Biology

For

Associate Nursing Program

S6

Teacher's Guide

Second Edition

Kigali, 2024

FOREWORD

Dear Teacher,

The Rwanda Basic Education Board is pleased to present this Teacher's Guide for the Associate Nursing Program. This guide is designed to support competence-based teaching and ensure consistency in delivering Biology subject.The Rwandan educational philosophy aims to help student-associate nurses achieve their full potential, preparing them to address community health needs and pursue career opportunities.

To enhance education quality, the government of Rwanda emphasizes the alignment of teaching materials with the syllabus. Effective teaching relies on the relevance of content, pedagogical approaches, assessment strategies, and instructional materials. The guide focuses on activities that promote learning, allowing students to develop ideas and make discoveries.

In a competence-based curriculum, learning involves actively building knowledge and skills through activities, scenarios, and real-life applications. Your role as a teacher includes:

- Planning lessons and preparing teaching materials.
- Organizing group discussions and collaborative learning.
- Engaging students through active learning methods such as inquiry, research, and group work.
- Supporting and facilitating the learning process by valuing student contributions and guiding them towards integrating their findings.

This guide is divided into three parts:

1. Explains the book's structure and provides methodological guidance.
2. Offers sample lesson plans for reference.
3. Provides detailed teaching guidance for each concept in the student book.

Although the guide includes answers to student book activities, please review each question and activity before assessing student responses.

I extend my gratitude to everyone involved in developing this guide, including the Ministry of Health, University of Rwanda, and other institutions. Special thanks go to faculty members, nurses, midwives, teachers, illustrators, designers, Health Workforce development staff/MoH, and REB staff for their dedicated work.

Dr. MBARUSHIMANA Nelson

Director General, REB

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Ms. MURUNGI Joan

Head of Curriculum, Teaching, and Learning Resources Department / REB

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I. GENERAL INTRODUCTION

Rwanda is striving to build a knowledge-based economy, with particular emphasis on science and technology as engine for socio-economic development. One of the national priorities in the education system is to ensure that the quality of education continues to improve through closer integration of curriculum development, quality assurance and assessment, improved supply of learning materials, particularly text books, and improved teaching and learning strategies.

The Nation has reviewed its curricula and teaching methods in order to equip the critical mass of young people and population as whole with knowledge, skills and attitudes to be highly competitive in the region and global market. Therefore, since 2015 a competence-based curriculum has been put in place to drive the Nation to the economic development it desires as it is stipulated in vision 2020.

This Biology Teaching Guide was collaboratively developed and reviewed by educators from public and private schools, colleges, and universities. Teaching Guide was studied and reviewed by education curriculum developers and pedagogy experts, and was improved with appropriate methodologies and strategies. Rwanda Education Board believes that teachers are the most important partners in improving education quality and key factor in determining learners' success. Incorporated in this Teaching Guide is a framework that will guide them in creating lessons and assessment tools, support them in facilitating activities and questions, and assist them towards deeper content areas and competencies to be achieved by the learners.

Through this Teaching Guide, teachers will be able to facilitate an understanding of the value of the lessons, for each learner to fully engage in the content on both the cognitive, psychomotor and affective levels of learning.

Teachers should also aim for deep understanding of the subject matter where they lead learners to analyze and synthesize knowledge. When teachers empower learners to take ownership of their learning, they develop independence and self- direction, learning about both the subject matter and themselves.

This Teaching Guide is mapped and aligned to the National Curriculum, designed to be highly usable for teachers. It contains classroom activities and pedagogical notes, and is integrated with innovative pedagogies. All of these features are presented in the different parts of this guide which provides also a hands-on/laboratory activity, connecting to a real-life problem and show step-by-step solutions to sample problems in each unit.

1.1 Structure of the guide

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

Overall structure

The whole guide has three main sections as follows:

I: Methodology.

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

II: Sample lesson plan

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

III: Unit development

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

Structure of a unit

Each unit is made up of the following sections:

- **Unit title:** from the syllabus
- **Key unit competence**: from 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 teacher 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 integrated 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; teachers 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 learner's book. This section of the teacher's guide provides guidance on how to conduct this activity and related answers. Note that learners may not be able to find the right solution but

they are invited to predict possible solutions or answers. Solutions are provided by learners 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 a list of lessons that are in a unit, lesson objectives copied or adapted from the syllabus and duration for each lesson. Each lesson / sub-heading is then developed.

- **End of each unit**

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

- **Summary** of the unit which provides the key points of content developed in the student's book.
- **Additional information** which provides additional content compared to the student's book for the teacher to have a deeper understanding of the topic.
- **End of unit assessment** which provides the answers to questions of end unit assessment in the textbook 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 learner (slow, average and gifted) based on end 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 teacher 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. Teachers 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 text book:

- **Exercises/application activities/self–assessment**

  This provides questions and answers for exercises/ application activities/self-assessment

1.2 Methodological guidance

1.2.1 Developing competences

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. Learners 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 is evaluated against set standards to achieve a specific unit competence before moving onto the next unit.

In addition to specific subject competences, learners also develop generic competences which are transferable throughout a range of learning areas and situations in life. Below is example of how generic competences can be developed in biology**:**

Generic competence	Examples of activities that develop generic competences
Critical thinking	Classifying living organisms Observe, record, interpret data recorded during experiments Choose the best reagent to test for a substance or to distinguish substances Collect, observe and identify specimens. Compare and contrast between biological concepts

Research and Problem solving	Research using internet or books from the library Design a project for health and disease Design a questionnaire for data collection during field visit
Innovation and creativity	Develop a graph to illustrate information Design a data collection survey/questionnaire Conduct experiments with objectives, methodology, observations, results, conclusions Identify local problems related with biology such as malnutrition and ways to resolve them
Cooperation, Personal and Interpersonal management and life skills	Work in Pairs Small group work Large group work
Communication	Organize 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.

a) Critical Thinking

- These are activities that require students to think critically about subject content. Groups can be organized to work in different ways e.g. taking turns, listening, taking decisions, allocating tasks, disagreeing constructively etc.
- Collect data locally through designing surveys, questionnaires, interview formats then analyses data, draw conclusions and present findings
- Observe, record, interpret – e.g. Mark out areas in the school and get different groups to record insect, animal, bird life and then to try to explain why different habitats have different species Experiment

- Research and discuss
- Compare and contrast exercises
- Debate (see communication)
- Identify a problem and design a methodology to collect the information needed to solve the problem
- Make basic science equipment out of locally available materials
- Reasoning games and tests for students

b) Research and problem solving

- Use the internet
- Use a library
- Create a school library
- Collect data through observation and Recording
- Collect data through surveys, questionnaires and different kinds of interviews
- Develop sampling Rules for data collection

c) Creativity and Innovation

- Write a story or poem
- Design a poster
- Write and design a booklet
- Make a model
- Create an experiment to prove a point
- Invent new ways of doing traditional things
- Design your ideal house
- Develop a graph to illustrate information
- Create a flow chart to show the main stages in a process
- Design a data collection survey/questionnaire
- Identify a problem which requires data collection to solve

- Conduct experiments with objectives, methodology, observations, Results, and conclusions
- Make hypotheses and identify ways to test them
- Identify local problems and devise ways to resolve them

d) Communication Skills

- Tell/Write a story, poem or drama
- Describe an event or situation
- Present Ideas - verbally, in writing, graphically, digitally
- Set out pros and cons
- Argue a case – verbally, in writing, graphically (compare and contrast), digitally
- Observe, record, interpret
- Write letters for different purposes

e) Teamwork, cooperation, personal and interpersonal management and life skills.

Work in Pairs – particularly useful for shared reading and comprehension in lower grades but can also be useful in higher grades for planning research, problem solving, planning experiments etc.

- Small group work
- Large group work
- Data collection from the community
- Collect community photographs and Interview residents to make a class/ school History of the local Community

Note: The teachers' Guide should improve support in the organisation and management of groups

f) Lifelong Learning

- Take initiative to update knowledge and skills with minimum external support.
- Cope with the evolution of knowledge and technology advances for personal fulfilment

- Seek out acquaintances more knowledgeable in areas that need personal improvement and development
- Exploit all opportunities available to improve on knowledge and skills.

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:

a) Genocide Studies

Genocide Studies provides young people with an understanding of the circumstances leading to the genocide and the remarkable story of recovery and re-establishing national unity. Genocide Studies helps learners to comprehend the role of every individual in ensuring nothing of the sort ever happens again.

b) Environment and sustainability

The growing awareness of the impact of the human race on the environment has led to recognition of the need to ensure our young people understand the importance of sustainability as they grow up and become responsible for the world around them. Hence Environment and Sustainability is a very important cross-cutting issue. Learners need basic knowledge from the natural sciences, social sciences and humanities to understand and interpret principles of sustainability. They also need skills and attitudes that will enable them in their everyday life to address the environment and climate change issue and to have a sustainable livelihood.

C) Gender

There is a strong moral imperative to afford every individual their basic human rights and gender inequality results in women and girls being treated less favourably than men. A strongly negative impact of unequal treatment which affects the nation as a whole is the fact that it results in women being held back and their talents and abilities not being fully realised. With a good understanding of the principles of Gender Equality, it is intended that future generations will ensure that the potential of the whole population is realised.

d) Comprehensive sexuality education (HIV/AIDS, STI, Family planning, Gender equality and reproductive health)

Comprehensive sexuality education which is age appropriate, gender sensitive and life skills based can provide young people with the knowledge and skills to make informed decisions about their sexuality and life style. Preparing children and young people for

the transition to adulthood has been one of humanity's great challenges with human sexuality and relationships at its core. Few young people receive adequate preparations for their sexual lives. This leaves them potentially vulnerable to coercion, abuse and exploitation. Unintended pregnancy and sexually transmitted infection (STI) including HIV/AIDS. Many young people approach adulthood faced with conflicting and confusing messages about sexuality and gender. This is often exacerbated by embarrassment, silence, disapproval and open discussion of sexual matters by adults (parents, teachers) at very time when it is most needed. Comprehensive sexuality education supports a rights- based approach in which values such as respect, acceptance tolerance, equality, empathy and reciprocity are inextricably linked to universally agreed human right. A clear message concerning these dangers and how they can be avoided, from right across the curriculum, is the best way to ensure that young people understand the risks and know how to stay healthy.

e) Peace and Values Education

The need for Peace and Values Education in the curriculum is obvious. Peace is clearly critical for society to flourish and for every individual to focus on personal achievement and their contribution to the success of the nation. Values education forms a key element of the strategy for ensuring young people recognize the importance of contributing to society, working for peace and harmony and being committed to avoiding conflict.

f) Financial Education

Financial education makes a strong contribution to the wider aims of education. It makes learning relevant to real life situations. It aims at a comprehensive financial education program as a precondition for achieving financial inclusion target and improves the financial capability of Rwandans. Financial education has a key role of not only improving knowledge of personal but also transforming this knowledge into action.

It provides the tools for sound money management practices on earnings, spending, saving, borrowing and investing. Financial education enables people to take appropriate financial services both formal and informal that are available to them and encourages financial behaviors that enhance their overall economic wellbeing.

g) Standardization Culture

Standardization Culture develops learners' understanding of the importance of standards as a pillar of economic development and in the practices, activities and lifestyle of the citizens. It is intended that the adoption of standardization culture should have an impact upon health improvement, economic growth, industrialization, trade and general welfare of the people. While education is the foundation and strength of our nation, standards are one of the key pillars of sustainable economic development.

h) Inclusive Education

Inclusive education involves ensuring all learners are engaged in education and that they are welcomed by other students so that everyone can achieve their potential. Inclusive practice embraces every individual regardless of gender or ability including those with learning difficulties and disabilities. The almost focus of inclusive curriculum is on ensuring participation in education of learners with different learning styles and other difficulties. To be successful, it entails a range of issues including teacher's positive attitudes, adapting the learning resources, differentiation of teaching and learning methods and working together. Overall the benefits of an inclusive curriculum extend to all learners.

Some cross cutting issues may seem specific to particular learning areas/subjects but the teacher need to address all of them whenever an opportunity arises. In addition, learners should always be given an opportunity during the learning process to address these cross cutting issues both within and out of the classroom.

Below are examples on how cross-cutting issues can be addressed in Biology:

Cross-cutting issue	Examples on how to integrate the cross-cutting issue
Inclusive education	Involve all learners in all activities without any bias. E.g. Allow a learner with physical disability (using wheelchair) to take notes or lead the team during an experiment.
Gender	Involve both girls and boys in all activities: No activity is reserved only to girls or boys. Teachers should ensure equal participation of both girls and boys during experiments as well as during cleaning and tidying up related activities after experiments.
Peace and Values Education	During group activities, debates and presentations, the teacher will encourage learners to help each other and to respect opinions of colleagues.

Standardization culture	Some lessons involve carrying out experiments. Instruction should be clear for learners to always check if they are not using expired chemicals or defective apparatus. In addition, when performing experiments learners have to record data accurately. For tasks involving calculations, they have to always present accurate results.
Environment and sustainability	In order to avoid the environment pollution, before, during or after experiments learners avoid throwing away chemicals anywhere; special places or appropriate containers should be used. Learners have to avoid uprooting /cutting down of plants and killing of animals

1.2.3 Attention to special educational needs specific and inclusive education

In the classroom, learners learn in different way depending to their learning pace, needs or any other special problem they might have. However, the teacher has the responsibility to know how to adopt his/her methodologies and approaches in order to meet the learning needs of each student in the classroom. Also teachers need to understand that learners with special needs, need to be taught differently or need some accommodations to enhance the learning environment. This will be done depending to the subject and the nature of the lesson.

In order to create a well-rounded learning atmosphere, teachers need to:

- Remember that learners 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 learners with special needs to stay on track during lesson and follow instruction easily;
- Vary the pace of teaching to meet the needs of each learner. Some learners process information and learn more slowly than others;
- Break down instructions into smaller, manageable tasks. Learners 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 learner 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. Both learners will benefit from this strategy;
- Use multi-sensory strategies. As all learners learn in different ways, it is important to make every lesson as multi-sensory as possible. Learners 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 learner is unique with different needs and that should be handled differently.

Strategy to help a learner with developmental impairment:

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

Strategy to help a learner with visual impairment:

- Help learners 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 learner has some sight, ask them what they can see;
- Make sure the learner has a group of friends who are helpful and who allow him/her to be as independent as possible;
- Plan activities so that learners work in pairs or groups whenever possible.

- Strategy to help a learner with hearing impairment:
- Strategies to help learners with hearing disabilities or communication difficulties;
- Always get the learner 's attention before you begin to speak;
- Encourage the learner 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 learners to also use them;
- Keep background noise to a minimum.

Strategies to help a learner with physical disabilities or mobility difficulties:

- Adapt activities so that learners who use wheelchairs or other mobility aids, or other learners 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 learner to reach it or fit their legs or wheelchair under;
- Get advice from parents or a health professional about assistive devices.

Adaptation of assessment strategies

Each unit in the teacher's guide provides additional activities to help learners achieve the key unit competence. Results from assessment inform the teacher which learner 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.

1.2.4 Guidance on assessment

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 learners' learning and teacher's teaching whereas assessment of learning/summative assessment intends to improve the entire school's performance and education system in general.

a) Continuous/ formative assessment

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

b) Summative assessment

The assessment can serve as summative and formative depending to its purpose. The end unit assessment will be considered summative when it done at end of unit and want to start a new one. It will be formative assessment, when it is done in order to give information on the progress of students and from there decide what adjustments need to be done. The assessment done at the end of the term, end of year, is considered as summative assessment so that the teacher, school and parents are informed of the achievement of educational objective and think of improvement strategies. There is also end of level/ cycle assessment in form of national examinations.

1.2.5 Students' 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 materials available; the physical/sitting arrangement of the classroom, individual students' 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; **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."

1.2.5 Teaching methods and techniques that promote the active learning

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

a) What is Active learning?

Active learning is a pedagogical approach that engages students 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.

b) The role of the teacher in active learning

- The teacher engages learners 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 learners to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication and cooperation.
- Teacher supports and facilitates the learning process by valuing learners' contributions in the class activities.

c) 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-centered 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.

d) 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 learners are involved in the learning process. Below are those main parts and their small steps:

1) Introduction

Introduction is a part where the teacher makes connection between the current and previous lesson through appropriate technique. The teacher opens short discussions to encourage learners to think about the previous learning experience and connect it with the current instructional objective. The teacher 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 learners' findings, exploitation, synthesis/summary and exercises/application activities, explained below:

Discovery activity

Step 1

- The teacher discusses convincingly with students 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 teacher let the students work collaboratively on the task.
- During this period the teacher refrains to intervene directly on the knowledge
- He/she then monitors how the students are progressing towards the knowledge to be learned and boost those who are still behind (but without communicating to them the knowledge).

Presentation of learners' productions

- In this episode, the teacher invites representatives of groups to present the students' productions/findings.
- After three/four or an acceptable number of presentations, the teacher decides to engage the class into exploitation of the students' productions.

Exploitation of learner's productions

- The teacher asks the students to evaluate the productions: which ones are correct, incomplete or false
- Then the teacher judges the logic of the students' products, corrects those which are false, completes those which are incomplete, and confirms those which correct.

Institutionalization (summary/conclusion/ and examples)

- The teacher 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
- Teacher guides learners to make the connection of what they learnt to real life situations. At this level, the role of teacher 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, learners work individually on the task/activity. The teacher avoids intervening directly. In fact, results from this assessment inform the teacher on next steps for the whole class and individuals. In some cases, the teacher can end with a homework assignment.

II SAMPLE LESSON PLAN

Teacher's name:…… School Name: .....

Term	Date	Subject	Class	Unit N°	Lesson N°	Duration	Class size
1st	23rd Feb 2018	Biology	S6 MCB	3	3 of 4	40 minutes	45 students
Type of Special Educational Needs and number of learners				2 Blind students			
Unit title		Effects of human activities on ecosystem					
Key Unit Competence:		To be able to evaluate the effects of human population size, resource use, and technology on environmental quality.					
Title of the lesson		Pollution.					
Plan for this Class (location: in / outside)		Inside and outside the class					
Instructional Objectives		Being taken on field work, students will be able to assess effectively a polluted area and advocate against pollution					
Learning Materials (for all learners)		A nearby school polluted area, 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). *Biology, Pearson international Edition, San Francisco, USA, 8th edition*					

Timing for each step	Description of teaching and learning activity: Learners visit a polluted area, observe and identify features that indicate the pollution.		Competences and cross cutting issues to be addressed
	Teacher's activities	Learner's activities	
1. Introduction (5 minutes):	Through questioning techniques, asks whether students have experienced any sign of pollution. Let learners think individually, share their points of view two by two and therefore involve other students. Ask students to identify a nearest polluted area to visit Ask a volunteer to take the whole class to the nearest polluted area.	Students think individually about the features of a polluted area thereafter they share their ideas in pair and in plenary. Volunteers describe the nearest polluted area to be visited. Decide on the site to visit from the description of volunteers.	Critical thinking as Learners think about the polluted area and its features. Communication skills as volunteers describe the nearest polluted area to visit and convince the remaining of the class to. Inclusive education: As in the classroom there are blind students, the teacher needs to make sure that the place to visit is free of any physical barriers that can prevent them to access the area.

2. Development of the lesson 30 min			
2.1. Discovery activity	Follow the volunteers to the nearest polluted site. Through questioning technique, help students to identify characteristics of the polluted area. Also ask the visual impairment students to describe the polluted site and associate some classmates to help them. What are the evidences that this site is polluted? What are their causes and consequences?	Follow the direction of the volunteer who orients the class to the nearest polluted site. Observe individually the polluted site and write down their features. Exchange and supplement ideas to brainstorm causes and effects of pollution of the visited area. Allow the blind to give their contributions and ask their questions where need be.	Environment and sustainability This will be addressed by the visit as well as questions that will be asked to students and by students Cooperation and interpersonal management As they interact among themselves to get answers. Inclusive educations as the blind students are working together with the gifted students.

2.2. Presentation of findings	Bring students back in the classroom and gives them opportunity to present their findings in form of brainstorm Ask further questions to make sure that even students with special education need are involved in the learning process.	Present their findings and supplement to each other The visited area is polluted because of the bad smell, such as bad smell, flies, maggot, plastic debris, and causes such as deforestation, massive urination, presence of plastic bottles/bags etc. The causes of pollution on the visited area are the following: human activities, sewage, livestock etc. the consequences of such pollutions are: Death of some organisms Poor development of plants in the polluted area Reduction of soil fertility Diseases….	Communication skills during the presentation Lifelong learning. These competences will be developed from presentation of their works, working in groups, and from producing a poster Learners particularly those with visual impairment will be given time to present what has been discussed in groups Inclusive education 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.

2.3. Exploitation of students findings	Through problem solving approach, asks learners to explain how the features observed on polluted areas visited can lead to eutrophication.	By using critical thinking and logical reasoning, relate the pollution of the visited site to the phenomenon of eutrophication.	Critical thinking is developed as learners relate the observed pollution to eutrophication.
2.4. Conclusion: 4 minutes	Uses a ball design at least three students to summarize what they have learnt from this lesson.	The student who receives the ball summarizes the lesson and throws it to design another student randomly.	Communication skill expressed through their confidence to answer the question.

3. Assessment 5 min	Put the following questions on a Manila paper and organizes a gallery walk to answer them: What are the causes of pollution? What are the causes and effects of eutrophication and non-biodegradable materials	Learners move around the classroom to read questions and answer the questions: Industrial emissions, *poor* disposal of wastes, mining, deforestation, use of fossil fuels and agricultural activities Eutrophication is caused by excess of too N, P, K released in water. It causes death to organisms living in water due to algae bloom Poor disposal of plastic bottles They prevent water from getting into the soil. Non-biodegradable materials cause death to soil living organisms.	Environment and sustainability awareness as they learn the causes and side effects of the environmental pollution. Inclusive education: Blind students can do the assessment orally or using computer if they have the right software installed in the machine.
Comments on the lesson delivery	The lesson was conducted very nicely since every learner was involved and is capable to achieve the key competence of the lesson		

UNIT1: POPULATION AND NATURAL RESOURCES

1

1.1 Key Unit Competence

Explain the factors affecting population size and the importance of natural resources.

1.2 Prerequisites /Introduction/Revision

Students will learn better the population and natural resources if they have understanding on: concept of ecology, ecosystem, community and population. Ask learners to describe those concepts. The answer will include:

- Ecology is the scientific study of interactions of organisms with other organisms and with the physical and chemical environment.
- Ecological population is a group of organisms of the same species that live in the same area at a certain period of time.
- Community is a group of interacting populations in a particular area.
- 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 (i.e. Community plus environment).

1.3 Cross-cutting issues to be addressed:

a)Environment and sustainability

- As a facilitator, emphasise to the learners that environment must be sustainably protected for different reasons such as:
- Environment is the habitat of all populations of living organisms.
- Environment contains all resources needed by all populations in order to grow.
- If pollution is not prevented, the population sizes of populations should decrease because pollutants kill organisms in different ways.

b)Comprehensive sexuality education

As a facilitator, explain to learners that a population grows as a result of sexual or asexual reproduction. Clarify that human population is exponentially growing and that they must take measure to control such growth. Highlight these measures to students:

- To be aware that, in future, you will be totally responsible of paying your own needs without pleading them from any one. This responsibility must motivate learners to write their own life vision (goals) for their sustainable development. Then, write their own actions plans leading to the achievement of that vision. One of actions that must appear on that plan is legal and religious marriage which will occur at the time they have planned. This responsibility, vision and plan will surely help them to avoid unwanted pregnancies that contribute to human population explosion.

- A good learner must avoid bad peer pressure and bandwagon (Ikigare) that lead him or her to unplanned sexual intercourse.

- Assess if their friends are likely to help their fellow friends achieve future goals or destroy their future.

- Make appropriate decisions and implement them. These good decisions will help them to control themselves in order to avoid undesirable consequences like contacting diseases (e. g HIV/AIDS, STIs), unwanted pregnancies, stress and depression.

c) Inclusive education

This unit requires the calculations such as calculation of Lincoln index, population density, birth and death rates and species frequency. As a facilitator:

- Place learners with visual impairment in appropriate places. Those with short-sightedness (myopia) must sit on front desks in class. If you have children with low vision, remember to print in appropriate font size (large print). Those with long - sightedness must sit on back desks.

- Invite or visit the parents whose children have hearing impairment and learn from them how they do communicate with them.

- Provide blind learners with Braille materials and other tactile materials.

d) Gender

This unit contains some practical activities such as estimation of population size. As a teacher:

- Involve girls asking them to use quadrats or line transects to take different samples and achieve related calculations.

- Inspire active participation of boys and girls in activities, not only boys. Make sure that all learners are actively involved.

1.4 Guidance on the introductory activity

Before starting the first lesson of this unit titled population and natural resources, ask learners to attempt an introductory activity. This activity intends to:

- Relate the unit with learners' daily life to attract their attention.
- Assess learners understanding of the concepts of population and resources.

a) Methodological steps

As a facilitator, request learners to:

- Carefully observe the figures 1.1 and 1.2 in the student book
- In group or in pairs, answer the questions related to the figures.
- Each group records the answers.
- Appoint any 2 groups to write their answers on the chalkboard or flipchart.
- Ask other groups members if they have something to add on what is written on the chalkboard or flipchart.
- Focus on the answers related to lesson 1(population characteristics).

Answers of the introductory activity

1) The following are the answers of the question 1 :

- a) As similarity, both of them show organisms in their natural environment. A and B show different species
- b) A represents a population while B represents a community
- c) A is a population and B is a community

2) The following are the answers of the question 2 :

a) A population density is the number of individuals of the same species per unit area or volume.

b) Age structure is the number or proportion of individuals in each age group within a population.

- c) Population growth patterns are graphs (population growth curves) in which increases in size are plotted per unit time.

- d) Birth rate is the ratio of live births in a specified area to the adults in population of that area.

- e) Death rate is the ratio of deaths to the adults in population of a particular area during a particular period of time.

3) The following are the answers of the question 3 :

- A renewable resource is a resource that will be replenished naturally in the course of time,

- A non-renewable resource is a resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption.

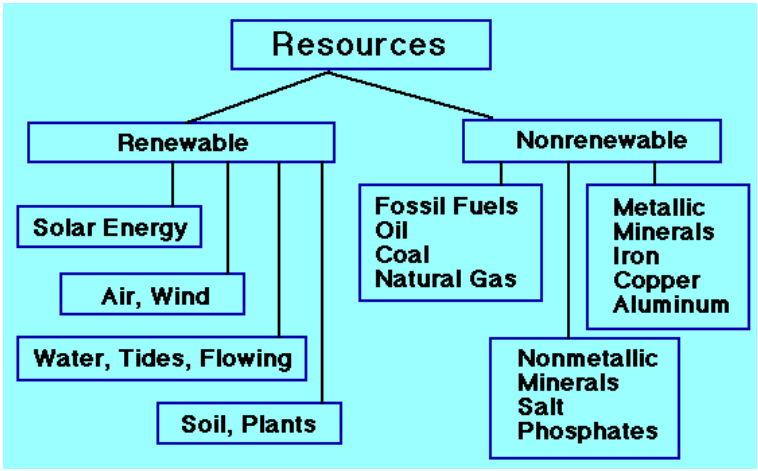


Figure 1.3: Renewable and non-renewable natural resources

1.5 List of lessons/sub-heading (including assessment)

N°	Lesson titles	Objectives	Number of periods
1	Lesson 1: Population characteristics	State and define population characteristics. Research how the human population has grown over the past 250 years. Compare statistics on the population age-sex structure of developing and developed countries. Support that human population explosion impacts negatively on the environment. Justify the practice of family planning as a tool for reducing population explosion.	1 period
2	Lesson 2: Population density	Explain factors that affect population density.	1 period
3	Lesson 3: Methods or techniques of measuring population density	Demonstrate methods used in estimating populations by using quadrats and line transects.	4 periods
4	Lesson 4. Population growth patterns and environmental resistance	Explain population growth patterns. Explain how environmental resistance affects the balance of nature.	2 periods

5	Lesson 5. Natural resources and their importance on economic growth of Rwanda	Explain the importance of natural resources in growth of the Rwandan economy. Analyse the costs and benefits of managing renewable and non-renewable resources. Recognize that some resources are renewable and others are non-renewable and that effective use of these resources is of great value.	2 periods
6	Lesson 6. Methods of conserving natural resources	Explain the methods of conservation of natural resources.	2 periods
7	Assessment standard	Explain clearly the factors affecting population size and the importance of natural resources.	2 periods

Lesson 1: Population characteristics

This is the first lesson of unit 1 and is a single lesson. This means that it has only one period (40 Minutes). The first lesson also covers the introduction of the whole unit.

a) Prerequisites/Revision/Introduction:

Learners will learn better the population characteristics, if they have the understanding on the concept of population, community, ecosystem and family planning. Ask learners to explain orally those concepts. The answers are already defined in the general introduction of the unit in the student book.

b) Teaching resources

As a facilitator, use the illustrations in the students' book page (……) or draw them on a manila paper, flipchart etc.

c) Learning activities

Before introducing the lesson, you must introduce the whole unit. Ask learners to attempt the introductory activity first, then activity 1.1 which leads students to the first lesson of this unit.

d) Methodological steps

As a facilitator, you are expected to guide learners through the following steps:

Activity 1.1.

- Form group of 3 to 6 learners depending on their performance results and class size.
- Ask them to do the activity 1.1.
- Move around groups guiding and facilitating them.
- Select some groups (1 or 2) to share their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart.
- Ask other groups to add any ideas on what other groups have presented if they have them.
- Allow the class to ask questions related to the presented findings.
- Firstly, request the members of groups which have presented to respond to the questions; secondly, if they are not able to clarify, ask the same question to other groups; finally, if all groups are not able to respond, deliver the answer to the whole class by writing on the chalkboard or flipchart and speaking loudly so that those who have low hearing ability or visual impairment get what you say.
- During the discussions, ask learners to relate human sexual reproduction to age –sex structure, population growth pattern and birth rate in order to integrate the cross-cutting issue (comprehensive sexuality education).
- At the end of the lesson development, write the summary on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson by letting students attempt self- assessment 1.1. Students can do this exercise either in the course of this lesson if there is still time or as home work. Make sure you mark the students' homework. Let each student do individually this self- assessment.

Answer for activity 1.1

- Population density: is the number of individuals of the same species per unit area or volume
- Age structure of a population: is the number or proportion of individuals in each age group within a population
- Population growth pattern: Population growth patterns are graphs (population growth curves) in which increases in size are plotted per unit time. When a population size increases, the growth rate also increases
- Birth rate: is the ratio of live births in a specified area to the adults in population of that area
- Death rate: is the ratio of deaths to the adults in population of a particular area during a particular period of time.

Answers for self –assessment 1.1

1) Population density is the number of individuals of the same species per unit area or volume whereas age structure is the number or proportion of individuals in each age group within a population.

2) The following are the answers:

a) Birth rate = $\frac{\text{number of births}}{\text{number of adults in the population}}$,the number of birth is 10

elephants /year while the number of all population is 100 elephants, so the birth rate= $\frac{10}{100} = 0.1$ elephant per year

b) Number of death is 2 elephants /year and the number of all population is 100 elephants

The death rate= $\frac{2}{100} = 0.02$ per elephant per year

3) Population explosion can have the following impacts on the environment: Pollution leading to the ozone depletion, eutrophication, acid rain, global deforestation, soil erosion and desertification

4) The family planning techniques include:

- Long-acting reversible contraception, such as the implant or intrauterine device (IUD). These contraceptive methods last for a long time. Long acting reversible contraception are more than 99% effective at preventing pregnancy.

- Hormonal contraception. These are contraceptives that use hormones to prevent pregnancy. Hormonal contraceptives include pills and injections. The pill and injections are more than 99% effective at preventing pregnancy if they are used correctly.

- Barrier methods: Barrier methods stop sperm from entering the vagina. The two barrier methods are: Condoms and female condoms (femidoms). They protect against sexually transmissible infections (STIs) as well as unintended pregnancy

- Fertility awareness is learning the signs of fertility during menstrual cycle that help to plan or avoid pregnancy.

- Permanent contraception is called sometimes sterilization, prevents all future pregnancies. It is irreversible methods. For male it is vasectomy and for male it is tubal ligation.

Lesson 2: Population density, Dependent and independent factors

The population density - dependent and density - independent factors are included in the second lesson of this unit. Learners are expected to be able to explain factors affecting population density.

a) Prerequisites/Revision/Introduction

As a facilitator, ask students to describe orally the population size and population density in order to test those prerequisites. Answers include:

- Population size is the number of individuals contributing to the population's gene pool.

- Population density is the number of individuals of the same species per unit area or volume.

b) Teaching resources

Use the illustrations in the students' book or draw them on a manila paper of flipchart. You can even use other figures from internet.

c) Learning activities

The learning activity 1.2 is written in students' book However, you can add more questions. Ask learners to do this activity.

d) Methodological steps

As a facilitator, you are expected to guide learners through the following steps:

Activity 1.2

- Ask the formed groups to do the activity 1.2.
- Pass around groups guiding and facilitating them.
- Identify 2 groups to present their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart.
- Ask other groups to add any ideas on what other groups have presented if they have them.
- Enable the class to ask questions related to the presented findings.
- Initially, request the members of groups which have presented to respond to the questions; secondly, if they are not able to clarify, ask the same question to other groups; finally, if all groups are not able to respond, deliver the answer to the whole class by writing on the chalkboard or flipchart and speaking loudly so that those who have low hearing ability or visual impairment get what you say.
- As learners discuss, ask them to relate high reproductive rate as factor to human population explosion in order to integrate the cross-cutting issue (comprehensive sexuality education).
- Write the lesson summary on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Assess the lesson by letting students attempt self- assessment1.2. Students can do this exercise either in the course of this lesson if there is still time or as home work. Make sure you mark the students' homework. Each student must do individually this self- assessment.

Answers for activity 1.2

1) The two categories are:

- **Density- dependent factors** are: competition, predation, parasitism, behaviour of organisms in the environment and diseases
- **Density -independent factors**: space, shelter, natural disasters, sunlight, temperature, water, human activities, physical characteristics of the environment.

2) The figure A = (predation) represents the density dependent factor while the letter

3) B = (drought) represents the density independent factor

Answers for self-assessment 1.2

The natural disasters cause death to some individuals of a population. So, the population size decreases. The population growth rate is reduced.

Lesson 3: Methods or techniques of measuring population density

a) Prerequisites/Revision/Introduction:

Students will learn better the methods or techniques of measuring population density, if they have prior knowledge and skills about sampling methods seen in Senior 4. Ask learners to explain orally quadrat method and line transect method. The answers include:

- A quadrat is a square frame that marks off an area of ground, or water, where you can identify different species present and/or take a measurement of their abundance.
- Line transect is a tape or string laid along the ground in a straight line between two poles as a guide to a sampling method used to measure the distribution of organisms.

b) Teaching resources

Activity 1.3	Materials
In student's book	Pegs, strings/ropes, meter-ruler ,quadrats, decametre, calculator
Activity 1.4.	Materials
In student's book	Calculator , aluminium disks ,fishing net , fish pond

c) Learning activities

The activity 1.3 is a practical field work. The activity 1.4 can be done practically or theoretically by calculation depending on presence or absence of ponds in the school area.

d) Methodological steps

- Indicate the location of activity 1.3 and 1.4 to learners.
- Deliver the teaching resources to learners.

- Provide learners with the procedure of activity 1.3 written on page in student's book.
- Lead learners to your school ground where they must take samples.
- During this sampling, remember to integrate, in the lesson, the cross-cutting issue called environment and sustainability by telling to learners that they must not harm plants and animals which must not be sampled.
- Move around groups guiding and facilitating them during the sampling process.
- Ask each group to do required calculations of activity 1.3.
- If your school has the fish pond, ask your learners to proceed as Mukamana said in the activity 1.4.
- Request all groups to do required calculation of the activity 1.4.
- Order all learners to return in their class.
- Select 2 groups to write their findings on the chalkboard for the activity 1.3 and 1.4.
- Enable learners to ask questions related to the presented findings.
- Write the lesson summary on the blackboard and give to learners the time for noting it.
- Assess the lesson by asking learners to respond individually to self-assessment 1.3.

Answer for activity 1.3.1

The answers will depend on samples taken by students.

Answer for Activity 1.3.2

Estimated total population=$\frac{N1xN2}{N}$, where N1 is the number of organisms in initial sample, N2 is the number of organism in a second sample, and N is the number of marked organisms recaptured. From the data, N1=240, N2=250 and N=15. By the use of the formula$\frac{N1xN2}{N}$, the estimated total population = $\frac{240x250}{15} = 4000$ fishes

Answers for Self-assessment 1.3

1) The following are the answers:

a) Number of quadrats containing couch grass=5 quadrats, while the total number of quadrats =10 quadrats. The Species frequency =$\frac{5}{10}$x100=50%.

On the other hand, the total number of couch grasses counted =12 couch grasses,

while the total surface area=0.50m2x10 = 5m2. The species density of couch grass = $\frac{12}{5} = 2.4$ couch grasses perm^2

b) It might be more appropriate to use species frequency rather than species density to record the abundance of a species when it is not possible to count individual organisms. For example, the organisms like grass plants are often difficult to count them as they are interconnected, while some organisms form a covering over the surface of rocks and it is impossible to count them.

c) Percentage cover =$\frac{50}{200}$x100 = 25%

2) Population of insects =820 insects, while the total surface area=1.2km^2. The population density of insects = $\frac{820}{1.2} = 683$ insect per km^2. When the total number of flowering plants=560 flowering plants while the total surface area=0.2km2. The Population density of flowering plants=$\frac{560}{0.2} = 2800$ flowering plants per km^2. Based on these results, it is clear the flowering plants have higher population density than the population density of insects. That is 2800 >683

Lesson 4 : Population growth patterns and environmental resistance

a) Prerequisites/Revision/Introduction

To study better this lesson, learners must remember the population size and the factors affecting the population density. As a facilitator, ask learners to brainstorm them. Concerning the answer, the factors affecting the population density are:

- Density – dependent (biotic) factors such as diseases, predation and competition.
- Density – independent (abiotic) factors such as fire and flood.

b) Teaching resources

Use textbooks and internet, manila paper Take the example of data shown in the activity 1.5.

c) Learning activities

The activity 1.5 in student's book requires that learners plot data on the growth curve.

d) Methodological steps

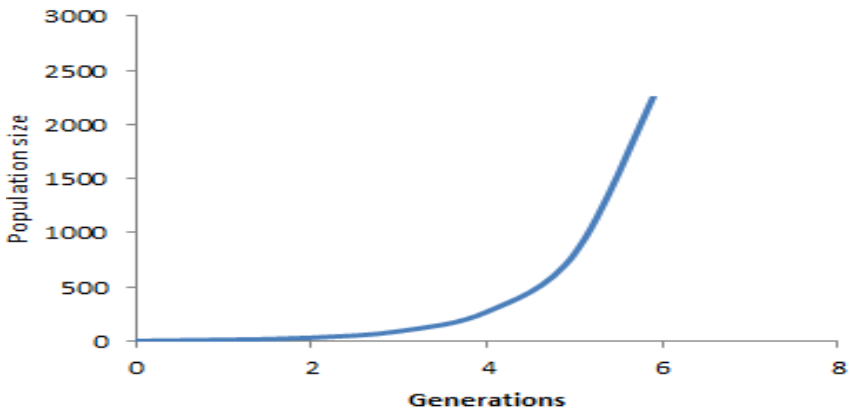
- As a facilitator, suspend, in front of learners, the Manila paper on which you have written 2 sets of data that learners will plot to discover the exponential growth pattern and logistic growth pattern.

- Ask each learner to plot each set of data on a graph to get the exponential growth pattern and logistic growth pattern and respond to the activity 1.5.
- Choose 4 learners who present their answers to the whole class.
- Enable other classmates to ask questions to those who presented; if they are not able to respond properly, clarify the answers.
- As you intervene in responding, remember to include the comprehensive sexuality education, telling to learners that the exponential growth curve they have got can result from uncontrolled sexual reproduction of some learners who engage early in sexual intercourse or prostitution. Encourage learners to avoid such bad behaviours.
- Show the summary on the chalkboard and let sufficient time to learners so that they note it in their notebooks.
- Finally, assess the lesson by letting learners do the self –assessment 1.4.

Answer for Activity 1.4

The answers are:

1) The plotted graph in the function of generations looks like the following:



Graph in 1a is the exponential growth curve while the graph shown in 1b is logistic (sigmoid) growth curve.

b) The plotted graph in 1a is the exponential growth curve while the graph shown in 1b is logistic (sigmoid) growth curve.

Similarities

- Both curves show lag phase and exponential phase,
- Both curves, the plotted population sizes are affected by environmental factors.

Differences

The graph in a, is factor independent while the graph given shows factor dependent

The graph in a shows low carrying capacity while the given one shows high carryingcapacity

2) Environmental resistance prevents the maximum reproductive potential (biotic potential) from being realized by a population. So, due to it, the population does not continue to grow exponentially but the population size tends to decline as some individuals die. So, environmental resistance contributes to the destruction of nature.

Answer for Self-assessment 1.4

1) Any three biotic factors that affect the balance of nature include competition, predation and disease

2) Carrying capacity and biotic potential can be distinguished as follows:

- The carrying capacity of a biological species in an environment is the maximum population size of the species that the environment can sustain (support) indefinitely, given the food, habitat, water, and other necessities available in the environment.
- The biotic potential is the maximum population growth under optimum (best / ideal) environmental conditions.

3) Environmental resistance causes the population growth to be stationary as it kills some individuals of a population.

Lesson 5: Natural resources and their importance on economic growth of Rwanda

a) Prerequisites/Revision/Introduction

The prior knowledge that learners must have is about factors affecting economic growth seen in Senior 5 entrepreneurship (Unit 15). Ask them to state those factors including the natural resources. In relation to the answer, the natural resources that contribute to the economic growth of Rwanda are:

- Renewable natural resources such as solar energy, water and plants of parks.
- Nonrenewable natural resources such as minerals like gold, coltan and wolfram

b) Teaching resources

Draw different natural resources on a manila paper or use those provided in the activity 1.6. Also, use internet.

c) Learning activities

The activity 1.6 requires that learners observe different natural resources categories and discuss about their contribution to Rwandan economic growth.

d) Methodological steps

- Request the groups to do the activity 1.6.
- Hang the manila paper on which you have drawn the natural resources in front of learners
- 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 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 that, after mining in an area, this area must be flattened with soil so that animals do not fall in the hole. Include also the financial education saying that, after getting the degree, students can request the loan, from a bank or cooperative, which can be used as capital to invest in mining and so create their own job.
- Write the lesson summary on the blackboard, PowerPoint and share it with the learners.
- At the end, assess learners with self-assessment 1.5 or formulate your own assessment questions that must be answered by each learner.

Answer for activity 1.5

1) The two categories are summarized in the following table:

Renewable resources	Non-renewable resources
Solar energy, Lake Burera	Coltan, Tin, Gold, Peat coal, Wolfram, Methane gas, Limestone

2) Renewable and non-renewable resources contribute to the economic growth of Rwanda as follows:

- Solar energy is used as source of electricity that is sold and increases the economy of a Rwanda.
- The methane gas extracted from Lake Kivu is the source of electricity bought by different people and so Rwandan economy grows. This lake is also the habitat of some sold fishes.
- The lake Burera water contributes to electrical production of Ntaruka. Also, this lake is the habitat of some fishes. Both products (electricity and fishes) are sold in order to increase the Rwandan economy.
- Coltan, tin, gold, peat coal, wolfram, limestone is extracted from the soil and sold for increasing Rwandan economy. Most of those minerals are used in industrial production.

Answer for self – assessment 1.5

The answers include:

1) Their job increases the economic growth of Rwanda in this way:

- They hire employees whose life status is improved.
- They pay taxes used in different economic development activities.
- They get interest used in other economic activities.

b) They must flatten that site from which they have extracted those minerals so that it is used in other economic purposes such as agriculture and to prevent accidental deaths of individuals who may fall in it.

2) Water has different physiological and economic roles, hence it must be carefully and wisely conserved. Its physiological roles include nutrients transport in blood, reactant in photosynthesis, involvement in hydrolysis. Its economic importance includes contribution to electrical production and being sold in order to be used in domestic activities such as hygiene and cooking.

Lesson 6: Methods of conserving natural resources

a) Prerequisites/Revision/Introduction

To understand this lesson, learners must have prior knowledge about the effects of human activities on the ecosystem. Ask probing questions to test whether they remember those effects. For example: What are the effects of human activities on the ecosystem? The answer looks like this of this question include: Pollution leading to acid

rain, eutrophication and global warming, soil erosion, desertification, species extinction and genetic modification.

b) Teaching resources

Use the textbooks such as student's book. You can even use internet. This internet link:https://www.conserve-energy-future.com/terrific-ways-to-conserve-natural-resources.phpshows different ways to conserve the natural resources.

c) Learning activities

The activity 1.7 in student's book involves learners in the description of methods of natural resources conservation.

d) Methodological steps

- Guide to learners the location of the activity 1.7.
- Ask learners to join their respective groups and do that activity.
- Select the 3 groups which present the answers to the whole class.
- If there are some methods which are not mentioned by presenters, ask other groups to add them.
- Permit learners to ask questions to presenters and intervene if they are not able to respond accurately.
- Summarize the lesson and let learner to write the summary in their notebooks.
- Finally, assess the lesson objective by using the questions mentioned in the self –assessment 1.6 or formulate other questions that individual learner does. Have a habit of giving a homework at the end of every lesson and mark it. This homework can come from the self –assessment and end unit assessment seen in student's book or from other book.

Answers for activity 1.6

Answers are given in the following table:

Method	Name of method
A	Terraces for erosion prevention
B	Biogas use in cooking

C	Water conservation in a tank
D	Protection of national parks by guardian

2) The possible methods for conservation of natural resources include:

- Use of alternative sources of power such as solar and wind energy
- Tree planting to prevent soil erosion
- Practicing of judicious ways to conserve water in our homes
- Use pipelines to transport oil
- Growing vegetation in catchment areas
- Treatment of industrial wastes and sewages before they are released in water bodies
- Practice of in-situ or on site conservation of wildlife
- Practice ex-situ or offsite conservation of wildlife
- Formulation of policies and regulations to curb poaching
- Practice judicious ways of conservation energy
- Use of bio-fuels
- Ensure the recycling of wastes
- Make use of electronic mails
- Purchase hybrid cars instead of the conventional cars
- Water the lawns and farms in the evening
- Reuse old furniture
- Practice crop rotation
- Translocation of wild animals
- Establish special schemes to preserve endangered plant and animal species
- Constructions of reservoirs
- Formulate regulations to stop overfishing

3) Some measures established by Government of Rwanda for environment, biodiversity and natural resources conservation include:

- Use of methane gas from lake Kivu
- Tree planting to prevent soil erosion
- Practice of judicious ways to conserve water in our homes by advising people to keep rain water at home in tanks.
- Rwandans are advised by the government to grow vegetation in catchment areas
- Practice of in-situ or on site conservation of wildlife
- Practice ex-situ or offsite conservation of wildlife
- Formulation of policies and regulations to curb poaching
- Practice judicious ways of conservation energy
- Use of bio-fuels such as biodiesel
- Practice crop rotation
- Translocation of wild animals
- Establish special schemes to preserve endangered plant and animal species
- Constructions of reservoirs
- The government of Rwanda has formulated regulations to stop overfishing in Rwandan lakes

Answer for self – assessment 1.6

1) In-situ conservation is the on-site conservation or the conservation of genetic resources in natural populations of plant or animal species, such as forest genetic resources in natural populations of tree species; while ex-situ conservation is the preservation of components of biological diversity outside their natural habitats.

2) The energy sources that Rwandans should use for protecting the environment include:

- Biogas in cooking and electrical production
- Biofuels such as biodiesel in vehicles
- Solar energy and other electrical energy in cooking and in industries.
- Save 80 cooking system

1.6 Summary of the unit

Ecological population is a group of organisms of the same species that live in the same area at a certain period of time. It is characterized by a population density, age structure, growth pattern, birth rate and death rate. Both density- dependent (biotic) factors, like diseases, and density-independent (abiotic) factors, such as flood, affect the population density. The methods or techniques of measuring population density includes quadrat method, line transect method and capture-recapture method. Population growth patterns are graphs, also called population growth curves, in which the increases in size are plotted per unit time. A population growth pattern is affected by environmental resistance which is the sum total of limiting factors, both biotic and abiotic, which act together to prevent the maximum reproductive potential, also called biotic potential, from being realized.

A renewable natural resource can or will be replenished naturally in the course of time, while a nonrenewable natural resource is a resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption. Those resources increase the economic growth of Rwanda. This is the reason why they must be methodically protected. Some of their protection methods are terraces, use of biogas, afforestation (planting trees) and use of alternative sources of power such as solar energy and wind energy.

1.7 Additional information

It is possible to calculate the change in population size as the time passes. This change can be calculated using the formulae shown below.

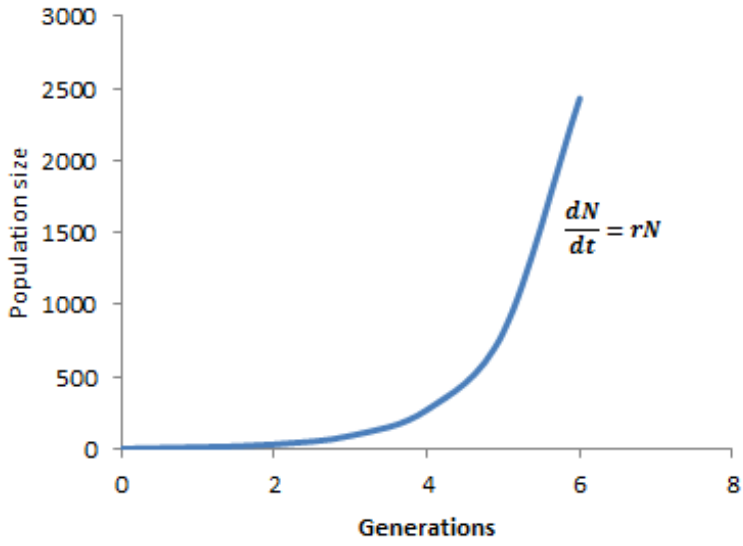


Figure 18: Exponential growth curve.

In this curve formula, N=population size, t: time, $\frac{dN}{dt}$=change inpopulation size, r=intrinsic

rate of natural increase. For logistic growth, to calculate the population growth as time passes, use this formula:

$\frac{dN}{dt} = rN(\frac{K-N}{K})$, Where N=population size, t: time, $\frac{dN}{dt}$=change inpopulation size, r=intrinsic rate of natural increase, K=carrying capacity, $\frac{K-N}{K}$=effect ofcarrying capacity on population growth.

