** × **aa**

Offspring: **Aa** and **aa** in a ratio of 1 : 1.

13.9.3. Extended activities

Red Poll cattle are homozygous for an allele that gives red coat colour. White Shorthorn are homozygous for an allele that gives white coat colour. When crossed, the offspring all have a mixture of red and white hairs in their coats, producing a colour called roan.

- a) Suggest suitable symbols for the two alleles of the coat colour gene.
- b) List the three possible genotypes for the coat colour gene and their phenotypes.
- c) Draw genetic diagrams to show the offspring expected from the following matings:
 - i. a Red Poll with a roan
 - ii. two roans.

Answer to extended activities 13.9.3.

- a. Symbols should use the same capital letter of the alphabet, with a different superscript for each allele. For example: **C^R** to represent the allele for red coat **C^W** to represent the allele for white coat
- b. **C^RC^R** red coat
C^RC^W roan coat
C^WC^W white coat
- c. i. Red Poll × roan gives **C^RC^R** (red coat) and **C^RC^W** (roan coat) in a ratio of 1 : 1.
ii. Roan × roan gives **C^RC^R** (red coat), **C^RC^W** (roan coat) and **C^WC^W** (white coat) in a ratio of 1 : 2 : 1.

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