1.8 Answers for end unit assessment 1

1) d
2) b
3) d
4) a
5) The term that best completes the sentence are:

- a) Carrying capacity
- b) Immigration
- c) Higher maximum

6) Answers include:

i) b

ii) a

7) Answers are:

a) The human activities shown on the figure that harm the natural resources is the deforestation (cutting trees).

b) Deforestation has many negative effects such as:

- Erosion
- Lack of sufficient oxygen that should be produced by plants during photosynthesis.
- Increase of atmospheric CO_2 included in greenhouse gases that contributes to global warming. This CO_2 should be used as reactant in photosynthesis.
- Desertification.
- Insufficiency of animals and human's food
- Decrease of most population growth.

c) The possible measures to solve such problems include:

- Establishment of rules and regulations for preventing ecosystems against degradation such as deforestation.
- Punishment to people who practice deforestation.
- Use of other alternatives of energy sources such as biogas and other gases in cooking.
- Use of metallic materials in houses construction.
- Practice of family planning to reduce birth rate that could contribute to the environmental degradation in search for shelter or habitat.

8)The following are the answers:

a) Species frequency

Number of quadrats in first garden containing blackjack = 6 quadrats
Total number of quadrats = 10 quadrats

$$\text{Species frequency} = \frac{6 \times 100}{10} = 60\%$$

Number of quadrats in the second garden containing blackjack= 3 quadrats
Total number of quadrats = 10 quadrats

$$\text{Species frequency} = \frac{3 \times 100}{10} = 30\%$$

b) Species density:

Total number of blackjacks counted in first garden = 17 blackjacks
Total area sampled = 10 × 1.0 m2 = 10.0 m2

$$\text{Species density} = \frac{17}{10} = 1.7\% \text{ blackjacks per m2}$$

Total number of blackjacks counted in the second = 8 blackjacks

Total area sampled = 10 × 1.0 m2 = 10.0 m2

$$\text{Species density} = \frac{8}{10} = 0.8\% \text{ blackjack per m2}$$

c) For species frequency, the species frequency of the 1st garden is greater than the species frequency of the 2nd garden. That is 60% > 30%. With respect to species density, the species density of first garden is greater than the species density of the 2nd garden. That is 1.7 blackjacks per m^2 0.8 blackjack per m^2

d) Using random quadrats ensures that the results are representative of the whole area. The quadrat samples are not biased in any way, e.g. not all taken from one part of the area being studied or an area with most species, fewest species or with large areas of bare ground.

9) When, in the age–structure pyramid, there is a largest group of many reproductive females and males who do not practice family planning, the rate of human population growth is maximal under ideal conditions. If the largest group of age–structure contains females who have reached the menopause, the rate of human population growth is low.

10) The answer is:

- From 1818 up to 2018 (year of first edition of this book), there are 2 centuries (200 years). In this period, there is exponential growth of world human population (population explosion). In 200 years ago, there were less than one billion humans living on earth. Today, according to United Nations calculations, there are over 7 billion of people. This is the most conspicuous fact about world population growth: for thousands of years, the population grew only slowly but in recent centuries, it has jumped dramatically. Between 1818 and 2018, the increase in world population was three times greater than during the entire previous history of humanity.

- This population explosion is due to factors such as low practice of family planning linked to high birth rate, medical discoveries and development associated with low death rate and food availability.

11) The answers are:

a) Calculations are summarized in the following table:

Quadrat of side/cm	Area/cm2
10	100
25	625
50	2500
75	5625
100	10000

b) The students took five results for each quadrat in order:

- To collect reliable results.

- To calculate a mean.
- To see how much variation there is in the number of species per quadrat.

c) They choose the 50 cm quadrat because:

- The 50 cm quadrat includes most of the species present in the habitat.
- If the quadrat was larger, there would be many more individuals to count (which would take longer time).
- If the quadrat was smaller, some of the species might not be counted each time as sample is taken

d) The answer is:

They would use the 50 cm quadrat to estimate the abundance of different plant species in the field as follows: As the field is likely to be a uniform habitat, quadrats are placed randomly, mark out a grid using tapes and take random numbers to find coordinates across the grid to place the quadrat; record presence or absence of species(for frequency)in order to collect reliable results , to calculate a mean and to see how much variation there is in the number of species per quadrat. Record the number of species and calculate species' density or record percentage cover (for those species is difficult to count.)

12) The answers are:

a) Estimated total population = $\frac{N1xN2}{N}$ where N1 is the number of organisms in initial sample, N2 is the number of organism in a second sample, and N: the number of marked organisms recaptured. So, N1=39, N2=35, N=20. The Estimated total population = $\frac{39x35}{20}$ =68

b) These are the assumptions that must be made in order to make this estimate:

- The marking must not harm the animal or be non-toxic.
- The marking must not influence the animal's behaviour.
- The marking must not put animals at greater risk of predation.
- Animals must mix at random after release.
- There is no immigration into the waste ground / emigration from the waste ground, no 'birth' of beetles or death between the two sampling times.

c) One way to do this is by random sampling with quadrats because:

- Generates random numbers to give coordinates for positioning quadrats; put 10 (or more) quadrats on the field.
- Leave for several hours; (because putting down the quadrats may have disturbed the animals)
- On return, move the rice plants gently to disturb the plant hoppers and count them;
- Calculate the mean number per quadrat;
- Calculate an estimate of the number of plant hoppers in the field by dividing the area of the field by the area of the quadrat and multiplying the answer by the mean number of plant hoppers per quadrat.

1.9 Additional Activities

1.9.1 Remedial activities

1) Explain what can be done in order to reduce the population explosion.

Answer: To reduce the population explosion, family planning must be practiced. A family planning is the practice of controlling the number of children in a family and the intervals between their births. If sexually active, family planning may involve the use of contraception and other techniques to control the timing of reproduction. Other techniques commonly used include sexuality education, prevention and management of sexually transmitted infections, pre-conception counselling and management, and infertility management.

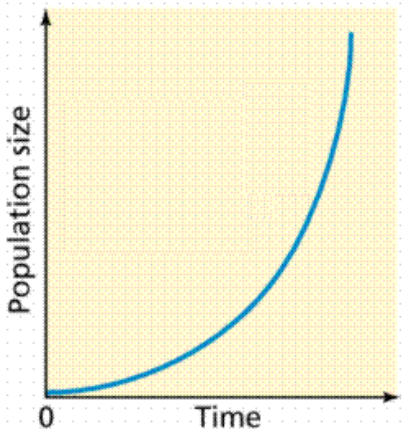
2) Distinguish between density –dependent and density-independent factors.

Answer: Density-dependent factors are factors whose effects on the size or growth of the population vary within the population density. The types of density dependent factors include availability of food, predation, disease and migration. However, food availability is considered as the main factor. Whereas density- independent factors can affect the population without being necessary based on the density. They include natural disasters (droughts, floods, hurricanes and fires), temperature, sunlight, seasonal cycle, human activities, and levels of acidity, cited among many others.

3) Make a brief description of species frequency

Answer: Species frequency is a measure of the chance (probability) of a particular species being found within any one of the quadrat, and it is found simply by recording whether the species was present in each analysed quadrat and it is found simply by recording whether the species was present in each analysed quadrat.

4) You are provided with the graph below:



a) Suggest the title of this graph.

b) Explain why you have suggested such title.

Answer:

a) The drawing is showing the exponential growth pattern

b) It is exponential growth pattern because a population starts out growing slowly but grows faster as population size increases.

5) Differentiate between renewable and non-renewable resources.

Answer: A renewable resource is a resource that can or will be replenished naturally in the course of time while a non-renewable resource is a resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption.

6) Describe briefly the importance of making terraces.

Answer: Terraces are made in order to prevent erosion and to increase crop production.

1.9.2 Consolidation activities

Suggestion of questions and answers for deep development of competences.

1) Explain the impact of a disease and a good food supply on a population size.

Answer:

- Some diseases cause the death to most individuals of the population. Therefore, the disease decreases the population size.
- A good food supply increases the population size

2) An area of 5 m^2 contains 3 mice (one male mouse and 2 female mice),1 cat, few grasses, 2 cows and 5 goats.

a) Identify the density –dependent factors which will be observed in this area.

b) Describe what will happen the population of mice.

Answer:

a) The density-dependent factors which will be observed in this area:

- Predation (cat will hunt, kill and eat mice).
- Food (few grasses)
- Interspecific competition (cows and goats will compete for grasses)

b) The growth rate of mice population will decrease because a cat will hunt, kill and eat them.

3) There are 100 small squares in one quadrat. If plants are found within about 20 squares within that quadrat, calculate the percentage species cover of that area.

Answer: The percentage species cover of that area = 20%.

4) Describe the stationary phase of a logistic growth curve.

Answer: A stationary phase is a phase in which the number of births plus the number of immigrations is balanced with the number of deaths plus the number of emigration. The causes of the stationary phase **include:**

- Predators and disease increase mortality
- Build-up of wastes such as excrement or excess carbon dioxide
- Competition for available resources increases: food, space, shelter, minerals. The habitat has reached its carrying capacity.

5) You are provided with the following picture taken from Lake Kivu.

Identify at least 5 natural resources included in Lake Kivu and describe their impact on economic growth of Rwanda.

Answer:

- Methane gas extracted from Lake Kivu is the source of electricity bought by different people
- It contributes to the growth of the economy of Rwanda
- Fishes taken from this lake are sold and increase the rwandan economy.
- Water of this lake is used for different purposes such as transport of goods from Rwanda to Congo or vice-versa.
- The taxes from this trade increase the Rwanda economy.

6) Discuss the negative effects of poaching on the ecosystem.

Answer:

- Poaching reduces the population size of organisms in the ecosystem.
- Poaching can lead to the extinction of certain species.

19.3 Extended activities:

1) Explain the intrinsic rate (r)of natural increase of a population

Answer: The intrinsic rate (r) of natural increase of a population is the maximum per capita rate of population increase under ideal conditions. It is influenced by birth rate, immigration, death rate and emigration. r = birth rate per capita- death rate per capita.

2) Establish the relationship between Zero population growth, birth rate, death rate and demographic transition.

Answer:

- Zero population growth = High birth rate - High death rate or Zero population growth = Low birth rate - Low death rate
- The movement from high birth and death rates toward low birth and death rates, which tends to accompany industrialization
- Improved living conditions, is called the **demographic transition.**

3) There are 100 adults' elephants in a population of an area. Each year, 10 elephants are produced while 2 elephants die.

a) Calculate the birth rate (x) of that population

b) Calculate the death rate (y) of that population

c) Calculate the intrinsic rate (z) of natural increase given that z= x-y

Answer:

a) Birth rate = $\frac{\text{number of births}}{\text{number of adults in the population}}$,since the number of birth is 10 elephants/year and Number of all population is 100 elephants, so X= Birth rate=$\frac{10}{100}$ =0.1 per elephant per year,

b) The number of death is 2 elephants/year and the number of all population is 100 elephants, so, Y= Death rate = $\frac{2}{100}$=0.2 per elephant per year

c) Z = 0.1-0.02=0.08 per capita per year.

4) You are provided with the following statistics on population size of insects in the following table:

Generation	Population size
1	10
2	30
3	90

4	270
5	810
6	2430

a) Calculate the net reproductive rate (R) of this population

b) Calculate the population sizes of the seventh and eighth generations.

c) Identify the type of growth pattern of this population.

Answer:

a) R= 2430 / 810 = 3.

b) It is general for all population sizes of all generations of insects. For exponential growth, to calculate the population size from year to year, the formula Nt+1 =R Nt, Where N t+1 is the population size in the following year and R the net reproductive rate is used.

c) The net reproduction rate (R) is the average number of individuals that are produced by a female if she passed through her lifetime conforming to the age-specific fertility and mortality rates of a given year. If N t is the number of females already present . For 7th population, Nt+1 = 3 x 2430 = 7290 and for 8th population, Nt+1 = 3 x 7290 = 21870

5) Mahoro is a fish farmer in Burera district. She wanted to know the total population in her fish pond. She netted 240 fishes and tagged (marked) their opercula with aluminium discs. She released those fishes into the pond. After one week, she netted again 250 fishes among which 15 had the aluminium discs. Calculate the Lincoln index.

Answer:

Lincoln index = $\frac{N1xN2}{N}$, Where N1 is the number of organisms in initial sample,N2 is the number of organism in a second sample, and N: the number of marked organisms recaptured. If N1=240, N2=250 and N=15. The Lincoln index = $\frac{240 \text{ X } 250}{15}$ = 4000 fish

6) Describe the impact of carrying capacity on the population size

Answer:

- When the carrying capacity is reached, there is no further growth of the population.

- Then, the growth curve reaches the stationary phase.

7) Describe how endangered species can be umbrella species.

Answer:

- Endangered species is a species which tends to undergo extinction as its population size decreases at a higher rate. Suppose that gorillas tend to undergo extinction.

- An umbrella species is a species whose protection enables the protection of other species. For instance, gorillas in Volcanoes National Park in Rwanda can be considered as umbrella species because their protection enables the protection of plants of that park.

UNIT 2: CONCEPT OF ECOSYSTEM

2

2.1 Key Unit Competence

Analyses the different components of an ecosystem, biogeochemical cycles and how energy flows in an ecosystem.

2.2 Prerequisite (knowledge, skills, attitudes and values)

To succeed well this unit, make sure that the learners have learned and have understood well the other units of previous years which are 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 the previous units.

The previous units that learners should know before studying the concept of ecosystem are:

- Unit 1 Senior 4, Introduction to biodiversity.
- Unit 1, Senior 5, Interdependence between organisms with their environment
- Unit 1, Senior 6, Population and natural resources

2.3 Cross-cutting issues to be addressed:

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

a) Environment and sustainability will be addressed when students will acknowledge the interdependence among 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 livings. 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.

2.4 Guidance on the introductory activity:

Introduce the unit1by using pictures of introductory activity and ask the students to do the following:

a) Teacher's activity

- Invite the learners to observe the pictures of introductory activity
- Give time to think about the given questions
- Allow them to express their ideas
- Consider their ideas and then inform what they will learn in this unit

b) Learner's activity

In their groups, the learners are going to do an introductory activity in student book unit 2

c) Answers to the introductory activity

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

2.5 List of lessons/sub-heading (including assessment)

	Lesson title	Learning objectives	Number of periods
1	Ecosystem definition and its types	Describe an ecosystem State the types and properties of an ecosystem Describe the main components of an ecosystem Define the terms: population, community, ecosystem, biome, niche and biosphere Distinguish between individuals, populations, communities, niche, habitat, ecosystems, biomes, biosphere	1 period
2	Properties of ecosystem and ecological factors influencing the life of organisms	Explain the ecological factors influencing the life of organisms in an ecosystem Describe feeding relationships in an ecosystem Distinguish between abiotic and biotic factors Appreciate the existence of different components of an ecosystem and their roles in the life of organism	1 period

3	Energy flow in ecosystem	Describe a food chain and a food web Explain the relative merits of pyramids of numbers Explain energy flow and the recycling of nutrients in an ecosystem Analyse the relation between organisms (example: producers, consumers, decomposers) and their trophic levels. Interpret energy flow diagrams Recognize the source and transfer of energy in an ecosystem	3 periods
4	Bioaccumulation/ Bio magnification	Beware of the effect of bioaccumulations at different trophic levels.	2 periods
5	Efficiency of production	Explain what is meant by trophic efficiency Compare gross primary, net primary production and secondary production	2 periods
6	Biogeochemical cycles	Describe biogeochemical cycles Identify processes, components, and roles of organisms in the hydrologic, carbon and nitrogen cycles Distinguish between primary and secondary succession in biotic communities	3 periods
7	Assessment standard:	Analyse fully the different components of an ecosystem, biogeochemical cycles and how energy flows in an ecosystem, develop and present explanations using language for precision and effect.	2 Periods

Lesson 1: Ecosystem definition and its types

a) Prerequisites/Revision/Introduction

The prerequisites of the lesson ecosystem definition and its types are some ecological terms that learners learned in senior six, 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.

b) Teaching resources

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

c) Learning activities 2.1

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners to form groups
- Provide a diagram 2.1 and ask them to do the related questions Attribute to each group, activity 2.1 given in student textbook
- 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
- Learner in their groups present their findings. In their groups, the learners are going to do an activity 2.1 in student book

Answers for activity 2.1

1) 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. There are two types of ecosystem: natural ecosystem and artificial ecosystem. The natural ecosystem also is divided into two categories: terrestrial and aquatic.

2) Differences are:

- An individual: is any living thing or organism. A group of individuals of a given species that live in a specific geographic area at a given time.
- Population: A group of organism of the same species which live in the same habitat at the same time where they can freely interbreed.
- Community: All the populations of the different species living and interacting in the same ecosystem
- Niche: in an ecosystem, refers to the unique ways an organism survives, obtains food and shelter, and avoids danger.
- The habitat: is the physical environment in which a species lives and to which it is adapted.
- 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
- A biome: is a broad regional type of an ecosystem characterized by distinctive climate and soil conditions and a distinctive kind of biological community adapted to those conditions
- The biosphere: is the portion of Earth inhabited by life and which represents the sum of all communities and ecosystems.

Answers for self-assessment 2.1

The expected answer is the same as the expected answer of activity 2.1 Number 2

1) The examples of aquatic and terrestrial ecosystems are:

- Terrestrial ecosystem of Rwanda such as Nyungwe, Volcanoes, Akagera national parks
- Aquatic ecosystem such as lakes (Kivu, Muhazi,) rivers: Nyabarongo, Akanyaru

2) 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. They are two major classifications of ecosystems: natural ecosystem and artificial ecosystem.

Natural ecosystems are those ecosystems that are capable of operating and maintaining themselves without any major interference by man. Natural ecosystems are furthermore classified into **terrestrial ecosystems** including forest, grassland and desert, and in **Aquatic ecosystems** including fresh water ecosystem such as ponds, lakes, rivers and marine ecosystems such as ocean, sea or estuary.

In the same habitat, two different species cannot occupy the same niche in the same place for very long. This is known as the competitive exclusion principle. If two species were to occupy the same niche, they would compete with one another for the same food and other environmental resources

Lesson 2: Properties of an ecosystem and ecological factors influencing the life of organisms

a) Prerequisites/Revision/Introduction:

You should start this lesson by asking questions on the previous lesson and revise shortly the previous lesson "definition of ecosystem and its types". It should facilitate the learners to understand more this lesson because it is linked with the previous one.

b) Teaching resources

- Charts and illustrations indicating the ecosystems.
- Video/ movies of ecosystem downloaded from you tube
- The school environment.
- Student textbooks, internet, pictures
- Projector

c) Learning activities 2.2

Teacher's activity:

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

- Attribute the activity questions 2.2 to each learner
- Bring the learners to the school garden environment
- Let the learners collect different things.
- 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
- Individually, the learners are going to activity 2.2 in student book

Answers for activity 2.2

1) Characteristics of collected living and non-living things are summarized in the following table:

Living things	Non-living things
Move, Breathe, Reproduce, Are made up of cells, Grow	Do not move, Do not breathe, Do not reproduce, Are not made up of cells, Do not grow

2) The students should group living things starting from plants(A), and animals (B, C, D, E, F, and G). The classification of this living things based on the process of being eaten is: Producers: G, Consumer: A, B, C, D, E, F, Carnivores: A, B, C 2 and Herbivores: E, F, D.

Answers for self-assessment 2.2

1) All ecological factors are present in Akagera National Park. Biotic factors (many plant species are present (e g. acacia…), animal species (mainly herbivores (antelopes,), carnivores are also present but in short number (e.g. lions). Abiotic factors (mountains, rocks, decaying plants and animals)

2) Soil is made up of minerals from rocks, organic matter from plants and animals, many species live in the soil. Earthworms keep soils clean by digesting the soil and their movement keeps the soil fresh, bacteria in the soil recycle nitrogen and carbon; fungi transport nutrients and help to decompose organic matter. Intricate root systems of plants and trees provide shelter and food for lots of organisms. Soil is a thriving ecosystem. The organic matter in soils contains nutrients which are essential for plant growth, which is incredibly important to us as we need plants to eat. Vegetables, fruits, cereals all need to be grown, as well as crops to be used as feed for animals.

Micro-organisms in the soil convert toxic compounds within the soil into useful nutrients for plants, soil is incredibly useful. It acts as a drainage system when it rains to absorb water therefore preventing floods. This drainage also filters water to clean it as minerals and micro-organisms in the soil detoxify the water of pollutants. These processes are referred to as ecosystem services, where natural processes benefit humans. Micro-organisms in the soil convert toxic compounds within the soil into useful nutrients for plants. For example, ammonia is converted into nitrogen in the nitrogen cycle. These micro-organisms also decompose organic matter for it to be recycled through the carbon cycle.

Lesson 3: Energy flow in an ecosystem

a) Prerequisites/Revision/Introduction:

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

Teaching resources

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

c) Learning activities 2.3

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners to form pairs

- Provide a diagram 2.11and ask them to do the related questions, attribute to each group, the activity 2.3 given in student textbook
- 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 their pairs, the learners are going to do an activity 2.3 in student book

Answers for activity 2.3

1) Producer gets energy from sun, then it is converted into chemical energy, 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 lost in heat. Some energy from A to C is lost as heat

2) A= Primary consumer, B= Secondary consumer, C= decomposer

3) 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

4) When A is removed from the diagram, B will be affected; finally, will die due to lack of food, while producers will increase

Answers for self-assessment 2.3

1) Answers are:

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.

d) It potentially could have a positive/negative effect on the amount of vegetation available within the ecosystem. Positive, in that the plants this particular herbivore was consuming now are not being consumed; negative, in that the lack of plant consumption has now increased the competitiveness of all the plants struggling for survival. The balance between producers, herbivores, and carnivores is a delicate part in the maintenance of an established ecosystem. Interrupt too many links in the food chain and the whole thing can come screeching to a halt.

d) Soil erosion, land degradation, loss of valuable species will appear in Akagera national park

2) Only a fraction of solar radiation strikes plants or algae, only a portion of that fraction is of wavelengths suitable for photosynthesis and much energy is lost as a result of reflection or heating of plant tissue

3) A: the producer is a single plant such as a tree, B: the producer is a single plant which is infested with parasites (primary consumers) and the latter are parasitized by further parasites, C: A large number of producers are eaten by a single primary consumer which is infested with parasites and D: Normal pyramid for comparison

4) Energy passes through an ecosystem, entering as sunlight and leaving as heat. It is not recycled within the ecosystem

Lesson 4: Bioaccumulation and Biomagnification

a) Prerequisites/Revision/Introduction:

Introduce this lesson by asking the learners to make critical thinking on this scenario. Medical doctors have found the DDT in breast feeding of certain woman in King Faisal Hospital so they wondered to investigate where breast feeding came? From your point of view where do you think DDT in breast feeding originates?

b) Teaching resources

- Charts and illustrations indicating different types of ecosystems.
- Video/ movies showing bioaccumulation and bio magnifications downloaded from you tube

– Student books, pictures showing the bioaccumulation and biomagnification, internet

– Projector

d) Learning activities 2.4

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

– Facilitate the learners to form groups

– Provide activity 2.4 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

– In their groups, the learners are going to do an activity 2.4 in student book

Answers for activity 2.4

1) 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.

Answers for self-assessment 2.4

1) Adding nutrients causes population explosions of algae and the organisms that feed on them. Increased respiration by algae and consumers, including detritivores, depletes the lake's oxygen, which the fish requires

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

Lesson 5: Efficiency of ecological production

a) 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.

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) 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 2.5 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 their individually, pairs or groups, the learners are going to do an activity 2.5 in student book

Answers for activity 2.5

1) 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 - 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 (g C m–2 yr–1) is most often used as the unit of measurement.

Answers for self-assessment 2.5

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= 100J-50J-30J= 20J.

b) The production efficiency: In their respective groups, the student calculates the production efficiency basing on the formula they learned

Lesson 6: Biogeochemical Cycles

a) Prerequisites/Revision/Introduction:

- Introduce this lesson a learning situation whereby living and non-living materials are presented to the students. Ask the following questions:
- As a biology, chemistry and geography students, what do you think to be the biochemical substance / component within the presented materials
- If you may leave those materials on the surface, do you think the substance will remain as they are? What will happen to them?

b) Teaching resources

- Charts and illustrations indicating water cycle, carbon cycle and nitrogen cycle.
- Video/ movies showing the efficiency of ecological production
- Student books, pictures, internet

c) Learning activities 2.6

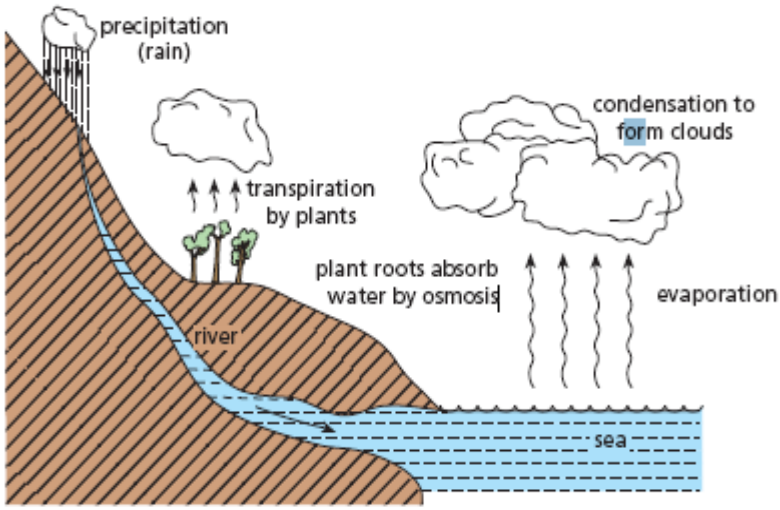
- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners to form groups
- Provide the diagrams given in student textbook
- Attribute the activity 2.6 given in student textbook.
- Allow the learners to use the school library and the internet
- 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
- Individually, in pairs or groups, the learners are going to do an activity 2.6 in student book

Answers for activity 2.6

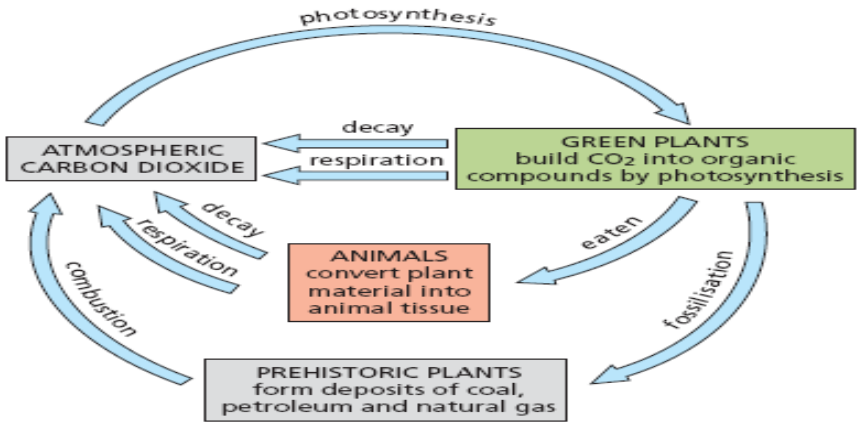
1) X= Water cycle, Y= Carbon cycle, Z= Nitrogen cycle

2) The following are the answers:

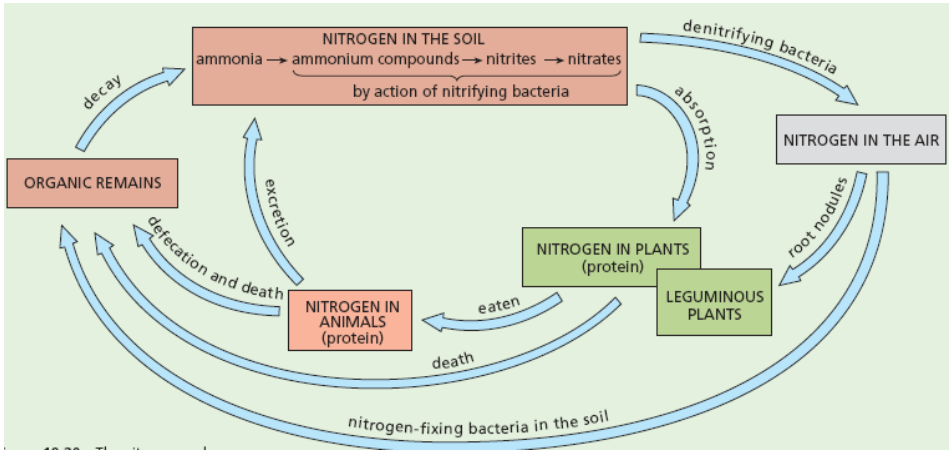
(i) A= evaporation, B= condensation to form clouds. Basing on the diagram below, the learners should use their own words and explain effectively the process of water cycle



(ii) A= atmospheric carbon dioxide, B= Photosynthesis, C= green plants build CO_2 into organic compounds by photosynthesis. Basing on the diagram below, the learners should use their own words and explain perfectly the process of carbon cycle



(iii) A=Nitrogen, B= Nitrogen in plants, C= Nitrogen in animals, D= Organic remains. As they have done the previous questions, the learners should summarize the nitrogen cycle in their own words



3) 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

4) 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.

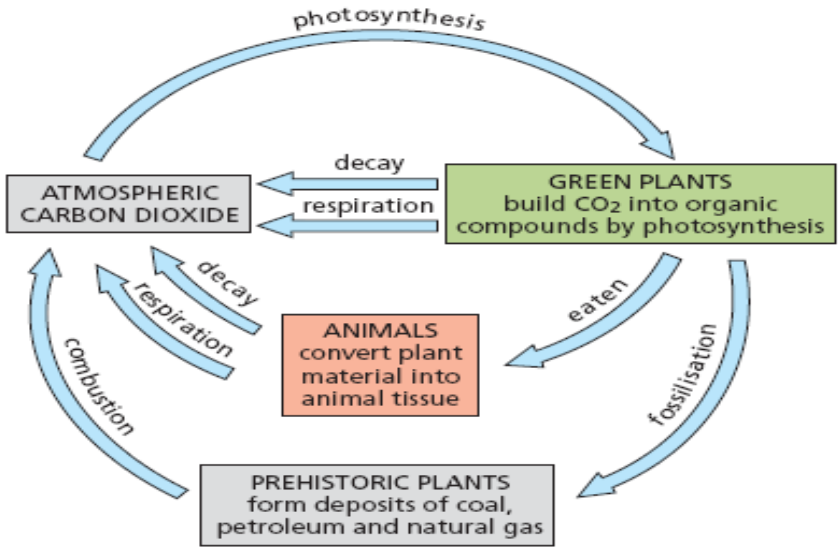
Elements or water may be held for various lengths of time by different components of a biogeochemical cycle. Components that hold elements or water for a relatively short period of time are called exchange pools. For example, the atmosphere is an exchange pool for water. It holds water for several days. 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.

Answers for self-assessment 2.6

1) You would need to know how much biomass the zebras ate from your plot and how much nitrogen was contained in that biomass. You would also need to know how much nitrogen they deposited in urine of feces

2) Because higher temperatures lead to faster decomposition, organic matter in these soils could be quickly decomposed to CO_2, speeding up global warming

3) The answer is:



The learners should draw other diagram and indicate the movement of matter from abiotic and biotic reservoirs.

4) Removal of the trees stops nitrogen uptake from the soil, allowing nitrate to accumulate there. The nitrate is washed away by precipitation and enters the streams

2.6 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.) 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.

Carbon cycles quickly between organisms and the atmosphere. It cycles far more slowly through geological processes. The nitrogen cycle moves nitrogen back and forth between the atmosphere and organisms. Bacteria change nitrogen gas from the atmosphere to nitrogen compounds that plants can absorb. Other bacteria change nitrogen compounds back to nitrogen gas, which re-enters the atmosphere.

2.7 Additional Information

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.

2.8 Answers for end unit assessment 2

Answer for multiple questions

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

Answers for Short questions

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 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 essay questions

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 monitor 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) The following are the answers:

A : Rhizobium/ Azotobacter/ Clostridium/ Bacillus/ Klebsiella etc...
B : Nitrosomonas/ Nitrococcus/ etc...
C: Nitrobacter
D: Pseudomonas/Bacillus/ Thiobacillus/etc
Anaerobic conditions such as water -logged soil/ bogs/ marshes

15) The following are the answers:

a) Two points have to be considered:

– 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.

– 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

b) 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

16) The following key points have to be considered:

– Change or often an increase in species/ diversity of organisms present; resulting in change to their environment, which benefits other species, for example addition for nutrients to the water in the lake

– 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

– 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

17) The following are the answers:

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

The study of ecosystems mainly consists of the study of certain processes that link the living, or biotic, components to the non-living, or abiotic, components. The two main processes that ecosystem scientists study are energy transformations and biogeochemical cycling. As we learned earlier, ecology generally is defined as the interactions of organisms with one another and with the environment in which they occur. We can study ecology at the level of the individual, the population, the community, and the ecosystem.

Abiotic components	Biotic components
Sunlight	Primary producers
Temperature	Herbivores
Precipitation	Carnivores
Water or moisture	Omnivores
Soil or water chemistry (e.g., P, NO_3, NH_4)	Detritivores

c) Energy enters the biological system as light energy, or photons, is transformed into chemical energy in organic molecules by cellular processes including photosynthesis and respiration, and ultimately is converted to heat energy. This energy is dissipated, meaning it is lost to the system as heat; once it is lost it cannot be recycled. Without the continued input of solar energy, biological systems would quickly shut down. Thus the Earth is an open system with respect to energy. Elements such as carbon, nitrogen, or phosphorus enter living organisms in a variety of ways.

Plants obtain elements from the surrounding atmosphere, water, or soils. Animals may also obtain elements directly from the physical environment, but usually they obtain these mainly as a consequence of consuming other organisms. These materials are transformed biochemically within the bodies of organisms, but sooner or later, due to excretion or decomposition, they are returned to an inorganic state (that is, inorganic material such as carbon, nitrogen, and phosphorus, instead of those elements being bound up in organic matter).

Ecosystems are complex with many interacting parts. They are routinely exposed to various disturbances: changes in the environment that affect their compositions, such as yearly variations in rainfall and temperature. Many disturbances are a result of natural processes. For example, when lightning causes a forest fire and destroys part of a forest ecosystem,

the ground is eventually populated with grasses, followed by bushes and shrubs, and later mature trees. Thus, the forest is restored to its former state. This process is so universal that ecologists have given it a name succession.

The impact of ecosystem disturbances caused by human activities is now as significant as the changes wrought by natural processes. Human agricultural practices, air pollution, acid rain, global deforestation, overfishing, oil spills, and illegal dumping on land and into the ocean all have impacts on ecosystems. Humans can control and alter the ecosystem. Farming by humans increases the amount of food by encouraging plants to grow by cultivation. Humans can also control the environment to compensate for disabilities. Humans can permanently damage the environment. The resources and minerals that are removed from the ground are not renewable.

18) Abingondo is missing the plant biomass eaten by herbivores and the production allocated to plant roots and belowground tissues.

2.9 Additional activities

Remedial Activities

Multiple questions

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) 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 out number 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 with short answers

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

– Biotic factors include sunlight, soil, temperature, and water.

Answer: F

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

Answer: T

6) 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

7) 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.

8) 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.

9) 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.

10) 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.

11) 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

12) 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.

13) 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.

During possible steps of the cycle, water may still be stored in subterranean reserves or in the form of ice in mountains and oceans, and may also be used in the metabolism of living organisms, incorporated into the body of individuals or excreted through urine, faeces and sweat.

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

Answer: 100000× 10 = 1000000 kilocalories: 100 = 10000 kilocalories

2.9.2 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

2.9.3 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:

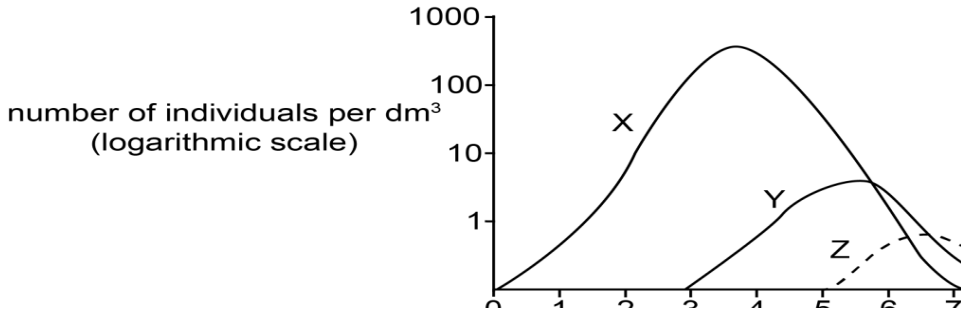
– Ecosystem Conservation.

– 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.

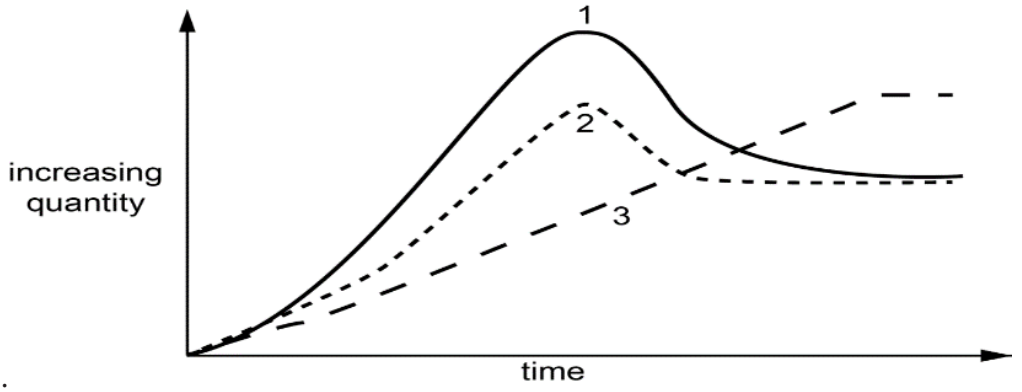


Basing on what you have learned on ecosystem in your class, Identify the trophic levels indicated by X, Y and Z, make an interpretation of the graph.

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



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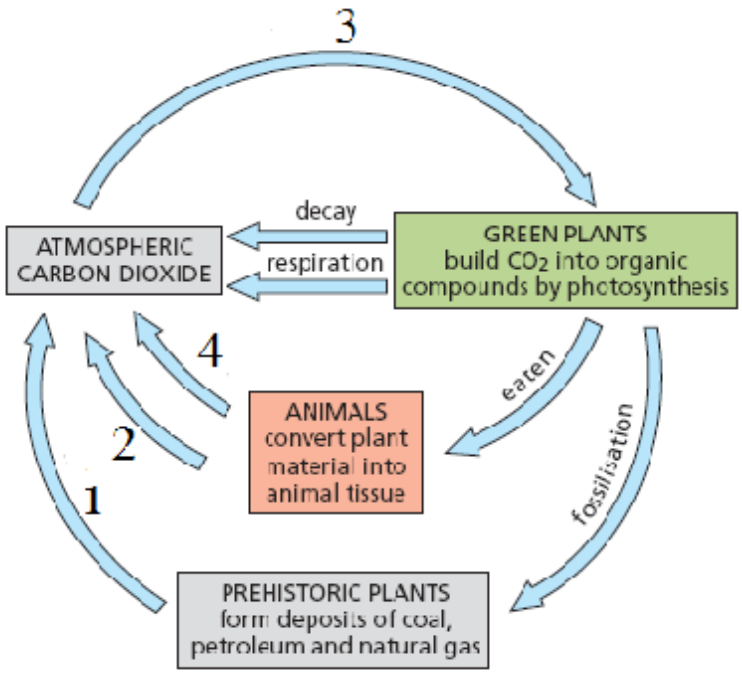
What do the 1, 2, 3 lines represent?

Answer

1: Gross primary production of biomass
2: Biomass leaving as respiratory loss
3: Total biomass accumulated

4)The flow diagram shows the main events of the A cycle. Basing on what you have learned in class.



a) Name A cycle?
b) Name1, 2, 3 and 4
c) Interpret A cycle

Answer

a) Carbon cycle.
b) 1: Combustion, 2: Respiration, 3: Photosynthesis, 4: Death
c) In their own words, the learners write notes on carbon cycleμ

UNIT 3: EFFECT OF HUMAN ACTIVITIES ON ECOSYSTEM AND BIOLOGICAL CONSERVATION

3

3.1 Key Unit Competence

Evaluate the effects of human population size, resource use, and technology on environmental quality

3.2 Prerequisite (knowledge, skills, attitudes and values)

In order to succeed well this unit, students should possess **knowledge and understanding, skills and attitudes** that are related to previous units particularly those pertained to **ecosystem unit 2.** They should also be able to do **observation, interpretation of the event and then capable to present and or communicate the results.**

3.3 Cross-cutting issues to be addressed

Among the cross cutting issues that are to be addressed by the competence - based curriculum, the issues of **environment and sustainability, financial education as well as inclusiveness** will be addressed by this unit for satisfying the present needs without compromising those of the future generations.

Environment and sustainability will be addressed when students will be involved in activities related to visiting areas that have been polluted by human actions on the Earth and then take or suggest measures or ways and do practices aimed at reducing and stopping the destruction of the natural resources.

For **financial education,** this issue will be addressed when students will be discussing how modern agricultural technologies lead to high production from economies of scale since the misuse of them leads to economic depletion as well to other human's effects that will need more money to overcome them in terms of the money that is invested in the process and that will be used to deal with consequences.

Additional questions may be asked at the end of each lesson after students' presentation of the findings as well as the conclusion for emphasizing on finance as well as environment and sustainability.

Since, there are some pictures within this unit; special attention should be paid for catering and including **students with special needs**. Therefore, you should provide

Braille/ tactile or using a scenario for students with visual impairment. Also, use sign languages for involving the learners in class activities are suggested. For the clarity and visibility of teaching materials, make sure that students can see the pictures. As you will be taking students in a field study trip, care about all students particularly those with disabilities.

3.4 Guidance on the introductory activity

Inform students to use pictures and the scenario provided in student' textbook on the introductory activity in student's textbook and or contextualise the scenario / learning situation and then do the following:

- Ask them what they can do for sustainably conserving as well as using any of the ecosystems?
- Ask them to briefly suggest what can be done for sustainably conserve natural ecosystems.
- Give students time to think about the question and then give room to them to express their ideas in brainstorming way.
- Finally, appreciate their ideas/ thoughts

Inform them that by studying this unit, students will be aware about how humans have impacted and are now impacting Earth's ecosystems and then change their everyday practices for maintaining a healthy environment in which they can live together in harmony as well as to conserve and use ecosystems sustainably with less harmful to future generations.

Expected students' feedback

Not throwing waste materials in environment such as plastic bottles, collect the waste materials from the environment, proper disposal of the wastes, planting trees, avowing deforestation, mining wisely, protecting habitat.

3.5 List of lessons

	Lesson title	Learning objectives	Number of periods
1	Modern agricultural technologies for food production	Explain how modern agricultural technology has resulted in increased food production Appreciate the balance between society, environment and the economy	2
2	Impacts of human activities on ecosystem	Explain the negative impacts to an ecosystem of large scale monoculture of crop plants Explain the reasons for habitat destruction (agriculture and extraction of natural resources) Explain the undesirable effects of habitat destruction Assess the negative impacts to an ecosystem of intensive livestock production Research the effects of the excessive use of fertilizers on the environment Appreciate the balance between society, environment and the economy Recognize that extinction is a natural part of the evolution of life on earth but has taken place in an unprecedented rate, mainly as a result of human activities Adapt regulations designed to prevent overfishing into action	4

3	Pollution	Explain the sources and effects of the pollution of air, water and land Explain the causes and effects of acid rain, eutrophication and non-biodegradable plastics Carry out a research project on recycling sewage Demonstrate ways of reducing pollution and protecting the environment Support the Rwandan government policy of protecting the environment	3
4	Biological conservation and restoration	Explain the main methods of the conservation of resources Describe an example of conservation in action Conduct shows and dramas on wildlife conservation Assess the different methods of the conservation of nature Carry out research on the African species endangered by human activity Organize clubs focused on environmental and wildlife protection Suggest ways in which one could take positive action to help conserve biological resources	3
5	Assessment standard	Evaluate fully the effects of human population size, resources use and technology on the quality of the environment.	2

Lesson 1: Modern agricultural technologies for food production (… periods)

a) Prerequisites/Revision/Introduction

Ask students how the agriculture is done in their areas. With the emphasis to equipment used, ask also whether the equipment used have increased the food production or not. Ask them to predict reasons for the increase in food production.

b) Teaching resources

Students textbooks, internet, physical resources or illustrations or photographs (e.g. farming machines),

c) Learning activities 3.1

Help learners to develop competencies of this lesson by doing the following:

- Help students to make groups of not more than six students each,
- Ask students to do a research using internet and their textbooks and then do the activity number 3.1.
- You are also requested to take them to an area where agriculture is modernized if any is nearby your school.
- After they have discussed, give opportunity to them so that they present what they come up with or say how they find the modern agricultural practices towards the increase of yield.
- Use students' findings, challenge students through questions like do you agree? What do you think about colleagues' ideas etc. and move towards the conclusion?
- Extend the lesson by connecting it to how modern agricultural activities promote finances.

Answers for activity 3.1

- Machinery use: Large land is faster cultivated, seeding and harvesting is also done quickly, no yield can be lost in harvesting or being eaten by birds or other plant pests since harvesting is done at once.
- Fertilizer application: Fertilizers increase food production by augmenting soil fertility which makes the crops to grow fast and being big for high production.
- Use of pesticides: Pesticides prevent plant weeds or insects to grow thus plants grow properly and produce more.

- Use of herbicides: to reduce competition of weeds for the available nutrient
- Selective breeding: this involves the use of high breed crops and animals to improve on both food production and animal products like milk and beef production among others

Answers on self-assessment 3.1.

1) Modern technology is the use of sophisticated methods in production ie. In agriculture this can involve the use of machinery I ploughing, weeding, spraying, milking and harvesting among others.

2) Use of selected breeds is beneficial;

3) Use of selected breed insures food security since and crops can endure environmental problems like, dry season, too much rainfall, pest and diseases among others.

4) There is sustainable income as the farmer is assured of production.

5) Increase in government revenue and foreign exchange earner as farmers export their produce to other countries.

Lesson 2: Impacts of human activities on ecosystem

a) Prerequisites/Revision/Introduction

Start the lesson by asking students whether they have seen an area in nearby their school which endangered or damaged by human activities. Ask them to brainstorm how humans have endangered that area.

b) Teaching resources

Internet, textbooks, pictures / illustrations, physical environment, farming using machines

c) Learning activities 3.2

- Help learners to develop competencies of this lesson by doing the following:
- Help them to form groups of not more than 6 students
- Invite them do make a research (using books or internet) on the effects of excessive use of fertilizers on the environment.
- Take them to a polluted site near your school and ask them to investigate or assess the impact of industrial sewage and application of fertilizer on nearby land to wetlands and water bodies.

- At the site of study, ask them to do questions given in student' s activity 3.2
- Guide them how they will produce a proposal suggested in learners' textbook. Emphasize on the three main components of a report (introduction, development and conclusion)

Answers for activity 3.2

1) For question 1 & 2) large scale monoculture and intensive livestock as well as habitat destruction seriously impacted the ecosystem through: 1 Soil compaction when mechanical machines are used and bovines move for grazing, soil erosion due to soil compaction or deforestation as monoculture requires large land and then people cut trees, soil acidification due to bovines' manures as well as chemical fertilisers, 2. decline of organisms that depend on grasslands for food and habitat, new plants are introduced due to loss of native grassland plants, 3. contribution to reducing water bodies oxygen levels and harms fish and plant populations, 4. greenhouse effects and climate change from methane gas (CH_4) from enteric fermentation and nitrous oxide (N_2O) from their manures; cause acid rain and ozone depletion.

2) Undesirable effects of habitat destruction include extinction/ decrease of biodiversity, soil deterioration, greenhouse effects and climate change/ global warming, water contamination by minerals, acid rain, and ozone depletion etc.

3) The deforestation may cause flooding since trees absorb too much of heavy rain water and allow water to be retained or be given chance to penetrate into the soil. The absorbed water is used by a plant as well as lost during plant transpiration. Without trees, useful land becomes desert as the useful one is washed off by erosion.

4) Overfishing impacts water ecosystem due to lack or diminution of one species which favour the increase of another or one species lack food. Deforestation causes soils containing nutrients and chemicals to be washed into water

5) Mining and industrialization impact ecosystem by: Compaction of soil, emissions of gases, industrial water sewage, and loss of habitat of biodiversity.

Answers on self-assessment 3.2

1) Reasons for habitat destruction include: land for agricultural activities, construction of houses, search for fire woods as well money, poaching, searching for minerals

2) Effects of natural habitat deterioration are: biodiversity degradation, soil pollution, air pollution and water pollution and migration of some species to other area or death of species.

3) The following are the answers:

- Excessive use of fertilizers has impacted the ecosystem by eutrophication.
- It leads to change in the PH of water bodies as a result of run offs in them which can have an effect on some aquatic life.

4) The following are the answers:

- Impacts on soil include soil pollution in terms of compaction, lack of oxygen, killing soil living organism, soil erosion, toxicity of the soil increases due to fertilizers and pesticides
- Impacts on the water include eutrophication as a result of fertilizers run off, cause death to aquatic living as a result of suffocation, accumulation of heavy metals, oil spill may appear into water from mechanical machineries

Lesson 3: Pollution

a) Prerequisites/Revision/Introduction

Start the lesson by asking whether they have experience any sign of pollution. Ask students to brainstorm how a polluted area looks like and to predict what causes pollution and its consequences to other livings.

b)Teaching resources

Physical environment, scenario, photographs.

c) Learning activities 3.3

- Help learners to develop competencies of this lesson by doing the following:
- Organize students in groups of not more than six members
- Take them to a nearby your school site (water pond or land) that is suffering from degradation
- Invite them to conduct a survey about how the area is polluted
- Ask them to predict the pollutant of that area with justifications/ assumptions.
- Ask them to do learning activity questions 3.3. provided in their textbook

– Ask students to produce a proposal showing how they can take action on the impact of industrial sewage and fertilizer application on nearby land to wetlands and water bodies.

– Guide them how they will produce a proposal suggested in learners' textbook. Emphasize on the three main components of a report (introduction, development and conclusion)

Answers for activity 3.3

1) Answers include;

a) A picture of a visited polluted area

b) Main sources of pollution are: Main cause of environmental pollution include: industrial emissions, poor disposal of wastes, mining, deforestation, use of fossil fuels and agricultural activities.

c) Causes of acid rain are:

– The emissions of Sulphur oxides by industries and other equipment. Acid rain affects living organisms particularly plants and animals

– Eutrophication is caused by excess of too much nitrogen, phosphorus and potassium that ends by being released in water. Eutrophication causes death to organisms living in water due to algae bloom followed by suffocation

– Poor disposal of plastic bottles is the cause of non-biodegradable plastics. They prevent water from getting into the soil. They cause death to soil living organisms.

2) Ways of reducing pollution: proper disposal of the wastes, planting trees, not releasing domestic or industrial wastes into surface water, not using carbon dioxide releasing equipment, etc.

3) A proposal containing abolishing of all kind of CO_2 releasing activities (burning, deforestation, cars and industrials emissions. Other greenhouse effects gases such as water vapours, chlorofluorocarbons, methane, ozone, nitrous oxides, chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs), as well as sulfur hexafluoride (SF6) should be reduced

Answers for self-assessment 3.3

1) A polluted area by fertilizers is indicates by many aquatic plants particularly algae due to nitrogen, phosphorus, and potassium that is contained within the fertilisers

2) Non-biodegradable plastics are very dangerous to farmers and other soil dwelling organisms since they prevent water from getting into the soil. They cause death to soil living organisms by dehydration and suffocation.

3) Ways of mitigating pollution include proper disposal of wastes, not using equipment that release more carbon dioxide, planting plants.

Lesson 4: Biological conservation and restoration

a) Prerequisites/Revision/Introduction:

- For introducing this lesson, interact with students through questions as follow:
- Ask students to brainstorm some areas of Rwanda where plants and animals are conserved.
- Invite them to predict which one from the animals and plants are known to play a great role in ecosystem.
- Ask them to think and share ways through which the important plants and animals are protected in Rwanda

b) Teaching resources

Internet, physical environment like a park, students' textbooks, illustrations or photographs

c) Learning activities

- Facilitate learners to develop competencies of this lesson by doing the following:
- Put students in groups of not more than six members each,
- Ask them to carry out research on the endangered species in Africa as a result of human activity and the methods of conservation of resources.
- Tell them to discuss on the activity no… given in students textbook and also do other activities that are related.

Answers for activity 3.4

1) People should care about because of the interdependence that exists among the living organism. Endangered species include gorillas, elephant and amphibians

2) The most endangered species in Africa include, elephants for their tusks, impala, and others.

3) Main methods of the conservation of resources include: Bioremediation, Biological augmentation, mowing, grazing or burning to halt success, coppicing, creating protected areas or zones, Restricting urban and industrial development, Reclaiming derelict sites or other areas, legally protecting endangered species, Prohibiting the release or introduction of non-native/ invasive animals and plants into an area, Controlling pollution, especially in sensitive environments in which species are at risk of extinction, Recycling materials such as paper, glass bottles and clothes,

Conserve energy, do not burn domestic wastes, plant a tree, park cars since they contribute to smog, use less fertilizer, never pour anything especially waste oil or leftover chemicals, do not trash into water streams or ponds, water the area/ lawn in the early morning, recycling materials, do not put hazardous materials in the trash, use digital thermometer, do not buy more than you need use paper bags instead of plastics, use both paper sides, etc.

Report to comprise elements given in number 3.

Clubs are formed and a threat or drama about wild life and will be played

Answers for self-assessment 3.4

1) Depollute the area

2) Coppicing increases by providing a wide range of microhabitats

3) If the population keeps increasing in dramatic way, the natural environment including parks and water ponds will be deteriorated or threatened by human actions.

4) The answer includes

- Planting trees
- Farming in a way which is not destroying natural environment
- Use of organisms usually prokaryote, fungi or plants to detoxify polluted ecosystems
- Use organisms to add essential materials to the degraded ecosystem
- Do not burn domestic wastes
- Use adequate amount of fertilizers
- Do not trash into water streams or ponds waste materials
- Use paper bags instead of plastics

5) The aquatic livings will end up by not having their habitat if soil eroded from hillsides keep on being reaching and taken by Nyabarongo river which is ecosystem of a number of aquatic wildlife. The way of restoring Nyabarongo river is by removing the soils and preventing other soils to get into that river.

3.6 Summary of the unit

This unit consists of four lessons which are: modern agricultural technologies for food production, impacts of human activities on ecosystem, pollution and biological conservation and restoration.

The first lesson describes how modern agricultural technologies increase for food production. It is followed by the impact of human activities on ecosystem whereby within this lesson, the negative consequences of large scale monoculture and livestock farming are presented.

In the third lesson which is about pollution, types, causes and effects of pollution are provided. Regarding to the lesson of biological conservation and restoration, different practices of conservation and restoration are discussed.

In every lesson, pre-requisites knowledge and skills, teaching resources and learning activities, together with expected answers are provided. Moreover, end unit assessment tasks are provided with extra activities where possible.

3.7 Additional Information

This section provides additional content for the teacher to have a deeper understanding of the topic.

3.8 Answers for end unit assessment 3

1) Humans impact the ecosystem by:

   - Deforestation (cutting trees);
   - Agricultural activities that use agricultural machines, pesticides, fertilizers; intensive farming and monoculture;
   - Overfishing;
   - Doing mining;
   - Industrial activities;
   - Releasing domestic and or industrial wastes in the open environment

2) The major and single cause of the deforestation in tropical area is the conversion of forest to cropland (agricultural land) and pasture (livestock farming).

3) Advantages and disadvantages of agricultural practices (deforestation, applying nitrogenous fertilizers to crops, burning agricultural waste such as straw, growing crop plants with genetically engineered resistance to herbicide e.g. glyphosate)

a) Deforestation

Advantages: wood used as fuel; land cleared for agriculture to grow more food; profit made from selling timber for export;

Disadvantages: burning of timber releases additional carbon dioxide which contribute to greenhouse effect as there is fewer producers to absorb carbon dioxide; soil may be eroded; eventually desertification; silting up of rivers etc.; heavy rain no longer absorbed by forests leads to increased risk of flooding; loss of biodiversity/ habitats/ species/

b) Applying nitrogenous fertilizers to crops

Advantages: increased productivity/ total yield of farmland; increased growth rate of crops; poor land can be used for agriculture;

Disadvantages: eutrophication/ soluble excess fertilisers increase algal growth in rivers/lakes, decomposer organisms thrive when this decays, reducing oxygen content and killing aerobic organisms/ population in water; excess fertiliser wastes money/ reduces profits; too little fertiliser may not enough increase in yield to pay for cost of fertiliser

c) Burning agricultural waste such as straw

Advantages: quick/easy clearance of waste; destroy fungal spores/parasitic eggs

Disadvantages: increased amounts of carbon dioxide, adding to greenhouse effect; less humus/organic material to return to, and improve the quality of soil

d) Growing crop plants with genetically engineered resistance to herbicide e.g. glyphosate

Advantages: weeds controlled more easily/less labour/cost involved in overcoming weeds; increased crop yield as less completion for resources; increasing profits

Disadvantages: herbicide resistance may theoretically spread to weeds; consumers may dislike the idea of genetically engineered foods; maybe more expensive than normal crop plants.

g) Increased in minerals cause algal bloom / algae/ small water plants to multiply rapidly/ eutrophication so much growth occurs that light prevented from reaching plants / algae below surface which then die; massive increase in aerobic, decomposer bacteria decreases concentration of oxygen. Thus, as the decrease in amount of oxygen threaten fish population.

4) The following are the key points of the answer:

- Zoologists and conservationists fear that many if not all species of amphibians (frogs, toads, and salamanders) would distinct since they are in deep trouble due to global pollution and climate change.
- Industrial Combustion of fossil fuels/ oil/ coal: release of nitrogen oxides/ Sulphur dioxide which will form dilute nitric acid/ sulphuric acid when dissolved in rain. Acid rain may be carried by wind from one country or industry to another
- Agricultural pesticides are also pollutants of the amphibians
- Those pollutants affect directly amphibians' eggs; harm indirectly tadpoles (irritate their gills, heavy metals may increase in concentration, and poisoning the tadpoles as well as food chain); some herbicides kill all vegetation, so could destroy adult's habitat/ food source for tadpole in herbivorous stage; if young affected, overall population of amphibians may decline
- Adult amphibians live on land, apart from breeding season, so are less likely to be vulnerable to pollutants in water; eggs/ tadpoles are aquatic for all of their lives, so have greater exposure to pollutants than adults; soluble material may enter soft/ unshelled eggs by diffusion; water passing over tadpole gills come into close contact with circulatory system, so harmful material, dissolved in water could diffuse into tadpole's blood; amphibians have thin skins, allowing pollutants to diffuse easily across tadpole skin.

5) Adding nutrients cause population explosion of algae and the organisms that feed on them increased respiration by algae and consumers, including detritivores, depletes the lake's oxygen which the fish use to survive. Thus, fish may die due to the lack of oxygen.

6) At lower trophic level, because biological magnification increases the concentration of toxins up the food chain.

7) The newly introduced species damage natural environment/ecosystem by the substances that they produce and secrete into the soil. Those substances are not suitable to the native organisms. In addition, they are sometimes good competitors with the native species so that they have high adaptation to the new environment.

8) Modern agriculture is a solution to humans as the increase food production. However, they are also an issue as they destroy the environment in different ways through pollution, destruction of natural environment, and so on.

3.9 Additional activities

3.9.1 Remedial Activities

1) Referring to modern agriculture and extraction of natural resources, explain the reasons for habitat destruction.

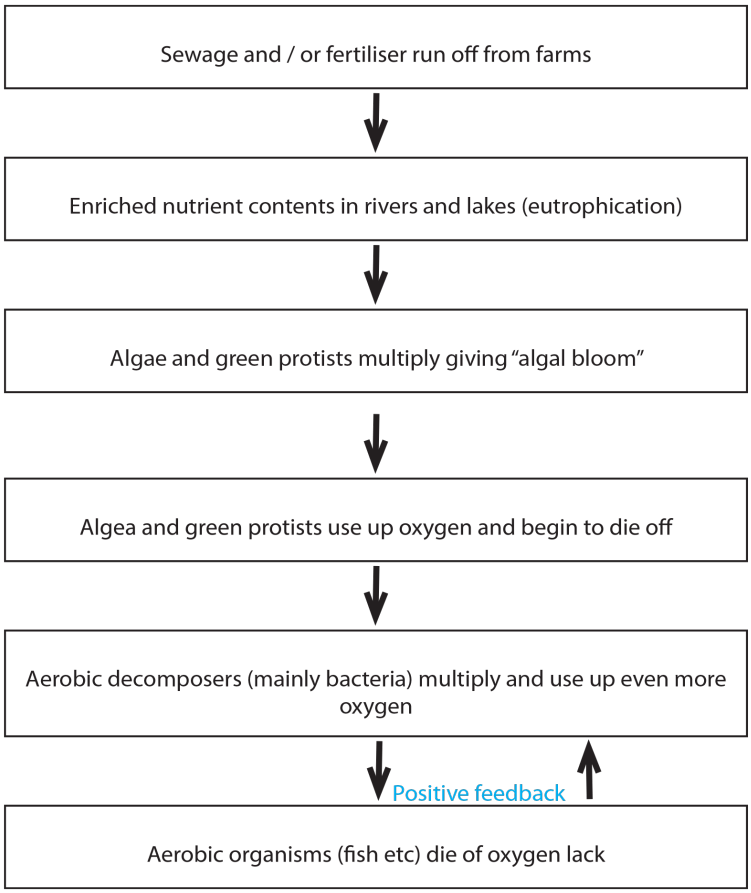
   Answer: Reasons for habitat destruction are mainly about searching land for agricultural services, intensification of livestock, economic services by searching timber/ charcoal, mining and overfishing.

2) Describe how you can identify the area polluted by excess of fertilizers by Bio-indicators.

   Answer: This can be done by observing whether there is algal bloom which will cause eutrophication

3.9.2 Consolidation activities

1) Create a flowchart showing the sequential events that lead to eutrophication



1) Design a poster indicating:

a) Acid rain formation

b) Green house effects

Answer: Student's textbook, lesson 3

3.9.3 Extended activities

1) Make a research on the bio-indicators and their indications vis-à-vis the pollution

Answer: The commonly used bio indicators and their indications include: lichens, liverworts that indicate the area contaminated by sulphur dioxide; diatoms/ unicellular marks an area with rapid eutrophication; bacteria which change their colour or the light they emit due to change in their proteins as a result of the minerals exposed that are exposed to.

2) Describe how it is very dangerous the newly introduced species damage natural ecosystem

Answer: Invasive species damage natural environment/ ecosystem by destroying or harming the native species

3) Why do Rwandans need to conserve elephant? Suggest how its conservation can be ensured?

Answer: A keystone species for example an elephant is an animal that plays a unique and crucial role in the way an ecosystem functions. If the attention is not paid to them, the ecosystem would be dramatically different or cease to exist altogether or species being animals or plants would diminish to extinction.

4) Using resources wisely is one of the recommendation by REMA. How the misuse of them has great impact to entire ecosystem?

Answer: By being released in different ecosystems being water, land, and air. Once released, they contribute to harming or threatening natural ecosystem

UNIT 4 : ENERGY FROM RESPIRATION

4

4.1 Key Unit Competence

Describe the structure and the importance of ATP, and outline the roles of the coenzymes NAD, FAD and coenzyme A during cellular respiration

4.2 Prerequisite

To succeed well this unit learners should have the knowledge and understanding, skills and attitudes pertained to photosynthesis and macromolecules of life. They should also be skilful in doing interpretation, calculations, analysis and presentation among others. Team working spirit and creativity should have also been developed among students.

4.3 Cross-cutting issues to be addressed

Since female students have been fearing tough science content including this related to respiration, attention should be paid during all the process of the lessons. To address this issue, you are advised to group students based on their differences in gender and also in academic achievement. You need also give more opportunity particularly to female students so that they can be leaders in group activities suggested and also take lead in sharing the findings from those activities. In that way, the boredom will be alleviated as they will find this unit easier and more understandable, and interesting.

4.4 Guidance on the introductory activity:

Start the unit by challenging students through the following questions: What do you understand about energy used by living organisms? Where that energy is obtained from? How that energy is it obtained from the source you have mentioned? Ask them to brainstorm about the aforementioned questions. Use students' feedback or ideas, then inform what will be covered within this unit.

Students' feedback: Energy is a chemical molecule, food, ATP. It is obtained from food, sugar, from plants, solar energy.

4.5 List of lessons

	Lesson title	Learning objectives	Number Periods
1	Need for energy by organisms	Discuss the need for energy in living organisms as illustrated by anabolic reactions, active transport, and the movement and maintenance of body temperature Appreciate the importance of energy in the life of organisms	1
2	Structure of ATP	Describe the structure of ATP as a phosphorylated nucleotide formed by condensation reaction Acknowledge the role of ATP as the energy currency of the cell	1
3	Synthesis and breakdown of ATP	Explain that ATP is synthesized in substrate-linked reactions in glycolysis and in Krebs (tri-carboxylic acid [TCA] cycle Explain that the synthesis of ATP is associated with the electron transport chain on the electron transport chain on the membrane of the mitochondrion and chloroplast	2
4	Respiratory substrates and their relative energy values	Explain the relative energy value of carbohydrate, lipid and protein as respiratory substrate and explain why lipids are particularly energy-rich.	2

5	Measurement of respiration and respiratory quotient	Define the term Respiratory Quotient (RQ) as the ratio of the volume of CO_2, evolved to the volume of O_2 uptake during aerobic respiration. Design simple experiments using respirometers to determine the RQ of germinating seeds or small invertebrates. Example: woodlice. Calculate RQ values from the equations of respiration of different substrates Interpret graphs for varying RQ values during seed germination	2
6	Assessment	Learners can describe the structure and the importance of ATP, and outline the roles of the coenzymes NAD, FAD and coenzyme A during cellular respiration	2

Lesson 1: Need for energy by organisms

a) Prerequisites/Revision/Introduction: Ask students to think about and then brainstorm what energy means and what is it used for.

b) Teaching resources: Books, textbooks, and internet access

c) Learning activities

- Help learners to develop the expected competencies of this lesson by:
- Ask students to use the books from the school library and make further research on the internet about metabolism reactions.
- Make group and invite them to do activity questions 5.1 provided in student's textbook.
- Ask them to use the searched information and discuss the reasons why all living organisms need energy to survive.
- After they have discussed, give them opportunity to present their findings.
- Be based on students' findings, harmonize and conclude the lesson.

Answers for self-assessment 4.1

1) The energy is the capacity to do work.

2) The energy is used for the chemical potentials produced and consumed during metabolic reactions including catabolic and anabolic biochemical reactions.

3) The sun is the major source of energy for organisms and the ecosystems of which they are a part. Some organisms get the energy from food.

4) If the sunlight is not available, plants shall not be able to synthetize food. Food will be scarce for all living things which finally may die. Without the sunlight, there is no life.

5) Living things need to take food almost always for a continuous supply of energy, and hence a continuous of biological functions.

6) Photosynthesis is an anabolic reaction because;

   – It combines micro molecules like CO_2 and H_2O to form organic molecules of glucose.

   – It uses energy thus an anabolic reaction

Lesson 2: Structure of ATP

a) Prerequisites/Revision/Introduction: Introduce the lesson by making a review on the previous learning

b) Teaching resources: Internet, textbooks, structure/ figure of ATP

c) Learning activities

- Help learners to develop competencies of this lesson by ask students to use books from the school library and search further information on the internet about ATP.

- Ask them to use the collected information for discussing the structure and biological functions of ATP and then do activity 4.2 provided in student textbook:

- Give them opportunity to share their findings

- Use their findings in consolidating as well as concluding the lesson

Answers for activity 4.2

The building blocks of Adenosine Triphosphate (ATP) are carbon, nitrogen, hydrogen, oxygen, and phosphorus, contained in the ribose sugar, a nitrogen base called adenine

and a chain of phosphate group. ATP has various biological functions including active transport, cell signaling, maintenance of the cell structure, muscle contraction, synthesis of DNA and RNA

Answers for self-assessment 4.2

1) ATP is the source of all energy needed by organisms for different biological activities. Without it, biological activities shall not be possible.

2) Answers are:

a) The figure represents a molecule (one mole) of ATP.

b) The letter a represents Adenine group, B represents a ribose sugar, and C represents the phosphate group.

c) Without ATP, there will be muscles seizure, severe cardiac arrhythmia leading to cardiac failure and probably death.

Lesson 3: Synthesis and breakdown of ATP

a) Prerequisites/Revision/Introduction: Begin this lesson by asking students to brain storm on the following: What do you think to happen to ATP molecules that are contained within any living organisms if the organisms are dynamic? Use their ideas and then move to learning activities provided in your teaching guide for this lesson.

b) Teaching resources: The resources that are to be used for this lesson are internet and textbooks.

c) Learning activities: Ask students to use books/textbooks and search further information on the internet about ATP. After they have read, invite them to discuss about the synthesis and breakdown of ATP as given in activity 5.3 in student textbook.

Answers for activity 4.3

During respiration, the energy stored in food molecules is made available for an organism to do biological work. In this process, the energy stored in food molecules is transferred to molecules of ATP. This can be done either through anaerobic or aerobic respiration. ATP is synthesized from adenosine diphosphate (ADP) and inorganic phosphate through a process of glycolysis, Krebs cycle and electron transport system. The synthesis of ATP is a reversible reaction. Its hydrolysis produces one molecule of ADP and inorganic phosphate. The breakdown of phosphate bond frees the energy which is used for different biological functions by organisms.

Answers for self-assessment 4.3

1) Based on chemical equations:

a) Synthesis of ATP: ADP+ P_i + free energy → ATP+H_2O. Formation of ATP is a synthesis reaction i.e. anabolic reaction and consumes energy.

b) Hydrolysis of ATP: ATP+H_2O→ADP+P_i+free energy. The hydrolysis of ATP is a decomposition (catabolic) reaction. It releases the energy

2) Reactions of synthesis and hydrolysis of ATP are reversible reactions

- The energy for hydrolysis: -14 kcal/mol or –57 kJ/mol
- The energy for synthesis: 14 kcal/mol or 57 kJ/mol

2) The hydrolysis of ATP is a decomposition (catabolic) reaction. It releases the energy. The Synthesis of ATP is a synthesis (anabolism) reaction. It consumes the energy.

3) The following are the answers:

a) Under standard conditions, one mole of ATP produces –7.3 kcal or –30.5 kJ. In the same conditions, 5 moles of ATP produce -7.3 kcal x5 or -30.5 kJ x5 equals to -36.5 kcal or 152.5 kJ.

b) In a living cell, one mole of ATP produces -14 kcal or –57 kJ. Under the same conditions, 5 moles of ATP produce -14 kcal x 5 or –57 kJx5 equals to -70 kcal or 285kJ.

4) If the hydrolysis reaction of ATP id not reversible, there shall not be the synthesis of ATP. The energy produced during photosynthesis shall be used by the organisms and when it ends, the living organisms might die because there is no any other supply of energy.

Lesson 4: Respiratory substrates and their relative energy value

a) Prerequisites/Revision/Introduction:

Introduce the lesson by asking students to brainstorm about the substrates of respiration and predict their relative energy value. Use the brainstormed and predicted ideas for engaging students in the main activity 4.4 of the lesson.

b) Teaching resources: Internet and students' textbooks

c) Learning activities

- Use the students' ideas generated in the introduction of the lesson and ask students to do the following:

- Use books from the school library and search further information on respiration as given in student's textbook learning activity 5.4.
- Answer to the questions that are provided.
- Give time to do them and ask them to present the findings
- Consolidate and conclude the lesson based on students' findings

Answers for activity 4.4

1) Respiratory substrate is the substrate required for cellular respiration to derive energy through oxidation. In other words, a respiratory substrate is a molecule from which energy can be liberated to produce ATP in a living cell.

2) They include carbohydrates, fats, and proteins.

3) Most of the energy released in respiration comes from the oxidation of hydrogen to water. The more hydrogens there are in the structure of a molecule of respiratory substrate, the greater the energy value. It is hydrogen atoms that are used to generate ATP via the electron transport. So, the more hydrogen atoms are in a respiratory substrate, th more energy release is high from it.

Answers for self-assessment 4.4

1) The oxidizing agent is NADH

2) NAD+ is oxidized.

3) Most CO_2 from catabolism is released during glycolysis.

4) The chemical equation of the decomposing of one molecule of glucose is:

   $C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$+Energy (ATP + heat). The amount of the energy produced one mole of decomposed glucose is 2 870 kJ.

5) One mole of glucose decomposed release - 686 kcal or - 2,870 kJ per mole of glucose. A moles of glucose will produce - 686 kcal x $^1/_2$or - 2,870 kJ x $^1/_2$equals to -343kcal or -1435 kJ

6) They are often used interchangeably to indicate the reduced form of NAD+. The overall reaction when oxidizing some molecule represented by RH_2 is: RH_2 + NAD+ to produce NADH + H+ + R. The proper reduced NAD+ is NADH which accepts electrons and one proton, but sometimes $NADH_2$ or NADH + H+ is used to account for that second hydrogen that gets removed from the substrate being oxidized. FAD and FDH_2 are explained in the same way.

7) During respiration process, glycolysis produces2 ATP per one molecule of glucose.

Lesson 5 : Measurement of respiration and respiratory quotient

a) Prerequisites/Revision/Introduction:

Introduce this lesson by informing students that all livings respire. And then, ask them to brainstorm how can someone do the measurement of respiration? What is the respiratory quotient for a human being for example? Use the brainstormed ideas and then go to learning activity 4.5 given in student textbook.

b) Teaching resources: Textbooks and internet

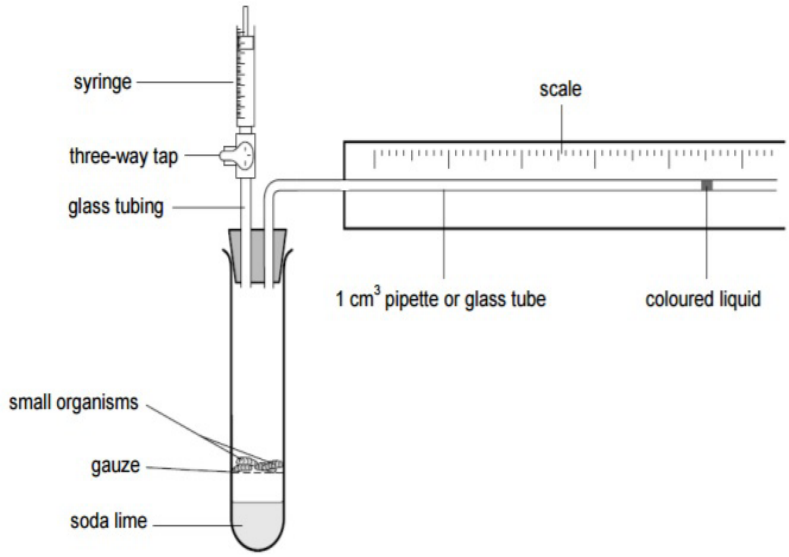
c) Learning activities

- Request learners to work in groups, use books from the school library and search further information related to respiration and do activity 4.4 provided in their textbook.
- Ask them to present the findings
- Consolidate students' ideas, cope with them and then conclude the lesson

Expected answers for activity 4.5

1) The respiratory quotient is a dimensionless number used in calculations of basal metabolic rate when estimated from carbon dioxide production. It is calculated from the ration of carbon dioxide produced by the body to oxygen consumed by the body.

2) The following is the figure of respirometer:



The role of a respirometer:

A respirometer is a device used to measure the rate of respiration of a living organism by measuring its rate of respiration of a living organism by measuring its rate of exchange of oxygen and /or carbon dioxide. They allow the investigation into how factors such as age, or chemicals affect the rate of respiration.

3) Form the rate of exchange between oxygen and carbon dioxide, the respiratory coefficient is calculated as follows:

$$RQ = \frac{\text{Volume of carbon dioxide given out}}{\text{Volume of oxygen taken in}}$$

Expected answers for self-assessment 4.5

1) The answer is:

   a) $RQ = \frac{\text{Volume of carbon dioxide given out}}{\text{Volume of oxygen taken in}} = \frac{36}{51} = 0.17$

   b) The substrate being respired is a protein

2) When RQ equals 1 for a germinating maize grain, this means that the volume of carbon dioxide given out equals the volume of oxygen taken in for the decomposition of a given substrate.

3) To conclude:

   a) The anaerobic respiration: RQ is greater than 1.

   b) The aerobic respiration: RQ is less than 1.

4) The volume of gases in manometer can be calculated by $\pi r^2 h$. Based on the given data in the question, r = 1.7cm, h = 3cm, while π is fixed and equals 3.14. From these specifications, $V = 3.14 \times (1.7cm)^2 \times 3cm = 27.2\ cm^3$

4.6 Summary of the unit

Organisms must do work to stay alive. The energy input necessary for this work is either light, for photosynthesis, or the chemical potential energy of organic molecules. Some organisms, such as mammals and birds, use thermal energy released from metabolic reactions to maintain their body temperature. Reactions that release energy must be harnessed to energy requiring reactions. This involves an intermediary molecule, ATP. ATP can be synthesized from ADP and phosphate using energy, and hydrolyzed to ADP and phosphate to release energy. ATP therefore acts as an energy currency in all living organisms. Respiration is the sequence of enzyme-controlled steps by which an organic molecule, usually glucose, is broken down so that its chemical potential energy can be used to make the energy currency, ATP.

The energy values of respiratory substrates depend on the number of hydrogen atoms per molecule. Lipids have a higher energy density than carbohydrates or proteins. The respiratory quotient (RQ) is the ratio of the volume of oxygen absorbed and the volume of carbon dioxide given off in respiration. The RQ reveals the nature of the substrate being respired. Carbohydrate has an RQ of 1.0, lipid 0.7 and protein 0.9. Oxygen uptake, and hence RQ, can be measured using a respirometer.

4.7 Additional Information

Before you teach this unit, you should have a deeper understanding pertained to aerobic and anaerobic respiration.

4.8 Answers for the end unit assessment 4

1) Chemical energy is the most important type of energy potential for life, because the energy is either released out or consumed through metabolism reactions. Metabolism reactions constitute the sum of all chemical reactions taking place in a living cell. The biological process by which metabolic pathways breakdown molecules into smaller units that are either oxidized to release energy is called catabolism, while the biological process by which a set of metabolic pathways construct molecules from smaller units through reactions consuming energy is called anabolism. During catabolism reactions, energy is released to the surrounding environments. These are exergonic reactions. During anabolism reactions, energy is absorbed from the surrounding environment. These are endergonic reactions.

2) All organisms need energy to realize their biological functions. Specifically, it is used for active transport, cell signaling, structural maintenance, and muscle contraction and in the synthesis of DNA and RNA. The principal source of energy is the sunlight. The energy from the sun is incorporated in living things through photosynthesis of producers including green plants, algae and some bacteria. Autotrophic living things gain the energy from food by directly consuming producers or by consuming primary consumers. Some living organisms are omnivores and get food by consuming either producers or consumers or both.

3) ATP is made by Adenine, Ribose sugar and Phosphate group. Bonds between these three functional groups are illustrated in the following figure.

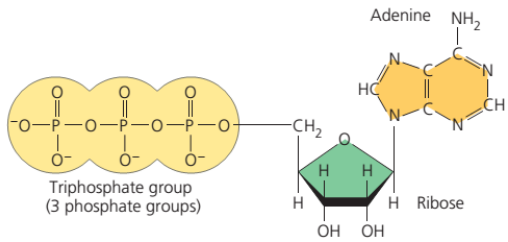


Image from www.wikipedia.com

ATP stands for Adenosine triphosphate and it is a complex organic chemical that participates in many processes. Found in all life forms of life, ATP if often referred to as the molecular unit of currency of intracellular energy. When consumed in metabolic processes it converts to either the di or monophosphate, respectively Adenosine Diphosphate (ADP) or Adenosine Monophosphate (AMP). Other processes regenerate ATP as the store of the energy which used for different biological functions.

4) $RQ = \frac{\text{Volume of carbon dioxide given out}}{\text{Volume of oxygen taken in}} = \frac{57}{80} = 0.7125$

5) The following are the answers:

a) One mole of ATP produces -14 kcal/mol or −57 kJ/mol in a living cell. 3 moles of ATP will produce 3(-14 kcal/mol) or 3(−57 kJ/mol) in a living cell, equivalent to -42 kcal/mol or -171 kJ/mol.

b) Since the synthesis of ATP is a reversible reaction of its hydrolysis. The amount of energy consumed for its synthesis equals the amount of the energy produced in its hydrolysis. Since one mole of ATP produces -14 kcal/mol or −57 kJ/mol in a living cell. The same amount will be consumed but now it will have the negative sign: - (-14 kcal/mol or −57 kJ/mol) = 14 kcal/mol or 57 kJ/mol. From this relationship:

Moles of ATP will produce (14 kcal/mol) or (57 kJ/mol) in a living cell, equivalent to 10.5 kcal/mol or 42 kJ/mol.

c) One mole of glucose produces -686 kcal (2,870 kJ) per mole of glucose decomposed. 5 moles of decomposed glucose produce 5(-686 kcal) or 5 (2,870 kJ) equals to -3430 kcal or 14350kJ.

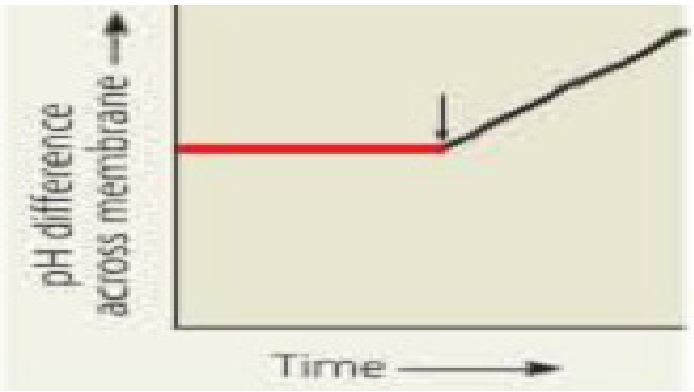
6) The following are the answers:

a) Aerobic respiration is occurring and the oxygen is used up in respiration, specifically in electron transport chain. Finally, it combines with hydrogen as it is the final acceptor of hydrogen with which they form water.

b) ATP production decreased and if the process continues for a long period of time, the production of ATP may stop. Electron transport can no longer release energy to produce ATP, oxidative phosphorylation stops, Krebs cycle stopped, hydrogen carriers and NAD cannot be recycled and no more oxygen taken up.

7) The total number of ATP molecules formed from one molecule of glucose during respiration equals 38. Each ATP molecule traps 50kJ, therefore 28x50kJ = 1900kJmol-1, 2881kJ could be made available from glucose, therefore the % efficiency = x100 = 65.9%.

8) When a metabolic poison is added and completely inhibits all function of mitochondrial ATP synthase, the pH difference across the membrane will increase from the end point as it is illustrated on the following figure:



9) The following are the answers:

a) The gas trapped in the beaker B is the air containing oxygen

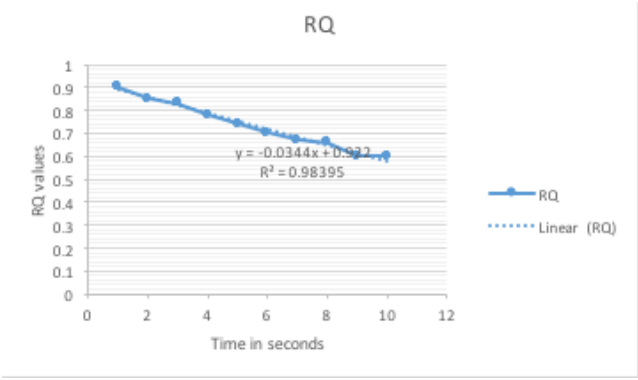
b) The mouse is still alive because it receives oxygen from beaker B

c) Lime water in the first beaker turns milky due to carbon dioxide produced by respiration

d) Since carbon dioxide is given out, it is the decomposition reaction. Hence, the experiment is related to respiration and energy production.

10) RQ is the ratio of the volume of carbon dioxide given out over the volume of oxygen taken in. Based on the figure, the value of RQ is decreasing in the function of time and stays constant for the last three seconds. It indicates that the volume of carbon dioxide is remarkably reduced so that RQ remains constant.

11) a) The graph looks as follows:



b) There is no change in RQ for the last three seconds because there is no longer the volume of carbon dioxide given out.

4.9 Additional activities

4.9.1 Remedial Activities

1) Choose the best answer

(i) When living cells break down molecules, energy is:

a) Stored as ADP

b) Stored as ATP

c) Released as heat

d) Both b and c

(ii) Energy is required for a variety of life process including

a) Growth and reproduction

b) Movement

c) Transport of certain materials across cell membranes

d) All of the above

(iii) The formation of ADP and inorganic phosphate from ATP and water is an example of which kind of reaction?

a) Condensation

b) Polymerization

c) Hydrolysis

d) Endergonic

(iv) ATP contains:

a) Contains five phosphate groups

b) Is essential for a cell to perform all the tasks necessary for life

c) Is found only in bacteria

d) All of the above

(v) When cells break down food molecules, energy

a) is released all at once

b) is released entirely body heat into the environment

c) is temporarily

d) Causes excitation of electrons in chlorophyll molecules

2) The following statements are about the molecule ATP (adenosine triphosphate). For each statement, indicate first whether it is true or false. Then, if it is false, rewrite the statement so that it is correct.

a) ATP is an unstable molecule.

b) Energy is released when the nitrogen-containing base in ATP is removed.

c) ATP is a form of kinetic energy.

d) ATP is the primary source of energy for chemical reactions occurring in all cells of all living organisms.

e) Energy released when ATP is hydrolysed to ADP is used in cells by coupling this endergonic reaction to other reactions in the cell that are exergonic.

Answers for remedial Activities

1. i) D, ii) D, iii) C, iv) B, v) C

2. A) True

B) False. Energy is released when one or two of the phosphate groups in ATP is removed

C) False. ATP is a form of potential energy

D) True

E) False. Energy released when ATP is hydrolysed to ADP is used in cells by coupling this exergonic reaction to other reactions in the cell that are endergonic

4.7.2 Consolidation activities

1) Calculate the amount of energy produced for:

a) 3 moles of hydrolyzed ATP

b) $^{3}/_{4}$ moles of synthesized ATP

c) 5 moles of decomposed glucose

Answers for consolidation activities

a) One mole of ATP produces -14 kcal/mol or −57 kJ/mol in a living cell. 3 moles of ATP will produce 3(-14 kcal/mol) or 3(−57 kJ/mol) in a living cell, equivalent to -42 kcal/mol or -171 kJ/mol. Since the synthesis of ATP is a reversible reaction of its hydrolysis. The amount of energy consumed for its synthesis equals the amount of the energy produced in its hydrolysis.

b) Since one mole of ATP produces -14 kcal/mol or −57 kJ/mol in a living cell. The same amount will be consumed but now it will have the negative sign: - (-14 kcal/mol or −57 kJ/mol) = 14 kcal/mol or 57 kJ/mol. From this relationship: Moles of ATP will produce (14 kcal/mol) or (57 kJ/mol) in a living cell, equivalent to 10.5 kcal/mol or 42 kJ/mol.

c) One mole of glucose produces -686 kcal (2,870 kJ) per mole of glucose decomposed. 5 moles of decomposed glucose produce 5(-686 kcal) or 5 (2,870 kJ) equals to -3430 kcal or 14350kJ.

4.9.3 Extended activities

1) Explain the roles of coenzymes nicotinamide adenine dinucleotide (NAD), flavin adenine dinucleotide (FAD) and coenzyme A in respiration.

Answer for Extended activities

Both FAD and NAD are electron carriers which have many roles to perform. At various chemical reactions, the NAD+ picks up an electron from glucose during glycolysis process, at this point it becomes NADH. The NADH along with the molecule of $FADH_2$ transport the electrons to the mitochondria where the cell can harvest energy stored in the electrons. One of the main differences that can be seen between FAD and NAD is in the difference of accepting hydrogen. NAD can accommodate one hydrogen and become NADH while FAD can accommodate two hydrogens and become $FADH_2$. These are achieved through oxido-reduction reactions where NAD is reduced to NADH and FAD is reduced to $FADH_2$. Another difference is that NADH reduces cytochrome I and feeds into the electron transport chain at complex 1 yielding 3 ATP for every NADH, while $FADH_2$ reduces Cytochrome II and feeds into the electron transport complex 11 and gives 2 ATP for every $FADH_2$.

Coenzyme A is naturally synthesized from pantothenate (Vit B5) which is found in food such as meat, vegetables, cereal grains, legumes, eggs and milk. It functions as an acyl group carrier assisting in transferring fatty acids from the cytoplasm to mitochondria.

UNIT 5: CELLULAR RESPIRATION

5

5.1 Key Unit Competence

Describe the process of cellular respiration.

5.2 Prerequisites /Introduction/Revision

Students will learn better process of cellular respiration if they know better the need for energy in living organisms, the structure of ATP and other coenzymes involved in cellular respiration seen in unit 5. They need also to know how ATP is formed and how it is hydrolysed to produce the energy.

The teacher can introduce the lesson by asking to the learners the origin of the carbon dioxide we breathe out during the gaseous exchange.

5.3 Cross-cutting issues to be addressed

The cross-cutting issues that will be addressed by this unit include environment and sustainability, inclusive education and gender education.

1. Environment and sustainability

As a facilitator, emphasise to the learners that environment must be sustainably protected. This emphasis could be done when you facilitate students to relate this lesson to environment and sustainability. For effective facilitation, you can ask questions about the interrelation between environment and respiration. From this question, students will realise the intimate relationship between environment and respiration so that they will take positive side to environment protection for the sustainability of all livings. Then, you can extend their ideas by providing other reasons for environment protection and sustainability like being the source of food which is used during respiration, habitat of producers which produce food need for all living organisms etc.

2. Inclusive education

The issue of inclusive education will be addressed through activities that will be conducted. As a facilitator, place learners with visual and audio impairment in appropriate places. Those with short-sightedness (myopia) must sit on front desks in

class. If you have children with low vision, remember to print in appropriate font size (large print). Those with long - sightedness must sit on back desks. This has to be done during video watching.

There is also to invite or visit the parents whose children have hearing impairment and learn from them how they do communicate with them. The braille materials and other tactile materials should be provided to blind students.

3. Gender

- This unit contains some practical activities such as estimating the respiration rate of different individuals.
- As a teacher, involve girls asking them to make the report about the activities done in groups.
- Inspire active participation of boys and girls in activities, not only boys. Make sure that all learners are actively involved.

5.4 Guidance on the introductory activity

Before starting the first lesson of this unit (Overview of respiration and glycolysis), as a facilitator, request learners to do introductory activity questions given in student textbook from observing the picture:

- In group of three or four learners, answer the questions written in the introductory activity.
- Each group records the answers.
- Choose randomly any 2 groups to write their answers on the chalkboard or flipchart.
- Ask other groups members if they have something to add on what is written on the chalkboard or flipchart.
- Based on their answers, introduce a whole unit and then move to the lesson one of the unit.

Expected answers of the introductory activity

4. 1. The process of cellular respiration

   2. Characteristics of all living organisms: growth, respiration, nutrition, irritability, reproduction, movement and excretion.

   3. All living organisms need a continuous supply of energy for the following reasons:

- The synthesis of complex substances from simpler ones (anabolic reactions), such as the synthesis of polysaccharides from monosaccharides, lipids from glycerol and fatty acids, polypeptides from amino acids, and nucleic acids from nucleotides

– The active transport of substances against a concentration gradient, such as the activity of the sodium potassium pump.

– Mechanical work such as muscle contraction and other cellular movements; for example, the movement of cilia and flagella, amoeboid movement and the movement of vesicles through cytoplasm.

– Movement, transport of nerve impulses, movement of blood, muscle contraction…

4. The energy is produced in the 4 phases of cellular respiration: glycolysis, the link reaction. Further information about these processes will be in this unit.

5.5 List of lessons (including assessment)

	Title of the lesson	Learning objectives	Periods
1	Lesson 1: Overview of respiration and glycolysis	Outline the four stages in aerobic respiration (glycolysis, link reaction, TCA cycle and oxidative phosphorylation) and state where each occurs in the eukaryotic cells.	2
2	Lesson 2: The link reaction and the TCA cycle.	Explain that reactions in the TCA cycle involve decarboxylation and dehydrogenation and the reduction of NAD and FAD.	6
3	Lesson 3: Oxidative phosphorylation.	Outline the process of oxidative phosphorylation including the role of oxygen (details of the carriers are not required).	4
4	Lesson 4: Efficiency of aerobic and anaerobic respiration.	Compare the theoretical ATP yield during aerobic and anaerobic respiration.	3
5	Lesson 5: Factors which affect the rate of respiration.	Carry out simple investigations, using simple respirometers, to measure the effect of temperature on the respiration rate of germinating seeds or small invertebrates.	2

6	Lesson 6: Use of other substrates in respiration.	Explain how other substrates are involved in glycolysis and the TCA cycle.	2
7	Assessment	criteria: Learners can describe the process of cellular respiration	2

Lesson 1: Overview of respiration and glycolysis

This is the first lesson of unit 1 and is a double lesson. This means that it has two periods (80 Minutes). The first lesson also covers the introduction of the whole unit.

a) **Prerequisites/Revision/Introduction:** Learners will learn better the process of cellular respiration, if they have understood the structure of ATP, the structure and roles of coenzymes in respiration.

b) **Teaching resources:** Student's books, computer and a projector.

c) Learning activities

- Activity 5.1 comprises to sub-activity: 5.1.1 and 5.1.2 as found in student textbook. As a facilitator ask them to do them and you are expected to do the following:
- Form group of 3 to 4 learners depending on the class size.
- Ask them to do the activity 5.1.1 and 5.1.2
- Move around groups guiding and facilitating them.
- Select some groups (1 or 2) to share their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart. In this practice, ask learners of both sexes to present their ideas. (gender)
- Ask other groups to add any ideas on what other groups have presented if they have them.
- Allow the class to ask questions related to the presented findings.

Firstly, request the members of groups which have presented to respond to the questions; secondly, if they are not able to clarify, ask the same question to other groups; finally, if all groups are not able to respond, deliver the answer to the whole class by writing on the chalkboard or flipchart and speaking loudly so that those who have low hearing ability or visual impairment get what you say.

At the end of the lesson development, help students to summarise the lesson through questions and then write the feedback as being amended on the chalkboard or flipchart and ask learners to note it in their notebooks.

Finally, assess the lesson by letting students attempt self- assessment 5.1. Students can do this exercise either in the course of this lesson if there is still time or as home work. Make sure you mark the students' homework. Let each student do individually this self-assessment.

Answers for activity 5.1.1

1) - Glucose is a monosaccharide of 6 carbon compound while pyruvate is a 3 carbon compound,

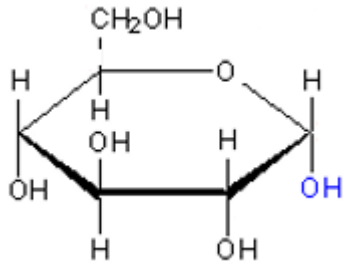
   - Glucose is broken down in the process of glucolysis during cellular respiration while pyruvate is a result of glucose molecule breakdown and it is broken down into acetyl coenzyme A, through the process of decarboxylation reaction i the link reaction stage of cellular respiration

2) Glycolysis helps in the production of energy. It is very important for anaerobic organisms which produce energy by the process of glycolysis.

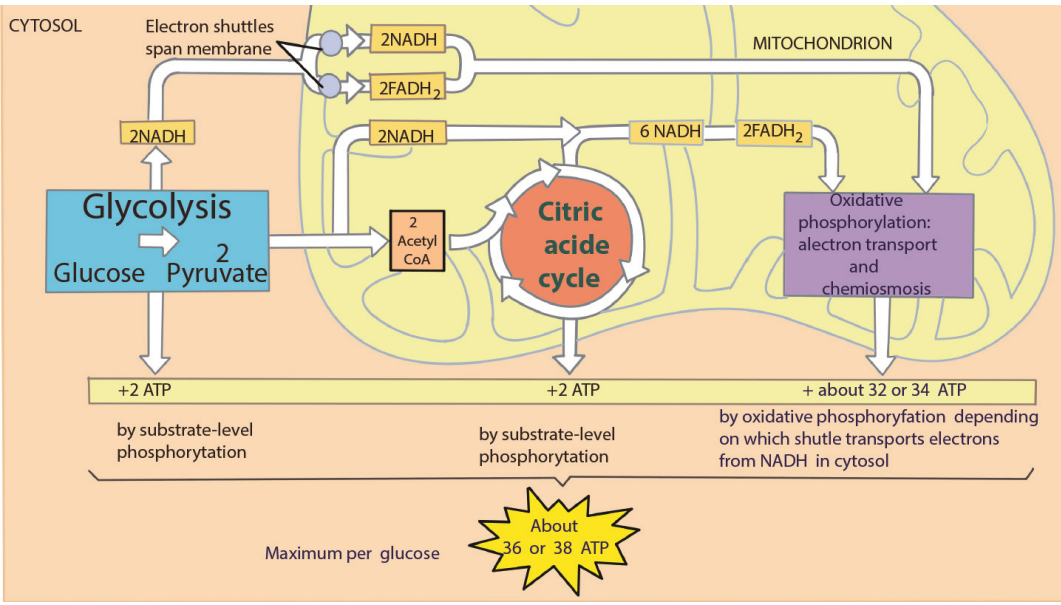
Answers for activity 5.1.2

1. Glucose breakdown can be divided into four stages: **glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation.**

2. The following is the structure of a glucose molecule:



3. The following is the flow chart of respiration:



Answers for activity 5.1.1

1) Glucose has 6 carbons; pyruvate has three carbons.

2) Glycolysis helps in the production of energy. It is very important for anaerobic organisms which produce energy by the process of glycolysis.

Answers for self –assessment 5.1

1) The ATP used in this process has 2 advantages: the charge of the phosphate group traps the sugar in the cell because the plasma membrane is impermeable to large ions. Phosphorylation also makes glucose more chemically reactive.

2) 2 ATP

3) 2 NADH.

Lesson 2: Link reaction and the Calvin cycle

The learners are expected to explain what happens to the pyruvate molecule when oxygen is available. This lesson deals with the link reaction and the Calvin cycle.

a) Teaching resources

Use the illustrations in the students' book which show the link reaction and the Calvin cycle. You can even use other figures from internet. A simulation which shows the process of cellular respiration can be shown, but the emphasis will be put on the link reaction and the Calvin cycle.

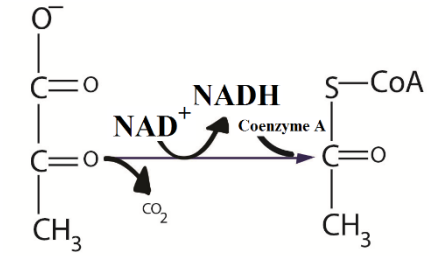
b) Learning activity

Ask student to do the learning activity 6.2 which is written in students' book but you can add more questions. For the success of this activity, your role as a facilitator is to:

- Help learners to form groups of 4 learners for each group.
- Ask the formed groups to do the activity 5.2.
- Pass around groups guiding and facilitating them.
- Identify 2 or 3 groups to present their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart.
- Ask other groups to add any ideas on what other groups have presented if they have them.
- Enable the class to ask questions related to the presented findings.
- Initially, request the members of groups which have presented to respond to the questions; secondly, if they are not able to clarify, ask the same question to other groups; finally, if all groups are not able to respond, deliver the answer to the whole class by writing on the chalkboard or flipchart and speaking loudly so that those who have low hearing ability or visual impairment get what you say.
- Write the lesson summary on the chalkboard or flipchart and ask learners to note it in their notebooks.

Answers for activity 5.2

1) 2 carbon atoms
2) In the conversion of pyruvate to Acetyl-CoA, one molecule of NADH and one molecule of CO_2 are formed. This step is also known as the link reaction or transition step, as it links glycolysis and the Krebs cycle.



3) The main products of the Krebs cycle from one glucose molecule (2 pyruvate molecules) are 6 NADH, 2 FADH2, and 2 ATP.

Answers for self-assessment 5.2

1) Matrix of mitochondria

2) 2 ATP

3) Citric acid

Lesson 3: Oxidative phosphorylation and electron transport chain

a) Prerequisites/Revision/Introduction:

Students will learn better the oxidative phosphorylation and electron transport chain, if they have prior knowledge about the electron transport chain seen in the unit 7 in Senior 5 in photosynthesis. Ask learners to explain what they know about an electron transport chain.

b) Teaching resources

The teaching resources includes books, illustrations and simulations showing the oxidative phosphorylation and the electron transport chain.

c) Learning activity 5.3

- The activity 5.3 is a practical field work. It has to be done as described below:
- The teacher will help to align students in order to simulate the electron transport chain.
- The students can simulate an electron transport chain by moving warm stones (or bricks) from one area to another.
- Each learner will have to pass the stone to the next until reaching the last learner.

– The last learner may have a bucket or another container in which the stones are thrown.

– The bucket illustrates the function of water in the process of respiration.

Answer to activity 5.3

In this activity, the students simulate the carriers that are involved in the electron transport chain. The stones represent the electrons that are carried by the carriers NADH and FADH. The bucket simulates the function of oxygen in cellular respiration.

Learners will realize that if the last learners have nowhere to throw the stone, the process will stop as what will happen if there no oxygen in the electron transport chain to accept the electrons from the carriers.

The movement of electrons from one carrier to another can be compared to the way the stone is moved from one person to another. NADH and FADH enter the electron transport chain at different points as the stone can start from the first person to the last one or from the third to the last.

The electron transport chain comprises the electron transport chain that establishes a proton gradient across the inner membrane by oxidizing the NADH produced from the Krebs cycle. ATP is synthesized by the ATP synthase enzyme when the chemiosmotic gradient is used to drive the phosphorylation of ADP. Chemiosmosis is the production of ATP from ADP using the energy of hydrogen ion gradients. The electrons are finally transferred to oxygen and, with the addition of two protons, water is formed.

Answer for self-assessment 5.3

1) NADH and FADH2 are high energy molecules and they can be used as reducing agents by the cell. They carry high energy electrons which are used to make ATP.

2) 3 ATP

3) 2 ATP

4) 38 ATP

Lesson 4: Efficiency of aerobic and anaerobic respiration

a) Prerequisites/Revision/Introduction

To study better this lesson, learners must be able to differentiate the aerobic and anaerobic respiration. They need to know that anaerobic respiration takes place only when oxygen is absent. The knowledge of the unit 5 in chemistry (alcohol and ethers in the lesson: local preparation of ethanol by fermentation) will help to understand this lesson

b) Teaching resources: Use textbooks and internet, manila paper

c) Learning activity 5.4

The activity 5.4 in student's book requires the learners to move to a bakery and to observe how bread is made. After observation, they write in their note books the answers of the activity 5.4. Students need also to make further research in the books or on the internet because in some areas the bakery may not be available.

Answer for Activity 5.4

Sugar, flour, water and yeast

1) Yeast
2) Anaerobic respiration is a respiration which takes place in absence of oxygen.
3) Some applications of anaerobic respiration in everyday life: production of beer, production of wine, production of yoghurt, production of cheese and production of bread
4) Comparison between aerobic and anaerobic respiration

Anaerobic respiration or fermentation	Aerobic respiration
$C_6H_{12}O6 \longrightarrow 2CH3CH2OH+2CO2+ 2ATP$ $C6H12O6 \longrightarrow 2CH3CH(OH)CHOOH+ 2$ ATP	$C6H12O6+6O6 \longrightarrow 6H2O+6CO2+38$ ATP
Doesn't require oxygen	Requires oxygen.
Produce a low quantity of energy (2ATP produced per glucose molecule).	Produces a big quantity of energy (38ATP produced per glucose molecule).
Incomplete oxidation of glucose.	Complete oxidation of glucose.

Uses the coenzyme NAD as electron acceptor in different redox reaction of its stage.	Uses the coenzyme NAD and FAD as electron acceptor in different redox reaction of its stages.
Consists of one stage in cytosol (glycolysis).	Consists of three stages: glycolysis in the cytosol and the Krebs cycle and the electron transport chain in mitochondrion.
Last electron acceptor is pyruvic acid in lactic acid and acetaldehyde in alcoholic fermentation.	Last electron acceptor is an oxygen molecule.

$$\text{Efficiency of aerobic respiration} = \frac{\text{Energy required to make ATP x 100}}{\text{Energy released by oxidation of glucose}}$$

$$\text{Efficiency of aerobic respiration} = \frac{38\ ATP \times 7.3\ Kcal \times 100}{686\ \text{Kcal}} = 40\%$$

$$\text{Efficiency of anaerobic respiration} = \frac{\text{Energy required to make ATP x 100}}{\text{Energy released by oxidation of glucose}}$$

$$\text{Efficiency of anaerobic respiration} = \frac{2\ ATP \times 7.3\ Kcal \times 100}{686\ \text{Kcal}} = 2\%$$

Aerobic respiration is more efficient because it generates too much ATP (ATP) compared to anaerobic respiration (2 ATP).

Answer for self-assessment 5.4

1) Lactic acid

2) Anaerobic respiration takes place in animal cells when the muscles are not receiving enough oxygen to support the process of aerobic respiration. Without oxygen, muscle cells produce a small amount of energy by anaerobic respiration.

3) $\text{Efficiency of aerobic respiration} = \frac{2\ \text{ATP} \times 7.3\ Kcal \times 100}{500 Kcal} = 55.48\%$

4) $\text{Efficiency of anaerobic respiration} = \frac{2\ ATP \times 7.3\ Kcal \times 100}{500\ \text{Kcal}} = 2.92\%$

Lesson 5: Factors which affect the rate of respiration

a) Prerequisites/Revision/Introduction

The prior knowledge that learners must have is about understanding of what is cellular respirations. When starting the lesson, the learners can observe different person in different activities such people running, playing football, people who are sitting.

b) Teaching resources: Books, images from the student's book

c) Learning activity 5.5

- You ask students to carefully observe the pictures given in activity 5.5.
- You request them to do questions which are given in that activity.
- Pass around groups, guiding and facilitating them.
- Invite students to report the work done.
- Consolidate the works of students and help students to summarize as well as drawing a conclusion through questions.

Answer for activity 5.5

1) The person A has a respiration rate which higher than that of person B. The person A is performing sport activities which increases the metabolic reactions in his body and the rate at which oxygen is inhaled has increased.
2) The person who is doing physical exercise.
3) The temperature has increased, the blood is circulating at high rate, the inspiration and expiration rate has also increased.

Answer for Self-assessment 5.5

1) Neurons, skeletal muscle cells
2) The rate of the cellular respiration increases if the body temperature is increased. The lower the temperature, the slower the rate of cellular respiration. The reason for this is enzymes which are present in cellular respiration process. Enzyme reactions require optimum temperatures.

Lesson 6: Use of other substrates in respiration

a) Prerequisites/Revision/Introduction

To understand this lesson, learners must have prior knowledge about all the types of nutrients that our body needs to stay healthy. They also need to know what a balanced diet is.

b) Teaching resources

Use the textbooks such as student's book and other books from the library. You can even use internet or other programs such as ENCARTA 2009.

c) Learning activity 5.6

- Ask students to do research and answer to the questions given in activity 6.6 found in student textbook.
- Consolidate their work from students' presentation.
- Help them to summarize the lesson and conclude the lesson through questions.

Answer for activity 5.6

1) Food containing fats take a long time for digestion than foods containing carbohydrates. This because fats are not easily digested and they are not easily transported in the body as carbohydrates.

2) Carbohydrates. Because bonds between atoms of glucose molecule are easily broken down.

Answer to self- assessment 5.6

1) Lipids need to be hydrolysed into glycerol and fatty acids. Glycerol can inter the glycolytic pathway whereas fatty acids are first converted to acetyl-coA before entering the Krebs cycle. Proteins are first hydrolysed into amino acids. The amino acids can enter the respiratory pathway in different pathways. Some can be converted to pyruvate or converted into intermediates of the glycolytic or the Krebs cycle.

2) They are not easily transported at the site of cellular respiration.

5.6 Summary of the unit

Cellular respiration begins in the cytoplasm and, in the case of aerobic respiration, is completed in mitochondria in eukaryotes; it takes place in the cytoplasm of prokaryotes.

Mitochondria possess two membranes: a smooth outer membrane and a highly folded inner membrane that contains many proteins used in cellular respiration.

ATP may be formed by substrate-level phosphorylation or oxidative phosphorylation.

Substrate-level phosphorylation does not require oxygen; oxidative phosphorylation does. In substrate-level phosphorylation, a phosphate group is attached to ADP in an enzyme-catalysed reaction. Oxidative phosphorylation is made up of redox reactions involving NAD, FAD, an electron transport chain, the inner mitochondrial membrane, ATPase, and oxygen as the final electron acceptor.

Glycolysis occurs in the cytoplasm. It produces two three-carbon pyruvate molecules from a six-carbon glucose molecule. Glycolysis produces two ATP (net) and two NADH. Pyruvate oxidation occurs in the mitochondria. In the process, a CO2 portion is cleaved from pyruvate and removed from the cell as waste. The remaining two-carbon acetyl group attaches to coenzyme A to produce Acetyl-CoA. In this reaction, two NADH and two CO2 are formed (one for each of the two pyruvate molecules).

The Krebs cycle occurs in the mitochondrial matrix. It begins when Acetyl-CoA reacts with oxaloacetate to produce citrate. The two carbon atoms introduced by Acetyl-CoA are removed as two CO_2, one ATP molecule is produced by substrate level phosphorylation, one FADH2 and three NADH are produced, and the final step regenerates oxaloacetate.

The electron transport chain, associated with the inner mitochondrial membrane, transports electrons through a series of redox reactions that release the free energy used to pump protons into the mitochondrial intermembrane space, creating an electrochemical gradient that is a source of free energy.

In chemiosmosis, protons move through ATPase complexes embedded in the inner membrane, releasing free energy that drives the synthesis of ATP.

Oxygen is the final acceptor of electrons that pass through the electron transport chain. If oxygen is not available, the Krebs cycle, electron transport, and chemiosmosis come to a halt.

5.7 Additional information to the teacher

Cells need substances as well as energy. Not all the organic molecules of food are destined to be oxidized as fuel to make ATP. In addition to calories, food must provide the carbon skeleton that cells require to make their own molecules. Some organic molecules obtained from digestion can be used directly. For example, as previous mentioned, amino acids from the hydrolysis of proteins in food can be incorporated into the organism's specific molecules that are not present as such in food. Compounds formed as intermediates of glycolysis and the Krebs cycle can be diverted into anabolic pathways as the precursor from which the cell can synthesize the molecules it requires. For example, human can make about half of 20 amino acids in proteins by modifying

compounds siphoned away from the Krebs cycle. Also glucose can be made from acetyl-coA. Of course these anabolic pathways do not generate ATP, but instead consume it.

In addition, glycolysis and the Krebs cycle function as metabolic interchanges that enable our cells to convert some kinds of molecules to others as we need them. For instance, carbohydrates and proteins can be converted to fats through intermediates of glycolysis and the Krebs cycle.

5.8 Answers for end unit assessment 5

Multiple choice questions

1) (c) Before the Krebs cycle can proceed, pyruvic acid must be converted into acetyl-coA

2) (b) The net number of ATP made directly by glycolysis is 2.

3) (b) Cellular respiration is similar to photosynthesis in that they both involve chemiosmosis.

4) (b) By accepting electrons and protons, the oxygen used in aerobic respiration turns into H2O.

5) (c)The Krebs cycle occurs in the mitochondrial matrix

6) (a) During each turn of the Krebs cycle, two CO2 molecules are produced.

7) (d) Most of the ATP synthesized in aerobic respiration is made through chemiosmosis.

Long answer questions

8) Differences between photosynthesis and cellular respiration are given in the following table:

	Photosynthesis	Cellular Respiration
Overall reaction	$6CO_2 + 12H_2O$ + sunlight$\rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$	$C_6H_{12}O_6 + 6O2 \rightarrow 6CO_2 + 6H_2O$ + 36ATP
Reactants	Carbon dioxide, water, sunlight	Glucose, oxygen
Products	Glucose	Energy
By-products	Oxygen	Carbon dioxide and water
Cellular location	Chloroplasts	Cytoplasm, mitochondria

Energetics	Requires energy (endothermic reaction)	Releases energy as ATP (exothermic reaction)
Time during which it takes place	During the day (in presence of sunlight energy)	During the day and night (all the time)
Chemical pathways	Light reactions and Calvin Cycle	Glycolysis, Krebs cycle, and electron transport system
Summary	Sugar synthesized using the energy of the sun (anabolic reaction)	Energy released from the breakdown of sugar (catabolic reaction)

9) Comparison between aerobic respiration with anaerobic respiration or fermentation.

Anaerobic respiration or fermentation	**Aerobic respiration**
$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH+2CO_2+ 2ATP$ $C_6H_{12}O_6 \rightarrow 2CH3CH(OH)CHOOH+ 2$ ATP	$C_6H_{12}O_6+6O_6 \rightarrow 6H_2O+6CO_2+38$ ATP
Doesn't require oxygen	Requires oxygen.
Produce a low quantity of energy (2ATP produced per glucose molecule).	Produces a big quantity of energy (38ATP produced per glucose molecule).
Incomplete oxidation of glucose.	Complete oxidation of glucose.
Uses the coenzyme NAD as electron acceptor in different redox reaction of its stage.	Uses the coenzyme NAD and FAD as electron acceptor in different redox reaction of its stages.
Consists of one stage in cytosol (glycolysis).	Consists of three stages: glycolysis in the cytosol and the Krebs cycle and the electron transport chain in mitochondrion.
Last electron acceptor is pyruvic acid in lactic acid and acetaldehyde in alcoholic fermentation.	Last electron acceptor is an oxygen molecule.

10) The following are the answers:

a) Objective: to investigate energy (heat) production by respiring tissue/ germinating seeds.

b) Observation: Flask A – rise in temperature; flask B- temperature remained the same. Flask A – soaked seeds became active and started germinating, respiration took place and some heat energy was produced. Flask B – dried seeds lacked moisture therefore no germination took place. In conclusion

c) They prevent heat loss or heat gain.

d) They serve as a control experiment.

11) X is pyruvate; Y is lactate and Z is ethanol (or ethyl alcohol).

12) Completed the table:

	Input(s)	Output(s)	Location in cell/organelle
Glycolysis	Glucose, ADP, Pi, NAD+	Pyruvate, ATP, NADH	Cytoplasm
Fermentation	Pyruvate, NADH	NAD+, ethanol and CO_2 or lactic acid	Cytoplasm
Citric acid cycle	Acetyl-coA, NAD+, ADP, Pi	NADH, CO_2, ATP, FADH	Mitochondrial matrix
Respiratory chain	NADH, FADH, O_2	ATP, NAD+, FAD+, H_2O	Inner mitochondrial membrane

13) The following are the answers:

a) 6 carbons in glucose; 3 carbons in glyceraldehyde 3-phosphate and 3carbons in pyruvate.

b) 2 ATP

c) To activate the glucose/to make the glucose more reactive/prevents the glucose from leaving the cell since the membrane is impermeable to glucose-6-phosphate.

d) AD; NAD+ picks up H+ and 2 electrons to form reduced NAD/NADH (may also be written as NADH+H); reduced NAD carries hydrogen and electrons into mitochondrion.

e) Cytoplasm

f) The following might happen:

(i) taken into mitochondrion for Krebs cycle

(ii) Stays in the cytoplasm and undergoes anaerobic respiration.

5.9 Additional activities

5.9.1 Remedial questions

1) Copy and complete the table below to show how much ATP is used and produced for each molecule of glucose respired in the various stages of respiration.

	ATP used	ATP produced	Net gain in ATP
Glycolysis			
Link reaction			
Krebs cycle			
Oxidative phosphorylation			
Total			

2) Until the Krebs cycle, aerobic respiration can be described without mentioning oxygen, the chemical element after which the reaction gets its name. Where in the process does this chemical element take part? What is its importance?

Answer to remedial question

1) Completed table:

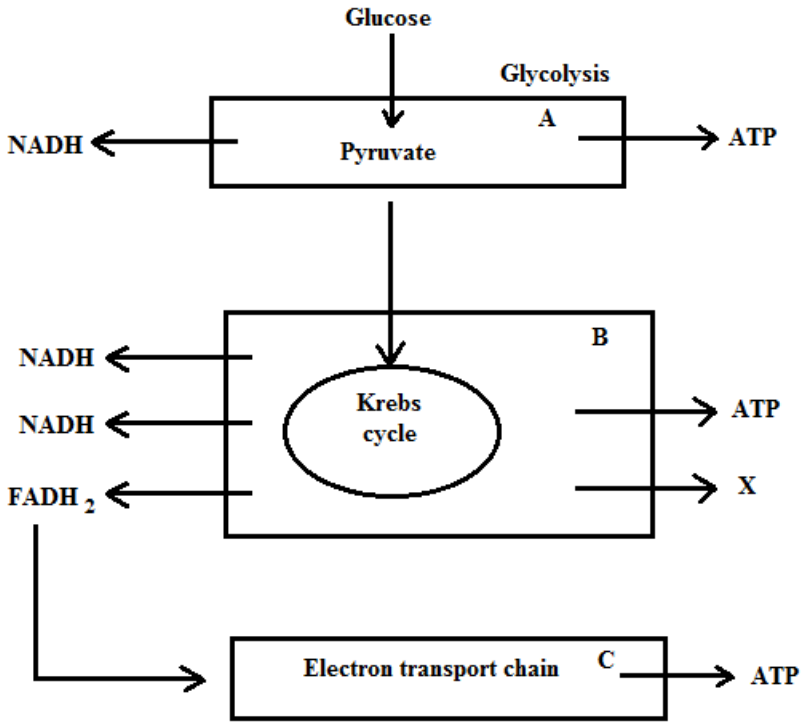
	ATP used	ATP produced	Net gain in ATP
Glycolysis	-2	+4	+2
Link reaction	0	0	0
Krebs cycle	0	+2	+2
Oxidative phosphorylation	0	+34	+34
Total	-2	+40	+38

2) Oxygen enters the aerobic respiration in its final phase, the respiratory chain. Oxygen serves as the final acceptor of electrons. By accepting electrons from the last molecule in the electron transport chain, oxygen allows additional electrons to pass along the chain. As a result, ATP can continue to be synthesized. Oxygen also accepts the protons that were once part of the hydrogen atoms supplied by NADH and FAD2. By combining with both electrons and protons, oxygen forms water as shown in the following equation.

5.9.2 Consolidation questions

1) Describe the function of the electron transport chain. Where is it located in the mitochondrion?

2) The figure below represents the main stages of aerobic respiration.

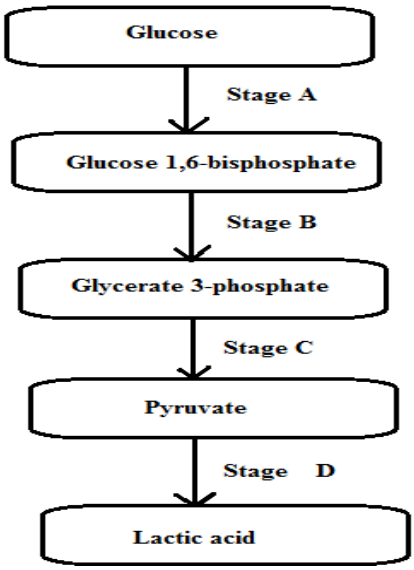


a) State precisely where the reaction in boxes A, B and C occur in the cell.

b) What substance is X?

c) A total of 38 molecules of ATP is formed during the complete breakdown of one molecule of glucose. State how many molecules are formed at each stages A, B and C.

1) The diagram below shows some of the three stages in anaerobic respiration in a muscle.



a) Name the process shown by stages A to C.

b) Where in a cell this process occurs?

2) Answer the following questions:

a) Give two uses of ATP in cells

b) At which of the stages shown in the diagram is ATP used?

c) NADH + H+ is a reduced coenzyme which is involved in anaerobic respiration. At which of the stages shown is NADH + H+ oxidized?

Answers to extended questions

1) To generate ATP; re-oxidation of the reduced electron/hydrogen carriers; to oxidize hydrogen to form water; on the inner membrane.

2) The following are the answers

a) A: cytoplasm / cytosol; B: matrix of mitochondria; C: inner membranes of mitochondria / cristae of mitochondria

b) Carbon dioxide

3) Stage A: 2 molecules of ATP (net); Stage B: 2 molecules of ATP; Stage c: 34 molecules of ATP

a) Glycolysis

b) Cytoplasm / cytosol

4) The following are the answers:

a) Active transport / ions pumps; phosphorylation / donation of phosphate to a substrate / named substrate / stage A used as an example e.g. protein synthesis, muscle contraction; DNA replication; cell division; light-independent stage of photosynthesis.

b) Stage A

c) Stage D

5.9.3 Extended questions

How can the knowledge about fermentation explain the origin of muscle cramps and pains after intense physical exertion?

Answer

A typical fermentation process due to oxygen scarcity happens in the muscle tissue. Under intense use muscles demand too much energy (ATP) and consume much more oxygen to produce that energy. High consumption leads to oxygen scarcity and the muscle cells begin to make lactic fermentation trying to satisfy their energetic needs. In this situation muscle pain, cramps and fatigue are due to the lactic acid released by fermentation.

UNIT 6: EXCRETION AND OSMOREGULATION

6

6.1. Key Unit Competence

Explain the principles of excretion and osmoregulation.

6.2 Prerequisites /Introduction/Revision

To succeed well this unit, learners should have the knowledge, understanding, skills, attitudes and values of the transport across the cell membrane which is in the second unit in S5. Also make sure that the learners have learned and have understood well the other units of previous years which are closely related with excretion and osmoregulation such as the unit 11: General principles of homeostasis in S5.

6.3 Cross-cutting issues to be addressed

The cross cutting that will be addressed include financial education and environment and sustainability. Financial education will be addressed to the learners in order to help them to understand that the treatment of kidney diseases such as dialysis and kidney transplantation costs very much money. It will be also addressed when they will understand, practise and change their attitudes how they can prevent diseases related to kidney by doing physical exercises, eating a balanced diet, taking enough water and reducing the consumption of much alcohol. You can also extend their understanding by explaining or asking them to talk about how some of people suffering by kidney related are treated in developed countries such USA and Europe which requires high amount of money.

As this unit deals with the excretion of metabolic waste products. Students need to understand how and why such wastes should be well disposed through challenging questions like what could happen if there is no proper disposal of wastes including metabolic wastes. If so, what can be done?

6.4 Guidance on the introductory activity

Start the lesson by orally asking the learners the questions that are in introductory activity in learners' textbook. What are the metabolic waste products produced by our body? Which organs produce those wastes? You can ask them where urine is made or where the sweat is produced. Through these questions, you will be able to introduce

the whole unit by communicating what will be covered as a result of the students' ideas considered.

Expected answers of the introductory activity

- Urea, ammonia, uric acid
- Metabolic wastes are produced by the excretory organs such as the kidney, lungs, skin and liver.
- Excretion

6.5 List of lessons

	Title of the lesson	Learning objectives	Periods
1	Lesson 1: Structure and functions of excretory organs in mammals	Describe the structure and role of excretory organs in mammals. Dissect, display, draw and label the urinary system of a toad, rat/rabbit etc.	4 periods
2	Lesson 2: Structure and the functions of the nephron.	Describe the detailed structure of the nephron with its associated blood vessels	2 periods
3	Lesson 3:Formation of urine and purification of blood	Describe how the process of ultrafiltration and selective reabsorption are involved in the formation of urine in the nephron. Describe and outline the ornithine cycle and its role in the conversion of ammonia to urea.	2 periods
4	Lesson 4: 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.	2 periods

5	Lesson 5: Kidney transplants and dialysis machines.	Describe the use of dialysis in kidney machines. Describe how kidney transplants are performed. Compare the advantages and disadvantages of kidney transplants with dialysis machines.	2 periods
6	Lesson 6: Principles of osmoregulation in marine, freshwater and terrestrial organisms.	Explain the principles of osmoregulation in organisms living in marine, freshwater and terrestrial habitats.	2 periods
7	Lesson 7: Excretion and osmoregulation in other organisms – protoctista, insects, fish, amphibians and birds.	Explain the principles of osmoregulation in protoctista, insects, fish, amphibians and birds.	3 periods
8	Lesson 8: Excretion in plants.	Explain why plants do not have specialised excretory organs. State the excretory products of plants and how they are eliminated.	2 periods
9	Assessment standard	Can explain the principles of excretion and osmoregulation	2 periods

Lesson 1: Structure and functions of excretory organs in mammals

This is the first lesson of the unit. It starts by general introductory activity of the unit. And it has to be covered in 4 periods but depending to school timetable for biology course, this can be done in the first period.

a) Prerequisites/Revision/Introduction

To introduce the lesson by asking the learners to identify the waste products and where they are made. After that the learners will start to perform the practical activity 7.1 described in the student's book.

b) Teaching resources

Student's book,dissection kits, rabbit, dissecting tray, chloroform.

c) Learning activity 6.1

- 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.

d) Answers to the activity 6.1

The urinary system of a rabbit can be seen below:

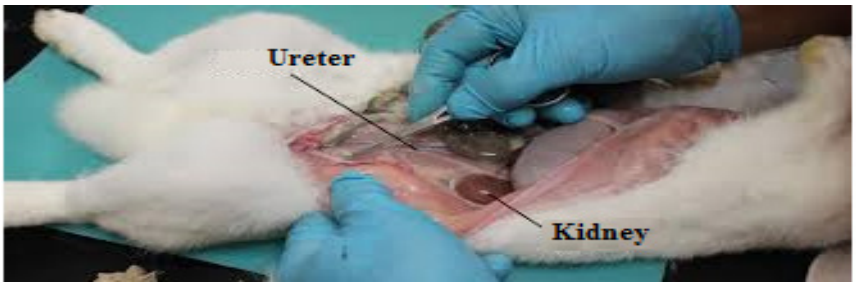


Figure 7.1: Dissection of the rabbit

- The functions of the different parts of the urinary system of a rabbit
- Kidney: removes metabolic waste products from the blood.
- Ureter: carries urine from the kidney to the bladder.
- Urethra: allows passage of urine to the outside of the body.
- Bladder: stores urine.

Answer to self-assessment 6.1

1) Nephrons

2) Renal cortex, renal medulla, renal pelvis, renal artery and renal vein.

3) Renal vein.

4) Renal artery.

Lesson 2: Structure and the functions of the nephron

a) Prerequisites/Revision/Introduction

To study the structure and the functions of the nephron, a chart showing the parts of the nephron may be shown in order to help students to know and identify different parts of the nephron.

b) Teaching resources

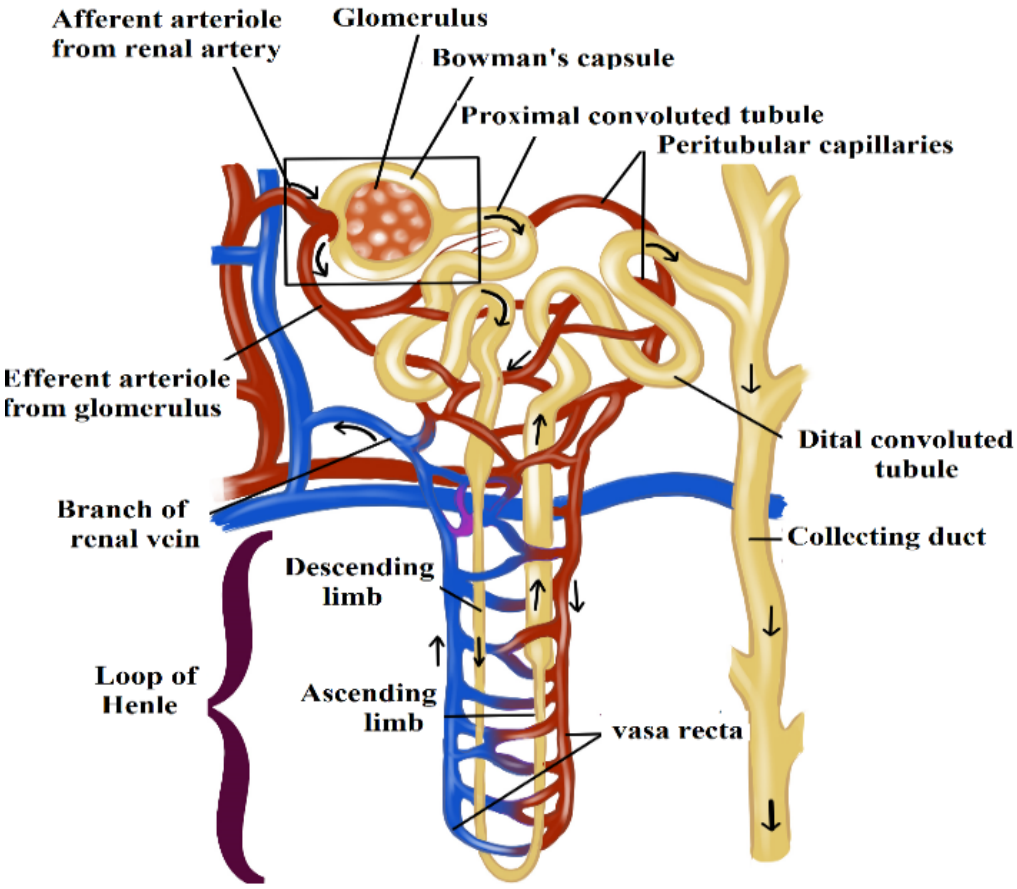
- Student's book,
- A downloaded movie showing the parts and the working of nephrons. A chart showing the structure of the nephron,
- Computer and projector. The link on YouTube can be seen in the student's book.

c) Learning activity 6.2

Learners will watch a movie about the working of the nephron and will make a group discussion about the working of the nephron.

Answers for activity 6.2

1) The following is the figure:



2) The answers are:

a) Q: Afferent arteriole, W: glomerulus, U: efferent arteriole, S: Proximal convoluted tubule, V: Bowman's capsule, T: loop of Henle, R: collecting duct.

b) The fluid is called glomerular filtrate. It has the same composition as blood except that it does have not blood cells and other large molecules.

Answers for self –assessment 6.2

1) Afferent arteriole, glomerulus, efferent arteriole, proximal convoluted tubule, bowman's capsule, loop of Henle, distal convoluted tubule, and collecting duct.

2) The following are the answers:

a) Ultrafiltration takes place in the glomerulus/Bowman's capsule

b) Reabsorption takes place mainly in the proximal convoluted tubule, loop of Henle, distal convoluted tubule.

c) Secretion takes place mainly in the distal convoluted tubule and collecting duct

3) The main function of the loop of Henle is the reabsorption of water and salts

Lesson 3: Formation of urine and purification of blood

a) Prerequisites/Revision/Introduction

Before beginning this lesson, learners should be able to recall different parts of kidney. The teacher provides to the students the chart of human kidney and asks them to locate each part of the kidney and asks them also to state their functions.

b) Teaching resources

The needed teaching resources are: computer/video simulation, a projector, chart showing the parts of the kidney, student books.

c) Learning activity 6.3

The teacher forms group of 4 or 5 students and watch audio visual simulation of working of the kidney. When the projector is not possible teacher may use a computer and put the movie in full screen mode. If the computer is also not available, the teacher may use a chart showing the parts of the urinary system.

- Teacher has to facilitate the students in the activity 6.3 as follow:
- Whole class watch the simulation or observe the chart but sitting in their respective groups.
- Within their groups students summarize the process of working of the kidneys and formation of urine.
- The teacher will move to different group to guide them.
- Allow groups to present their findings
- The teacher harmonizes the process of working of the kidney and formation of urine based on students' presentations.

Answers to the activity 6.3

1) Urine formation depends on three functions, ultra-filtration**,** selective reabsorption, tubular **secretion**

2) The main components of urine are; water, excess of salts, metabolic wastes such as urea and uric acid.

3) The following are the answers:

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.

Answers to self –assessment 6.3

The correct order:

- Blood enters the afferent arteriole
- Fluids pass from the glomerulus into the Bowman's capsule
- Na^+ ions, glucose, and amino acids are actively transported from the nephron
- Urine passes from the kidneys into the ureters
- Urine is stored in the bladder
- Urine is excreted by the urethra

Lesson 4: Role of the hypothalamus, pituitary gland, adrenal gland and nephron in varying the osmotic pressure of blood

a) Prerequisites/Revision/Introduction

As the introduction the teacher will ask students about how about the location of some endocrine glands especially the hypothalamus and the pituitary gland and some of their secretions.

Expected answer: The hypothalamus is located in the diencephalon. The hypothalamus is on the upper part of the pituitary gland.

b) Teaching resources

Charts showing the endocrine glands and their secretions. A movie showing the endocrine glands may also be used if available.

c) Learning activity 6.4.

- For smooth facilitation of the activity, you will do the following:
- Provide to the students prepared charts showing the endocrine glands in their respective groups of 4 or 5 students.
- Clearly instruct what to do and facilitate students in their work
- Ask students to observe the chart and answer to the questions in the activity 4.5.
- Ask some groups chosen randomly based on the differences in their work to present their findings.
- Ask other groups to add their comments on what their colleagues have presented
- Harmonize and help students to summarize the activity through questions.
- Inform students to write short notes on the activity as the lesson goes on.

Answers to the activity 6.4

1) When humans drink seawater, their cells are thus taking in water and salt. While humans can safely ingest small amounts of salt, the salt content in seawater is much higher than what can be processed by the human body. Human kidneys can only make urine that is less salty than salt water. Therefore, to get rid of all the excess salt taken in by drinking seawater, one has to urinate more water than they drank. Eventually, one dies of dehydration even as they become thirstier.

2) The pituitary gland, the hypothalamus and the adrenal glands.

3) ADH, aldosterone

Answers to self-assessment 6.4

1) Negative feedback mechanism where by the reduction in levels of water causes release of ADH.

b) Hypothalamus

c) in full is Anti Diuretic Hormone. ADH and is produced by the hypothalamus. It is stored and released by the posterior pituitary gland.

Lesson 5: Kidney transplants and dialysis machines

a) Prerequisites/Revision/Introduction.

The teacher asks students what is transplantation and a transplant organ. Ask whether if it is possible to transplant an organ from one person to another. If they say yes, the teacher can ask them to state the names of organs that can be transplanted from one person. The teacher asks them to explain what dialysis is.

b) Expected answer: Kidney, skin

Teaching resources: Textbooks and charts**,** Movie**,** Computer and Projector

c) Learning activity 6.5

- The teacher will help students to form groups and provide them textbooks and a movie to watch.
- Teacher will guide the activity in the following way:
- Using text book and the other books from the library, learners will discuss the dialysis and transplantation.
- Allow different groups to present their ideas.
- As students are presenting, the teacher will intervene supporting correct ideas then help students to summarize the lesson and draw conclusion through questions of both teacher and students

Answers to the activity 6.5

1) Dialysis and transplantation.

2) Advantages and disadvantages of dialysis

Advantages of dialysis

- Dialysis help in the filtration of blood for a person with kidney failure.
- Dialysis helps a person with kidney failure to stay alive for a given time.

Disadvantages of dialysis

- Takes a long time (up to three hours and 3 to 4 times a week)
- The operation is expensive.
- It doesn't cure the disease

Advantages and disadvantages of transplantation:

Advantages of transplantation

- The patient can return to a normal lifestyle dialysis may require a lengthy session in hospital, three times a week, leaving the patient very tired after each session.
- The dialysis machine will be available for other patients to use.

Disadvantages of transplantation

- Transplants require a suitable donor with a good tissue match. The donor may be from a dead person, or from a close living relative who is prepared to donate a healthy kidney (we can survive with one kidney).
- The operation is very expensive.
- There is a risk of rejection of the donated kidney, immunosuppressive drugs have to be used.
- Transplants are not accepted by some religions.

Answers to self-assessment 6.5

1) The most difficult challenge to overcome in achieving successful kidney transplants is to match the immune characteristics of the donor and recipient to reduce the tendency for the recipient's immune system to reject the transplanted kidney. Even with careful matching, however, recipients have to take medication for the rest of their lives to suppress their immune systems so that rejection is less likely.

2) It is beneficial to humans to have two kidneys rather than one because when one kidney is not working correctly, the other kidney can remove the metabolic wastes so that someone can live without problem.

Lesson 6: Principles of osmoregulation in marine, freshwater and terrestrial organisms

a) Prerequisites/Revision/Introduction

To introduce this lesson, ask the learners to explain what osmoregulation is and explain why animals need to maintain constant the internal environment as it has been seen in senior 5 in the unit 11 of homeostasis.

b) Teaching resources

Textbooks, internet, Encarta 2009, beaker, earthworm, water, and salt.

c) Learning activity 6.6

- As facilitator the teacher guide students as follow:
- The teacher provides textbooks and computer with internet in different formed groups.
- In groups, students will take the earthworms and the amphibian and put them in beakers containing the tap water or concentrated salt solution as it is described in the student's book.
- Students will write short notes and explain their observations.
- The teacher moves within groups helping them during their discussions and guiding them.
- Students present their findings.
- The teacher based on their work, clearly helps to distinguish the osmoregulation in different animals.

Answers to the activity 6.6

- The three earthworms will continue to move in the beaker containing water. The water in the beaker has no observable effect on the earthworms.
- The earthworms will lose their body water to the concentrated salt solution and will die. Their tissues will be destroyed.
- The amphibian will continue to move in the water without problem.
- The amphibian will also lose water to the concentrated salt solution and will finally die.
- Water always moves from hypotonic solution to the hypertonic solution through a semi-permeable membrane. The tap water is hypotonic to the cells of the earthworm and that of an amphibian. Water molecules will enter the earthworm and the amphibian through their skin. The excess water will be removed from their bodies by the excretory system.

Answers to self-assessment 6.6.

Organisms in aquatic and terrestrial environments must maintain the right concentration of solutes and amount of water in their body fluids because metabolic wastes and excess of salts would be toxic if allowed to accumulate in the blood.

Lesson 7: Excretion and osmoregulation in other organisms protoctista, insects, fish, amphibians and birds

a) Prerequisites/Revision/Introduction

The teacher will introduce the lesson by asking the students to identify the excretory organs in different organisms. After that the teacher asks them to explain the osmoregulation in organisms such as amoeba or paramecia. The students will then do the activity 7.7 found in the student's book.

b) Teaching resources

Textbooks, computer, bucket, fish, water, salt

c) Learning activity 6.7

The teacher will guide students in the activity 6.7 which is in student textbook in the following ways:

- The teacher will help students to form groups, provide to them books and the materials necessary for performing the activity.
- In their respective groups students attempt the activity 7.7 using fish.
- Teacher move in different guiding them to discuss about the activity.
- Allow the students to present their findings.
- During presentation teacher intervene harmonizing to what students present.
- Help students to summarize the lesson and doing lesson self-assessment

Expected answers for activity 6.7

1) The fish will continue to swim in the water.

2) The fish will die.

3) The fish is in a hypotonic solution. Water enters into its gills by osmosis. The excess water is removed from its body by the kidneys. The fish will lose water to the salt solution and will become dehydrated. As a result, it will die.

Answers for self-assessment 6.7

1) Uric acid is relatively non toxic and does not readily dissolve in water. It therefore can be excreted as a semi solid paste. This is a great advantage for animals with little access to water. This is an adaptation for living in areas where there is a small amount of water (arid conditions).

2) Amoeba makes use of contractile vacuoles to collect excretory wastes, such as ammonia, from the intracellular fluid by diffusion and active transport. As osmotic action pushes water from the environment into the cytoplasm, the vacuole moves to the surface and disposes the contents into the environment.

Lesson 8: Excretion in plants

a) Prerequisites/Revision/Introduction:

Students will learn better the excretion in plants if they do remember the internal structure of the leaf and the mechanism of opening and closing of stomata.

b) Teaching resources

- Student's book
- Chart showing the internal structure of the leaf

c) Learning activity 6.1

- The activity 8.1 requires the observation of the structure of the leaf and the discussions about how plants make their excretion. Thus, you are requested to do the following:
- Indicate the location of activity 8.1 to the learners.
- Deliver the teaching resources to learners.
- Help students to make groups of 4 or 5 students
- The teacher moves within groups helping them during their discussions and guiding them
- Students present their findings.

Expected answers for activity 6.1

- Stomata, lenticels, cuticle, bark of the stem.
- Humans have excretory systems such as the kidney and lungs whereas the plants have no excretory organs.
- Plants do not have complex excretory systems. This is because of the following 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.

Answers for self-assessment 6.1

1) Tannins, essential oils, gums and resins

2) 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.

3) 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.

6.6 Summary of the unit

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.

6.7 Additional information to the teacher

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 NaCI 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.

6.8 Answers for end unit assessment 6

1) (b)

2) (d)

3) (d)

4) The following are the answers:

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.

5) The following are the answers:

a) D

b) E

c) B

d) F

6) From the figure, the following are the answers:

a) The afferent arteriole: C. The efferent arteriole: A.

b) The increase in blood pressure in area (B) would increase the rate of blood filtration and as a result would lead to increase of production of urine.

c) They are too big to pass through the glomerulus.

d) D: in the proximal convolute tubule

6.9 Additional activities

6.9.1 Remedial activities

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 reabsorbed by the nephron tubules?

Answers to remedial activities

a) Excretion is the process of elimination of metabolic wastes and other toxic substances from the body.

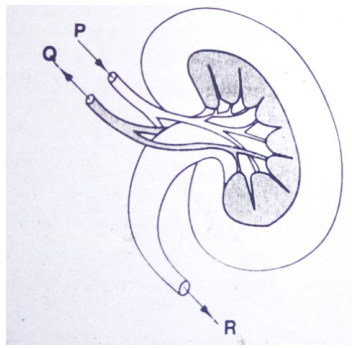
b) The nitrogenous waste product of a fish is ammonia while that of an insect is uric acid.

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.

6.9.2 Consolidation 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 consolidation 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

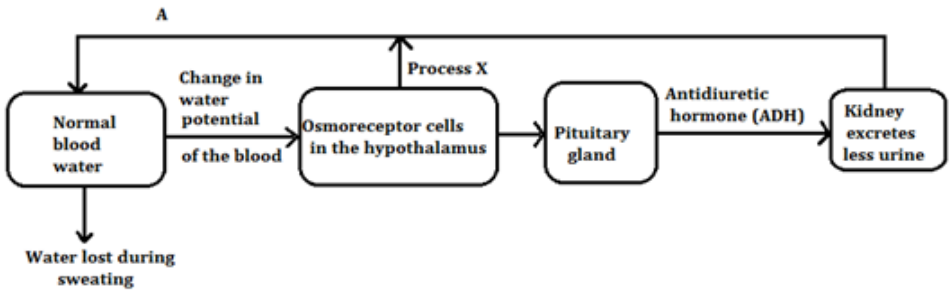
c) Glucose and Proteins

d) Urinary bladder

6.9.3 Extended questions

1) Explain why drinking alcohol causes a sensation of thirst.

2) 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

3) Describe how ADH gets from the pituitary gland to the kidney

4) 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 7 : GENERAL PRINCIPLES OF RECEPTION AND RESPONSE IN ANIMALS

7

7.1 Key Unit Competence

Explain the general principles of reception and response in animals.

7.2 Prerequisite (knowledge, skills, attitudes and values)

To succeed well this unit, make sure that your learners have learned and have understood well other units of previous years which are closely related with response and coordination in animals. Before starting to introduce this unit, make sure also that the learners have already revised well the knowledge, skills, attitudes and values of the previous unit such as the response and coordination in animals. The previous unit that learners should know before studying the general principles of reception and response in animals is: Unit 12, Senior 3, Response and coordination in animals

7.3 Cross-cutting issues to be addressed

Within this unit, inclusive education will be addressed by this unit.

Inclusive education

- Since, there are many pictures, movies and some experiments such as a mammalian eye dissection within this unit; special arrangement should be paid for catering the students with special needs.
- You should provide Braille/ tactile for example the mammalian eye dissection or telling those with visual impairment learners how a mammalian eye is dissected and what is observed. There is also need to use sign languages for involving the learners in class activities and
- 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.
- You need also to seek for the information regarding the child from the parents about how they often communicate with children at home.

7.4 Guidance on the introductory activity:

Introduce the unit 7: General principles of reception and response in animals by using a scenario and pictures of introductory activity and ask the students to do the following:

- Invite the learners to read the scenario and to understand it
- Call them to observe and interpret the pictures of introductory activity
- Allow them to express their ideas by answering or asking questions.
- Consider their ideas and then inform what they will learn in this unit

Answers to the introductory activity

The students will give all possible reasons why the moth escapes the predator which is a bat, because of having sense organs with sensory receptors that detect different stimuli. The students should give all functions of sensory receptors, the same case for the snail which is near the cultivating human, the students should explain well that because of having different sense organs including tentacles, the snail can recognize the surrounding situation by hearing, and seeing. Finally, it escapes from the predator. From students' ideas and answers, introduce all unit and then move to the lesson 1.

7.5 List of lessons/sub-heading

	Lesson title	Learning	Number of periods
1	Types of sensory receptors and stimuli	Explain the necessity of responding to internal and external changes in the environment. Describe the main types of sensory receptors. Recognize the role of sense organs in the perception of different stimuli.	2 periods
2	Components of the sensory system: transduction, transmission and processing	Discuss the main functions of a sensory system. Explain the significance of sensory adaptation Interpret graphs on sensory adaptation in response to a constant stimulus. Appreciate the role of sensory adaptation in protecting the sense organs from overload with unnecessary or irrelevant information.	2 periods

3	Structure and functioning of the eye	Describe the structure of the human eye Describe the structure of the retina. Explain how rods transduce light energy into nerve impulses. Explain how retinal convergence improves sensitivity. Explain how the cones achieve visual acuity. Explain how cone cells produce colour vision. Discuss the significance of binocular vision Relate the number of retinal cells to sensitivity and visual acuity	3 periods
4	Structure and functioning of the ear	Describe the structure of the human ear and the functions of its main parts. Describe the process of hearing and balance.	1 period
5	Structure and functioning of the tongue.	Locate the taste buds on the tongue	1 period
6	Structure and functioning of the skin	Locate sensory cells in the skin.	1 period
7	Assessment standard:	Explain clearly the general principles of reception and response in animals.	2Periods

Lesson 1 : Types of sensory receptors and stimuli

You are informed that the lesson one starts all unit. Within this lesson, a general introduction should be done at the beginning and being connected to the one of this lesson, then to the learning activity.

a) Prerequisites/Revision/Introduction:

The prerequisites of this lesson are knowledge, skills and attitudes such are stimuli, receptors, sensation, and perception that resulted from sense organs that learners learned in senior three and response and coordination in animals.

b) Teaching resources

- Charts and illustrations indicating different types of sensory receptors

– Video/movies of mechanoreceptors, photoreceptors, and chemoreceptors downloaded from you-tube https: //www.youtube.com/watch? v=rS-Wzt099. Projector, Student books

c) Learning activity 7.1

– Help the learners for developing competences related to the above lesson by doing the following:

– Facilitate the flow of all activity

– Provide some charts from your school library to your students and ask them to do the related questions

– Ask them to present their findings

– 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

Answers for activity 7.1

1) The main sensory receptors are:

– Mechanoreceptors which detect changes in mechanical energy, such as movements, pressures, tensions, gravity, and sound waves.

– Chemoreceptors which detect chemical stimuli, for example, through taste and smell.

– Thermoreceptors which detect temperature changes.

– Electroreceptors which detect electrical fields.

– Photoreceptors which detect light and other forms of electromagnetic radiation.

Answers for self-assessment 7.1

1) Mechanoreceptors which detect changes in mechanical energy, such as movements, pressures, tensions, gravity, and sound waves.

Chemoreceptors which detect chemical stimuli, for example, through taste and smell.

Thermoreceptors which detect temperature changes.

Electroreceptors which detect electrical fields.

Photoreceptors which detect light and other forms of electromagnetic radiation.

2) Primary receptor consists of a single neurone which is sensitive to a particular stimulus and transmits nerve impulses to another neurone or effector, whereas a secondary receptor consists of a modified epithelial cell sensitive to a particular stimulus and a neurone

3) Intereceptors

4) Electromagnetic receptors in general detect only external stimuli. Non-electromagnetic receptors, such as chemoreceptors or mechanoreceptors can act as either internal or external sensors.

Lesson 2 : Components of the sensory system: transduction, transmission and processing

a) Prerequisites/Revision/Introduction:

You should start this lesson by asking questions on the previous lesson 'Types of sensory receptors and stimuli'. It should facilitate the learners to understand more this lesson because it is linked with the previous one.

b)Teaching resources

- Charts and illustrations indicating the transduction, transmission and processing
- Video/ movies of transduction, transmission and processing downloaded from you tube https://www.youtube.com/watch?v=fHRC8SlLcH0

- Student textbooks, internet, pictures
- Projector

c) Learning activities 7.2

- Help the learners for developing competences related to the above lesson and do the following:
- Ask student or students in groups to do activity questions 8.2 which is in their textbook or write it on chalkboard
- Facilitate the learners in this activity
- Let learners do present their findings
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson through questions and also by welcoming questions.

Answers for activity 7.2

Each student should give the components of sensory system which are; Stimulus, receptors, conducting neurones, coordinator/CNS; it should be easy to give the answers of this activity 8.2 because they have learned it in the previous lesson.

Answers for self-assessment 7.2

1) The amplitude of a generator potential is proportional to the stimulus intensity whereas the amplitude of an action potential is always the same. It obeys the all or none law). An action potential is a wave of depolarization while a generator potential is the initial depolarization that occurs when a stimulus strikes a receptor/neuron.

2) Receptors are adapted to detect potentially harmful or beneficial changes in the environment. When given an unchanging stimulus, most receptors stop responding so that the sensory system does not become overloaded with unnecessary or irrelevant information. Loss of responsive is brought about by a process called **sensory adaptation** and enables an animal respond to only respond to vital stimuli.

3) **Transduction:** Receptor cells gather sensory information and then convert it into a form of information that can be used by the animal (nerve impulses)

Transmission: Sensory neurons transmit nerve impulses from the receptors to the central nervous system

Processing: the central nervous system processes the information so that appropriate responses can be made to environmental changes

4) You would perceive the electrical stimulus as if the sensory receptors that regulate that neuron had been activated. For example, electrical stimulation of the sensory neuron controlled by the thermoreceptor activated by menthol would likely be perceived as a local cooling

Lesson 3 : Structure and functioning of the eye

a) Prerequisites/Revision/Introduction:

Introduce this lesson by the following scenario: "During the night I am reading and revising my biology textbook in my classroom. At a certain time, the power cut off". Brainstorm what do you think about to happen to the reading and revising of the textbook?

b) Teaching resources

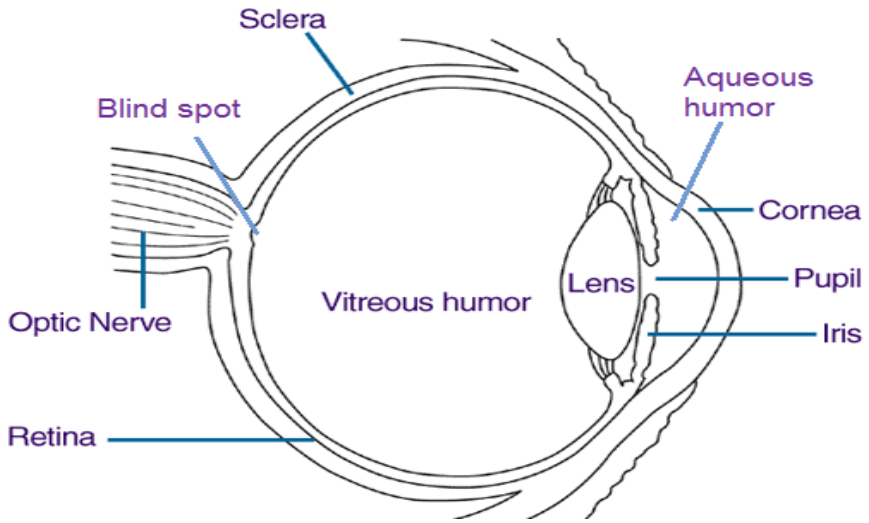
- Charts and illustrations indicating the structures of human eye.
- Video/ movies showing human eye structure and functions downloaded from you tube https://www.youtube.com/watch?v=BEtdh-G8wFE
- Student books, pictures, internet
- Projector

c) Learning activities 7.3

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners to form groups
- Provide a cow eye and all required materials to each group and ask them to follow the procedures of eye dissection found in the activity 8.3 given in student textbook
- Facilitate them in that activity
- Let learner groups to present their findings after dissecting an aye
- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson
- In their groups, the learners are going to do an activity 7.3 in student book

Answers for activity 87.3

The learners should give the drawing and labels a mammalian eye as indicated below



b) The parts and functions of the mammalian eye are:

- The lens: Refracts light and focuses it on retina. Made up of elastic material that adjusts when the eye focuses on far or near object.
- The ciliary body: made up of muscle fibres which contract or relax to change the shape or curvature of the lens. It produces aqueous humour.
- The suspensory ligament: The suspensory ligament is a tissue that attaches the edge of the lens to the ciliary body.
- The iris: is coloured part of the eye, it has radial and circular muscles which control the size of the pupil; it has melanin pigment that absorbs strong light to prevent blurred vision.
- Pupil: It is a hole at the centre of the iris through which light pass into the eye.
- Aqueous humour: Has fluids to maintain the shape of eye ball and to refract light rays. It contains oxygen and nutrient for cornea and lens. It is a transparent and allow light to pass through
- Vitreous humour: It is the space behind the lens and it is filled with fluids, a transparent, jelly-like substance. Vitreous humour keeps the eyeball firm and helps to refract light onto the retina.
- Cornea: Is transparent part of the eye and allows the passage of light. It refracts light ray. It is made up of tough tissues to strength the eye.
- Choroid: The choroid is the middle layer of the eyeball that lies between

the sclera and retina. It has two functions, one being able to prevent internal reflection of light as it is pigmented black. Secondly, it contains blood vessels that bring oxygen and nutrients to the eyeball and remove metabolic waste product.

- Retina: is the innermost layer of the eyeball. It is the light sensitive layer on which images are formed. It contains light sensitive cells called photoreceptors. Photoreceptors consist of rods and cones. Cones enable us to see colours in bright light while rods enable us to see in black and dim light. The photoreceptors are connected to the nerve endings from the optic nerve.

- Blind spot: The blind spot is the region where the optic nerve leaves the eye. It does not contain any rods or cones. Therefore, it is not sensitive to light.

- Optic nerve: It is a nerve that transmits nerve impulses to the brain for interpretation when the photoreceptors in the retina are stimulated.

- Fovea or yellow spot: It is a small yellow depression in the retina. It is situated directly behind the lens. This is where images are normally focused. The fovea contains the greatest concentration of cones, but has no rods. The fovea enables a person to have detailed colour vision in bright light.

- Conjunctiva: Thin and transparent to allow light to pass through.

- Sclera: It is a tough, white outer covering of the eyeball, which is continuous with the cornea. It protects the eyeball from mechanical damage.

- The eye brows: Prevent sweat and dust from entering the eye.

- The eye lashes: Prevent dust particles from entering the eye.

- The tear glands: Secrete tears that wash away dust particles in the eye and keep the eye moist.

Answers for self-assessment 7.3

1) Is the ability of the eye to regulate the amount of light entering by adjusting the size of the aperture of the pupil using the iris?

2) a) In bright light: The circular muscles contract while the radial muscles relax. The iris then becomes elongated and pupils narrower. Little light is allowed to enter the eye

b) In dim light: The radial muscles contract while circular muscles relax. The iris then shortens and the pupils widen. More light will be allowed to enter the eye.

3) Close each eye in turn. An object floating on the surface of an eyeball will

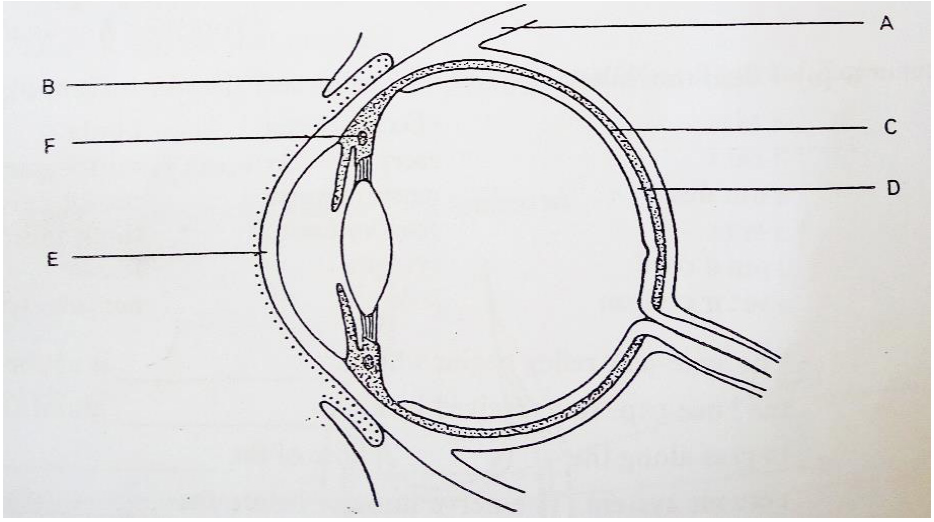
appear only when that eye is open.

4) **Visual acuity:** is the ability of an eye differentiating between two points of image close to each other as separate points.

Adaptation: is the ability of the eye to adjust to various levels of light.

Photoreception: is the detection and stimulation of photoreceptors by light rays which result into firing of an impulse along a sensory neurone to the brain.

5) Lens thickens (becomes more rounded).



6) The answer is given in the following table:

Function	Letter	Name
Prevents the reflection of the light rays	C	Choroid
Sensitive to light	D	Retina
Helps to bend rays of light	E	Cornea
Causes change of shape of lens	F	Ciliary muscle
Moves the eyeball up and down	A	Extrinsic muscles of the eye

7) Those are cones and rods

Lesson 4 : Structure and functioning of the ear

a) Prerequisites/Revision/Introduction

You should start this lesson by asking questions on the previous lesson 'structure and functioning of the aye' because all sense organs are connected

b) Teaching resources

- Charts and illustrations indicating different parts of human ear
- Video/ movies showing human ear downloaded from you tube https://www.youtube.com/watch?v=KHyqhh4TLio
- Student books, pictures
- Projector

c) Learning activity 7.4

- Help the learners for developing competences related to the above lesson and do the following:
- Facilitate the learners to form groups and do all learning activity
- Provide activity 7.4 given in student textbook ask them to do the related questions
- 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
- In their groups, the learners are going to do an activity 8.4 in student book

Answers for activity 7.4

The learners should draw and label the human ear, and make sure that the drawing possesses the main parts following parts: outer part, middle part and inner part and other parts.

Answers for self-assessment 7.4

1) Vestibular apparatus consisting of semi-circular canals, the utricle and saccule

2) To amplify sound vibrations.

3) Eustachian tube

4) Pitch refers to frequency of sound waves whereas intensity refers to their amplitude.

5) As a sound that changes gradually from a very low to a very high pitch

6) The stapes and the other middle ear bones transmit vibrations from the tympanic membrane to the oval window. Fusion of these bones, as occurs in otosclerosis, would block this transmission and result in hearing loss

Lesson 5 : Structure and functioning of the tongue

a) Prerequisites/Revision/Introduction

Introduce this lesson by challenging the learners through questions related to different categories of foods and drinks such as why taste of foods and drinks are different? Which organ of the body in charge of recognising those tastes? Allow learners to give their point of view.

b) Teaching resources

- Charts indicating the human tongue.
- Student books, pictures,
- Projector

c) Learning activities

- Help the learners for developing competences related to the above lesson and do the following:
- Ask students to do activity 7.5 given in student textbook or write it on chalkboard to each student
- Allow the learners to use the school library and the internet
- 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
- Individually, the learners are going to do an activity 7.5 in student book

Answers for activity 7.5

1) Are salty and sugary taste buds, students should answer also by drawing a

diagram of tongue and locate the taste buds.

2) Sour and bitter, students should answer also by drawing a diagram of tongue and locate the taste buds.

Answers for self-assessment 7.5

1) Both taste cells and olfactory cells have receptor proteins in their plasma membrane that bind certain substances, leading to membrane depolarization through a signal transduction pathway involving a G protein. However, olfactory cells are sensory neurons, whereas taste cells are not.

2) Because the sweet, bitter, tastes involve G-protein-coupled receptors (G PCR) proteins but the sour taste does not, you might predict that the mutation is in a molecule that acts in the signal transduction pathway common to the different GPCR receptors.

Lesson 6 : Structure and functioning of the skin

a) Prerequisites/Revision/Introduction

You should introduce this lesson by asking questions if hot thing touches your skin you feel hot, if cold thing touches your skin you feel cold, if a sharp object pricks your soles of the feet, you feel pain. What do you think the causes of those events? Allow learners to give their point of view

b) Teaching resources

- Charts and illustrations indicating the human skin
- Video/ movies showing the location of human skin sensory cells.
- Student books, pictures, internet

c) Learning activities 7.6

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

- Facilitate the learners to form groups
- Provide the diagrams given in student textbook
- Attribute the activity 7.6 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 their respective groups, the learners are going to do an activity 8.6 in student book

Answers for activity 7.6

- The students draw and label a mammalian skin, make sure that the drawing possesses main parts: epidermis, dermis and subcutaneous layers and other small parts of the skin
- The students should give and locate the skin sensory cells such as the sensory cells for touch, for cold, for hot, for pain, for temperature
- Mention a function corresponding to the part of the skin identified

Answers for self-assessment 7.6

1) The following are the descriptions

Protection: The body is protected by the skin in many ways. The melanin in the skin protects it from harmful UV rays. Keratin, a type of protein found in the skin, helps promote elasticity and supports the structure that forms the skin. The skin protects organs, inner tissues and even bones from being exposed to the outside world. More exact examples are protection against sun damage, physical trauma and bacterial invasion.

Temperature Regulation: When you become hot, your skin releases sweat from the sweat glands to help cool you down. The tiny blood vessels in your skin can also fill with blood when you are cold, making you warmer. The release or retention of heat depends on temperature outside of the body. This is one of the crucial functions of the skin.

Immunity: Certain cells in the skin work closely with the immune system to fight off bacteria, viruses and other nasty things that land on your skin. The skin prevents them from getting into your body and making you sick. Those cells include epidermal dendritic cells, phagocytic cells and Langerhans cells.

Permitting Movement and Growth: The elastic properties of the skin and the tissues underneath it allows your body to grow and change. They also make it much easier to move. If your skin were rigid and hard, you would suffer pain when moving, if you were able to move at all. The recoil properties of the skin mean that it bounces back to its original form, without leaving "dings and dents" in your body

Excretion: Your body needs to get rid of the waste products somehow. Some of these wastes can be excreted through the skin, such as urea, water, uric acid and ammonia. This helps rid your body of the things that might make you sick if your skin didn't serve as a gateway to the outside.

Endocrine: This function lies in the synthesis of Vitamin D. On the list of functions of the skin, your skin does a marvelous job of absorbing Vitamin D from the sun, and then turning it into something your body can use. An organic chemical in your skin reacts with the sunlight and gives you this essential vitamin. Be careful not to get too much sun, because some harmful rays can cause sunburns and possibly skin cancer later in life.

Sensation: Your skin can be very sensitive and allow you to feel the slightest changes in temperature, pressure and the like. Nerve endings in your body react to the sensations the skin feels, alerting your brain to the new feeling in an instant. This means you can react to hot or cold, to pain or injury, and even to a gentle touch in the appropriate manner.

Absorption: Your skin actually "breathes." You can absorb oxygen, nitrogen and other necessities through your skin. Though you still need your lungs to breathe, some animals have skin so advanced that they can actually take in all the air they need through the skin. The cells on the outside of your skin are affected by the amount of oxygen in the room; this is why you are encouraged to let your skin "breathe" by wearing cotton clothing and the like.

Water resistance: The skin serves as a barrier to water. This is important because it prevents your body from losing all the necessary nutrients and minerals that it stores up. The outer skin is covered with oils and nutrients that form a natural barrier against water.

Other functions: There are more functions of the skin. It prevents the evaporation of the water in your body by forming a barrier that keeps it all inside. It also serves as a complex storage center for lipids and water; sometimes skin will swell as a result of the water inside the body, especially during times of illness of injury. That water is eventually reabsorbed, and only the skin keeps it from being evaporated.

2) The capsaicin present in the spice mix activates the thermoreceptor for high temperatures. In response to the perceived high temperature, the nervous system triggers sweating achieve evaporative cooling.

7.6 Summary of the unit

Animal sense organs contain receptors which detect stimuli:

Photoreceptors in the retina of the human eye transduce light energy into nerve impulses, enabling us to see. Information from the eyes and ears goes to the brain where it is processed.

Mechanoreceptors detect mechanical stimuli; provide sensations of touch, pressure, vibration, and hearing and equilibrium; also monitor stretching of blood vessels and internal organs, enable us to hear different sounds, detect body movements, and maintain balance

Thermoreceptors detect changes in temperature.

Nociceptors respond to painful stimuli resulting from physical or chemical damage to tissue.

Chemoreceptors detect chemicals in mouth (taste), nose (smell), and body fluids.

General senses include somatic senses (touch, pressure, vibration, warmth, cold, pain, itch, tickle,) and visceral senses; special senses include the modalities of smell, taste, vision, hearing, and equilibrium.

7.7 Additional information for teachers

To teach effectively this unit, the following additional information is necessary to help you to know more on this unit.

Eye infections

a) Conjunctivitis

This is an inflammation of the conjunctiva which causes redness, pus and mild burning in one or both eyes. The eyelids always stick together after sleep. Often people with conjunctivitis become very sensitive to light. It can be caused by:

- Hay fever called allergic conjunctivitis
- Foreign matter in the eye
- Harmful liquids
- A scratch on the cornea
- Acute glaucoma iritic
- Prolonged exposure to sunlight

The conjunctivitis is treated by the use of eye ointment

b) Cataract

c) Glaucoma

d) Trachoma (from Greek word which means rough eye)

This is a very serious and a painful condition caused by a bacterial infection which makes the eyelid turn inwards so that the eyelashes scratch the surface of the eye. In the early stage, antibiotics can be used to treat this infection. If left untreated, the infection can cause blindness. Later stage of the condition can be corrected with surgery.

e) Iritic inflammation

This is an inflammation of the iris. Pain begins suddenly and the eye waters a lot. Characteristics of the iritic inflammation: It hurts in bright light, vision is blurred and there is no pus

Healthy practices that favour eye health

- To consult the ophthalmologist in case of eye illness
- To avoid reading under a weak light
- To avoid scratching eyes in case of contact with dust or with foreign matter
- Never expose eyes to strong sunshine
- To hold the book between 25 and 30 cm while reading
- Never look at the solar eclipse without appropriated glasses

Disorders and diseases of the ear

a) Deafness: Deafness is when a person cannot hear because either one or both ears are not working correctly.

Causes of deafness

- Conductive deafness can be caused by the hereditary abnormality of the bones of the inner ear.
- Perceptive deafness may be inborn or caused by an injury or disease of the cochlea, auditory nerve or the hearing centres in the brain.

Corrections

- People with deafness can be helped through sign language and lip reading.
- Those with conductive deafness may be helped by hearing aids.
- Those with perceptive deafness may be helped by a cochlear implant with a special processor attached directly to the auditory centres in the brain.

b) Otitis

- Otitis is the inflammation of the ear due to infection. External otitis occurs in the auditory canal and is easily treated with antibiotics.
- Inflamed conditions of the middle or inner ear are more serious; they carry the risk of deafness and of passing the infection to the brain. Treatment is with antibiotics or, more rarely, by surgery.

C) Ruptured eardrum

- A ruptured or burst eardrum can be caused by a very loud sound or sudden change in external pressure.
- This causes the membrane to split.
- Although, the membrane may heal, there may be scarring which can cause temporary deafness.

Healthy practices for ears

- Never introduce sharp objects into the ear because you can damage the eardrum and become deaf. If you need to clean your ears, use a soft object such as cotton bud.
- If you think that a build-up wax is affecting your hearing, see doctor or a nurse.
- Avoid loud noise or excessive sound intensities that can damage the eardrum

The human nose

The general location of the nose

The nose which has the sense of smell is located at the level of nasal fossea. The latter are two cavities separated by the thin septum and they're located above the mouth cavity.

Structure of the human nose

The nose has two nostrils, each leading to a cavity that is divided by three turbinal bones into four passages:

- The lower three passages are for breathing
- The top passage which is just below the brain is for smelling.
- This passage is lined with a special epithelium which contains olfactory cells. The cell body of the neurone is found in the epithelium neurones

layer.

- Special microscopic cilia, which from the dendrites of the neurone, poke out of the epithelium and are bathed by mucus that covers this tissue. On the other side of the neurone, an axon transmits the message or impulse to the olfactory area of the cerebral cortex of the brain.
- Each olfactory cell is a bipolar neurone.

Functions of the nose

- The main function of the nose is smell.
- The nose is also called olfactory organ
- Olfactory means to do with the sense of smell. This word comes from the Latin words oleo meaning a smell and facio meaning to make.
- We are only able to smell the chemicals that dissolve in moisture.
- The sense of smell (the nose) together with that of taste (the tongue) helps us to identify food flavours (quality which gives a thing taste or smell).
- The nose is the part of the breathing system through which air passes before reaching the lungs.

Note that:

(i) A cold in the nose partially weakens the sense of smell: This happens because the nasal membrane reacts to the cold virus by producing large amount of mucus which covers the smell receptors. This reduces the ability to taste which shows that the flavour of food is a combination of taste and smell.

(ii) Man's sense of smell is poor compared to the dog or the antelope.

The sense of smell is highly developed in the dog; hence its actions depend on it.

The process of smelling

Olfactory cells or receptors are the simplest of the special receptors in humans. There are about 25 million smell receptors in your nose and they enable you to detect all the different smells that exist. Olfactory receptors are referred to as **chemoreceptors.** This is because they are stimulated by chemicals in solutions.

Smelling occurs in the following steps:

- Gas molecules, for example given off from food, are in the air
- These enter the nose and dissolve in the mucus lining the epithelium. Before the gas can stimulate the receptor, it must be first dissolved in the mucus

- The cilia of the dendrites of the olfactory cells are stimulated
- A series of impulses travel to the olfactory area in the cerebrum of the brain.
- The brain recognizes the smell

The healthy practices of the nose

- How can you maintain a healthy nose?
- Do not sniff solvents
- Do not push things up your nose
- Keep your nasal passages and sinuses clear by blowing your nose

Summary on nose

The nose

- The nose is the receptor organ for smelling (olfaction) since smell is due to chemicals in the air; it is an example of chemoreceptor but which stimulates at a distance.
- The detection of chemicals in air is done in nasal cavity when they dissolve in the mucus in it and stimulates the sensory cells to produce impulses sent to the olfactory lobe of the brain.

Diseases and disorders of the skin

Common disorders and diseases of the skin include:

Burns and scalds

- These are caused by hot objects and liquids. A burn caused by a hot liquid or steam (vapour) is usually called scald. Burns can also be caused by strong acids and alkalis.
- In light-skinned people, burns can be caused by the sun.

Treatment

- For a mild burn (on the epidermis), place the burn area in cold water for at least 10 minutes.
- For a serious burn, see a doctor

Acne (Pimples)

- This is the name given to the condition prevalent in adolescents in whom spots develop on the face and shoulders. It is largely due to increased activity of the sebaceous glands brought on by puberty.

– Signs of acne appear as little lumps that form small white heads of pus. These lumps may become sore and large.

Treatment

– There is no guaranteed cure for teenage acne but the following may help:

– Good hygiene to keep skin clean

– Expose the skin to a moderate amount of sunlight

– Use of astringents (skin tonics)

– Drink a lot of water

– Get enough sleep

– Eat a balanced diet

Dermatitis

– Dermatitis means inflammation of the skin.

Symptoms of dermatitis

– Dermatitis symptoms vary with all different forms of the condition.

– They range from skin rashes to bumpy rashes or including blisters. Although every type of dermatitis has different symptoms, there are certain signs that are common for all of them, including redness of the skin, swelling, itching and skin lesions (wounds) and sometimes oozing and scarring (mark of skin after damage).

Ringworm

– Ringworm is not caused by a worm. It is a fungal infection of the skin and can affect any part of the body. It can affect the nails and hair as well as the skin. It is spread by skin-to-skin contact with an infected area. Ringworm causes itchy, scaly patches on the skin. If nails are affected they become thick and crumbly.

Treatment

– Keep skin dry and if possible, use anti-fungal powders, lotions or creams.

Itching rash, welts or hives

– These may come and go rapidly. They can be caused by food, medicine, touching or inhaling certain substances.

– Signs of itching rash, welts or hives appear as thick hives or spots.

Treatment

– Stay away from the things that cause the itch

Cancer

– There are several forms of skin cancer. One of the commonest is called melanoma (tumour of skin) and is caused by two much exposures to the sun.

Healthy practices of the skin

Good practices to keep the skin healthy include:

– Being carefully when handling hot materials

– Bathing every day with soap

– Avoiding prolonged exposure to the sun

– Wearing shoes outdoors (outside or in open air)

– When appropriate, wearing protective clothing to avoid exposure to chemicals such as acids, alkalis and other industrial chemicals

7.8 Answers for end unit assessment 7

A. Answers of multiple questions

1) b

2)b

3)c

B. Answer by True or False

4) True

5) True

6) True

C. Answers of essay questions

7) Bleaching occurs: retinal and opsin break apart, altering the permeability of the cell surface membrane of a rod cell; this may lead to an action potential if the light stimulus is high enough

8) Blue, green and red

9) The following are the answers:

a)Arrow drawn vertically upwards.

b)Absorbs light not detected by receptors; prevents reflection/ scattering of light and hence less precise detection by receptors; contains capillary network, supplies receptors with oxygen and glucose

c) Answers:

(i) Many rod cells share/ synapse with a single relay neurone/ synaptic convergence; gives increased sensitivity to low levels of light

(ii) Individual cone cells have their own relay neurone; giving greater visual acuity

10) Detect changes of movement in any direction.

7.9 Additional activities

7.9.1 Remedial activities

Multiple choice questions: Choose the best answers

1) Which of the following sensory receptors is incorrectly paired with its category?

a) Hair cell-mechanoreceptor

b) Muscle spindle-mechanoreceptor

c) Taste receptor-chemoreceptor

d) Rod-electromagnetic receptors

e) Olfactory receptor-electromagnetic receptor

2) Which of the following is an incorrect statement about the vertebrate eye?

a)The vitreous humour regulates the amount of light entering the pupil.

b)The transparent cornea is an extension of the sclera.

c)The fovea is the centre of the visual field and contains only cones.

d) The ciliary muscle functions in accommodation.

e) The retina lies just inside the choroid and contains the photoreceptor cells.

Questions with short answers

3) Give 3 main parts of human ear

4) Which part of eye where image is formed?

5) State and locate the taste buds of the human tongue

Answers

1) e

2) a

3) Outer, middle and inner ear

4) on fovea centralis of the retina

5) Salty and sugary taste, sour, bitter. Their location salty and sugary at tips of the tongue, sour at both sides of the tongue, bitter at back part of the tongue.

7.9.2 Consolidation activities

1) Describe the change which occurs in the photosensitive cells when light of varying intensity strikes the retina

Answers

- Each rod cell has in its outer segment up to 1000 vesicles, each containing a photosensitive pigment called rhodopsin. Rhodopsin is made up of the protein opsin and retinal, a derivative of vitamin A. Light causes retinal to change shape from its normal cis isomeric form to trans-isomeric form. As result, retinal and opsin break apart; a process called bleaching. This triggers a series of events which alters the permeability of rod's cell surface membrane.

- If light stimulation exceeds the threshold level, an action poetical is set up in a bipolar neurone, and then passes along a neurone in the optic nerve. The pattern of nerve impulses transmitted along different neurones is interpreted in the brain as patterns of light and dark.

- Before the rod cell can be activated again, the opsin and retinal must first be resynthesized into rhodopsin. This resynthesis is carried out by the mitochondria found in the inner segment of rod cell, which provide ATP for the process. Resynthesis takes longer time than splitting of rhodopsin but is more rapid in lower light intensity.

- Rhodopsin of rods spits into opsin protein and retinal (derivative of vitamin A). About 3 minutes are required to reform again. That is why our eyes

need some minutes to adapt to dark when we come from bright light

- The spitting of iodopsins of cone cells also produces an action potential (impulse) but they quickly re-form. There are three types of iodopsins and each responds to the wavelength of a particular colour: red – green – blue.

- The impulses are then transmitted along the optic nerve to the visual area of the brain. There, the image is interpreted.

7.9.3. Extended activities

1) Explain why nocturnal animals see during the night and can't see during the day and how image is formed in your eyes?

Answers

- Nocturnal animals have lot of rods in their retinas, but no cones. The levels of light at night are very low, so even if the animals have lot of cones, they would not be able to see in colour because the level of light is too low to stimulate the cone cells. At night, animals need to be able to detect shape and movement and the very sensitive rod cells are ideal of this because they are stimulated by very low levels of light

- Images are formed on the retina (they're upside down because the lens is biconcave).

- When light enters the eye, it is refracted by the curved surface of the cornea, the lens, the aqueous and vitreous humour.

- The refraction of light causes the image to be formed upside down on fovea centralis.

- When cones and rods are stimulated by light, they send impulses through the optic nerves to the brain where the correct impression of the object is formed

UNIT 8: NERVOUS COORDINATION

8

8.1 Key Unit Competence

Describe the structure of neurones and explain the mechanisms of impulse transmission.

8.2 Prerequisite (knowledge, skills, attitudes and values)

- To succeed well this unit, make sure that the learners have learned and have understood well previous units that are 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

8.3 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.
- 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.

8.4 Guidance on the introductory activity

- Introduce the unit 8 by using the written information in introductory activity and do the following:
- Invite the learners to think about the written information of introductory activity
- Give time to think about the given questions
- Allow them to express their ideas
- Consider their ideas and then inform what they will learn in this unit

Expected answers to the introductory activity

The students should give advantages and disadvantages of communication tools as follows:

- Advantages: Very convenient, Easy to set up, Easy to access, Free, Participants can interact
- Disadvantages: More difficult to set, requires training/ management to maintain, requires some technical knowledge to set up, requires some technical knowledge to set up

The student should also be able:

- To collect the information about the internal and external environment.
- To process and integrate the information, often in relation to previous experience.
- To act upon the information, usually by coordinating the organism's activities.

8.5 List of lessons/sub-heading

	Lesson title	Learning objectives	Number of periods
1	Lesson 1: Overview of control and co-ordination in mammals.	• Appreciate the importance of a coordinated behavior in organisms	1 period
2	Structure, types and functions of neurone	• Describe the structure neurones	2 periods

3	Nature and generation of a nerve impulse	• Explain how a resting potential is maintained. • Explain how an action potential is generated. Interpret graphs for all or nothing law and refractory period	3 periods
4	Transmission of nerve impulses	• Explain how a nerve impulse is propagated along a neurone. • Explain the factors affecting the speed of impulse transmission. • Describe the properties of a nerve impulse limited to: saltatory conduction, all or nothing law, and refractory period. • Explain how information passes across a synapse from one neurone to another or from a neurone to its effector. • Investigate the nature of a nerve impulse in a nerve tissue of a frog.	3 periods
5	Structure and function of a cholinergic synapse	• Outline the roles of synapses. • Describe the roles of neuromuscular junctions	2 periods
6	Functions of sensory, relay and motor neurones in a reflex arc	• Describe the arrangement of neurons in a reflex arc. • Relate the structure of a cholinergic synapse to its functions. • Show concern about the need to have reflexes as rapid responses	1 period
7	Assessment standard:	Describe correctly the structure of neurones and explain the mechanisms of impulse transmission	2 Periods

Lesson 1: Overview of control and co-ordination in mammals

a) Prerequisites/Revision/Introduction

Ask some questions to check students' understanding. The questions should focus control and co-coordination in mammals.

b) Teaching resources

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

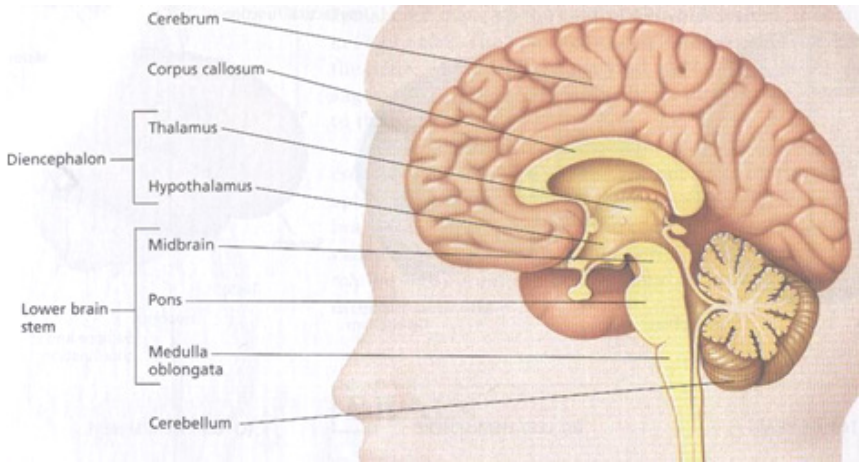
c) Learning activity 8.1

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 activity 8.1

1.The learners draw the labelled human brain:



2) Functions of the parts of the human brain:

1. Cerebrum: Controls all body's voluntary activities (movements, walking, singing, eating, it is the center for judgment, memory, reasoning, learning and imagination.

2. Thalamus**:** Is the center for perception of pain, **and pleasure,**

3.Hypothalamus: Regulates and monitors **the temperature and water** content of blood, Is a coordinating center for activities of the internal organs such as the rate of heart beat, blood pressure, Is the center for feeling such as hunger, thirst, sex drive, satisfaction, sleep, speech,

4.Pons controls automatic functions, movement and posture.

5.Medulla oblongata: Controls of automatic functions (**heartbeat, breathing**, Reflex centers for vomiting, coughing, sneezing, swallowing, and hiccupping, Coordination of body movement.

6. Cerebellum It coordinates voluntary and semi **voluntary movements,** It ensures equilibration of the body and muscle contraction, Maintain posture and balance, Control all unconscious activities of the body

Answers for self- assessment 8.1

The information is conveyed in nervous system in form of nerve impulse, and this nerve impulse is characterized by the following features:

- Refractory period: Is the period where action potential cannot be generated for at least 1ms.
- Absolute refractory period: Is the period that lasts around1ms and during this period no new impulses can be propagated however intense the stimulus.
- Relative refractory period: Is the period lasts 5ms and during this period new impulses can be propagated only if the stimulus is more intense than normal threshold level.
- Saltatory conduction: It is movement or jump of nerve impulses from one node of Ranvier to another along the axon membrane of neurone.

Lesson 2 :Structure, types and functions of neurone

a) Prerequisites/Revision/Introduction:

You should start this lesson by asking questions on the previous lesson and revise shortly the previous lesson "overview of control and co-ordination in mammals".

b) Teaching resources

- Charts of neurones.
- Video/ movies of types neurones downloaded from you tube
- https://www.youtube.com/watch?v=X4uuCgElLK8
- Student textbooks, internet, pictures
- Projector.

Learning activity 8.2

- 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 8.2

1) The learners should give the parts of a neurone: dendrites, cell body, axons, axon terminals, myelin sheath, Schwann's cell,

2) The students should classify the neurones basing on their functions, in this case the students should give sensory, motor and intermediate neurones or basing on the processes they possess; they should give bipolar, unipolar and multipolar.

Answers for self-assessment 8.2

If cell body damaged, the neuron dies, and is not replaced by cell division in mature brain. If the axon is damaged or severed at a distance from the soma, when a nerve is damaged a clearly defined sequence of events take place. Severing the axon (the cable along which neural signals are transmitted) causes a number of degenerative

changes to take place. Firstly, communication between the damaged neuron and all other neurons to which it is connected ceases. The distal portion (or the section of the severed axon that is furthest from the cell body) slowly starts degenerating. The cells that had synaptic connections (points of cell-cell communication) with the damaged cell also start to degenerate.

Lesson 3 :Nature and generation of a nerve impulse

a) 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. Ask also them to.

b) Teaching resources

- Charts illustrating the generation of nerve impulse
- Video/ movies of generation of nerve impulse downloaded from you tube.
- Student books, pictures, internet.
- Projector

Learning activity 8.3

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

- Facilitate students to do activity 8.3 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 activity 8.3

The answers should be the description of an action potential phases. 1. Resting potential 2. Depolarization 3. Repolarisation 4. Hyperpolarization

Answers for self-assessment 8.3

(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 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 nerve impulses

a) Prerequisites/Revision/Introduction:

You should start this unit by revising the previous lesson, after you should ask the students brainstorm how the body responds to a stimulus.

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=iBDXOtuHTQ
- Student books, pictures, internet
- Projector

c) Learning activity 8.4

- Help the learners for developing competences related to the above lesson and do the following:
- Ask students to do activity 8.4 or write it on chalkboard or whiteboard
- Facilitate the activity by supporting those who got stuck
- Let groups of learners 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

Expected answers for activity 8.4

In this experiment, you will stimulate the frog's sciatic nerve, activating a large number of individual nerve fibres simultaneously, and record the resulting aggregate electrical activity, i.e., the Compound Action Potential (CAP). The particular objectives are to:

- Study the characteristics of the frog's sciatic nerve CAP.
- Construct a strength/duration curve of the nerve.
- Study the refractory period of fibres

Answers for self-assessment 8.4

1) A decrease in permeability to K+, an increase in permeability to Na+. Or both
2) Based on the figure:
   a) M – Represents the resting potential. The resting potential of the axon is –mV. 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. The resting potential is then re-established by the Na+/K+ pump and the different permeability of membrane to K+ and Na+ ions.

b) The two factors that can determine the speed of transmission of a nerve impulse and how each affects the speed:

- Presence of a myelin sheath which acts as an electrical insulator. The action potential leaps from one node of Ranvier to the next node. This speeds up the rate of transmission of nerve impulse.
- The lager the diameter, the faster the speed of transmission

c) Sodium voltage –gates are sensitive to voltage changes. When some voltage –gated sodium channels are stimulated to open, Na+ ions diffuse into the neurone. This in turn stimulates more voltage –gated sodium channels to open and there is a rapid influx of Na+ ions. This is an example of positive feedback mechanism.

Lesson 5: Structure and function of a cholinergic synapse

a) Prerequisites/Revision/Introduction:

Introduce this lesson by asking the questions on previous lesson which is about the transmission of nerve impulse across synapse for example what is meant by a cholinergic synapse?

b) Teaching resources

- Charts illustrating the structure of a cholinergic synapse
- Student books, pictures, internet
- Projector

c) Learning activity

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

- Facilitate students to do activity 8.5 as given in their textbook.
- Let learners 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 activity 8.5

A labelled diagram showing a cholinergic synapse and a table of different functions of that synapse as seen in student textbook.

Answers for self- assessment 8.5

The following are the answers:

1) A-Myelin sheath, B-Node of Ranvier, C- Synaptic knob/bulb, D- Mitochondrion, E-Synaptic vesicle, F-Synaptic cleft

2) Student will draw an arrow- pointing towards synaptic knob

3) Acetylcholine

4) The answers are:
   a) Na^+ ion
   b) Cl^-/K^+ ion

5) To produce ATP for synthesis of acetylcholine

6) The answers are: Phospholipids

7) The myelin sheath (A) acts as an electrical insulator. The node of Ranvier (B) contains protein channels for movement of Na+ and K+ ions. An action potential can leap from one node to another node thus speeding the rate of nerve transmission.

Lesson 6 :Functions of sensory, relay and motor neurones in a reflex arc

a) Prerequisites/Revision/Introduction:

Introduce this lesson by doing a revision on the structure, types and functions of neurone, transmission of nerve impulse and the cholinergic synapse.

b) Teaching resources

- Charts of reflex arc or -Video/ movies showing the reflex arc
- Student books, pictures, internet

Learning activity 8.6

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

- Facilitate this activity through clear instructions and support for those with some learning difficulties
- Let groups of learners 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 activity 8.6

The labels of the diagram of reflex arc in students' text book

Answers for self- assessment 8.6

- Sensory (Afferent) neurons transmit impulses from the receptors to the central nervous system.
- Motor (Efferent) neurons transmit impulses from the central nervous system to effectors (motor organs) e.g. muscles or glands that carry out the response. Most motor neurones are stimulated by impulses conducted by interneurones. However, there are some which are stimulated directly by sensory neurones.
- Interneurones, intermediate, association, relay, interneurone) which connect the pathways of sensory and motor impulses, and are found mainly in the central nervous system.

8.6 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 unit of the nervous system, the key features of neurones are cell bodies, axons, dendrons, and in myelinated neurone there are; Schwann cells, myelin sheaths and nodes of Ranvier.

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.

8.7 Additional Information

To teach effectively this unit, you should read and understand the following

content if even it does not appear in curriculum syllabus.

Differences between reflex action and conditioned reflex

Reflex action	Conditioned reflex
Instinctive behaviour	Learned behaviour
Stimulus and Response are usually related	Stimulus and response need not be related
Association areas of the brain are not involved (may or may not involve the brain, hence nervous pathway is simple)	Association areas of the brain are usually involved (brain is always involved, hence nervous pathway is comparatively complex)

Essential differences between the somatic and the autonomic nervous system

Somatic nervous system	Autonomic nervous system
Impulse speed along motor fibres that extend from CNS to effectors without synapses (no ganglia)	Impulses speed along motor fibres that extend from CNS to ganglia where they synapse ,and from ganglion to effectors
Affects skeletal muscles	Affects glands, cardiac muscles and smooth muscles
Always stimulates effectors	May stimulate or inhibit effectors

Essential differences between the somatic and the autonomic nervous system

Sympathetic system	Parasympathetic system
• Ganglion is close to spinal cord	• Ganglion is close to effector
• The nerves emerge from thoracic and lumbar region of CNS	• The nerves emerge from sacral regions of CNS
• Activates the body for emergencies, to produce 'fight or flight responses	• Prepares body for relaxation and conservation of energy.
• Secretes norepinephrine / Noradrenalin as neurotransmitter	• Secretes instead acetylcholine as neurotransmitter
• Its post-ganglion nerve fibre is long.	• Its post-ganglion nerve fibre is short.
• Dilates the bronchioles	• Constricts the bronchioles
• Increases the heartbeat rate	• Decreases the heartbeat rate
• Slows peristaltic movements of stomach and inhibits secretion of digestive juices	• Stimulates peristalsis of the gut and stimulates secretion of digestive juices.
• Decreases urine output by relaxing bladder muscles and contracting the bladder sphincter	• Increases urine output by contrasting bladder muscles and relaxing the bladder sphincter.
• Dilates the pupil/iris of the eyes	• Constricts the pupil/iris of eyes.
• No effect on tear gland	• Stimulates secretion tears
• Stimulates the secretion of adrenaline and noradrenalin by adrenal glands.	• No effect on the adrenal glands

Types of disease of Nervous System

Catalepsy: It is a nervous disorder characterized by immobility and muscular rigidity, along with a decreased sensitivity to pain.

Epilepsy: It is an unpredictable, serious, and potentially fatal disorder of the nervous system, thought to be the result of faulty electrical activity in the brain

Encephalitis: It is an inflammation of the brain. It is usually caused by a foreign substance or a infection. Symptoms of this disease include headache, neck pain, drowsiness, nausea, and fever

Meningitis: It is an inflammation of the meninges (membranes) of the brain and spinal cord. It is most often caused by a bacterial or viral infection. Fever, vomiting, and a stiff neck are all symptoms of meningitis.

Huntington's: It is a degenerative neurological disorder that is inherited

Signs and symptoms: Every disease has different signs and symptoms. Some of them are persistent headache; pain in the face, back, arms, or legs; an inability to concentrate; loss of feeling; memory loss; loss of muscle strength, paralysis.

The health of the human nervous system

- The nervous system is a delicate system which should be looked after well to avoid malfunction.
- The disorders and diseases which affect it include: poliomyelitis, epilepsy, cerebral malaria, psychosis, depression and schizophrenia.

Healthy practices that favour the health of the human nervous system

- Most of these disorders and diseases (mentioned here above) can be avoided if you:

Learn to live well with yourself and others

- This will help you to avoid stress.
- Living well with others will decrease your chances of getting disorders such as psychosis (to hear sounds that do not exist), depression or schizophrenia (getting away from reality).

Exercise to relieve stress

Exercise helps to relax the nervous system thus promoting a healthy life.

Have enough sleep.

- This will go a long way in helping the body relax and gain composure (calmness).
- Lack of sleep can lead to being nervous, irritable and lack of concentration on your work.8 to 9 hours of sleep is recommended for the brain to function well

Eat a balanced diet

- This will keep the nerve cells healthy and functional. Mineral salts such as calcium, sodium and potassium are required for proper functioning of nerves. The brain needs a constant supply of glucose to function properly and avoid a blackout or fainting.

Avoid abusing drugs such as alcohol, cocaine, marijuana, etc.

These depress the brain and give you a false hope. They may lead you to become psychotic, that is, to hear sounds that do not exist or even schizophrenia which is getting away from reality.

When riding or doing work which can cause an injury to the head, wear protective helmet

- Damage to the brain may lead to epilepsy, convulsions or fits (Sudden illness or sudden loss of feeling).

Carry out relaxation activities

- Such as listening to the soft music, completing puzzles and reading newspapers, novels and interesting stories. These take the mind away from stressful information and situations. They relax the mind and sometimes make you laugh which is a very good activity for the nerves

8.8 Answers for end unit assessment 8

Answers of multiple choice questions

1.c
2.b
3.c
4.c
5.b
6.a

Short and long answers

8) The following are the answers:

A: Cerebral hemisphere/ cerebrum; B: medulla; C: cerebellum

Regulation of: heart rate; blood pressure; ventilation rate; swallowing; salivation; vomiting; coughing; sneezing

9) The following are the answers:

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

10) Based on the figure:

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

11) 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 +40mV; 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.

12) The complete table is the following:

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

13) 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.

C. Answers of essay questions

14. 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, Ca2+ions diffuse into synaptic knob. The influx of Ca2+ 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

8.9 Additional activities

8.9.1 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

Expected answers

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.

8.9.2 Consolidation

1) Describe what happens after a new action potential is generated at postsynaptic neurone

Expected answers

- 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

8.9.3 Extended activities

1) Describe the basic pathway of information flow through neurons that cause you to turn your head when someone calls your name

2) How would severing an axon affect the flow of information in a neuron? Explain

3) Suppose you treated a neuron with ouabain, an arrow poison and drug that specifically disable the sodium-potassium pump. What change in the resting potential would you expect to see? Explain

Expected Answers

1) 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.

2) It would prevent information from being transmitted away from the cell body along the axon

3) The activity of the sodium-potassium pump is essential to maintain the resting potential. With the pump inactivated, the sodium and potassium concentration gradients would gradually disappear and so would the resting potential.

UNIT 9: HORMONAL COORDINATION IN ANIMALS

9

9.1 Key Unit Competence

Identify the location and function of endocrine glands in the body.

9.2.Prerequisites /Introduction/Revision

Students will learn better the hormonal coordination in animals if they have well understood the working of the nervous system. They also need to know the process of coordination in animals seen in the previous unit and the coordination in plants seen in S4.

9 3.Cross-cutting issues to be addressed

Comprehensive sexuality education, gender and inclusive education are issues to be addressed by this unit.

Comprehensive sexuality education

This issue will be addressed when students will understand how their body works through the lesson and then decide how they should behave from the questions which will be asked.

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.

Inclusive education

In this unit, the students will need to observe photos on which they will observe different endocrine glands. So students with visual impairment may be given audio devices which can help them to understand about the endocrine glands. We will have to watch to different movies, so great care must be put to those with visual and audio impairment.

As a facilitator, place learners with visual impairment in appropriate places. Those with short-sightedness (myopia) must sit on front desks in class. If you have children with low vision, remember to print in appropriate font size (large print). Those with long - sightedness must sit on back desks. Invite or visit the parents whose children have hearing impairment and learn from them how they do communicate with them. Provide blind learners with Braille materials and other tactile materials.

9.4.Guidance on the introductory activity

Before starting the first lesson of this unit, ask learners to orally attempt an introductory activity given in student textbook.

Relate the unit with learners' daily life experience and ideas given to the questions to attract their attention and introduce the whole unit.

Expected answers of the introductory activity

Such changes are caused by hormones produced by the body. A hormone is a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs.

- Muscles develop, the beard appears on the chin, the testis and penis increases in size.
- Testis, ovary, and other endocrine glands
- The body being unable to produce sufficient hormones.

9.5 List of lessons

	Title of the lesson	Learning objectives	PERIODS
1	Lesson 1: Structure and function of the endocrine system in humans: location of endocrine glands and functions of their secretions.	Define hormones. Compare and contrast the actions of the endocrine and nervous systems.	6
2	Lesson 2: Principles of the negative feedback mechanism of hormonal action.	Describe the principle of the negative feedback mechanism by which hormones produce their effects on target cells. Draw and interpret the flow chart of negative feedback mechanisms.	2

3	Lesson 3: Effects of hormonal imbalance: diabetes, goitre, dwarfism and gigantism.	Explain why hormonal balance is necessary for coordinating the functions in the body Explain the effects of hormonal imbalances.	3
4	Lesson 4: Comparison of hormonal and nervous systems.	Compare and contrast the actions of the endocrine and nervous systems.	3
5	Assessment standard	Learners can identify the location and function of endocrine glands in the body	2

Lesson 1: Structure and function of the endocrine system in humans: location of endocrine glands and functions of their secretions

a) 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 teacher will help the learners to understand the meaning of the endocrine glands and different secretions they produce.

b) Teaching resources

Student's books, chart showing different endocrine glands, a movie showing the location of endocrine glands. The link is found in the learner's book.

a) Learning activity

- As a facilitator, you are expected to guide learners through the following steps:
- With a chart and books, the learners will identify all the endocrine glands of our body and some of their secretions that they know.
- The teacher as a facilitator will guide them by adding what they do not remember.

Answers to the activity 9.1

a) Endocrine glands are glands secrete their products (hormones) into the interstitial fluid surrounding the secretory cells rather than into ducts.

b) The adrenal glands are located a top the kidney

The pancreas is located below the stomach

c) The pancreas produces two hormones called insulin and glucagon. Insulin lowers blood glucose level whereas glucagon decreases blood glucose level.

d) The pituitary gland was once considered as the master gland because it makes hormones which control the activity of other endocrine glands.

Answers for self-assessment 9.1.

1) The thyroid glands make Triiodothyronine (T3), thyroxine (T4) and Calcitonin.

2) ADH: Promotes retention of water by the kidney. Oxytocin: Contraction of uterus during childbirth and ejection of milk from mammary glands

3) Hormones are transported by the blood.

Lesson 2: Principles of the negative feedback mechanism of hormonal action.

a) 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 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.

b) Teaching resources: The teaching resource is the text books

c) Learning activity 9.2

- As a teacher you need to do the following:
- The teacher will help the learners to form groups and to discuss and to present their findings

– From the findings of students, the teacher can help them to understand what is the feedback mechanisms and the types of feedback mechanisms.

Answers to activity 9.2

1) These are the answers:

– When the amount of water taken decreases, the quantity of urine is also decreased.

– When the amount of water taken is increased, the amount of urine produced is also increased.

– The body regulates the amount of water in the body in order to maintain homeostasis. This is called the negative feedback.

2) The body makes a hormone called glucagon which increases the amount of glucose in the blood up to the homeostatic level.

Answers for self-assessment 9.2

1) Two examples of positive feedback: blood platelet accumulation which causes blood clotting in response to a break or tear in the lining of blood vessels. Another example is the release of oxytocin to intensify the contractions that take place during childbirth.

2) The positive feedback not useful in homeostatic mechanisms because they take the variable out of range.

Lesson 3: Effects of hormonal imbalances

a) 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 and will try to identify the causes of these disorders. If possible, a movie showing different endocrine disorders will be given.

b) Teaching resources:

Books, internet, photos showing individuals with some disorders

c) Learning activity 9.3

– The learners observe discuss on the questions set in the activity 10.3 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.

- After class discussion, the learners will present their findings to the class
- The teacher helps students to harmonise their ideas through questions and make corrections where necessary.

Answer for Activity 9.3

1) The answers are:

a) Lack of insulin / or by the hypo secretion of the hormone called insulin.

b) Diabetes mellitus is treated by the injection of the hormone called insulin.

2) The person A has goitre which is caused by the lack of thyroid hormones. The person B has pituitary dwarfism which is caused by the hyposecretion of the pituitary gland hormone called GH.

Answers for self-assessment 9.3

1) The following are the answers:

- Gigantism: disorders resulting from increased levels of growth hormone before the fusion of the growth plate which unusually occurs at some points soon after puberty. This is most often due to abnormal tumour growths on the pituitary gland.
- Diabetes mellitus: A type of diseases that result in too much sugar in the blood (high blood glucose)
- Grave's disease: An immune system disorder that results in the overproduction of thyroid hormones (hyperthyroidism)

2) (a) The main symptoms of diabetes mellitus are the three polyuria, excessive urine production due to an inability of the kidneys to reabsorb water; polydipsia, excessive thirst; and polyphagia, excessive eating.

(b) Graves' patients often have a peculiar oedema behind the eyes called exophthalmos, which causes the eyes to protrude.

Lesson 4: Comparison of hormonal and nervous systems

a) Prerequisites/Revision/Introduction:

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

b) Teaching resources: books, internet

c) Learning activity 9.4

- The teacher asks the learners to compare the two systems under the following headings
- By means of transport
- Duration of the action
- Site of mediator molecules
- Types of target cells
- In groups, learners will make a table in which they will indicate the differences between the two systems. After working, choose three groups to present their findings.

Answers for the activity 9.4

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 stops

Answers for self-assessment 10.4

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.

9.6 Summary of the unit

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

Pituitary gland (Hypophysis): hangs from hypothalamus by the infundibulum

Thyroid gland is located on front and sides of trachea below the larynx. There are four parathyroid glands; two on posterior of each lobe of thyroid. The disorders of the endocrine system often involve either the hyposecretion, inadequate release of a hormone, or the hypersecretion, excessive release of a hormone. In other cases, the problem is faulty hormone receptors, an inadequate number of receptors, or defects in second-messenger systems. µ

9.7 Additional information for the teacher

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.

9.8 Answers for end unit assessment 9

1) (b)
2) (d)
3) (b)
4) (b)
5) (c)
6) 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

7) The answer is summarized in the following table:

	Raises 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

8) The answer is summarized in the following table:

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

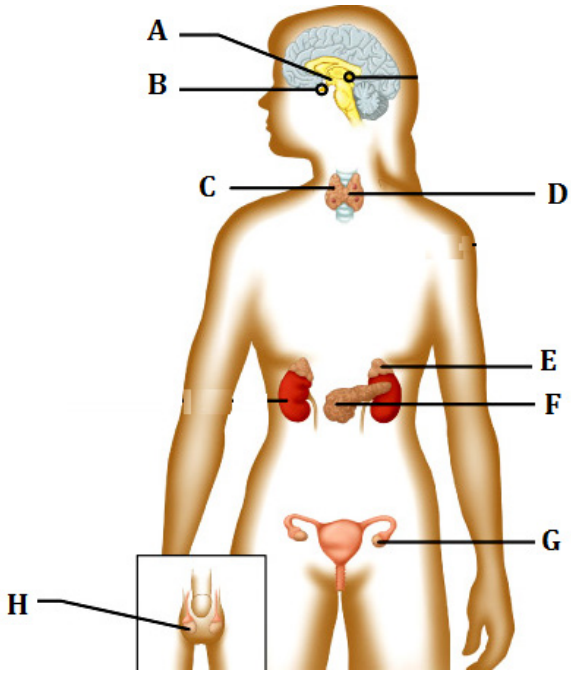
9) Diabetes insipidus and diabetes mellitus affect the kidneys in different ways. In diabetes insipidus, a deficiency of ADH or a lack of response by the kidneys to ADH affects the kidneys' ability to concentrate urine. A person with the disease produces large quantities of very dilute urine. In diabetes 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.

10) For the production of thyroxin, the hypothalamus secretes TSH (TSH 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.

9.9 Additional activities

9.9.1 Remedial activities

1) 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.

Answer for remedial question

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.

Any one from the following: GH, prolactin, TSH, ACTH, FSH, LH

9.9.2 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) How could an iodine-deficient diet lead to goiter, which is an enlargement of the thyroid gland?

Answers for consolidation activities

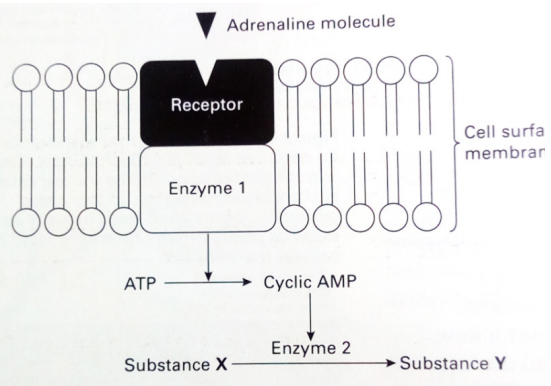
1) Aldosterone increases reabsorption of sodium and excretion of potassium by the kidneys. Results: hydrogen ions are excreted in exchange for sodium; chloride and bicarbonate ions and water follow sodium back to the blood; maintains normal blood pH, blood volume, and blood pressure.

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) Lack of iodine in the diet → diminished production of T3 and T4 → increased release of TSH → growth (enlargement) of the thyroid gland → goiter.

9.9.3 Extended activities

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

2) 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 ?

Answers to extended activities

1) 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

2) 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 / adenyl cyclase are needed to activate many molecules of substance Y / protein kinase / other named example; cascade effect.

UNIT 10: GROWTH AND DEVELOPMENT IN PLANTS AND ANIMALS

10

10.1 Key Unit Competence

Account for the processes of growth and development in plants and animals.

10.2 Prerequisites (Knowledge, skills, attitudes and values)

Before introducing this unit, it is essential to know that learners already have prior knowledge, attitudes and skills acquired in previous unit as follows: Knowledge about enzymes in Unit 10, plant tissues in unit 5 which enables learners to explain the processes of growth and development in plants and animals.

10.3 Cross-cutting issues to be addressed

The two main issues to be addressed by this unit include inclusive and gender education. Inclusive education will be addressed when particularly students with physical impairment will be involved in all learning activities particularly experimental ones where they will be playing role of giving instructions to students who are capable to do manipulation. They will also have to interpret and present the results.

Gender education will be addressed when anybody among learners irrespective of their gender will present and reports during learning activity. This cross cutting issue will be enhanced when students and teachers will give role models of those who are successful in real life.

10.4 Guidance on the introductory activity

Introduce the unit by using the situation given in introductory activity which is found in student textbook and ask students to brain storm what they think to be the causes of body changes in living organisms.

Expected answers for introductory activity

Cells divide; new cells absorb nutrients and water. They get bigger thus the organism increases in height and width: this is growth.

10.5 List of lessons/sub-headings

Lesson number	Lesson name	Learning objectives	Number of periods
1	Fruit, seed and bud dormancy.	Explain how dormancy is maintained and broken. Observe structures of endospermic and non-endospermic seeds. Demonstrate how fruit and seed dispersal takes place. State the conditions required for germination. Outline the role of enzymes in the process of germination. Appreciate the importance of fruit and seed dormancy and germination in the life cycle of plants.	2
2	Types and stages of germination.	Describe the stages and types of germination. Identify the hypocotyl and coleoptile in a germinating seed. Demonstrate hypogeal and epigeal germination.	1
3	Primary and secondary growth.	State that a meristem is a growing point of the plant and the main meristematic regions of a tree.	2
4	Determination of growth	Carry out an investigation to distinguish between primary and secondary growth.	1
5	Phytohormones.	State types of plant growth hormones and their functions.	2
6	Plant movements and Photoperiodism in plants.	Describe current views about photoperiodic control of flowering.	2

7	Metamorphosis and growth patterns in insects and amphibians	Carry out an experiment on the development of eggs at different temperatures. – Describe the process of metamorphosis in arthropods and amphibians. Distinguish the various stages of development in frogs. Analyse complete and incomplete metamorphosis. Compare growth patterns in arthropods and vertebrates. Appreciate the demands of the terrestrial environment to the adaptation of amphibians	3
8	Assessment:	Students can correctly explain the reasons for the changes in growth and development in insects, plants and amphibians during their life cycle.	1

Lesson 1: Fruit, seed and bud dormancy

Introduce all units within the period of this lesson. This means that you have to start with general introduction of the unit and then move to the lesson 1.

a)Prerequisites/Revision/Introduction:

Before starting to teach, remind students that they have learnt about fruit, seed and seed germination in senior three. Ask them some questions so that they may recall what they have learnt that are related to the aforementioned topics. Based on their ideas, move to the activity of the lesson of the day. During the lesson, create awareness of learners the fact that the content in this unit will help the learners to gain knowledge which help them to understand well the external and internal factors that affect the processes of plants growth and development. From that knowledge, the learners can control some factors and become successful farmers. Tell learners that more details on plants and animals growth will be studied at high levels of studying. This will enable learners to be familiar with the importance of learning plants and animals' growth and development.

b)Teaching resources

Different student's books, graph charts, seeds, plants in garden, butterfly, grasshopper, house fly frog, projector.

c)Learning activity 10.1

For students to develop competencies that are related to this lesson, you need to do the following:

- Ask learners to do individually activity 10.1 given in their student book
- Move around to monitor and support them in the activity
- Remember to assist those who are weak but without giving them the knowledge
- Invite students to present their findings
- Ask other students to follow carefully the presentations
- ask one of the presenting group member to note on chalk board/ Manila paper what they are presenting
- Exploit findings through challenging questions.
- Through questions harmonize and conclude the lesson. On the learned knowledge and still engage students in making that conclusion

Answer for activity 10.1

- Carry out the experiment
- Diagram in the student's book figure 10.1
- No. some organs are dormant (not active) due to changes in growth factors (internal as well as external factors), organs like seeds, bud and fruit depending on the period; can stop temporary growing or developing. However, if conditions become favorable, the dormancy breaks and the growth restarts.

Answers for self-assessment 10.1

- Dormancy is the period of low metabolic rate with little or no

growth in plant organs.

- The plant organ remains dormant until environmental conditions become favorable to allow the organ to grow again.
- Helps them to survive harsh conditions
- Water, Oxygen and temperature (warmth).
- Softening the seed-coat and activating the enzymes in the seed.
- Diagram in the student's book.

Lesson 2: Types and stages of germination

a)Prerequisites/Revision/Introduction:

This is the second lesson of unit 10. The first thing to do before starting teaching is to remind students that they have learnt about seed germination in senior three, and ask them to discuss about the types of seed germination so that they can prepare themselves for this lesson.

b) Teaching resources

Students' books, graph charts, seeds, grains, water, plastic container, soil, projector, improvised diagrams on manila paper.

c)Learning activity 10.2

Help students develop the knowledge, skills, attitudes and values that are expected by this lesson by doing the following:

- Ask learners to form and work in the groups of four.
- Asks students to carry out the experiment (project work) at least ten days before the lesson starts.
- Ask learners to record their observations.
- Invite students to report what has been recorded
- Build on what has reported and ask some challenging questions like why is it not good to pour more water? What would happen if much water in poured on the seeds?

– Through questions, help students to harmonize and conclude the lesson.

Answers for activity 10.2

Obtained results depend on the environmental conditions in which each group/ class worked.

Answers for self-assessment 10.2

– Imbibition, radicle sprouting and plumule sprouting

– Diagrams in student's textbook figure 11.3 and Figure 11.4

Lesson 3: Primary and secondary growth.

a)Prerequisites/Revision/Introduction:

Introduce this lesson by reminding what they have learnt about plant specialized tissue in unit 5 by using questions. Then ask them to think and mention about the plant tissues that are involved in the process of plant growth. Build on their ideas and then move to the learning activity 11.3.

b) Teaching resources

Students' textbooks, monocot plants, dicot plants, projector, Diagrams on manila paper.

c) Learning activity 10.3

Facilitate the smooth running of activity by:

– Asking students to work individually 10.3 in student's textbook.

– Asking them to get out from your classroom for visiting an area (school garden or a field) including monocot plants (most annual), dicot plants (most perennial) and ask questions as suggested in activity

– Invite them to present their findings.

– Ask other students to pay attention when their colleagues are presenting

– Help students to put their work on chalk board / manila paper.

– Harmonize their work through questions and by ticking the correct findings and correct and complete those ones which are incorrect or incomplete.

– Help students to summarize and draw the conclusion of the lesson through questions

Answer for the activity 10.3

– They are similar in vegetative structure (all have leaves, stem and roots) and they all grow in length. Differences in growth are given in the following table:

Monocots	Dicots
Grow shorter	Grow taller
Remain thinner	Grow bigger
Develop less or no lateral shoot	Develop lateral shoot
Are weak as they have herbaceous stem	Are hard as they have woody stem
When mature they dry out (are annual or biannual)	Exhibit unlimited growth (are perennial)

– They all have apical meristems

– Dicots have lateral meristems, vascular cambium and cork cambium which allow them to increase in width while monocot do not.

Answers for self-assessment 10.3

– Answers are summarized in the following table:

Primary growth	Secondary growth
is the increase in length	the increase in width
Occurs in all plants	Occurs in perennial plants only
it takes place on root and stem tips	in root and stem
Is controlled by apical meristems	Is controlled by lateral meristems

– The wood consists of secondary xylem cells that are strengthened by lignin and cellulose. Its role is to ensure mechanical support to the plant.

– The increase in length would slow.

– Suberin

Lesson 4: Determination of growth

a)Prerequisites/Revision/Introduction:

Remind students that they have learnt about length measurement in mathematics and physics. Then ask them to talk about the way of measuring length and width of plants. Use their ideas and move to the activity 11.4.

b)Teaching resources

Students' textbooks, graph charts, monocot plants and dicot plants prepared previously in the pots, computer, projector, Manila paper with diagrams for improvisation

c)Learning activities 10.4

For the success of this lesson, the following are needed:

– Ask students to work on the activity 10.4 in their previous groups of four.

– Take them to the potted plants (of beans and maize) and invite them to conduct the experiment as indicated in the activity 10.4

– Assist those who are weak but without giving them the knowledge.

– Invite some group to share what they have done.

– Challenge students through questions.

– Help students to make a summary of the lesson and draw the conclusion.

– Answer for the activity 10.4

– Recording from each group

Answers for self-assessment 10.4

– 12m

- The increase in the dry mass, length, thickness and the ability to reproduce.

- Girdling removes an entire ring of secondary phloem (part of the bark), completely preventing transport of sugars and starches from the shoots to the roots. Girdling also removes the cork, this phenomenon leads to severe water loss and the plant dies with dehydration.

Lesson 5: Phytohormones

a)Prerequisites/Revision/Introduction

Remind students that they have learnt about response and co-ordination in plants in senior three. Then ask them to brainstorm how plants respond to auxin hormone based on their experience.

b)Teaching resources

Students' textbooks, internet connection and computer, graph charts, manila paper with diagrams for improvisation

c)Learning activity 10.5

To make the lesson successful, you do the following:

- Start with the scenario in student's textbook

- Ask the learners to work on the activity 11.5 in pairs.

- Move around and monitor if they are having some problems and assist them.

- Invite any three pairs to present their findings to the rest of students.

- Harmonize the students work through questions so that they may concur or still disagreeing.

- Help them to make a summary and conclude the lesson.

Answer for the activity 10.5

- Increase of abscissic acid in avocado plants cause the fruit to drop before maturity

– The auxins that promote the growth in length move away from light so that as the plant grows longer the auxins concentrate in the lower part of the plants. This causes decrease in growth rate.

– Auxins stimulate flowering process by promoting cell division so that the flower turns away from light source to maintain necessary auxins concentration.

Answers for self-assessment 10.5

– There are five groups of plant hormones: Auxins or Indol Acetic Acid (IAA), Gibberellin or gibberellic acid (GA), Cytokinins, Abscissic acid (ABA) and Ethene or ethylene (C_2H_4).

– The answer is given in the following table:

Plant hormone	Functions
Auxins	Promote cell growth by cell elongation stimulation Promote root formation on stem and leaf cuttings Increase number of fruit Prevent abscission Prevent germination of stored potatoes and onions
Gibberellins (GA)	Promote growth of shoots and leaves Stimulate seed germination, and seedling growth Increase size of fruit Stimulates parthenocarpy
Cytokinins	Promote growth through cell division stimulation Promote lateral bud growth in dicots Slow down senescence
Abscisic acid (ABA)	stimulates stomatal closure during water stress stimulates seed dormancy Inhibits growth promoters so that it blocks growth
Ethylene	stimulate ripening of fruit Promotes flowering in mangoes and pineapples Promotes abscission (detachment of leaves). Stimulate seed dormancy

- The growth in height slows down and the lateral shoot grows dramatically.

Lesson 6: Movements and photoperiodism in plants.

a)Prerequisites/Revision/Introduction

Remind students that they have learnt about response and co-ordination in plants in senior three. Then ask them to discuss the way by which plants respond to the environmental factors like light so that they can prepare themselves for this lesson.

b)Teaching resources

Students' textbooks, internet connection, graph charts, computer, projector, Manila paper with diagrams.

c)Learning activity 10.6

For smooth running of the activities, help students by:

- Guiding them to work on the activity 10.6 in pairs.
- Supporting them when needed
- Calling at least three pairs to present their findings and asking the rest of the class to pay attention.
- Helping them to note on chalk board / Manila paper their ideas
- Harmonizing their work by asking questions and clarifying the correct findings
- Helping them to draw the conclusion

Answer for the activity 10.6.1

- The shoot grows toward the light but the root grows away from the light. It grows away from that physical material. The fold when touched.
- Because plants respond to the relative length of light and dark period in 24-hours cycle.
- Photoperiodism

Answers for self-assessment 10.6.1

- Phytochrome are photoreceptors (light-sensing) present in very

low concentration in many plant organs whose role is to detect the amount of light to induce flowering.

- Short-day plants (SDP) will only flower when the dark period is longer than a critical length while long-day plants (LDP) are those which only flower when the dark period is shorter than a critical length.
- They will not flower.

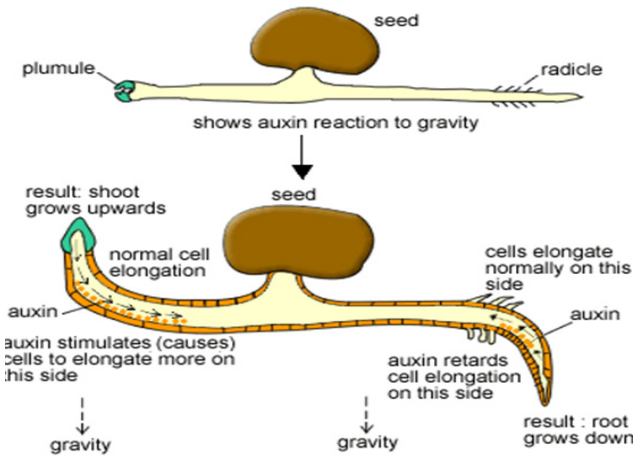
Learning Activity 10.6.2

Ask students to carry out a research project as indicated in student's textbook at least a week before teaching plant movements.

Answers for self-assessment 10.6.2

- The following is the answer

(a)



(b) Geotropism and photoperiodism

(c) The downward cells grow shorter than the upward cells.

(d) The use of clinostat

- If two or more growth hormones interact to give greater effect, those substances are synergists. For example, auxins and cytokinins work together for efficient growth. If a substance reduces the effect of the other, they work antagonically. For example, Abcissic acid maintains dormancy in seeds but gibberellins break it.

Lesson 7: Metamorphosis and growth patterns in insects and amphibians

a)Prerequisites/Revision/Introduction:

Remind students that they have learnt about characteristics of amphibians and insects in unit 1 of senior four. Then ask them to talk about the common characteristics for both amphibians and insects; so that they can prepare themselves for this lesson.

b)Teaching resources

Students' textbooks, internet connection, computer, projector, Manila paper with diagrams.

c)Learning activity 10.7

To facilitate the smooth running of the activity you need to do the following:

- Asking students to conduct the experiment stated in the activity 10.7 in groups of four
- Ask them to do the experiment as a research project
- Invite any three groups to present their findings to the rest of students.
- Ask them to note on chalk board / manila paper their findings.
- Affirm the correct findings and correct those which are incorrect.
- Through different questions, harmonize and conclude the lesson.

Answer for the activity 10.7

- In warmer climates, eggs may hatch within 1 or 2 days, while in colder environments they may take 30 to 40 days to hatch into tadpoles.
- They are similar
- Both amphibians and butterfly exhibit complete metamorphosis. Their eggs hatch into larva that are morphologically, physiologically and behaviorally different from the adult.

Answers for self-assessment 10.7

- Metamorphosis is a complete or marked change in the form of an animal as it develops into an adult, e.g. the change from tadpole to frog or from caterpillar to butterfly.

- The adult frog lay eggs.

  1. Each egg hatches into a tailed larva breathing through gills called tadpole.

  2. As the tadpole grows, it develops legs that replace the tail

  3. Lungs replace gills

  4. it also develops long, sticky, projectile tongue for catching insects

  5. when mature it is adapted to terrestrial life and then move from water to land as a mature frog

- The differences are given in the following table:

Differences	
Metamorphosis of a butterfly	Metamorphosis of a grasshopper
Is complete	Is incomplete
Larvae are wormlike	No larval stage the egg hatches into a miniature grasshopper
Similarities	
They both molt for metamorphosis	

10.6 Summary of unit

Growth in living organisms results from the interaction between the organism and its environment. Growth and development are affected by internal and external factors. Plants like animals need a certain amount of water, light and temperature to grow. Dormancy is a response to water and temperature changes preventing plants to grow when conditions are not favourable. Phytohormones are internal factors that have different effects on plant growth and plant development. Auxins for example promote the increase in length but inhibit buds and roots growth. Plants are also sensitive to the external factors like light, gravity, touch, water and chemicals. To the external factors or stimuli, plants respond by movement involving growth called

tropisms. Nastic movements like the folding and unfolding of leaves or flowers in response to touch, light or darkness are temporary and independent to the direction of the stimulus. The change in daylight and darkness length induces flowering in some plants. The response to daylight length by flowering is called photoperiodism.

10.7 Additional information

To be familiar with this unit, you should read different books and search on internet whenever is available so that you will be able to complete some student's incomplete findings. You should also be creative when you are introducing the unit and lesson to help students to engage themselves in different lessons. We welcome your advices, corrections and questions.

10.8 Answers for End of unit assessment 10

- Definitions in student's textbook
- Answers:

  a)The increase in the dry mass, the increase in the volume of protoplasm, the increase in the length, the increase in the thickness

  b)Temperature, light, moisture and carbon dioxide (CO_2).

Answers:

a) They are needed in a very low amount, they are produced in one part of a plant and transmitted to another part, and they affect plant growth and development.

b) Hormones

   i) Ethylene

   ii) Ethylene

   iii) Cytokinins

   iv) Gibberellins

(c) Parthenocarpic fruits are ones which develop from non-fertilized flower. Example: Banana

- The following are the answers:

a) The coleoptile will bend toward the light

b) Cells on the side A are shorter while cells in the side B appear longer.

10.9 Additional activities

10.9.1 Remedial activities

– Match the terms with the most suitable descriptions

a) Photoperiod-ism	(i) light induced control of plant growth and differentiation
b) Abscission	(ii) The process of ageing, loss of cellular functions, leading to death of plant parts or whole plant
c) Phytochrome	(iii) Low metabolic rate with little or no growth
d) Long-day plant	(iv) photoreceptor in plant involved in red light sensing
e) Short-day plan	(v) the response of a plant to the relative length of light and dark period in 24-hours cycle
f) Etiolation	(vi) the dropping of leaves, unfertilized flowers and fruits from a plant
g) Chromophore	(vii) Plants will only flower when the dark period is longer than a critical length
h) Senescence	(viii) Plants will only flower when the dark period is shorter than a critical length
i) Dormancy	(ix) elongation of the stem or seedling due to less light exposure
j) Defoliation	(x) the process of causing the leaves of a plant to fall off
	(xi)Non-protein light-absorbing part of phytochrome.

Answer:

(a) v (b) vi (c) iv (d) viii (e) vii (f) ix (g) xi (h) ii (i) iii (j) x

– Distinguish between complete and incomplete metamorphosis. Give two example for each.

Answer:

Complete metamorphosis: the egg hatches into wormlike larva called caterpillar, the caterpillar develops into pupa the pupa becomes imago (adult) whereas in incomplete metamorphosis, the egg hatches into a miniature organism which looks like the adult known as nymph, it develops into an adult.

– Explain the advantage of using a rooting powder.

Answer:

The use of rooting powder stimulates the formation of roots from plant cuttings helping quick vegetative propagation.

Choose the best answer.

– Which type of plants does a selective weed killer affect?

a) Broad leaves

b) Narrow leaves

c) Food crops

d) Trees

Answer: (a)

– Auxins promote plant growth through:

a) Increasing the plasticity of plant cell walls

b) Causing the elongation of stem

c) Increasing the growth of root tip

d) Promoting the uptake of water by seeds

e) Increasing photosynthesis rate

Answer: (a)

– Most plants have seeds that are stimulated to germinate by:

a) Exposure to red light.

b) Pollinator agents

c) Exposure to fire

d) Spraying auxin

e) Exposure to ethylene

Answer: (a)

– A tropism in which a plant "bends" towards the sun throughout the day.

a) Photoperiodism

b) Gravitropism

c) Phototropism

d) Hydrotropism

e) Chemotropism

Answer: (c)

– A pea plant is growing near a cassava plant describe the change in pea plant.

Answer: the pea plant wraps around a cassava tree, such response is called thigmotropism.

– While animals can change their location as a response to a stimulus, plants change their growth pattern. Answer by true or false.

Answer: true

10.9.2 Consolidation activities

– Dormant seeds require suitable environmental conditions to break dormancy. Suggest the reasons why people are advised not to put seeds deeply in the soil.

Answer:

Burred seed deeply in the soil do not germinate because sunlight which provides adequate temperature for activating enzymes and air providing oxygen for cellular respiration do not reach deeper the soil. Then the seeds remain dormant

– In a tabular form, identify the differences between tropisms and nastic movements.

Answer: Differences between tropisms and nastic movements.

Tropism	Nastic movement
The movement involves growth	Does not involve growth
Depends on the direction of the stimulus	is non-directional response
The response is irreversible	Is reversible
The frequency of the movement does not depend on the intensity of the stimulus	The frequency of such response increases as the intensity of the stimulus increases

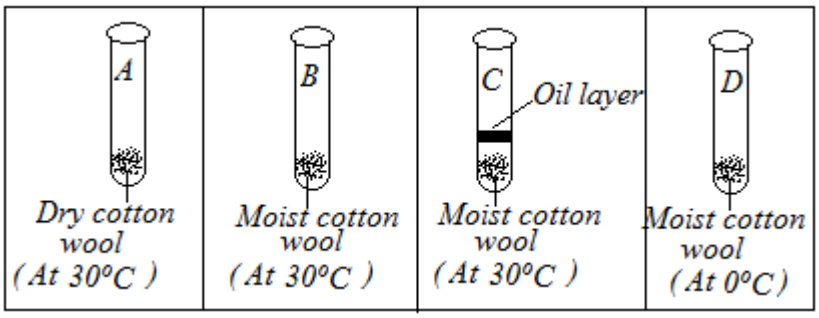
- Explain the importance of positive and negative phototropism with reference to the root and the shoot of a flowering plant.

Answer:

The shoot has a positive phototropism; it grows toward light that is an adaptation to effective photosynthesis. The root grows downward; negative phototropism this make the root being more adapted to storage.

10.9.3 Extended activities

– Four maize grains have been put in four test tubes having different condition as shown below:



– In which test tube are you expecting the germination to take place? Why?

Answer:

The test tube B because there are all suitable environmental conditions (moist, air and temperature).

– Explain why the germination will fail in each of the other test tubes.

Answer:

Germination will fail in the test tube A because there is no humidity (water), in C because the oil layer prevents air (oxygen) to reach the seeds, in D because there is very low temperature that cannot activate enzymes.

– Would you expect a tropical tree to have distinct growth rings? Why or why not?

Answer:

Not. The growth rings of a tree from the tropics would be difficult to discern unless the tree came from an area that had pronounced wet and dry seasons.

– Discuss the importance of apical and lateral meristems in plant growth.

Answer:

Apical meristems are located on the stem and root tips; they control the increase in length and formation of leaves, flowers, lateral shoot and fruits. This is primary growth. If the stem apex is cut off, the increase in length decreases. The secondary growth is controlled by lateral meristems which are

the vascular cambium and cork cambium. The multiplication of lateral.

– Discus reasons why complete metamorphosis may have greater adaptive value for an insect than incomplete metamorphosis.

Answer:

Complete metamorphosis has a greater survival advantage. As the larva and the adult are morphologically, physiologically and behaviorally different, they do not compete for the same resources (food, space) and they do not have the same predators. This will help some stage of life to survive harsh conditions even if the other stage is attacked.

UNIT 11: ASEXUAL REPRODUCTION IN PLANTS

11

11.1 Key unit competence

Explain how diversity is threatened by climate change and human activities.

11.2 Prerequisite (knowledge, skills, attitudes and values)

The learners learnt about asexual reproduction in plants in senior three in unit thirteen. Create awareness of learners the fact that the content in this unit will help them to gain knowledge, skills and attitudes that can lead them to career development in reproductive issues.

11.3 Cross-cutting issues to be addressed

This unit will address different cross-cutting issues particularly standardization culture, inclusive education, and gender education. The standardization culture will be addressed when students will appreciate the utilization of non-expired chemical reagents in relation to positive or good results of the activities. Emphasize should be made so that students should always check the date of manufactured and expiration of chemicals/substances even the food material.

For addressing **inclusive education,** while students will be conducting learning activities, instructional information should be given clearly and students with visual or physical impairment will be involved in learning activities by asking their colleagues who do not have impairment to perform tasks and asking them to report the results of learning activities. They can sometimes use their sense organs for identifying the results of learning activities.

For addressing issue of **gender,** both boys and girls should share equally responsibilities in different learning activities and arranging materials in learning activities for proper conducting learning activities

11.4 Guidance on the introductory activity.

Introduce this unit by challenging students through asking different questions like:

- Write on how lower organisms such unicellular plant and another like cassava, sugar cane and apple reproduce asexually.

- Difference between sexual reproduction and asexual reproduction
- Describe the techniques used by people to grow Irish potatoes, cassava and bananas.
- Describe each of the following methods of asexual reproduction: fragmentation, budding and spore formation.
- Ask them to brainstorm on the above questions so that they can come up with good results and give room to students so that they may share their thoughts. Use students' ideas and then introduce a whole unit.

11.5 List of lessons/sub-heading

	Lesson title	Learning objectives(from the syllabus including knowledge, skills and attitudes:	Number of periods
1	Difference between sexual and asexual reproduction	Differentiate between asexual and sexual reproduction.	2
2	Types of asexual reproduction	Describe the various methods of asexual reproduction: fragmentation, budding, and spore formation. Demonstrate asexual reproduction mechanisms in lower organisms.	3
3	Advantages and disadvantages of asexual reproduction	Discuss the advantages and disadvantages of asexual reproduction. Apply principles of artificial propagation in growing varieties of plants that are economically important.	2
4	Vegetative and artificial propagation in flowering plants	Describe the characteristics of vegetative reproductive parts in a flowering plant.	4
5	Application of artificial propagation in growing improved varieties of plants	Apply the know how to produce economically important plants. Appreciate the use of artificial propagation in increasing crop yields.	3
6	Assessment:	Learners can account for various methods of asexual reproduction as means of increasing crop yield.	2

Lesson 1: Difference between sexual and asexual reproduction

a) Prerequisites/Revision/Introduction

This is the first lesson of unit 11 and is a double period lesson. Before you start this lesson, you are requested to introduce the whole unit as given in the guidance on the introductory activity of this unit. Start this lesson by asking students to differentiate asexual and sexual reproduction, let students give their views. Build on students' ideas and then connect to learning activity of this lesson.

b) Teaching ressources

- Illustrations and computer aided materials.

c) Learning activity 11.1

Facilitate learners to do activity 13.1 and develop competencies in this lesson by doing the following:

- Ask learners to brainstorm the difference between asexual and sexual reproduction.
- Supervise the work how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask learners to make discussion in group.
- Ask learners to write the summary of the group discussions,
- Use students' products and further questions if need for summarizing and concluding the lesson.
- Through questions, guide learners to come up with a summary, write it progressively on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson through questions and then invite students to attempt self- assessment 11.1.

Answers to the activity 11.1

Expected answers are under the unit 16 (lesson one) in student book.

Answer for self-assessment 11.1

1. Asexual reproduction is a type of reproduction done by a single organism without production of gametes while sexual reproduction is a type of reproduction in which two parents are involved, each capable of producing gametes.

2. Expected answers are under the unit 13 (lesson one) in student book.

Lesson 2: Types of asexual reproduction.

a) Prerequisites/Revision/Introduction

Do introduction by asking students to brainstorm on asexual reproduction in lower organisms and write reports.

b) Teaching resources

Illustrations and computer aided materials.

c) Learning activity 11.2

Facilitate learners to do activity 11.2.1 and develop competencies in this lesson by doing the following:

- Ask learners to brainstorm the types of asexual reproduction in activity 11.2.1 and activity 11.2.2 on fragmentation method.
- Supervise the work how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask learners to make discussion in group.
- Ask learners to write the summary of the group discussions,
- Use students' products and further questions if need for summarizing and concluding the lesson.
- Through questions, guide learners to come up with a summary, write it progressively on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson through questions and then invite students to attempt self- assessment 11.2

Answers to the activity 11.2

Expected answers are under the unit 11 (lesson two) in student book.

Observation and Interpretation of results

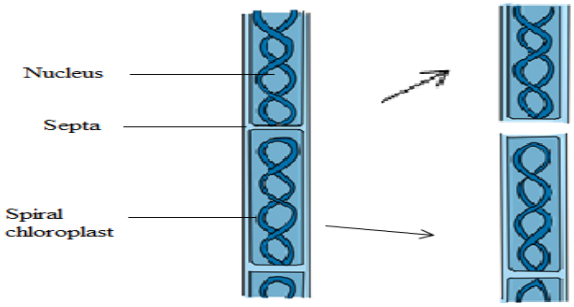


Figure 11.1: Asexual reproduction by fragmentation in Spirogyra.

It will be noticed that there is an increase in size of algae. However, the increase is not uniform. The spirogyra in beaker A and E show the least increase in size. Fastest growth reflected in size of algae is in beaker B, C and D. One of the factors that control the rate of growth is the amount of fertilizers in each beaker.

Table 11.1: Rate of growth

Beaker	Rate of growth	Reason
A	Low	The amount on fertilizer was little
B	Medium	The amount of fertilizers was more than that in beaker A
C	High	The amount of fertilizers was very high causing abnormal high rate of growth
D	Medium	The amount of fertilizers was too much that it altered the water potential in the beaker to be low. The alga is affect as its cells loose water to the beaker and end up with inadequate water.
E	Low	The amount of fertilizers was too much that it altered the water potential in the beaker to become very low. The algae are affected as their cells loose too much water to the beaker and fail to grow.

It is clearly demonstrated that spirogyra is capable of reproducing asexually by the fragmentation method. It should also be noted that artificial fertilizers have an effect on the rate of algae growth. Great care must be taken by farmers to avoid polluting rivers with excess fertilizers on their far.

Answer for self-assessment 11.2

1) Expected answers are under the unit 11 (lesson two) in student book.

2) Fragmentation is a form of asexual reproduction where a new organism grows from a fragment of the parent. Each fragment develops into a mature, fully grown individual. Fragmentation is seen in many organisms such as fungi, photosynthetic algae and plants.

Lesson 3: Advantages and disadvantages of asexual reproduction

a) Prerequisites/Revision/Introduction:

Through question of revision on the asexual reproduction, do you think on the asexual reproduction? Build on learners' ideas and then go to the activity 13.3 given in student textbook.

b) Teaching resources

- Illustrations and computer aided materials.

c) Learning activity 11.3

Help students to develop competencies that are related to this lesson you need to facilitate learners to do activity 11.3 by doing the following:

- Ask learners to brainstorm on the advantages and disadvantages of asexual reproduction.
- Supervise the work how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask learners to make discussion in group.
- Ask learners to write the summary of the group discussions,
- Use students' products and further questions if need for summarizing and concluding the lesson.
- Through questions, guide learners to come up with a summary, write it progressively on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson through questions and then invite students to attempt self- assessment 11.3

Answers for activity 11.3

Expected answers are under the unit 11 (lesson three) in student book.

Answers for self-assessment 11.3

Expected answers are under the unit 11 (lesson three) in student book.

Lesson 4: Vegetative and artificial propagation in flowering plants

a) Prerequisites/Revision/Introduction:

Learners have knowledge about vegetative and artificial propagation in flowering plants as they have learnt it from senior three in asexual reproduction and ask them to brainstorm on the asexual reproduction in plants by cuttings and build on learners' ideas and then go to the activity 16.4 given in student textbook.

b) Teaching resources

Illustrations and computer aided materials, sweet potatoes vines, elephant grass, sugarcane or cassava stems, secateurs/sharp knife and rooting hormone.

c) Learning activity 11.4

Facilitate learners to do activity 11.4 and develop competencies in this lesson by doing the following:

- Ask learners to brainstorm on the asexual reproduction in plants by cuttings.
- Supervise the work how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask learners to make discussion in group.
- Ask learners to write the summary of the group discussions,
- Use students' products and further questions if need for summarizing and concluding the lesson.

Through questions, guide learners to come up with a summary, write it progressively on the chalkboard or flipchart and ask learners to note it in their notebooks.

Finally, assess the lesson through questions and then invite students to attempt self- assessment 11.4.

Answers for activity 11.4

Observation and Interpretation of results

Through using of cassava stems, sugarcane, sweet potatoes planted in moist soil. After about 13 days, we observe the development of roots and leaves at nodes.

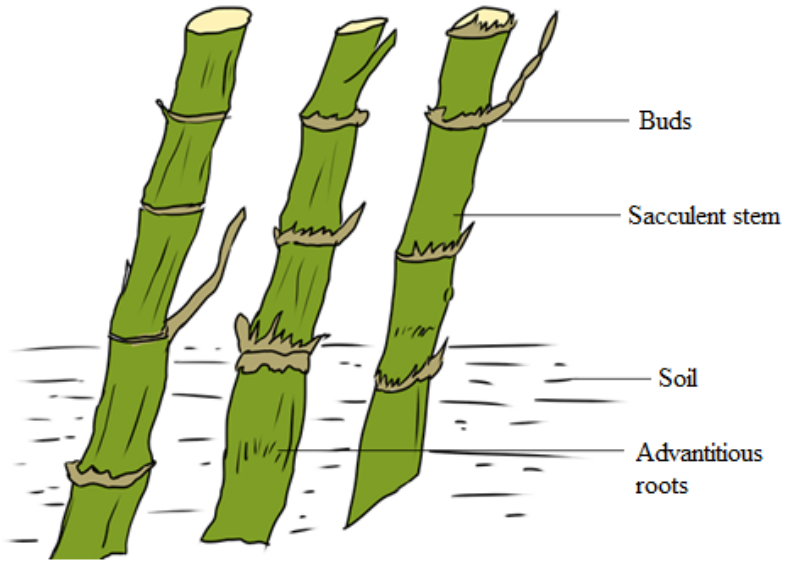


Figure 11.2. Asexual reproduction by cuttings in sugar cane

Answers for Self-assessment 11.4

1) Expected answers are under the unit 11 (lesson four) in student book.

2) The people prefer to grow cassava by cutting rather than germination of seed because of:

- Many new plants can be produced in a limited space from a few stock plants.
- It is simple and can be easily applied without having to learn the special techniques.
- It is rapid because there is no need to produce rootstocks.

3) Expected answers are under the unit 16 (lesson four) in student book.

Lesson 5: Application of artificial propagation in growing improved varieties of plants

a) Prerequisites/Revision/Introduction:

Through question of revision on the asexual reproduction, do you think on the asexual reproduction? Build on learners' ideas and then go to the activity 16.5 given in student textbook.

b) Teaching resources

- Illustrations and computer aided materials.

c) Learning activity 11.5

Help students to develop competencies that are related to this lesson you need to facilitate learners to do activity 11.5 by doing the following:

- Ask learners to brainstorm on the application of artificial propagation in growing improved varieties of plants.
- Supervise the work how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask learners to make discussion in group.
- Ask learners to write the summary of the group discussions,
- Use students' products and further questions if need for summarizing and concluding the lesson.
- Through questions, guide learners to come up with a summary, write it progressively on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson through questions and then invite students to attempt self- assessment 13.5

Answers for activity 11.5

Expected answers are under the unit 16 (lesson five) in student book.

Answers for self-assessment 11.5

Expected answers are under the unit 13 (lesson five) in student book.

11.6 Summary of the unit

Asexual reproduction generates offspring that are genetically identical to a single parent.There are five common modes of asexual reproduction: fission, budding, vegetative reproduction,spore formation and fragmentation. Asexual reproduction needs one parent only while sexual reproduction usually needs two parents, asexual reproduction depends on mitosis while sexual reproductiondepends on meiosis being present at some stage in life cycle to prevent chromosome doubling in every generation.The gametes are produced in asexual reproduction while sexual reproduction gametes are produced. In asexual reproduction offspring are identical to parent while in sexual reproduction offspring are not identical to parents. They show genetic variation as a result of genetic recombination. In asexual reproduction often results in rapid production of large numbers of offspring while in sexual reproduction there are less rapid increase in numbers

Important advantages of asexual reproduction include:Rapid population growth. The disadvantage of asexual reproduction includes the following: asexual reproduction does not have genetic diversity, there is less variation produced with the offspring, asexual reproduction usually leads to struggle for existence as well as overcrowding.

Vegetative and artificial propagation in flowering plants occur in cutting, layering and grafting.Artificial vegetative propagation is usually used in agriculture for the propagation of those plants which produce either very few seeds or do not produce viable seeds.

11.7 Additional information

This unit contains more practical activities you are advised to work on before you got to teach them the students in order to avoid the failure of any activities before students.

11.8 Answers for End of unit assessment 11

i) Answer is C

ii) Answer is D

iii) Answer is B

iv) Answer is B

5) Some plants that are grown by grafting method are the following: mango, apple, banana, pear, grape, pineapple and peach.

6) Grafting is a horticultural technique whereby tissues of plants are joined so as to continue their growth together.

8) The potato tubers have nodes or eyes from which the new growth begins. The new stems growing from each eye are called sprouts which gives rise to the new plant.

9) Cutting method.

10) The names of the different methods of artificial vegetative propagation are the following: Cutting, Layering and Grafting

11) Vegetative reproduction is a type of asexual reproduction found in plants where new individuals are formed without the production of seeds or spores by meiosis. Examples of vegetative reproduction include in strawberry.

11.9 Additional activities

11.9.1 Remedial Activities

1) What is fertilization?

2) List five common modes of asexual reproduction.

3) Define vegetative reproduction.

– Mention any two disadvantages of vegetative reproduction.

Answers for remedial activities

1) Fertilization is the moment when a sperm and egg join together, and the genes from the mother and father combine to form a new life. The prize is the egg, which is released from the ovary and then travels along the fallopian tube to meet the sperm.

2) There are five common modes of asexual reproduction: fission, budding, vegetative reproduction,spore formation and fragmentation.

3) Vegetative reproduction is the formation of a new individual from any

vegetative partof the plant body.

4) Disadvantages of vegetative reproduction.

i. Year after year same variety is produced. New varieties cannot be produced by this method.

ii. Since all the plants are genetically alike, they are susceptible to same diseases.

iii. The plants when grown repeatedly may lose vigor.

iv. Undesirable characters get transmitted from one generation to another.

11.9.2 Consolidation activities

1) State at least three differences between asexual and sexual reproduction.

2) Write on the spore formation.

3) Discuss the popular use of grafting.

4) Rose is propagated both by cutting and budding. What are the advantages of these methods?

Answers for consolidation activities

1 Answer:

Asexual reproduction	Sexual reproduction
No gametes are produced	Gametes are produced. These are haploid and nuclei of two gametes fuse (fertilization) to form a diploid zygote.
Depends on mitosis	Depends on meiosis being present at some stage in life cycle to prevent chromosome doubling in every generation.
Offspring identical to parent	Offspring are not identical to parents. They show genetic variation as a result of genetic recombination

2) This may look similar to seed formation in flowering plants, but spore production only occurs in non-flowing plants and in other microscopic organisms. Examples of such organisms include fungi, green algae,

protozoa, and ferns.

3) A popular use of grafting is to produce fruit trees, sometimes with more than one variety of the same fruit species growing from the same stem. Rootstocks for fruit trees are either seedlings or propagated by layering.

4) Both cutting and budding are artificial methods of vegetative propagation.

Advantages of cutting

i) is a very simple method.

ii) It takes less time and is less expensive.

Advantages of budding

i) New varieties with desired characters like color or disease-resistance can be obtained by taking recourse to sexual process.

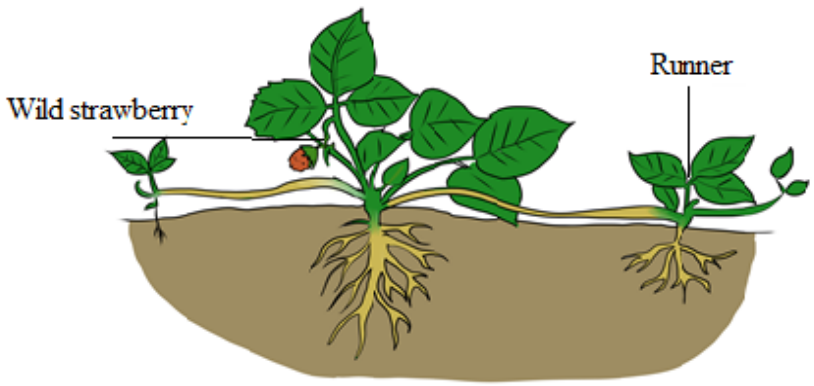
ii) It can be easily practiced.

11.9.3 Extended activities

i) Explain isogamy.

ii) Distinguish between Stocks from scion.

The diagram below shows one of the methods used in vegetative propagation of plants. Identify it and write short notes on how it is done.



Method X

Differentiate between cutting and grafting.

Answers for extended activities

1) The isogamy is union of structurally similar physiologically different gametes.

2) The stock is the plant of which the root system is taken on while the scion or graft is the plant of which the shoot is selected

3) Method is layering; Layering is a method of propagating a plant in which a shoot is fastened down to form roots while still attached to the parent plant. Layering has evolved as a common means of vegetative propagation of numerous species in natural environments. Layering is also utilized by horticulturists to propagate desirable plants. Natural layering typically occurs when a branch touches the ground, whereupon it produces adventitious roots.

Difference between cutting and grafting

Cutting	Grafting
-A single individual is involved.	Two different individuals are involved.
Short pieces of stem or root are taken, cut obliquely at the lower end and placed in soil.	The root portion (stock) of one plant attached with the stem portion (scion) of the other plant; the ends of stock and scion are cut obliquely, placed face to face and tied.
-It does not bring about any improvement in the subsequent plant.	It is practiced to improve the varieties or produce disease-resistant plants.
Examples: Coleus rose.	Examples: Mango, citrus, apple.

UNIT 12: SEXUAL REPRODUCTION IN PLANTS

12

12.1 Key unit competence

Describe sexual reproduction in plants.

12.2 Prerequisites

For the successive teaching learning process of this unity, students should have enough knowledge on plant anatomy. They have also to be well skilled on drawing a plant with all parts, manipulating the microscope so that they can observe micrographs under the microscope.

12.3 Cross-cutting issues to be addressed

The **"peace and value education."** It should be integrated in sub-heading including pollination. As a plant with female flowers needs another plant with male flowers for pollination and fertilisation, we also need each other.

- **Financial education.** This cross-cutting issue should be integrated in the sub-headings which require observing micrographs under microscope. When guiding students on how to manipulate the microscope, you should give a caution of handling them carefully as they are very expensive, and that the country spends a lot of money to buy them.

- **Gender education.** This cross-cutting issue should be integrated in all sub-headings which will involve formation and working in groups like. When forming groups for learning activities, when currying out practical activities, and when cleaning materials used during practical activities: both boys and girls should participate equally. It should also be integrated where ever teaching about the pollination and fusion of male and female gametes.

- **Inclusive education.** This cross-cutting issue should be integrated in all sub-headings. When forming groups for learning activities, when currying out practical activities, and when cleaning materials that have been used during practical activities: students with disability should be considered and helped regarding their specific cases: hearing impairment, vision impairment, students without arms and legs; you the teacher and other students should help them to achieve the competences as required in all teaching-learning activities.

12.4 Guidance on the introductory activity

- Provide the chart, books or micrographs with students which show different flowers containing insects or birds for pollination.
- Engage students to use resources provided, and work on the introductory activity.
- Give students the time to present their findings.
- Receive answers and ideas from students and summarize them by valuing students' contributions.
- Inform students about the general knowledge, skills and values that they will get from this unit.
- The expected answers for introductory activity
- Students should give answers related to pollination by insects and birds.
- The pictures are related to reproduction, as they represent flowers and pollination which are involved in reproduction in flowering plants.

12.5 List of lessons

	Lesson title	Learning objectives	Number of periods
1	Alternation of generations in bryophytes and pteridophytes	Explain alternation of generations in bryophytes and pteridophytes	3
2	Types and structure of flowers	To classify flowers To dissect a flower and a fruit. To appreciate fruits.	2
3	Pollination and double fertilization in flowering plants.	Identify pollinating agents Describe double fertilization	3
4	Structures, types of fruits and seeds	Classify fruits and seeds Describe the structure of seed and fruit	2
5	Fruits and seeds dispersal with their adaptations	Discuss dispersal agents. Explain adaptations of seeds and fruits to the mechanisms of their dispersion	2
6	End unit Assessment	Learners can describe sexual reproduction in lower organisms and plants.	2

Lesson 1: Alternation of generations in bryophytes and pteridophytes

a) Prerequisites

For a successful teaching-learning process of this unity, students should have enough knowledge on plant anatomy and plant physiology.

b) Teaching resources

The teaching aids or other resources needed include: microscope, prepared slides and micrographs. You may use also charts, computer, projector and other specific materials for disabled students. You can also use the students' text books.

c) Learning activity 12.1

- Ask students to form groups, and provide learning-materials to be used in the activity.
- Ask students in their groups to work on the Activity 12.1 from the students' text books,
- Monitor how the students are progressing towards the knowledge to be learned. Boost those who are still behind (but without communicating to them the knowledge).
- Move around the class, listening to students as they discuss and looking at their answers.
- Correct those which are false, completes those which are incomplete, and confirms those which correct. Help learners to summarize the lesson (short notes) and assess the lesson.

d) Answers for activity 12.1

Expected answer is found in the students' text books, unit 12, and lesson 12.1.

Answers for self-assessment 12.1

1) Alternation of generation is a phenomenon in the plant life cycle in which a diploid stage a sporophyte alternates with a haploid stage of gametophyte.

2) For fertilization to occur, the sperm of bryophyte must swim to an egg. Without water, this movement is impossible.

3) The archegonium is special reproductive organs in which eggs are produced, while antheridium is special reproductive organs in which sperms are produced. These organs are very important in the life cycle of mosses as they produce gametes which are involved is sexual cycle of bryophytes.

4) In ferns it is the sporophyte that dominates over the gametophyte

5) Sporophyte is a dominant generation over the sporophyte generation.

6) Gametophyte (haploid) produces eggs and sperms by mitosis, formed from spores, while sporophyte (diploid) produces spores by meiosis, formed during fertilization with fusion of egg and sperm.

7) Bryophytes like Liverworts reproduce asexually by producing gemmae, small multicellular reproductive structures. Gemmae can divide by mitosis to produce a new individual.

Lesson 2: Types and structure of flowers

a) Prerequisites

For a successful teaching-learning process of this unity, students should have enough knowledge of the parts of a flowering plant, and their functions.

b) Teaching resources

Student's books, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation

c) Learning activity 12.2

- Ask students to form groups, and provide learning-materials to be used in the activity.
- Ask students in their groups to work on the Activity 12.2 from the students' text books,
- Monitor how the students are progressing towards the knowledge to be learned. Boost those who are still behind (but without communicating to them the knowledge).
- Move around the class, listening to students as they discuss and looking at their answers.
- Correct those which are false, completes those which are incomplete, and confirms those which correct. Help learners to summarize the lesson (short notes) and assess the lesson.

Answers for activity 12.2

A typical hermaphrodite or bisexual flower contains the following parts:

- **Pedicel:** it is the stalk which attaches the flower on the main floral axis.

- **Receptacle:** it is the swollen part at the end of the stalk where other parts of the flower are attached.

- **The calyx:** it is the set of sepals, generally having green colour. They protect the internal parts of the flower. In some plants, the sepals are coloured and are called petaloids.

- **The corolla:** it is the set of petals, with different colours and nectar glands that produce sugary substances which participate in attraction of pollinating agents. In some plants, the petals are green and are called sepaloids. Both calyx and corolla are collectively called perianth. They are called floral envelope or accessory organs as they do not participate directly in reproduction, or in formation of fruits and seeds, they all insure the protection of internal parts of the flower.

- **Androecium:** is the male reproductive organ of the flower. It consists of many stamens. A stamen consists of: the filament which supports anther, and anther which contains the pollen grains or male gametes.

- **Gynoecium/pistil:** is the female reproductive organ. It consists of many carpels, and each carpel is made of: stigma (plural: stigmata), style and ovary with ovules.

i) **The stigmata:** receive pollen grains from anther during pollination.

ii) **Style:** supports the stigma in a good position to receive pollen grains.

iii) **Ovary:** a sac where ovules are produced. Ovules become seeds after fertilization.

2) **A flower** is a reproductive organ of a plant, which produces fruits and seeds

3) Expected answer is under the unit 12 (lesson two) in student book.

Answers for self-assessment 12.2

1) The male structures are the stamen (filament and anther), the female structures are the carpels (ovary, style and stigma).

2) Many flowers together in a single structure might attract more insects, which might improve chances of pollination.

3) The female gametophyte develops in the ovules, which are contained in the ovary of the flower.

4) Flowers are reproductive organs that are composed of four kinds of specialized leaves: sepals, petals, stamens, and carpels. Stamens produce male gametophytes, and the carpels produce male gametophytes.

Lesson 3: Pollination and double fertilization in flowering plants

a) Prerequisites

For a successful teaching-learning process of this unity, students should have enough knowledge of the parts of a flower, and their functions.

b) Teaching resources

Student's books, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation

c) Learning activity 12.3

- Ask students to form groups, and provide learning-materials to be used in the activity.
- Ask students in their groups to work on the Activity 12.3 from the students' text books,
- Monitor how the students are progressing towards the knowledge to be learned. Boost those who are still behind (but without communicating to them the knowledge).
- Move around the class, listening to students as they discuss and looking at their answers.
- Correct those which are false, completes those which are incomplete, and confirms those which correct. Help learners to summarize the lesson (short notes) and assess the lesson.

Answers for activity 12.3

1) The main pollinating agents include: insects *(entomophily), wind (anemophily), water (hydrophily), humans (anthropophily), and birds (ornithophily).*

2) The process of double fertilization in flowering plants begins when a

pollen grain adheres to the stigma of the carpel, the female reproductive structure of a flower. The pollen grain then takes in moisture and begins to germinate, forming a pollen tube that extends down toward the ovary through the style. The growth of the pollen tube is controlled by the **pollen tube nucleus.** In the pollen tube, the generative nucleus divides mitotically into two haploid nuclei which are the **male gamete nuclei.** These follow behind the tube nucleus as the pollen tube grows down the style towards the ovule. The tip of the pollen tube then enters the ovary and penetrates through the micropyle opening, releasing the two sperms in the megagametophyte or ovule.

The tube nucleus degenerates, leaving a clear passage for the entry of male nuclei. One nucleus fertilizes the eggcell to form a **diploid zygote (2N)**, which will grow into a new plant embryo; the other fuses with polar nuclei to form a **triploid nucleus (3N),** which will grow into a food-rich tissue known as endosperm, which nourishes the seedling as it grows. This process is described as **double fertilisation** and is typical of angiosperms.

Answers for self-assessment 12.3

1) Angiosperms are typically pollinated by animals such as insects, birds and bats carry pollen from one flower to another as they gather nectar.

2) It is a food rich tissue that nourishes the embryo during germination. It is inside the embryo sac.

3) Brightly coloured petals attract insects and other animals such as birds to the reproductive structures of the flower and increase chances of pollination.

4) Double fertilization is means two fertilizations that takes place between the male and female gametophytes. It may be one of the reasons that explain why angiosperms have been so successful.

5) Both disintegrate and disappear after fertilization since they do not have any important role to play.

Lesson 4 :Structures and types of fruits and seeds.

a) Prerequisites

For a successful teaching-learning process of this unity, students should have

enough knowledge of the parts of a flowering plant, their functions.

b) Teaching resources

Student's gooks, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation

c) Learning activity 12.4

- Ask students to form groups, and provide learning-materials to be used in the activity.
- Ask students in their groups to work on the activity 14.4 from the students' text books,
- Monitor how the students are progressing towards the knowledge to be learned. Boost those who are still behind (but without communicating to them the knowledge).
- Move around the class, listening to students as they discuss and looking at their answers.
- Correct those which are false, completes those which are incomplete, and confirms those which correct. Help learners to summarize the lesson (short notes) and assess the lesson.

Answers for activity 12.4

a) The fruit can have a dry pericarp or fleshy pericarp. The fruits with fleshy pericarp include: berry and drupe. Drupe is a fleshy fruit with only one seed, E. g. avocado.

Berry is a fleshy fruit having many seeds inside of it. E.g. tomatoes, orange, and pawpaw. The fruits with dry pericarp include indehiscent fruit or dehiscent fruit.

Indehiscent fruits do not open. Seeds remain inside of the fruits. E.g. fruits of coconuts.

Dehiscent fruits open and release seeds.

Self-assessment 12.4

1) **Drupe** is a fleshy fruit with only one seed, E. g. avocado.

2) **Drupe** is a fleshy fruit with only one seed, E. g. avocado, while Berry is

a fleshy fruit having many seeds inside of it. E.g. tomatoes, orange, and pawpaw.

3) If ovules in the flower do not develop, the seeds will not develop in the fruit.

4) Seeds dispersed by animals typically have a tough coat and are contained in fleshy fruits. Seeds dispersed by wind and water typically are lightweight and may be encased in wing-like structure.

Lesson 5: Fruits and seeds dispersal with their adaptations

a) Prerequisites

For a successful teaching-learning process of this unity, students should have enough knowledge of the parts and formation of seed and fruits and their functions.

b) Teaching resources

Student's gooks, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation

c) Learning activity 12.5

- Ask students to form groups, and provide learning-materials to be used in the activity.
- Ask students in their groups to work on the activity 14.5 from the students' text books,
- Monitor how the students are progressing towards the knowledge to be learned. Boost those who are still behind (but without communicating to them the knowledge).
- Move around the class, listening to students as they discuss and looking at their answers.
- Correct those which are false, completes those which are incomplete, and confirms those which correct. Help learners to summarize the lesson (short notes) and assess the lesson.

Answer for activity 12.5

a) The main agents of fruits and seed dispersal are wind, water, and

animals. Seeds dispersed by wind or water are typically lightweight, allowing them to be carried in air or to float on the surface of water. The wind carries also small seeds that have wing-like structure. Seeds dispersed by animals are typically contained in sweet, nutritious flesh fruits. They can be carried externally on their feet, fur, feathers, or beaks. Those seeds with hooks or sticky substances rely on the chance that they will attach themselves to a passing animal. Other seeds are eaten by animals and passed out in the faeces.

b) Seeds dispersed by animals are typically contained in sweet, nutritious flesh fruits. They can be carried externally on their feet, fur, feathers, or beaks. Those seeds with hooks or sticky substances rely on the chance that they will attach themselves to a passing animal. Other seeds are eaten by animals and passed out in the faeces.

Answers for self-assessment 12.5

1) It allows for long-distance dispersal and for germination under ideal conditions.

2) It enables the species to recover after a fire and ensures that seedlings grow in favorable environment.

3) The dispersal of seeds is important for the survival of the plant species because:

4) It minimizes overcrowding of plants growing around the parent plant that could then result in too much competition for nutrients and light;

5) It allows the plant species to colonise new habitats which can offer suitable conditions.

14.6 Summary of the unit

This unit: "Sexual reproduction in plants" is divided into five sub-units such as: Alternation of generations in bryophytes and pteridophytes, types and structure of flowers, pollination and double fertilization in flowering plants; structures and types of fruits and seeds, and fruits and seeds dispersal and their adaptations.

The unit deals with investigating the alternation of generations in bryophytes and pteridophytes which allows knowing stages of lifecycle of bryophytes and ferns and how they alternate.It helps to describe the structures and types

of fruits and seeds.This unit explains pollination and double fertilization in flowering plants.The unit describes structures and types of fruits and seeds and this unit talks about fruits and seeds dispersal and their adaptations.

12.7 Additional information for teachers

The longevity of lifecycle is controlled by phytohormones. The vegetative cycle is controlled by growth the hormone. When the growth hormone is enough in the plant, the vegetative cycle will be quick and then alternation of generations becomes also quick.

12.8 Answers for end of unit assessment 12

1) Answer are:

a) True b) True c) False d) False e) False

2) Answers are: a) iv (Stem) b) ii (carpel) c) ii (fruit)

d) ii (anthers) e) ii (gemmae) f) ii (fruit) g) ii (fronds)

h) i (gametophyte)

3) The seeds of angiosperms, because the seeds are enclosed in fruits, which are eaten by animals.

4) In seedless plants, the swimming of the male gametes is analogous to pollination in seed plants.

5) The diploid sporophyte; the gametophyte grows independently of sporophyte. The young sporophyte grows from the gametophyte.

6) Bryophytes produce sperms that must swim through water to reach the eggs of others.

7) Bryophytes are limited in size because they lack vascular tissues and therefore can draw only a few centimeters of water up from the ground by osmosis.

8) Favorable conditions may be short-lived (e.g. in autumn) and dormancy may increase the chances of germination occurring when there is prolonged period on favorable conditions (e.g. in spring). Dormancy increases the time during which seeds may be removed away from parents.

9) The gametophyte is dominant, recognizable stage and is the form that

carries out most of plant's photosynthesis. The sporophyte depends on gametophyte for water and nutrients.

10) Bryophytes depend upon the presence of water to complete their life cycle, because the only way the sperm can reach the egg is to swim through standing water or dew.

11) The dominant stage in the lifecycle of ferns is the diploid sporophyte, which, when mature consists of roots, underground stems called **rhizomes**, and **fronds**, which are large leaves. On the underground of fronds grow **sporangia**, which grow in clusters called sori that release **spores**.

12) Students' answers should reflect the concept that angiosperms have protected seeds and many ways in which the seeds can be dispersed, which increase the chances of survival.

13) Vascular tissue support a tall plant and curries water and nutrients from the soil to its upper region. Thus, ferns, which have vascular tissues grow tall, whereas moss plants cannot grow tall because they lack vascular tissues. Plants require a method to transport water and nutrients throughout the plant body in order to survive.

14) Answers are:

a) A= seed coast (testa), B= hypocotyl, C= endosperm (cotyledon).

b) Endosperm or cotyledon is the source of nutrients for a growing seedling.

15) The bright-coloured parts of the flower might attract insects and other animals for pollination.

16) Endosperm is the stored food supply in angiosperm seeds that nourish the embryo plant.

17) Fruit could not form on flowers that lack carpels, because fruits develop from the ovary, which is the part of the carpel.

18) Pollination is the transfer of pollen grains from anther to the stigma, whereas fertilization is the fusion of a male gamete with a female gamete.

19) Answers are: A= sepals, B= petals, C= stamen, D= carpel or pistil, E= anther, F= filament, G= stigma, H= style, I= ovary, J= ovule.B (petals) as brightly coloured structures they attract insects and birds which can

promote pollination.E (anther): it is where pollen grains are produced.G (stigma): receives pollen grain during pollination.

20) They all benefit. Bees obtain a food source, and flowers have a mean of pollination.

21) The main advantage of cross-pollination is to increase variation of offspring.

22) Stamens of wind-pollinated flowers have to be exposed to the air, whereas those of insect-pollinated flowers have to be enclosed so that insects have to brush past them.

23) Comparison between wind-pollinated and insect-pollinated flowers

Typical wind-pollinated flower	Typical insect-pollinated flower
Flower structure relatively simple	Complex structural modifications
Small petal not brightly coloured	Large coloured petal
Not scented	Scented
Nectarines absent	Nectarines present
Large branched and feathery stigma hanging outside flower to trap pollen	Small stigma, sticky to hold pollen and enclosed within flower
Stamens hanging outside flower to release pollen	Stamens enclosed within flower
Anthers attached only at midpoints at tip of filament so that they swing freely in air current	Anthers fixed at their bases or fused along their backs to the filaments so that they are immovable
Large quantities of pollen owing to high wastage	Less pollen produced
Pollen grains relatively light, small and smooth	Pollen grains relatively heavy, large and sticky.

24) Answers are: a) Mediterranean squirting cucumber; b) Sycamore or European maple;

c) Coconut; d) Mistletoe.

12.9 Additional activities

12.9.1 Remedial Activities:

1) Copy and complete the following sentence, by using the words: asexually, gametophyte, **sporophyte, and sexually** In all land plants the …….. Generation is haploid and produces…….. Whereas the …….. Generation is diploid and reproduces

2) How do the leaves of bryophytes differ from the true leaves of ferns?

3) Which part of the life cycle of ferns is most dependent on water?

4) Differentiate dioecious plants from monoecious plants.

Answers for Remedial activities:

1) In all land plants the **gametophyte** generation is haploid and reproduces **asexually**, whereas the **sporophyte** generation is diploid and reproduces **sexually.**

2) Bryophyte leaves are haploid whereas true leaves of ferns are diploid.

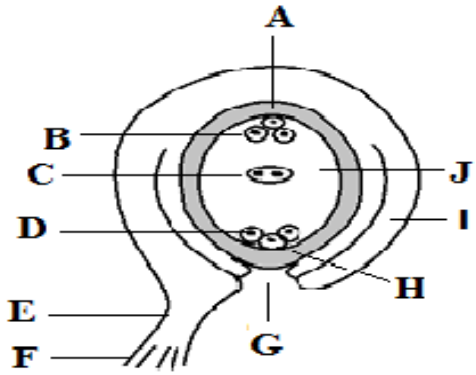
3) Gametophyte.

4) **Dioecious** plants are plants that have male flowers and female flowers on separate plants (e.g. papaya) whilst **monoecious** plants are plants that have both male and female flowers on the same plant (e.g. maize).

12.9.2 Consolidation activities

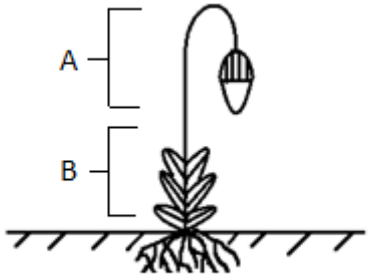
Why do many angiosperms produce less pollen than conifers?

Name all parts labeled on the diagram below:



1) What is parthenocarpy?

2) Study the diagram below and answer to the question



Funaria hygrometrica

a) Between A and B; which part is the gametophyte?

b) What name can you give to the remaining part A or B?

Answers for consolidated activities

1) Many angiosperms are insect-pollinated whereas most conifers are wind-pollinated.

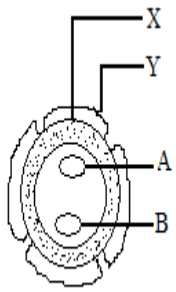
2) The answers are: A= nucellus; B= three antipodals, C= polar nuclei/ primary endosperm cell; D= two synergids; E= funicle; F= placenta; G= micropyle, H= egg cell/ ovum; I= integuments; J= embryo sac.

3) Parthenocarpy. It is when fruits mature without fertilization?

Answers are: a) A, b) sporophyte.

12.9.3 Extended activities

1) The diagram below represents a pollen grain.



Pollen grain

a) Names the parts labelled X, Y, A and B.

b) State any one function of the nucleus A and any one function of the nucleus B.

2) A flowering plant can avoid the self- fertilization by Protogyny or Protandry. Differentiate between Protogyny and Protandry.

3) With a diagram describe alternation of generations in a moss.

4) With a diagram describe alternation of generations in a fern.

Answers for extended activities

Answers are:

1) X= Intine; Y= exine; A= generative nucleus; B= pollen tube nucleus.

The **generative** nucleus divides to produce male gametes which fertilise the egg cell and polar nuclei, while the **tube** nucleus controls growth of pollen tube.

2) The answer is: **Protogyny**: it is when female reproductive organs mature before male reproductive organs, while **Protandry** is when male reproductive organs mature before female reproductive organs.

3) Expected answer is under the unit 17 (lesson one) in student book.

4) Expected answer is under the unit 17 (lesson one) in student book.

UNIT 13: PRINCIPLES OF GENE TECHNOLOGY

13

13.1 Key Unit Competency

Explain the principles of gene technology.

13.2 Prerequisite

Students will learn better the principles of gene technology if they have understanding on: concept of gene cloning and enzyme. Ask learners to describe those concepts.

Answer:

- Genetic engineering, also known as recombinant DNA technology or gene cloning is the alteration of the genes in a living organism to produce a genetically modified organism (GMO) with a new genotype.
- Enzyme is a protein that acts as a biocatalyst that speeds up the rate of a biochemical reaction.

13.3 Cross-cutting issues to be addressed

One of the cross-cutting issues that are to be addressed by this unit is peace and value education. This can be addressed when students will develop attitudes and values of appreciating technology without ignoring values and attitudes that promote beliefs and cultures.

13.4 Guidance on the introductory activity

Introduce this lesson by asking learners to attempt questions provided in introductory activity which is in student's book. This has to be done in the following way:

- Put students in groups and ask them to do the questions
- Ask them to present what they found
- Encourage or consider their findings and then introduce whole unit.

Expected answers for introductory activity

1) Explanations about Chargaff's rule:

a) Chargaff's rule states that DNA from any cell of all organisms should have a 1:1 ratio of pyrimidine and purine bases (base pair rule) and, more specifically, that the amount of guanine should be equal to cytosine and the amount of adenine should be equal to thymine. This pattern is found in both strands of the DNA. They were discovered by Austrian chemist Erwin Chargaff, in the late 1940.

b) Explanation of complementary base pairing:

- In DNA, Adenine (A) pairs with Thymine (T) by double hydrogen bonds and Cytosine (C) pairs with guanine (G) by triple hydrogen bonds
- In mRNA codons and t RNA anticodons bases paring during translation step of protein synthesis, Adenine(A) pairs with Uracil(U) by double hydrogen bond and Cytosine (C) pairs with guanine (G) by triple hydrogen bonds. This pairing is summarized in this table:

DNA:	RNA :
1. A=T	A=U
2. C =G	C =G

2) Gene expression is the activation or "turning on" of a DNA gene that results in transcription and the production of mRNA. Most of the mRNA produced in cells is translated into proteins.

2) The main action done to transform organic tomato into genetically modified organism(GMO), also called transgenic organism is the transfer of gene from one organism's DNA to another organism's DNA. After this transfer, that organism which has received a new gene becomes transgenic organism (genetically modified organism) and has new genotype. The offspring of the recipient can have the new phenotype that is different from that of natural organism; hence organic and GMO tomatoes are phenotypically different. Plasmids from bacteria such as *Agrobacterium tumefaciens* and Agrobacterium rhizogenesare mostly used in gene transfer in plants.

13.5 List of lessons/sub-heading

	Lesson title	Objectives	Number of period
1	Recombinant DNA and enzymes involved in genetic engineering	Define the term recombinant DNA. Explain the roles of restriction endonucleases, reverse transcriptase and ligases in genetic engineering.	3 periods
2	Properties of plasmid and gene manipulation.	Describe the properties of plasmids that allow them to be used in gene cloning.	2 periods
3	Transfer of genes from one organism to another	Explain that genetic engineering involves the extraction of genes from one organism or the synthesis of genes, in order to place them in another organism (of the same or another species) such that the receiving organism expresses the gene product. Explain the use of genes in fluorescent or easily stained substances as markers in gene technology. Interpret illustrations of the isolation and transfer of genes using plasmids in transgenic organisms (bacteria, plant or an animal). Sequence the processes involved in the extraction and transfer of genes from one organism to another. Appreciate that the easy transfer of some plasmids from one species of bacteria to another may carry genes for antibiotic resistance.	3 periods
4	Non-biological methods of gene transfer.	Acknowledge that advances in genetic engineering have enabled manipulation of genes to our advantage.	3 periods

5	Principles of Polymerase Chain Reaction in cloning and amplifying DNA.	Describe the principles of the Polymerase Chain Reaction (PCR) to clone and amplify DNA (the role of Taq polymerase should be emphasized). Interpret charts of the Polymerase Chain Reaction (PCR). Relate the mechanism of DNA replication to PCR and the amount of DNA produced in a given period of time.	3periods
6	Gel electrophoresis.	Describe and explain how gel electrophoresis is used to analyse proteins and nucleic acids, and to distinguish between the alleles of a gene (limited to the separation of polypeptides and the separation of DNA fragments cut with restriction endonucleases)	2periods
7	Use of microarrays in the analysis of genomes and in detecting mRNA.	Explain and outline how microarrays are used in the analysis of genomes and in detecting mRNA in studies of gene expression.	2 periods
8	Assessment standard	Explain the principles of gene technology	3 periods

Lesson 1: Recombinant DNA enzymes involved in genetic engineering

This is the first lesson of unit 1. It has three periods (120 Minutes). The first lesson also covers the introduction of the whole unit.

a) Prerequisites/Revision/Introduction:

Learners will learn better the recombinant DNA and gene manipulation, if they have understanding on the concept of DNA and gene. Ask learners to explain orally those concepts.

b) Teaching resources

Students' book, library books and internet.

c) Learning activity 13.1

As a facilitator, you are expected to do the following:

- Form groups of 3 to 6 learners depending on their performance results and class size.
- Ask them to do the activity 13.1.
- Move around groups guiding and facilitating them.
- Select some groups (1 or 2) to share their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart.
- Ask other groups to add any ideas on what other groups have presented if they have them.
- Allow the class to ask questions related to the presented findings.
- At the end of the lesson development, write the summary on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson by letting students attempt self- assessment 13.1.

Answer for Activity 13.1

1) The following are the answers:

a) A recombinant DNA is the DNA that contains genes from more than one source.

b) Transgenic organisms are organisms having foreign gene inserted into them.

c) Enzyme is a protein that acts as biocatalyst which speed up the rate of biochemical reaction

2) The gene is inserted into a vector which delivers the gene to the cells of the organism. Examples of vectors are plasmids, viruses and liposomes.

Answers for self –assessment 13.1

1) The following are the answers:

- DNA: Deoxyribonucleic acid
- GMO: Genetically Modified Organism
- RNA: Ribonucleic acid

2) The nomenclature of the enzyme EcoRI:

- E represents the genus Escherichia
- corepresents the species coli
- R represents the strain
- I mean that it was the first endonuclease isolated from this strain

3) Sticky ends are fragment end of a DNA molecule with short single stranded overhangs, resulting from cleavage by a restriction enzyme, while blunt ends are fragment ends of a DNA molecule that are fully base -paired, resulting from cleavage by a restriction enzyme.

4) T4 DNA ligase is an enzyme that originated from the T4 bacteriophage and which is used to join together DNA blunt or sticky ends.

Lesson 2 :Properties of plasmids and gene manipulation

a) Prerequisites/Revision/Introduction

As a facilitator, ask students to describe orally the general role of enzyme and to define a plasmid in order to test those prerequisites.

b) Teaching resources

Illustrations, students' book, drawing on manila paper / flipchart.

c) Learning activity 13.2

Facilitate the learning by:

- Ask the formed groups to do the activity 13.2.
- Pass around groups guiding and facilitating them.
- Identify 2 groups to present their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart.
- Ask other groups to add any ideas on what other groups have presented if they have them.
- Enable the class to ask questions related to the presented findings.
- Assess the lesson by letting students attempt self- assessment13.2. Students can do this exercise either in the course of this lesson if there is still time or as home work. Make sure you mark the students' homework. Each student must do individually this self- assessment.

Answers for activity 13.2

1) The properties of plasmids are

- It is big enough to hold the desired gene.
- It is circular (or more accurately a closed loop), so that it is less likely to be broken down.
- It contains control sequences, such as a transcription promoter, so that the gene will be replicated or expressed.
- It contains marker genes, so that cells containing the vector can be identified.

2) The vectors are used, in genetic engineering, to transfer the gene of DNA from one organism to another.

3) The main steps of gene manipulation are:

- Generation of DNA fragments using restriction endonucleases:
- Construction of a recombinant DNA molecule
- Introduction into a host cell
- Selection

Answers for self-assessment 13.2

1) The vectors are:

- Plasmids
- viruses
- liposomes

2) The genetic engineering tool kit consisting of: enzymes, vectors, genes.

3) This is the answer:

- A genome is the complete set of genes or genetic material present in an organism.
- While genes are pieces of DNA, carrier of the genetic information which determines all the characteristics of an individual such as eye colour, size, ability to resist disease, etc.

4) The second main step of gene manipulation is the construction of a recombinant DNA molecule: The target gene fragment is legated to a DNA vector (plasmids are one example) and is now recombinant DNA. The enzyme called DNA ligase is involved in this step and links that gene fragment to cleaved plasmid.

Lesson 3 :Transfer of genes from one organism to another

a) Prerequisites/Revision/Introduction:

Students will learn better the transfer of genes from one organism to another, if they have prior knowledge and skills about genetically modified organisms (GMO).

b) Teaching resources

Illustrations, students' book and drawings on a manila paper.

c) Learning activity 13.3

For helping learners learn well, do the following:

- Indicate the location of activity 13.3 to learners.
- Deliver the teaching resources to learners.
- Move around groups guiding and facilitating them.
- Select 2 groups to write their findings on the chalkboard for the activity 13.3.
- Enable learners to ask questions related to the presented findings.
- Write the lesson summary on the blackboard and give to learners the time for noting it.
- Assess the lesson by asking learners to respond individually to self-assessment 13.3.

Answer for activity 13.3

1) A pathogenic bacterium is a bacterium that can cause a disease.

2) A genetic marker is a gene or DNA sequence with a known location on a chromosome that can be used to identify individuals or species. Genetic markers used can be any identifiable site within the genome (locus), where the DNA sequence is variable (polymorphic between individuals). The most common genetic markers used for linkage analysis are microsatellite markers comprising short lengths of DNA consisting of repeats of a specific sequence (e.g. CAn). The number of repeats varies between individuals, thus providing

polymorphic markers that can be used in genetic analysis to follow the transmission of a chromosomal region from one generation to the next.

3) The following is the answer:

- Transformation is uptake and incorporation of external DNA into the cell thereby resulting in the alteration of the genome.
- While transduction is the transmission of a segment of bacterial DNA from one bacterial cell to another by a bacteriophage. Bacteriophage infects a bacterial cell and takes up bacterial DNA. When this phage infects another cell, it transfers the bacterial DNA to the new cell. The bacteria can then become a part of the new host cell.

4) The steps of formation of a transgenic plant:

- The agro bacterium cell contains a bacterial chromosome and a Tumor inducing plasmid (Ti Plasmid).
- The Ti plasmid is removed from the agrobacterium cell and a restriction enzyme cleaves the T-DNA restriction site. The transfer DNA (T-DNA) is the transferred DNA of the tumor-inducing plasmid of some species of bacteria such as *Agrobacterium tumefaciens*
- The T-DNA is transferred from bacterium into the host plant's nuclear DNA genome.
- Next foreign DNA, which is also cleaved by the same enzyme, is inserted into the T -DNA at the site that was cleavage site.
- The modified plasmid is then reinserted in the *agrobacterium* and the bacterium inserts the T-DNA, which now carries a foreign gene into the plant cell.
- The plant cell is then cultured and results in a new plant that has the foreign DNA trait.

5) The drawing and interpretation of gene transfer are shown in the student's book under the heading 13.3.1.

6) The diagrams showing how a transgenic plant and a clone are produced are illustrated in the student's book under the heading 13.3.2.

Answers of self-assessment 13.3

1) *Agrobacterium* tumefaciens

2) Biotechnologists transfer the DNA of the donor sheep's somatic cell into an egg cell, or oocyte, that has had its own DNA-containing nucleus removed. For example, the cell used as the donor for the cloning of Dolly sheep was taken from

a mammary gland and the production of a healthy clone therefore proved that a cell taken from a specific part of the body could recreate a whole individual sheep.

3) Transformation and conjugation contribute to increasing frequencies of antibiotic resistant genes because of genes transferring between different species.

4) The biotechnologists might transform harmless bacteria to pathogenic forms in the course of their studies by transferring genes from pathogenic bacteria to harmless bacteria.

Lesson 4 : Non-biological methods of gene transfer.

a) Prerequisites/Revision/Introduction

To study better this lesson, learners must remember the meaning of gene transfer from one organism to another.

b) Teaching resources

Textbooks and drawings

c) Learning activity 13.4

As a facilitator, suspend, in front of learners, the manila paper on which you have drawn some non-biological methods of gene transfer.

- Ask each learner's group to do the activity 13.4.
- Ask learners to present what they have done.
- Enable other classmates to ask questions to those who presented; if they are not able to respond properly, clarify the answers.
- Help learners to summarize the lesson through questions.
- Finally, assess the lesson by letting learners do the self –assessment 13.4.

Answer for activity 13.4

1) Non- biological methods of gene transfer include genetic transformation, shock wave-mediated genetic transformation, Electroporation, Biolistic, Vacuum infiltration, Silicon carbide whisker and Laser microbeams.

2) In biolistic method, high density carrier particles covered with genes are accelerated through the cells leaving the DNA inside by an adsorption mechanism.

3) The disadvantages of vacuum infiltration methods:

- Some strains of Agrobacterium are unable to infect certain cell types
- There is risk of multiple copies of the introduced genes.

Answer for self-assessment 13.4

1) From the figure,

a) A: Holding pipette, B: DNA solution

b) The process of using a fine glass micropipette to manually inject transgene at microscopic or borderline macroscopic level is known as microinjection. The transgene, in the form of plasmids, cosmids, phage or PCR products, can be circular or linear and need not be physically linked for injection. Microinjection involves direct mechanical introduction of DNA into the nucleus or cytoplasm using a glass microcapillary injection pipette.

2) Difference between ultrasound and shock waves technique are:

a) Ultrasound technique involves intensity, exposure time, central frequency, type of application (continuous or pulsed), pulse repetition frequency, and duty cycle.

b) While shock waves technique involves frequency, energy, voltage, shock wave profile and number of shock waves.

Lesson 5: Principles of Polymerase Chain Reaction in cloning and amplifying DNA.

a) Prerequisites/Revision/Introduction

The prior knowledge that learners must have is about gene cloning and DNA amplification.

b) Teaching resources

Drawing of PCR technique, textbooks and internet

c) Learning activity 13.5

Facilitate the learners to do the activity by:

- Hang the manila paper on which you have drawn the PCR process in front of learners
- Guide and facilitate them.

- Choose some groups to present.
- Ask other groups to add information which is different from what presented and ask questions.
- Help learners to summarize the lesson through questions.
- At the lesson end, assess learners with self-assessment 13.5 or formulate your own assessment questions that must be answered by each learner.

Answer for activity 13.5

1) The types of artificial DNA include:

   a) Recombinant DNA technology

   b) PCR

   c) Gene purification

2) The main steps of PCR:

   a) Step 1: denaturation.

   b) Step 2: annealing.

   c) Step 3: extension or elongation of primers.

3) The enzyme (Taq polymerase) used in PCR is derived from the thermophilic bacterium Thermus aquaticus, which grows naturally in hot springs at a temperature of 90°C, so it is not denatured by the high temperatures.

Answer for self – assessment 13.5

1) Artificial DNA synthesis, sometimes known as DNA printing is a method in synthetic biology that is used to create artificial genes in the laboratory.

2) The difference between PCR and DNA replication:

- Normally, in vivo where DNA replication occurs, the DNA double helix would be separated by the enzymes DNA gyrase and DNA helicase, but in PCR (in vitro) the strands are separated by heating to 95°C for two minutes. This breaks the hydrogen bonds.
- DNA polymerization always requires short lengths of DNA (about 20 bases pair long) called primers, to get it started. In vivo the primers are made during replication by DNA polymerase, but in vitro they must be synthesized separately and added at this stage.

Lesson 6 :Gel electrophoresis

a) Prerequisites/Revision/Introduction

To understand this lesson, learners must have prior knowledge about attraction of different charges. Ask probing questions like "explain what happen when 2 differently charged objects are closer to one another «and relate your explanation to gel electrophoresis.

b) Teaching resources

Textbooks and diagramme of gel electrophoresis technique on the manila paper.

c) Learning activity 13.6

Involve learners in the description of gel electrophoresis technique by:

- Showing to learners the location of the activity 13.6.
- Asking learners to join their respective groups and do that activity.
- Selecting the 3 groups which present the answers to the whole class.
- If there are some methods which are not mentioned by presenters, ask other groups to add them.
- Permitting learners to ask questions to presenters and intervene if they are not able to respond accurately.
- Summarizing the lesson and let learner to write the summary in their notebooks.
- Finally, assess the lesson objective by using the questions mentioned in the self –assessment 13.6 or formulate other questions that individual learner does have a habit of giving homework at the end of every lesson and mark it. This homework can come from the self –assessment and end unit assessment seen in student's book or from other book.

Answer for Activity 13.6

1) Gel electrophoresis is a laboratory technique used to separate mixtures of DNA, RNA or proteins according to molecular size.

2) The steps involved in gel electrophoresis:

a) The DNA samples are cut with a restriction enzyme into smaller segments of various sizes. The DNA is then placed in wells made on a thick gel.

b) An electric current runs through the gel for a given period of time. Negatively charged DNA fragments migrate toward the positively charged end of the porous gel. Smaller DNA fragments migrate faster and farther than longer fragments, and this separates the fragments by size. The gel floats in a buffer solution within a chamber between two electrodes.

c) The DNA is transferred to a nylon membrane and radioactive probes are added. The probes bind to complementary DNA.

d) The X-ray film is exposed to the radio labelled membrane. The resulting pattern of bands is called a DNA fingerprint.

Answer for self – assessment 13.6.

1) The gel electrophoresis is used in:

a) DNA analysis

b) Protein and antibody interactions

c) Testing antibiotics

d) Testing vaccines.

2) The DNA samples are cut with a restriction enzyme into smaller segments of various sizes. The DNA is then placed in wells made on a thick gel.

3) The most commonly used stain is ethidium bromide. Ethidium bromide is a flat molecule that fluoresces under ultraviolet (UV) light and is able to insert itself among the rungs of the ladder of DNA. When the gel is subjected to UV light, the bands of DNA are visualized because the ethidium bromide is inserted among the nucleotides.

Lesson 7: Use of microarrays in the analysis of genomes and in detecting mRNA

a) Prerequisites/Revision/Introduction

The prior knowledge that learners must have is about the genome, gene, protein synthesis and reverse transcriptase. Ask them to describe briefly those concepts.

b) Teaching resources

Drawing of microarray experiment on a manila paper and student's book.

c) Learning activity 13.7

Help learners to describe the microarray technique from:

- Hanged manila paper on which you have drawn the process of microarray experiment in front of learners
- Observing the process of microarray experiment.
- Enabling learners to ask for clarification from what the groups have presented and explain what the groups have not highlighted.
- Write the lesson summary on the blackboard and request learners to note the summary.
- At the end, assess learners with self-assessment 13.7 or formulate your own assessment questions that must be answered by each learner.

Answer for Activity 13.7

1) DNA microarray, also commonly known as RNA chip or gene chip or biochip, is technique consisting of a two-dimensional arrangement of DNA molecules representing thousands of cloned genes on a solid surface such as a microscopic slide.

2) The main steps of microarray process:

a) Isolate and purify mRNA from samples of interest.

b) Reverse transcribe and label the mRNA.

c) Hybridize the labelled target to the microarray.

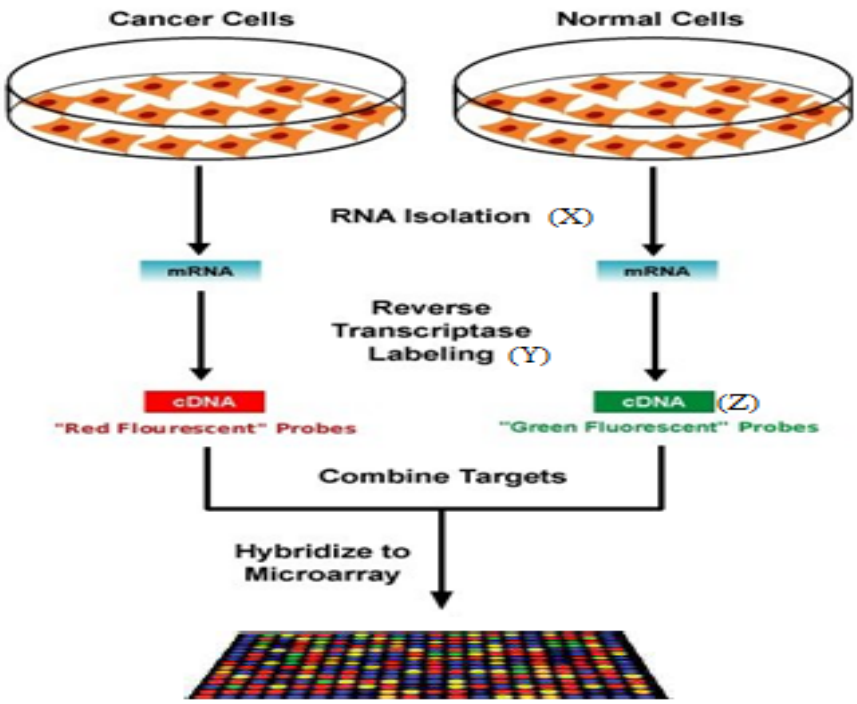
d) Scan the microarray and quantitate the signal.

Answer for self – assessment 13.7

1) The reverse transcriptase is used in synthesizing the cDNA from RNA

2) In molecular biology, a hybridization probe is a fragment of DNA or RNA of variable length (usually 100–1000 bases long) which can be radioactively labelled. It can then be used in DNA or RNA samples to detect the presence of nucleotide sequences (the DNA target) that are complementary to the sequence in the probe.

a) The microarray experiment involving the nucleic acids from normal cell and cancer cell:



b) The aim of this experiment is to investigate how cancer cell differ from normal cell. In this experiment, mRNA from the cancer cell is labelled with fluorescent dyes and poured onto the microarray slides. The more mRNA that binds to its complement at a particular spot on the slide, the brighter the colour, indicating that this specific gene is highly active. Physicians use DNA microarray analysis to classify patients' cancers. Such classification can lead to better-informed decisions about which type of treatment is best.

13.6 Summary of the unit

This unit focuses on recombinant DNA, enzymes involved in genetic engineering, gene manipulation, gene transfer, PCR, gel electrophoresis and microarray. The first lesson deals with recombinant DNA containing genes from different sources and enzymes involved in genetic engineering such as restriction endonucleases, DNA ligase, reverse transcriptase and DNA polymerase. The second lesson emphasizes on plasmids properties and gene manipulation in which genes can be taken from one organism to another. The third lesson describes how transgenic organisms are formed via gene transfer. The fourth is about the non-biological methods of gene transfer including genetic transformation, shock wave-mediated genetic transformation, electroporation, biolistic, vacuum infiltration, silicon carbide whisker and laser micro beams. The fifth lesson shows how PCR enables the production of millions of copies of a particular piece of DNA. The sixth lesson deals with gel electrophoresis used to separate mixtures

of DNA, RNA or proteins according to molecular size. The seventh lesson explains the DNA microarray as a technique consisting of a two-dimensional arrangement of DNA molecules representing thousands of cloned genes on a solid surface.

13.7 Additional information

The four main genetic engineering or gene technology applications are: application in agriculture, application to medicine for criminal identification and medical drugs synthesis, application to energy production, application to industries. Those applications are described in detail in unit 14.

13.8 Answers for end unit assessment 13

1) The correct answers are:

(i) d

(ii) b

(iii) d

2) Advantages of using plasmids as vectors:

a) They exist naturally in bacteria, which are able to take them up from their surroundings.

b) They are small so that they are easy to use.

c) They can be produced artificially by combining lengths of DNA from

d) different sources.

e) They are double stranded so genes from prokaryotes and from eukaryotes can be inserted into them.

They replicate independently within bacteria to clone any genes that are inserted into them.

f) They can be transferred between different bacterial species.

3) The following are the answers:

a) Gene probes from all of the genes in the human genome can be placed on a microarray. The mRNA from the cytoplasm of a cell is isolated and converted into single stranded DNA using reverse transcriptase that uses DNA nucleotides that have fluorescent tags. The quantity of this DNA can be increased by PCR. Single stranded cDNA is then applied to the microarray. The cDNA hybridizes with the appropriate gene probes on the microarray and these are detected

when the microarray is scanned. Spots that fluoresce indicate the active genes that have been transcribed to produce the mRNA that was isolated from the cytoplasm.

b) Mature red blood cells have no nucleus so transcription does not occur. However, there may still be some mRNA left in the cytoplasm especially if the red blood cell has only just left the bone marrow where it was produced from stem cells. Most of this mRNA will be for the α and β globin polypeptides for making haemoglobin molecules.

4) The following are the answers:

a) 256 molecules of DNA

b) There is no enzyme that will use an RNA template to make double stranded RNA. Instead, reverse transcriptase uses an RNA template to make single stranded DNA. This DNA can then be replicated using DNA polymerase and this can be used in PCR. In this way, multiple copies of cDNA can be made which hold the information in the original mRNA.

5) Answers are given by a table

Technique of using	Purpose
Restriction enzymes	To cut DNA at specific points, making small fragments.
DNA ligase	To join DNA fragment together
Vectors such as plasmids	To carry DNA into cells and ensure replication
Genetic markers	To identify cells that have been transformed
PCR	To amplify very small samples of DNA
Reverse transcriptase	To make a DNA copy of mRNA
DNA probes	To identify and label a piece of DNA containing a certain sequence
Gene synthesis	To make a gene from scratch
Electrophoresis	To separate fragments of DNA
DNA sequencing	To read the base sequence of a length of DNA

13.9 Additional Activities

13.9.1 Remedial activities

Questions	Answers
Identify the main action done in forming a transgenic organism.	The main action done in forming a transgenic organism is the alteration of the genes in a living organism.
Describe briefly the recognition site	Recognition site is a specific sequence within double-stranded DNA, usually palindromic and consisting of four to eight nucleotides, that a restriction endonuclease recognizes and cleaves.
Explain any 3 advantages of gene transfer form one organism to another.	Some advantages of gene transfer: a) It allows for a faster growth rate: Gene transfer allows of plants or animals to be modified so their maturity can occur at a quicker pace. Engineering can allow this maturity to occur outside of the normal growth conditions that are favourable without genetic changes as well. Even if there is a higher level of heat or lower levels of light, it becomes possible to expand what can be grown in those conditions. b) It can create an extended life: Genetic modification can help to create resistance to common forms of organism death. Pest resistance can be included into the genetic profiles of plants so they can mature as a crop without any further additives. Animals can have their genetic profiles modified to reduce the risks of common health concerns that may affect the breed or species. This creates the potential for an extended lifespan for each organism.

	c) Specific traits can be developed: Plants and animals can have specific traits developed through genetic engineering that can make them more attractive to use or consumption. Different colours can be created to produce a wider range of produce. Animals can be modified to produce more milk, grow more muscle tissue, or produce different coats so that a wider range of fabrics can be created. d) New products can be created: With genetic engineering, new products can be created by adding or combining different profiles together. One example of this is to take a specific product, such as a potato, and alter its profile so that it can produce more nutrients per kcal than without the genetic engineering. This makes it possible for more people to get what they need nutritionally, even if their food access is limited, and this could potentially reduce global food insecurity. e) Greater yields can be produced: Genetic engineering can also change the traits of plants or animals so that they produce greater yields per plant. More fruits can be produced per tree, which creates a greater food supply and more profits for a farmer. It also creates the potential for using modified organisms in multiple ways because there is a greater yield available. Modified corn, for example, can be used for specific purposes, such as animal feed, ethanol, or larger cobs for human consumption.

	f) Risks to the local water supply are reduced: Because farmers and growers do not need to apply as many pesticides or herbicides to their croplands due to genetic engineering, fewer applications to the soil need to occur. This protects the local watershed and reduces the risk of an adverse event occurring without risking the yield and profitability that is needed.

Summarize the main steps of biolistic	The main steps of biolistic: a) Isolation of protoplasts. b) Injection of DNA-coated particles using particle gun. c) Regeneration of transformed protoplasts into plantlets. d) Acclimatization of regenerated plantlets in a greenhouse.
Explain why Taq polymerase is used in PCR instead of using DNA polymerase	Taq polymerase is used because it is not denatured by the high temperatures (720C) in step 2 of PCR while DNA polymerase should be denatured and could not catalyse.
Describe briefly the DNA fingerprint.	The DNA fingerprint (also called DNA typing, DNA profiling, genetic fingerprinting, genotyping or identity testing) is a technique used especially for identification (as for forensic purposes) by extracting and identifying the base-pair pattern in an individual's DNA.
Relate the fluorescence with the expression of active gene during the microarray experiment.	The spots that fluoresce, in microarray; indicate the active genes that have been transcribed to produce the mRNA that was isolated from the cytoplasm.

13.9.2 Consolidation activities

1) Enumerate the main tools included in genetic engineering kit.

2) The table shows enzymes that are used in gene technology. Copy and complete the table to show the role of each enzyme.

3) Identify any 2 species of bacterium that are involved in formation of transgenic plant and explain their role.

5) Show the advantages of micro projectile technique.

4) Explain why it is important to heat up to 94°C in the first step of PCR

6) Suggest the applications of gel electrophoresis

7) Explain the role of hybridization probe in a microarray

Answers

1) The main tools included in genetic engineering kit are:

- Enzymes, such as restriction endonucleases (restriction enzymes), ligase and reverse transcriptase
- Vectors, including plasmids and viruses
- Genes coding for easily identifiable substances that can be used as markers.

2) The following is the answer:

DNA ligase	Joining gaps in sugar–phosphate chains of DNA
DNA polymerase	Replicates DNA
Restriction enzymes	Cut DNA at specific sites
Reverse transcriptase	Make cDNA from mRNA

Answers:

3) The species involved in formation of transgenic plant are:

- Agrobacterium tumefaciens
- Agrobacterium rhizogenes

They use their plasmids to transduce their genetic material to plants which become transgenic plants.

4) The advantages of micro projectile technique:

It is simple.

There is no need to treat the cell wall.

It allows transformation of different cells.

It is independent of the physiological properties of the cell.

It allows the use of multiple transgenes.

5) It is important to heat up to 94°C in the first step of PCR in order to separate the DNA strands by breaking the hydrogen bases between the complementary bases pairs.

6) The gel electrophoresis is used for different purposes such as DNA analysis, protein and antibody interactions, testing antibiotics and testing vaccines.

7) A hybridization probe is a fragment of DNA or RNA of variable length (usually 100–1000 bases long) which can be radioactively labeled. It can then be used in DNA or RNA samples to detect the presence of nucleotide sequences (the DNA target) that are complementary to the sequence in the probe.

13.9.3Extended activities

1) Answer the following questions:

- a) Draw the structure of Ti plasmid that can be used in genetic engineering
- b) Describe briefly the use of that plasmid.

2) Explain the importance of methylases

3) *Escherichia coli* can be used in genetic engineering in the production of insulin. Describe the importance of this insulin

4) Outline the non- biological methods of gene transfer from one organism to another.

5) Assess the importance of PCR

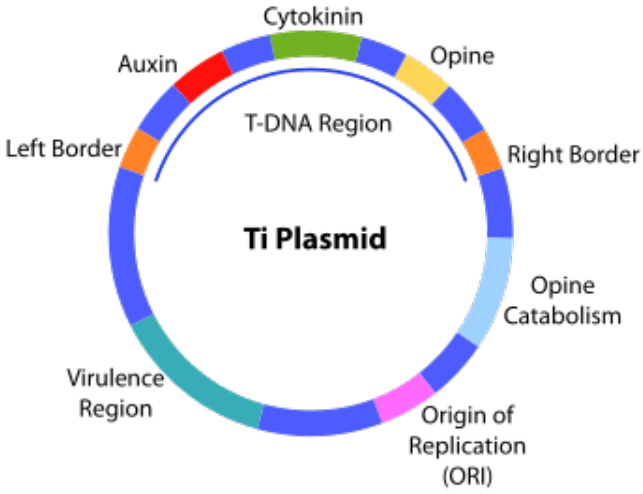
6) Draw and describe a diagram showing how DNA fragments are arranged during the gel electrophoresis

7) Describe the gene probes and 2 ways in which gene probes of microarray are used.

Answers

1) The following are the answers:

a) Sub question a



The structure of the tumor –inducing plasmid.

b) A Ti or tumour inducing plasmid is a plasmid that often, but not always, is a part of the genetic equipment that Agrobacterium tumefaciens and Agrobacterium rhizogenes use to transduce their genetic material to plants.

2) Methylases allow the molecular biologist to protect a gene fragment from being cleaved in an undesired location.

3) This insulin is given to some diabetic people and decreases the blood glucose level to normal level.

4) The non- biological methods of gene transfer from one organism to another are genetic transformation, shock wave-mediated, electroporation, biolistic, vacuum infiltration, silicon carbide whisker, laser microbeams and microinjection

5) The Polymerase Chain Reaction (PCR) is an important tool for many applications. For example, it can be used:

- To amplify a sample of DNA when there is not enough DNA to analyze (e.g. a sample of DNA from a crime scene, archeological samples),
- As a method of identifying a gene of interest,
- To test for disease.

6) The following is the figure:

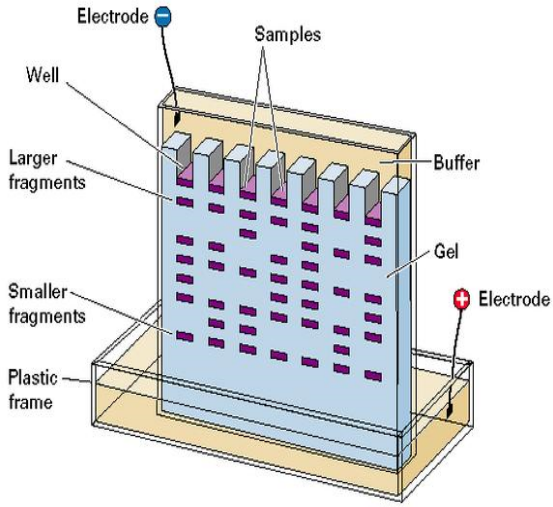


Figure: Drawing showing how DNA fragments are arranged during the gel electrophoresis. Smaller fragments are placed at the bottom while larger fragments are located on upper side.

7) Description of gene probe is given below:

a) A gene probe is a length of single-stranded DNA, which has a known base sequence and is used to hybridize with lengths of DNA which have the complementary sequence; probes are labelled in some way to make them 'visible' (e.g. with radioactive phosphorus). PCR and gene probes are used in forensic investigations to look for matches between the DNA left at crime scenes and the DNA of suspects.

b) Microarrays contain many thousands of gene probes and are used in two ways:

- To analyze the presence or absence of genes in different genomes.
- To detect the presence of mRNA from cells to detect the genes that is being expressed at any one time.

UNIT 14: APPLICATIONS OF GENE TECHNOLOGY

14

14.1 Key Unit Competence

Evaluate how gene technology is applied in areas of medicine, forensic science and agriculture.

14.2 Prerequisites /Introduction/Revision

Students will learn better **Applications of gene technology** if they know better Principles of gene technology seen in unit 13. They must be able to explain the principles of gene technology. The teacher can introduce the lesson by asking learners why there is different varieties of organisms belonging in the same species.

14.3 Cross-cutting issues to be addressed

The cross-cutting issues that will be addressed by this unit include environment and sustainability, and inclusive education.

Environment and sustainability

As a facilitator, emphasizes that environment must be sustainably protected.This emphasis could be done when you facilitate students to relate this lesson to environment and sustainability. For effective facilitation, you can ask questions about the effect of genetically modified crops on the environment. From this question, students will think about relationship between environment and gene application in agriculture so that they will take positive side to environment protection for the sustainability of all livings.

Inclusive education

The issue of inclusive education will be addressed through activities that will be conducted. As a facilitator, place learners with visual and hearing impairment in appropriate places. Those who look only nearby object must sit on front desks in class. If you have children with low vision, remember to print in appropriate font size (large print). Those who look only far object must sit on the back desks. This has to be done during video watching, in this case also there must be loud speakers when watching video to facilitate those with visual and hearing impairment.

Parents whose children have hearing impairment can be visited or invited and learn from them how they do communicate with their children. The braille materials and other tactile materials should be provided to blind students.

14.4 Guidance on the introductory activity

Before starting the first lesson of this unit (Applications of gene technology), as a facilitator, request learners to do introductory activity question given in student textbook by observing the figures provided:

- In pair learners, answer to the question asked in the introductory activity.
- Each pair records the answers.
- Choose randomly any 2 students to write their answers on the chalkboard or flipchart.
- Ask other members of the class if they have something to add on what is written on the chalkboard or flipchart.

Based on their answers, introduce a whole unit and then move to the first lesson of the unit.

Expected answers of the introductory activity.

1) That organisms present differences as result of modifying there genes which affect there phenotype and also can influence their productivity and resistance to diseases.In other words those differences are possible as result of gene technology.

2) The benefits of having different varieties of organisms of the same spiecies are:

- Having varieties with enhanced nutritive values.
- Having varieties which can grow inshort period of time.
- Having varieties that yield higher qualitiy and quantity production.
- Having varietes that have resistance to insect,weed,salinity.

14.5 List of lessons/sub-heading

	Lesson title	Learning objectives	Number of periods
1	Lesson 1. Bioinformatics.	Define the term bioinformatics. Outline the role of bioinformatics following the sequencing of genomes, such as those of humans and parasites, e.g. Plasmodium (Details of the methods of DNA sequencing are not required).	2
2	Lesson 2. Production of human proteins by recombinant DNA technology	Explain the advantages of producing human proteins by recombinant DNA techniques. (Reference should be made to some suitable examples, such as insulin, factor VIII for the treatment of haemophilia and adenosine deaminase for treating severe combined immunodeficiency (SCID)). Interpret a chart on the stages involved in the production of insulin by bacteria	2

3	Lesson 3. Genetic technology applied to medicine and forensic science.	Outline the advantages of screening for genetic conditions. (Reference may be made to tests for specific genes such as those for breast cancer, BRCA1 and BRCA2, and genes for haemophilia, sickle cell anaemia, Huntington's disease and cystic fibrosis). Outline how genetic diseases can be treated with gene therapy and discuss the challenges in choosing appropriate vectors, such as: viruses, liposomes and naked DNA, (Reference may be made to SCID, inherited eye diseases and cystic fibrosis). Appreciate the application of gene technology in medicine, and forensic science such as the detection of crimes e.g. rape, murder, and paternity disputes.	3
4	Lesson 4: Significance of genetic engineering in improving the quality and yield of crop plants and livestock	Explain the significance of genetic engineering in improving the quality and yield of crop plants and livestock in solving the demand for food in the world e.g. Bt maize, vitamin A enhanced rice (Golden rice TM) and GM salmon. Outline the way in which the production of crops such as maize, cotton, tobacco and rape seed oil may be increased by using varieties that are genetically modified for herbicide resistance and insect resistance. Analyse the application of gene technology in agricultural modernization. Appreciate the application of gene technology in agriculture through the improvement of crop varieties and animal.	3

5	Lesson 5. Ethical and social implications of using genetically modified organisms (GMOs) in food	Explain the ethical and social implications of using genetically modified organisms (GMOs) in food production. Research the benefits, hazards and implications of gene technology.	2
6	Assessment standard	To be able to evaluate how gene technology is applied in the areas of medicine, forensic science and agriculture	2

Lesson 1: Bioinformatics

a) Prerequisites/Revision/Introduction

Ask some questions to check students' understanding. The questions should focus on principle of gene technology.

b) Teaching resources

- Projector
- Student books and other books from library, pictures

c) Learning activity 14.1

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

- Form group of 3 to 4 learners depending on the class size.
- Facilitate the learners in the flow of the activity.
- Select some groups (1 or 2) to share their answers to the whole class by requesting the group representative to write them on the chalkboard or flipchart. In this practice, ask learners of both sexes to present their ideas
- Ask some questions to the remaining groups 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 activity 14.1

- Bioinformatics helps to hold information on the primary sequences of proteins and the functions of many proteins, such as enzymes.
- Bioinformatics helps in comparing primary biological sequence information, such as the primary sequences of different proteins or the nucleotide sequences of genes.
- All the information about the genome of Plasmodium are available in databases. This information is being used to find new methods to control the parasite. For example, being able to read gene sequences is providing valuable information in the development of vaccines for malaria

Answers for self-assessment 14.1

1) Bioinformatics is the collecting, processing and analysis of biological information and data using computer software.

2) The information available about the genome of Plasmodium is being used to find new methods to control the parasite. For example, being able to read gene sequences is providing valuable information in the development of vaccines for malaria.

Lesson 2: Production of human proteins by recombinant DNA technology

a) Prerequisites/Revision/Introduction:

You should start this lesson by asking questions on the previous lesson and revise shortly the previous lesson about 'recombinant DNA' from unit 13

b) Teaching resources

- Student textbooks, internet, pictures
- Projector.

c) Learning activity 14.2

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

- Ask student or students in groups to do activity questions 14.2 which is in their textbook or write it on chalkboard
- Facilitate the learners in this activity by moving in each group.
- Let learners do present their findings

- Ask some questions to check whether they agree with the findings from their colleagues
- Harmonize and conclude the lesson through questions and also by welcoming questions

Answers for activity 14.2

1) The figure represents the Production of human proteins by recombinant DNA technology.

2) A: Isolation of the gene of interest (donor DNA) for human growth hormone from the cell.

B: Restriction enzyme function as scissors for cutting the DNA molecules both donor in order to make DNA fragment with sticky ends

C: Isolation of plasmid from bacterial cell.

D: Restriction enzyme function as scissors for cutting the DNA molecules of plasmid in order to make DNA fragment with sticky ends.

E: Ligase enzyme is the joining enzyme that joins the vector DNA with the gene of interest. This will produce the recombinant DNA.

F: Recombinant DNA '(rDNA)' molecules are introduced into bacterial host cells, where it starts to produce human growth hormone.

Answers for self-assessment 14.2

1) Below are steps involved in production of human protein (With reference: Human insulin production)

- Extraction of mRNA for insulin from pancreatic β cells, which are the only cells to express the insulin gene.
- The mRNA was then incubated with the enzyme reverse transcriptase which comes from the group of viruses called retroviruses. As its name suggests, this enzyme reverses transcription, using mRNA as a template to make single-stranded DNA.
- These single-stranded DNA molecules were then converted to double-stranded DNA molecules using DNA polymerase to assemble nucleotides to make the complementary strand.
- The genetic engineers now had insulin genes that they could insert into plasmids to transform the bacterium Escherichia coli.

– When the bacterial cells copy their own DNA, they also copy the plasmids and the donor genes that plasmids carry. After the cells have grown into colonies, on an industrial scale in large fermenters insulin is extracted from the bacteria.

2) These are advantages of using human proteins produced from recombinant DNA:

– There is reliable supply available for increasing demand.

– Human proteins produced from recombinant DNA are not dependent on factors e.g.: meat trade.

– Human proteins produced from recombinant DNA act faster than animal insulin or slower over a long period of time.

Lesson 3: Genetic technology applied to medicine and forensic science

a) Prerequisites/Revision/Introduction:

Introduce the lesson by asking learners to brainstorm what they remember about gel electrophoresis discussed in unit 13.

b) Teaching resources

– Charts illustrating some infection caused by genetic diseases.

– Video/ movies showing the process of treatment of genetic diseases and detection of crimes using genetic technology downloaded from you tube.

– Student books, pictures, internet.

– Projector

c) Learning activity 14.3

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

– Provide books or internet connection if it is available.

– Facilitate students to do activity 14.3 in pair by providing clear instructions.

– Let 2 or 3 pairs present their findings by writing on chalkboard or flipchart

– Ask some questions to check whether they agree with the findings from their colleagues

– Harmonize and conclude the lesson through questions and also by welcoming questions.

Answers for activity 14.3

1) These are some social and ethical considerations of using gene testing and gene therapy in medicine:

- Some countries law allowed an embryo to be chosen in order to check if it does not have an allele for a genetic disease also a successful transplant of a tissue from one person to another is allowed.
- In other countries, foetus can now be screened for a genetic disease while in the uterus, using amniocentesis or chorionic villus sampling. From this screening parent can decide to terminate her pregnancy if the embryo is found to have a genetic disease. But there were some cases where the decision can be made when there is a relatively minor defect with which the child could be expected to lead a fairly normal life.
- Genetic screening can cause termination of pregnancies simply because the child is not the sex that they want.
- Pre-implantation genetic diagnosis (PGD) has been also used to select the sex of the embryo that is chosen to be implanted. Many think that this sex pre-selection, as it is called, is totally unethical.

2) Gene technology is used in the detection of crimes in the following way:

- DNA is isolated from material collected at the crime scene.
- The STR (short tandem repeats) loci are amplified by PCR using sequence-specific primers.
- These primers are designed in such a way that they can amplify the STR loci from any individual.
- The resulting DNA fragments are then processed using electrophoresis.
- Separation and detection of these fragments results in a unique pattern of bands, often referred to as a genetic fingerprint, and it is this unique pattern that is ultimately used in criminal investigations to match suspect DNA with DNA found at the scene.
- During paternity testing, polymerase chain reaction and restriction fragment length polymorphism can be used.

Answers for self-assessment 14.3

1) The gene that causes cystic fibrosis is recessive. The inserted gene would be dominant, so would be able to make its product and affect the phenotype.

2) These are some of the advantages of genetic screening:

- Genetic screening provides information about the increased risk of people having genetic conditions.
- Allows people to prepare for late onset genetic conditions, such as Huntington's disease.
- Genetic tests can identify whether embryos produced by IVF or embryos/ fetuses
- Developing in the womb are going to develop a genetic condition
- This identifies foetuses that will need early treatment if they go to full term
- Allows parents to prepare for the birth of a child who will need treatment for a considerable time or even throughout life
- Identifies carriers of genetic conditions
- Helps to provide early diagnosis

Lesson 4: Significance of genetic engineering in improving the quality and yield of crop plants and livestock

a) Prerequisites/Revision/Introduction

You should start this unit by revising the previous lesson, after you should ask the students brainstorm different applications of gene technology in agriculture and livestock farming.

b) Teaching resources

- Charts illustrating varieties of crops and livestock in Rwanda.
- Video/ movies showing
- Student books, pictures
- Projector

c) Learning activity14.4

The teacher organises a field study and go with student to Visit an agricultural and livestock farming centre or research stations available in the area where the school is located. If the field study is not possible, the teacher forms group of 4 or 5 students and watch audio visual simulation showing varieties of crops and livestock in Rwanda. If the computer and projector is also not available, the teacher may use a chart showing varieties of crops and livestock in Rwanda.

Teacher has to facilitate the students in the activity 14.4 as follow:

- Whole class observe on the field, watch the simulation or observe the chart
- Within their given groups students make a summary on varieties and progress both crop and livestock farming
- The teacher will move to different groups to guide them showing where they have to focus on as it was indicated in the student book.
- Allow groups to present their findings

The teacher harmonizes the presentations of students appreciating the progress of application of gene technology both crop and livestock farming in Rwanda.

Expected answers for activity 14.4

In Rwanda they are some institutions in charge of agricultural and livestock farming Centre and research like RAB and ISAR. These help in the modernization of agriculture and livestock farming. There many modified crops like maize, tomatoes, Banana, Irish potatoes and fruits like oranges. There are also modified domestic animals like cows, pigs, chicken. These modified crops and animals contribute a lot in improving the quality and yield of crop plants and livestock in Rwanda.

Answers for self-assessment 14.4

1) The following are the answers:

a) Transgenic organisms are organisms that contain genes from another species.

b) The following are the answers:

- Transgenic bacteria are used to produce human proteins for medical use.
- Transgenic animals are used to study genes, improve food supply, and provide human protein.
- Transgenic plant is used to improve food supply and increasing of nutritional values.

2) The following are the answers:

- The soil bacterium Bacillus thuringiensis produces crystal proteins called Cry proteins that are toxic to larvae of insects like Tobacco budworm, armyworm, beetles and mosquitoes.
- The Cry proteins exist as inactive protoxins and get converted into active toxin when ingested by the insect, as the alkaline pH of gut solubilizes the crystals.

- The activated toxin binds to the surface of epithelial cells of mid-gut and creates pores.
- This causes swelling and lysis of cells leading to the death of the insect (Larva).
- The genes (cry genes) encoding this protein are isolated from the bacterium and incorporated into several crop plants like cotton, tomato, corn, rice, soybean.

Lesson 5: Ethical and social implications of using genetically modified organisms (GMOs) in food

a) Prerequisites/Revision/Introduction:

Introduce this lesson by asking the questions on previous lesson which is about Significance of genetic engineering in improving the quality and yield of crop plants and livestock.

b) Teaching resources

- Student books, internet
- Projector

c) Learning activity

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

- Help student to form group of 4 or 5students and provide them books.
- Facilitate students to do activity 14.5 as given in student textbook.
- Let two or three groups present their findings
- Ask some questions to check whether they agree with the findings from their classmates
- Harmonize and conclude the lesson through questions.

Answers for activity 14.5

Most of concern rose against the growth of herbicide-resistant or insect-resistant crops as follow:

- The modified crop plants may become agricultural weeds or invade natural habitats.

- The introduced gene(s) may be transferred by pollen to wild relatives whose hybrid offspring may become more invasive.

- The introduced gene(s) may be transferred by pollen to unmodified plants growing on a farm with organic certification.

- The herbicide that can now be used on the crop will leave toxic residues in the crop.

- Genetically modified seeds are expensive, as is herbicide, and their cost may remove any advantage of growing a resistant crop.

- Growers mostly need to buy seed each season, keeping costs high, unlike for traditional varieties, where the grower kept seed from one crop to sow for the next.

Answers for self- assessment 14.5

1) There is no evidence that a crop is dangerous to eat just because it is GM. There could be risks associated with the specific new gene introduced, which is why each crop with a new characteristic introduced by GM is subject to close supervision. Growers are attracted to some GM crops like Bt maize hybrids because they come from the seller with innate pest resistance. Furthermore, growers are attracted to the yield protection and improved grain quality commonly found with Bt maize.

2) These are some bioethical issues of using genetically modified crops:

- Modified crop plants may become agricultural weeds and invade crop habitats.

- Introduced gene(s) may be transferred by pollen: To wild relatives and may produce more invasive hybrid offspring and to unmodified plants on farms with organic certification.

- Genetically modified seeds are as expensive as herbicides and growers need to buy new seeds every season.

- Genetically modified crops cause the loss of traditional varieties.

14.6 Summary of the unit

Many techniques used by genetic engineering contribute in the most numerous applications like production chemicals that are used in medicine or industries, production of new crops and animals that have desirable characters and treating genetic diseases.

Bioinformatics is the collection, processing and analysis of biological information and data using computer software. Databases like **UniProt** (universal protein resource) holds information on the primary sequences of proteins and the functions of many proteins, such as enzymes. The search tool **BLAST** (basic local alignment search tool)

is an algorithm for comparing primary biological sequence information, such as the primary sequences of different proteins or the nucleotide sequences of genes. All the information available about the genome of Plasmodium is now available in databases. This information is being used to find new methods to control the parasite. For example, being able to read gene sequences is providing valuable information in the development of vaccines for malaria.

Transferring of new DNA sequences into microbes, plants, and animals, or by removing or altering DNA sequences in the endogenous genome, completely new strains or varieties can be created to perform specific tasks. The first products were recombinant versions of proteins already used as therapeutics: **human growth hormone** and **insulin**.

Genetic screening is the detection of mutations known to be associated with genetic disorders before they manifest themselves in an individual. This can be done in adults, in a foetus or embryo in the uterus, or in a newly formed embryo produced by in vitro fertilization. There some genetic diseases that can be tested and treated using gene therapy. Among those diseases include **severe combined immunodeficiency (SCID), inherited eye diseases, haemophilia.**

Forensic science is deals with the application of scientific methods and techniques to matters under investigation by a court of law. It helps in criminal investigations, but it is also used to resolve civil disputes such as paternity disputes. DNA can be extracted from small sample of the cells found at the scene of the crime, for example in traces of blood, hair or saliva. In cases of rape, semen may be used.

Genetic engineering is used to improve the quality and yield of crop plants and livestock in ways designed to solve the demand for food across the world; examples are Bt maize (corn) and pro-vitamin A enhanced rice (Golden Rice). Crops, such as maize, cotton, tobacco and oil seed rape, have been genetically modified for herbicide resistance and insect resistance to decrease losses and increase production.

The social implications of genetic technology are the beneficial or otherwise effects of the technology on human societies. Ethics are sets of standards by which a particular group of people agree to regulate their behaviour, distinguishing an acceptable from an unacceptable activity. Each group must decide, first, whether research into gene technology is acceptable, and then whether or not it is acceptable to adopt the successful technologies.

14.7 Additional information to the teacher

Use of genetic technology in Environmental Clean-up

Apart from the application of gene technology discussed in unit 14, gene technology can be used in Environmental Clean-up. Increasingly, the remarkable ability of certain microorganisms to transform chemicals is being exploited for environmental clean-up.

If the growth needs of such microbes make them unsuitable for direct use, scientists can now transfer the genes for their valuable metabolic capabilities into other microorganisms, which can then be used to treat environmental problems. For example, many bacteria can extract heavy metals, such as copper, lead, and nickel, from their environments and incorporate the metals into compounds such as copper sulphate or lead sulphate, which are readily recoverable. Genetically engineered microbes may become important in both mining minerals and cleaning up highly toxic mining wastes.

Genetic engineers are also trying to engineer microbes that can degrade chlorinated hydrocarbons and other harmful compounds. These microbes could be used in wastes water treatment plants or by manufacturers before the compounds are ever released into the environment.

14.8 Answers for end unit assessment 14

I. Multiple choice questions.

1) a

2) c

3) a

3) c

4) c

II. Long answer questions

6) Steps involved in producing bacteria capable of synthesising a human protein such as insulin are arranged in the following way: ii, vi, iv, vii, iii, i, v.

7) Plasmids and the bacterium, Agrobacterium tumefaciens were used as vectors. Genes for the production of carotene were extracted from maize and the bacterium Pantonoea ananatis. These genes, together with promoters, were inserted into plasmids. The plasmids were inserted into bacteria called Agrobacterium tumefaciens. These bacteria naturally infect plants and so could introduce the genetically modified plasmid into rice cells.

8) 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.

Some of the hazards are:

- One of the possible harmful effects of planting GM crops is that their modified genes might get into wild plants. If a gene for herbicide resistance found its way, via pollination, into a 'weed' plant, this plant might become resistant to herbicides and so become a 'super weed'. The purpose of field trials is to assess the likelihood of this happening. Until it is established that this is a negligible risk.

- The modified plants may be a direct hazard to humans, domestic animals or other beneficial animals, by being toxic or producing allergies

- Insect-resistant crop may have a damaging effect on other species of insects.

- The herbicide that can now be used on the crop may leave toxic residues in the crop.

9) The most prominent examples include genes that make the crops resistance to insects, viruses and herbicides.

- **Herbicide tolerance.** The first GM characteristic to be widely adopted was resistance to a herbicide called Round up (or glyphosate) in soybeans. In herbicide tolerant crops, a range of different types of herbicides might be needed to clear out all the weeds before planting the crop. Another benefit of herbicide tolerant crops is that they can be planted into a weedy field, because the weeds can be controlled with herbicide. Disadvantages are that the farmer must buy the proprietary herbicide to match the herbicide tolerant crop, and this type of control runs counter to attempts to reduce the dependency of agriculture on chemical inputs.

- **Insect resistance**. The bacterium Bacillus thuringiensis (Bt) produces a group of proteins known as the Bt toxin, which are toxic for certain insects, but do not harm beneficial insects or other animals. Bacillus thuringiensis is used as an insecticide spray in organic farming. Genes for several Bt toxins have been introduced into many crops by GM.

- **Virus resistance.** GM has been used to resurrect the papaya industry of Hawaii as papaya ringspot virus almost destroyed its plantations in the 1990s. There are no known papaya varieties with natural resistance to this virus but by adding a gene to the papaya from the virus itself, resistant papaya strains were created.

10) Answers are:

a) Gene therapy is the treatment of a genetic disorder by altering the patient's genes whereas genetic screening: determination of a person's genotype using karyotype analysis for chromosome mutations and probes for identifying particular alleles.

b) When a genetic disorder is caused by a recessive allele, the 'normal' allele is dominant; adding a dominant allele allows some correct product to be made.

c) The individual effectively becomes heterozygous, the recessive allele may code for defective product or no products or production of some correct product may cure the disorder and adding a recessive allele cannot block a faulty dominant allele.

11) Because hepatitis A is an RNA virus, you could isolate RNA from the blood and try to detect copies of hepatitis A RNA by using RT PCR, in which reverse transcribe the blood RNA into cDNA and then use PCR to amplify the cDNA, using primers specific to hepatitis A sequences. If you then ran the products on an electrophoretic gel, the presence of a band would support your hypothesis.

12) The true biological father of the child is Q. Because the bars examined his genetic material sample match with the one of child.

13) The blood proteins that people need could be produced by bacteria that have been transformed with the human gene that encodes the needed protein.

14) All DNA contains the same four nucleotides and it is translated by the same mechanism and genetic code, so the DNA from bacterium could be used to make human protein

15) The following are the answers:

- The modified crop plants may become agricultural weeds or invade natural habitats.
- The introduced gene may be transferred by pollen to wild relatives whose hybrid offspring may become more invasive.
- The introduced gene may be transferred by pollen to unmodified plants growing on a farm with organic certification.
- The modified plants may be a direct hazard to humans, domestic animals or other beneficial animals, by being toxic or producing allergies.
- The herbicide that can now be used on the crop will leave toxic residues in the crop.
- Genetically modified seeds are expensive, as is herbicide, and their cost may remove any advantage of growing a resistant crop.
- In parts of the world where a lot of genetically modified crops are grown, there is a danger of losing traditional varieties with their desirable background genes for particular localities This requires a programme of growing and harvesting traditional varieties and setting up a seed bank to preserve them.

16) Answers are:

Sub question a

- Chloride channel; chloride moves out of cell by active transport.
- Upper face because of presence of carbohydrate chains.

Sub question b

- The allele variant form of a gene; recessive: only affects phenotype when dominant allele is not present.
- The thick, sticky mucus produced; mucus accumulates and reduced gas exchange causes more infections.

Sub question b

- The normal dominant CFTR allele added to viral DNA and virus is inserted DNA into cell.

14.9 Additional activities

14.9.1Remedial questions

1) Changing the DNA of an organism is called:

a) Genetic engineering

b) Hybridization

c) Selective breeding

d) In breeding

2) Discuss the importance of bioinformatics in the human genome project.

2) Explain why genetic engineering can be compared to reprogramming of a computer?

4) Describe any two types of medical products that can be produced using DNA technology.

5) Justify the reasons why one person would or would not be concerned about eating genetically modified food

Answer:

1) The answer is a

2) Answer:

- Bioinformatics helps to hold information on the primary sequences of proteins and the functions of many proteins, such as enzymes.
- Bioinformatics helps in comparing primary biological sequence information, such as the primary sequences of different proteins or the nucleotide sequences of genes

3) An organism's genetic information is stored in code. Different combinations of nucleotides with the bases adenine, thymine, guanine, and cytosine (A, T, G, C) in the DNA code for different amino acids, which will eventually fold into different protein Computers, are programmed in different kinds of programming languages or codes. For example, binary code is based upon different combinations of "0" and "1".

Genetic engineering is basically the process of changing around the different bases in the DNA (the code) to achieve a desired observable outcome (different or altered protein). Reprogramming a computer game is essentially doing the same thing: rearranging the code to achieve an observable change in the game.

4) Answer:

Product	Use
Insulin	Human hormone used to treat diabetes
Factor III	human blood clotting factor, used to treat haemophiliacs
AAT	Enzyme used to treat cystic fibrosis and emphysema
Rennin	Enzyme used in manufacture of cheese

5) Some may be concerned because the foods might harm humans, for example, by causing allergies. Others will not be concerned because they think the genetic modifications will not affect humans.

14.9.2 Consolidation questions

1) Clearly explain the importance of having genetic databases about plasmodium.

2) Explain how the technique of recombinant DNA is used manufacture the

protein somatotropin. Support your explanation using diagrams.

3) What is the advantage of using stem cells for gene therapy?

4) Identify at least three different properties that have been acquired by crop plants via genetic engineering.

5) Many countries have regulations regarding the release of genetically modified organisms into the environment. Explain the reasons why people have concerns regarding the release of such organisms

Answer:

1) All the information about the genome of Plasmodium is available in databases. This information is being used to find new methods to control the parasite. For example, being able to read gene sequences is providing valuable information in the development of vaccines for malaria

2) **Answer:**

- The gene for human growth hormone (h-GH) is isolated from human pituitary gland.
- Insertion of whole h-GH gene into plasmid vector and cloning into E. coli results into production of biologically inactive hormone because bacteria can translate the region of gene that are not translated in human thereby producing a pre-hormone containing an extra 26 amino-acids which might be difficult to remove.
- Hence the segment of gene that codes for the first 24 amino-acids of hormone is constructed chemically from blocks of nucleotide.

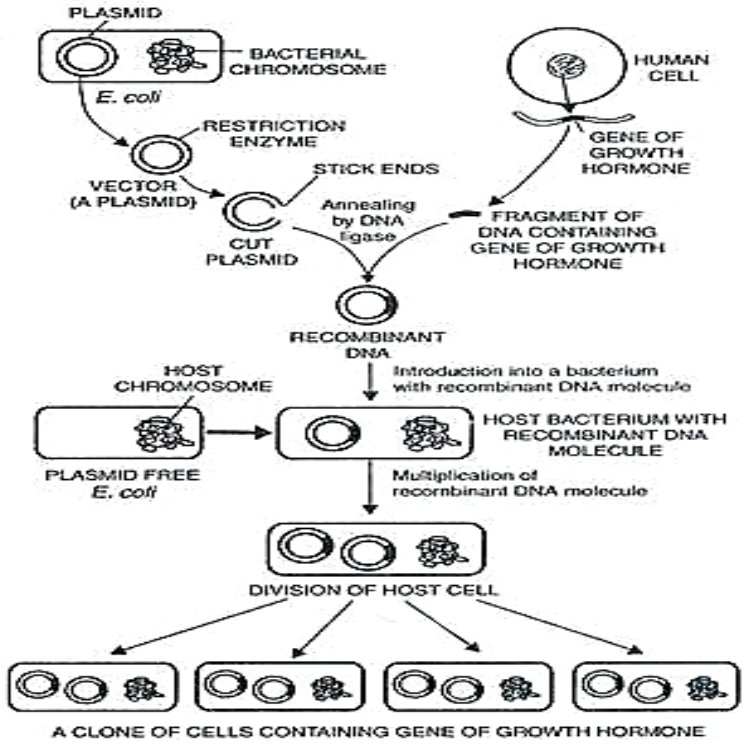


Diagram showing steps involved in cloning and expressing a hormone gene for growth hormone into *E. coli*.

3) The advantage of using Stem cells is that they continue to reproduce themselves.

4) These are some properties by crop plants via genetic engineering: herbicide resistance, pest resistance, disease resistance, salinity resistance, delayed ripening, and improved nutritional value.

5) The approaches of regulation of genetically modified organisms have been taken by governments in order to assess and manage the risks associated with the use of genetic engineering technology. The regulation of genetic engineering varies widely by country. Up to now there is no evidence to support the idea that the consumption of approved GM food has a detrimental effect on human health.

14.9.3 Extended questions

1) Describe how the rapid growth of the computer technology industry in the 1990s relates to the human genome project.

2) Using examples describe any 2 applications of genetic technology in agriculture

3) Advances in gene therapy are dependent on the pace of advancement in genetic screening technology. Comment on this statement.

4) Describe how a DNA fingerprint is prepared.

5) Describe a potential safety environmental concern with regard to genetically modified (GM) crops

Answer to extended questions

1) Human genome project was started in 1990 with the goal of sequencing and identifying all three billion chemical units in the human genetic instruction set, finding the genetic roots of disease and then developing treatments. The project was supposed to last 15 years however the rapid technological advances have accelerated and shifted the expected completion date to 2003 which was only 13 years. The new technologies stimulated rapid sequencing of the human genome and handling huge amounts of data.

2) These are the application of gene technology in agriculture

- T**he use of Insect pests-resistant plants. Example is Bt maize:Bt maize** is genetically engineered maize to express one or more proteins from the soil bacterium called Bacillus thuringiensis (Bt) hence the common name "Bt maize". The protein is poisonous to certain insect pests and the growers that use Bt maize often see higher yields due to this reduced insect injury.

- **Production of Golden Rice:** In the 1990s, a project was undertaken to produce a variety of rice that contained carotene in its endosperm. Genes for the production of carotene were extracted from maize and the bacterium Pantonoea ananatis. These genes, together with promoters, were inserted into plasmids. The plasmids were inserted into bacteria called Agrobacterium tumefaciens. These bacteria naturally infect plants and so could introduce the genetically modified plasmid into rice cells. The rice embryos, now containing the carotene genes, were grown into adult plants

3) Genetic testing has enabled researchers and clinicians to detect inherited traits, diagnose heritable conditions, determine and quantify the likelihood that a heritable disease will develop, and identify genetic susceptibility to familial disorders. The increasing availability of genetic testing has been one of the most immediate applications of Therapeutic gene transfer that holds the promise of providing lasting therapies and even cures for diseases that were previously untreatable or for which only temporary or suboptimal treatments were available.

4) **DNA fingerprinting**, also called **DNA typing, DNA profiling, genetic fingerprinting, genotyping, or identity testing,** in genetics, method of isolating and identifying variable elements within the base-pair sequence of DNA (deoxyribonucleic acid).The following are steps in fingerprint:

- The process of DNA fingerprinting starts with isolating DNA from any part

of the body such as blood, semen, vaginal fluids, hair roots, teeth, bones, etc.

- Polymerase chain reaction (PCR) is the next step in the process. In many situations, there is only a small amount of DNA available for DNA fingerprinting. Because of this, in a test tube, DNA replication is must occur to make more DNA. The DNA and the cells will undergo DNA replication in order to make more DNA to be tested.

- After the DNA is isolated and more copies of the DNA have been made, the DNA will be tested. The scientist will treat DNA with restriction enzymes (an enzyme that cuts DNA near specific recognition nucleotide sequences known as restriction sites).

- This will produce different sized fragments which are known as restriction fragment length polymorphisms (RFLPs).

- These fragments can then be observed doing an experiment called gel electrophoresis which separates DNA based on fragment sizes.

- Gel electrophoresis is the next step in this process of DNA fingerprinting. During gel electrophoresis, an electrical current is applied to a gel mixture, which includes the samples of the DNA.

- The electric current causes the DNA strands to move through the gel. This separates the molecules of different sizes.

- The fragments of separated DNA are sieved out of the gel using a nylon membrane (treated with chemicals that allow for it to break the hydrogen bonds of DNA so there are sing strands).

- The DNA (single stranded) is cross-linked against the nylon using heat or a UV light.

- The probe shows up on photographic film because the strands of DNA decay and give off light. In the end it leaves dark spots on the films which are also known as the DNA bands of a person. What make up the fingerprint are the unique patterns of bands. The patterns of bands are different because we are all different and unique (other than identical twins).

- Once the filter is exposed to the x-ray film, the radioactive DNA sequences are shown and can be seen with the naked eye. This creates a banding pattern or what we know as DNA fingerprints. This technique is called southern blotting.

5) Modified crop plants may become agricultural weeds and invade crop habitats. Introduced gene(s) may be transferred by pollen:

- To wild relatives and may produce more invasive hybrid offspring
- To unmodified plants on farms with organic certification.
- Modified plants can be toxic and produce allergies fatal to humans and animals that eat it herbicides will leave toxic residues on crops
- Genetically modified seeds are as expensive as herbicides and growers need to buy new seeds every season. Genetically modified may causeless of traditional varieties

UNIT 15 :VARIATION

15

15.1 Key Unit Competence

Explain variation and mutation as a source of biodiversity

15.2 Prerequisite (knowledge, skills, attitudes and values)

To succeed well this unit, make sure that the learners have learned and have understood well previous units that are closely related to variation. The previous unit that learners should know before studying is: unit 1 6 of senior sixwhich is genetics and unit 17 of senior sixwhich is mutations.

15.3 Cross-cutting issues to be addressed

Inclusive education is one of the cross-cutting issues 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 variation 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 children with disabilities from the parents about how they often communicate with children at home.

15.4 Guidance on the introductory activity

Introduce the unit 15 by using the written information in introductory activity and do the following:

- Invite the learners to think about the written information of introductory activity

- Give time to think about the given questions
- Allow them to express their ideas
- Consider their ideas and then inform what they will learn in this unit

Expected answers to the introductory activity

The students should give the following answers of introductory activity

- Variation, parents, environment, types

15.5 List of lessons/sub-headings

	Lesson title	Learning objectives	Number of period
1	Variation	Explain the meaning of variation Explain the importance of variation	1 period
2	Types of variation	Explain population traits and types of variation. Describe the differences between continuous and discontinuous variation. Interpret graphs of variations in blood groups and height. Construct genetic diagrams to show how sickle cell anaemia is inherited. Explain the genetic basis of continuous (many additive genes control characteristics) and discontinuous Express that discontinuous variation results in a limited number of phenotypes with no intermediates e.g. tongue rolling.	3 periods

3	Causes of variation in living things	Describe the causes of variation. Explain, with, examples, how the environment may affect the phenotype of plants and animals. Justify the effect of the environment on the phenotype of plants and animals. Explain why genetic variation is important in selection.	3 periods
4	The t-test	Use a t-test to compare the variation of two different populations	3 periods
5	Assessment standard	Students can clearly explain variation and mutation as a source of biodiversity	2 Periods

Lesson 1: Variation

Within this lesson, you start by introducing this unit through its activities as given in student textbook.

a) Prerequisites/Revision/Introduction

Ask some questions to check students' understanding. The questions should focus on genetics and mutations of senior five.

b) Teaching resources

- Charts and illustrations indicating the variation
- Student's books, pictures,

c) Learning activity 15.1

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

- Facilitate the learners in the flow of the activity.
- 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 activity 15.1

The students should write a summary on variation including the definition of variation, types of variation, origin of variation and the importance of variation. Refer to the student's book.

Answers for self- assessment 15.1

1) Variation may be due to either the effect of environment such as climate, or food supply or actions of other organisms. For example, the action of sunlight on a light- colored skin may result in its becoming darker. Such changes have little evolutionary significance as they are not passed from one generation to the next.

2) Importance of variation includes:

- Variations make some individuals better fitted in the struggle for existence.
- They help the individuals to adapt themselves according to the changing environment.
- Discontinuous variations produce new traits in the organisms.
- Variations allow breeders to improve races of useful plants and animals for increased resistance, better yield, quicker growth and lesser input
- They constitute the raw material for evolution.
- Variations give each organism a distinct individuality.
- Because of variations, species do not remain static. Instead, they are slowly getting modified forming new species with time.
- Pre-adaptations caused by the presence of neutral variations are extremely useful for survival against sudden changes in environment, e.g., resistance against a new pesticide or antibiotic

Lesson 2: Types of variation

a) Prerequisites/Revision/Introduction

You should start this lesson by revising what has learnt on "variation".

b) Teaching resources

- Charts of types of variation
- Student textbooks, internet, pictures

c) Learning activity 15.2

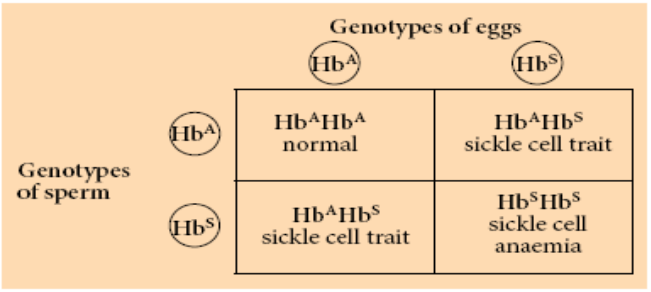
Help the learners for developing competences related to the above lesson and do the following:

- 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 15.2

1) There are two types of variation: continuous and discontinuous

2)The diagram showing sickle-cell anaemia:



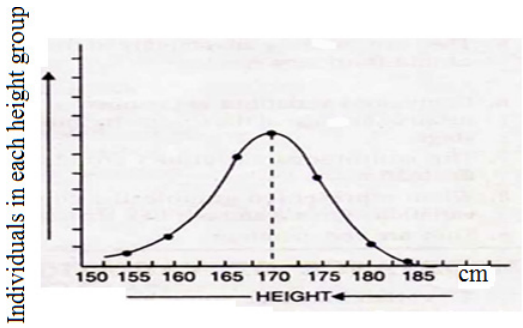
Answers for self-assessment 15.2

1) Continuous variation is quantitative and there are no distinguishable classes of, say height or mass. There is a range of height or mass between two extremes. Discontinuous variation is qualitative and falls into clearly distinguishable classes, with no intermediates

2) The interpretations of graphs on sickle cell anaemia and height:

a) The ability to roll the tongue (one is either tongue roller or non-tongue roller), fingerprints, sex (one is either male or female) and the ABO blood group system where one can only have blood group A, B, AB or O. and blood groups. In plants, a pawpaw tree is either male or female. These characteristics can be explained much more easily by simple rules of genetics and are less likely to be affected by other factors. Discontinuous variations are unchangeable and unaffected by the external environment.

b) The figure is the following:



Lesson 3: Causes of variation in living things

a) Prerequisites/Revision/Introduction

Introduce the lesson by asking the students to describe the types of variation.

b) Teaching resources

- - Charts illustrating the causes of variation
- - Student books, pictures, internet.

c) Learning activity 15.3

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

- Facilitate students to do activity 15.3 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 activity 15.3

a) Environmental causes (climate, temperature, medium, …)

b) Genetic causes (crossing over, random fertilization, random mating, non-disjunction)

Answers for self-assessment 15.3

1) Three environmental factors that causes variation are:

a) Crossing over: genes are interchanged resulting in new chromosomes (recombinants), different from the parental combination.

b) Non-disjunction: Non-disjunction results into doubling of the chromosome number due to failure of chromosomes to segregate during meiosis

c) Random mating involves individuals pairing by chance, not according to their genotypes or phenotypes. Random mating is a source of variation in a population

2) Random mating involves individuals pairing by chance, not according to their genotypes or phenotypes. Random mating is a source of variation in a population. Random fertilization that results during the fusion of the gametes also contributes to variation. Gametes are the egg and sperm, or pollen, produced by meiosis. Each gamete has a unique set of combination of genes

Lesson 4: T-test

a) Prerequisites/Revision/Introduction

You should start this unit by introducing the t -test, it is a new lesson.

b) Teaching resources

Student books, pictures, internet

c) Learning activity 15.4

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

- Ask students to do activity 15.4 or write it on chalkboard or whiteboard
- Provide different biology books.
- Let groups of learners 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

Expected answers for activity 15.4

The students should use the paired t-test to test the mean difference between these dependent observations. Independent samples: If you randomly sample each set of items separately, under different conditions, the samples are independent. If you randomly sample each set of items separately, under different conditions, the samples are independent. The measurements in one sample have no bearing on the measurements in the other sample.

Answers for self-assessment 15.4

1) $t = \dfrac{\bar{x}_1 = \bar{x}_2}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$, with $\bar{x}$ = mean of observations, n =number of observations (sample size) and s =standard deviation

2)Statistical tests are important for assessing data gathered through experimental research and also the limitations of such independent variable) and any variation that was due to chance fluctuation. It is used to calculate whether or not differences seen between the control and each experimental group are a factor of the manipulated variable or simply the result of chance.

15.6 Summary of the unit

Variation among organisms is genetic and phenotypic. Genetic variation is caused by differences in genotype (genetic makeup), whereas phenotype variation refers to the observable characteristics of an organism. Phenotype variation may be continuous (height or mass of an organism) or discontinuous (in the human ABO blood groups). Genotype variation results from mutations, either chromosome mutations or gene (point) mutations.

The genotype of an organism gives it the potential to show a particular characteristic. In many cases, the degree to which this characteristic is shown is also influenced by the organism's environment. Genetic variation within a population is the raw material on which natural selection can act.

Meiosis, random mating and the random fusion of gametes produce genetic variation within populations of sexually reproducing organisms. Variation is also caused by the interaction of the environment with genetic factors, but such environmentally induced variation is not passed on to an organism's offspring. The only source of new alleles is mutation.

All species of organisms have the reproductive potential to increase the sizes of their populations but, in the long term, this rarely happens. This is because environmental

factors come into play to limit population growth. Such factors decrease the rate of reproduction or increase the rate of mortality so that many individuals die before reaching reproductive age.

15.7 Additional Information for teachers

To teach effectively this unit, you should read and understand the following content of:

a) Genetics: monohybridism, dihybridism and polyhybridism from senior five.

b) Mutations/ aberrations: Chromosomal mutations and point (gene mutations): substitution, deletion, insertion or addition, duplication and inversion mutations.

15.8 Answers for end unit assessment 15

Answers of multiple choice questions

1) c

2) d

Short answers

3) Heterozygous

4) Continuous variation

5) An agent that causes a mutation (e.g. X-rays)

Answers for essay questions

6) Characteristics are passed from parents to offspring in their genes. Variation caused by the environment does not change the DNA of an organism.

7) The following are the answers:

a) Continuous variation is quantitative and there are no distinguishable classes of height or mass. There is a range of height or mass between two extremes. Discontinuous variation is qualitative and falls into clearly distinguishable classes, with no intermediates.

b) In continuous variation, different alleles of a gene have small effects on the phenotypic. Characteristic, different genes may have the same, often additive effect and many genes may be involved (polygenes). In discontinuous variation, different alleles of a gene have large effects and different genes have quite different effects on the phenotypic characteristic.

8) The following are the answers:

a) Height of wheat shows bimodal distribution

b) The good answer includes:

(i) Continuous variation; all possible heights represented with no steps in between or complete gradation shown

(ii) wwwEnvironmental variation or named environmental effect/light/water/ genetic variation within wheat strains

15.9 Additional activities

15.9.1 Remedial activities

1) What do you understand by variation?

2) List and explain any 3 causes of variation

3) What is meant by this term "non-disjunction"

4) Give 2 examples of discontinuous variation

Answers

1) The differences existing among living organisms

2) Genetic causes (random mating, random mating, crossing over) and environmental causes such as medium, climate

3) Non disjunction occurs during anaphase I of meiosis I, this means that at least one pair of homologous chromosomes did not separate. The end result is two cells that have an extra copy of one chromosome and two cells that are missing that chromosome.

4) Blood groups, Rhesus

15.9.2 Consolidated activities

Question

There are three genotypes of the gene for the β-globin polypeptide: HbAHbA, HbAHbS and HbSHbS. Copy and complete the table to show which genotypes have a selective advantage or disadvantage in different regions of the world.

	Region with no malaria	Region with malaria
Genotype(s) with selective advantage		
Genotype(s) with selective disadvantage		

Answers

	Region with no malaria	Region with malaria
Genotype(s) with selective advantage	Hb^AHb^A Hb^AHb_S	Hb^AHb^S
Genotype(s) with selective disadvantage	$Hb\ ^SHb^S$	Hb^AHb^A Hb^SHb^S

15.9.3 Extended activities

The snail Cepaea nemoralis may have a yellow, pink or brown shell. Each colour shell may have up to five dark bands, or have no bands. Both shell colour and number of bands are genetically controlled. The snails are eaten by birds such as thrushes, which hunt by sight. The following observations were made:

- Most snails living on a uniform background, such as short grass, have no bands.
- Most snails living on a green background, such as grass, are yellow.
- Most snails living on a non-uniform background, such as rough vegetation, have bands.

a) Suggest an explanation for these observations.

b) Predict the phenotype of snails living on a dark background of dead leaves.

c) Suggest what will happen, during the course of a year, to the frequencies of the different alleles controlling shell colour and banding in a snail population living in deciduous woodland. (Deciduous trees shed their leaves in autumn. The background for the snails will be made up of dead leaves in the autumn and winter, and green vegetation in the spring and summer.)

Answers

a) camouflage from bird predators hunting by sight; yellow blends into grass but pink or brown are easily seen; bands break up outline against rough vegetation; yellow or pink without bands are easily seen;

b) Brown; five bands;

c) Selection favors alleles for brown shell and for bands in autumn and winter; selection favors alleles for yellow shell and few or no bands in spring and summer; gradual change in selection pressures as seasons change; keeps all alleles in the population;

UNIT 16: NATURAL AND ARTIFICIAL SELECTION

16

16.1 Key Unit Competence

Explain the role of artificial and natural selection in the production of varieties of animals and plants with increased economic importance

16.2 Prerequisite (knowledge, skills, attitudes and values)

In order to succeed well this unit, students should possess **knowledge and understanding, skills and attitudes** that are related to natural and artificial selection and or evolution acquired in ordinary level senior 3, and unit 14 (gene technology) and 15 (variation) of senior 6. They should be also being able to **do observation, analysis, and interpretation** of the pictures as well as figures. **Calculation, presentation and communication skills are of a paramount.**

16.3 Cross-cutting issues to be addressed

Among the cross cutting issues that are to be addressed by the competence based curriculum, the issues of environment and sustainability, finance education as well as inclusive education are most likely to be addressed in this unit and by the unit.

By the content about natural and artificial selection, students will understand how each one contributes to the extinction or appearance of new species; students can develop sense of protecting natural environment and also appreciate artificial selection. Thus, environment and sustainability as well as financial education will be addressed. For addressing inclusiveness issue, use of clear and visible pictures, graphs, sign language as well as scenarios are recommended so that students with special needs (hearing as well as visual impairment) can be involved in the learning process.

Additional questions may be asked at the end of each lesson after students' presentation of the findings as well as the conclusion for addressing other cross- cutting issues such as peace and values.

16.4 Guidance on the introductory activity

Tell a scenario to students as slightly given in introductory activity in student textbook. Ask them to reflect or brainstorm on:

- Causes of their extinction as well as apparition of some species?
- How the major causes of their extinction as well as apparition played their role?

Appreciate their ideas/ thoughts. Inform students that by studying unit 16, they will understand variations or population diversity brought by natural as well as artificial selection as well as appreciating the advantageous of natural and artificial selection.

Expected students' feedback

The cause of their extinction as well as apparition is selection either natural or artificial, caused by environment as well as human actions. They play their role by selecting the fittest as they have selective advantages and those with unfavourable characteristics die and disappear. On other hand, the organisms with needed characteristics are obtained through artificial selection by action of breeders/ humans.

16.5 List of lessons

	Lesson title	Learning objectives (from the syllabus including knowledge, skills and attitudes):	Number of periods
1	Natural selection	Explain that natural selection occurs as populations have the capacity to produce many offspring that compete for resources. In the struggle for "existence" only the individuals that are best adapted survive to breed and pass on their alleles to the next generation. Explain, with examples, how environmental factors can act as either stabilizing, disruptive and directional forces of natural selection. Explain natural selection with specific examples: Antibiotic resistance in bacteria, pesticide resistance in insects and mammals and industrial melanism Interpret graphs on how fur length affects the number of individuals at different temperatures. Appreciate that the environment has considerable influence on the expression of features that show continuous (or Quantitative) variation.	1 period

2	Artificial selection	Describe how selective breeding (artificial selection) has been used to improve the milk yield of dairy cattle. Outline the following examples of crop improvement by selective breeding: The introduction of disease resistant varieties of wheat, tomatoes, Irish potatoes, and rice. Inbreeding and hybridization to produce vigorous, uniform varieties of maize Differentiate between natural and artificial selection. Appreciate the importance of selective breeding (Artificial selection) to improve features in ornamental plants, crop plants, domesticated animals and livestock.	3 periods
3	Allele frequency and its causes	Explain how selection, the founder effect and genetic drift may affect allele frequencies in populations. Explain how a change in allele frequency in a population can be used to measure evolution.	3 periods
4	Study of population genetic variation by Hard-Weinberg principle	Use the Hardy–Weinberg principle to calculate allele, genotype and phenotype frequencies in Populations.	2 periods
5	Assessment standard	Students can explain clearly the role of artificial and natural selection in the production of varieties of animals and plants with increased economic importance.	2 periods

Lesson 1: Natural selection

This is the first lesson of the unit. Before starting this lesson, you have to introduce a whole unit through introductory activity.

a) Prerequisites/Revision/Introduction

Start the lesson by asking learners to brainstorm what they understand about natural selection

c) Teaching resources

Internet, library, and teachers, graphs of types of natural selections on Manila paper.

d) Learning activity 16.1

Help learners to do questions which are under learning activity 16.1 found in student textbook by doing the following:

- Facilitating the smooth and focus discussions
- Help students for effective presentation of their works through challenging questions
- Consolidate students' presentation and conclude the lesson through questions
- You may extend the lesson for addressing one cross-cutting issue of environment and sustainability.

Answers for activity 16.1

1) Natural selection occurs by:

- Interaction of genomes with environment
- Such interaction, there are variations in traits from genotypic to phenotypic by starting to individual gene
- Variation occurs at cell, other cells, other individuals, populations, species at abiotic level
- resulting in difference in individuals' genes

2) Benefits of natural selection for a population include:

- New traits increase survival and reproduction of species / individuals
- Speciation or macroevolution which is the emergence of new species
- Fitness and strong offspring by new traits acquired from the parents or mean for population adaptability
- Populations that specialize to particular ecological niche

- Transmission of physical traits that are contained with the genes from generation to generation.

3) The analyzed graphs

- Graph A: Diversifying or disruptive selection. Individuals with extreme phenotypes or end phenotypic spectrum have greater survival and reproductive success. The intermediate phenotype is selected against and gradually decreases in number from generation to generation, and may become extinct.

- Graph B: Stabilizing selection. This selection favours the individuals in the population with the intermediate phenotypes. Such individuals have greater survival and reproductive success compared to those with extreme phenotypes that are less adaptive and are eliminated.

- Graph C: Directional selection. A population acquires characteristics or changes genetic variance or allele frequency continuously in one direction or one end of the spectrum of existing variation.

4) In a mammal like gorilla, the fur length increases at low temperatures while decreases with the increase in temperature. In camel, it is the reverse situation.

5) Discussions about natural selection with specific examples such as industrial melanism, antibiotic resistance in bacteria, pesticide resistance in insects and mammals:

- Environment changes gradually from light to dark environment. Thus increasing melanin pigmentation in wings/fur and body of animal for example moth or Biston betularia. With that melanism, species can escape the predators by camouflage themselves in dark places.

- Mutants resulting from environmental changes have evolved specific genes to control the synthesis of enzymes that can break down antibiotics. The alleles for antibiotic resistance are often found on bacterial plasmids. The resistance of some bacteria to certain antibiotics has then rendered certain drugs ineffective in the treatment of diseases caused by bacteria.

- The widespread use of insecticide acts as selection pressure on the population of many pests. Some insects' pests survive by produced enzymes that render them resistant to pesticides such as DDT, dielrin, Aldrin and malathion.

- Some diseases are no longer a problem by natural selection. E.g. Species such as oysters (shellfish) managed to survive and reproduce again due to the acquire mutant which made them resistant to new and devastating disease called Malpeque disease.

Answers for self-assessment 16.1

1) Types of natural selection includes:

- Stabilising selection keeps individuals with intermediate characteristics
- Directional selection favours population of one extreme. E.g. Black moth
- Disruptive selection keeps or favours species which have developed extreme characteristics (right or left) while those with intermediate characters. E.g. rabbits with the two extreme characteristics

2) Industrial melanism is the change in the environment that leads to melanism pigmentation in peppered moths. It is very beneficial to peppered moths as they give them ability to escape predators by camouflaging in dark places

3) Natural selection is one way of evolution as it leads to variations among individuals. But variations, individuals become suitable adapted to survive and reproduce species with favorable characteristics.

Lesson 2: Artificial selection

a) Prerequisites / Revision/Introduction:

Start the lesson by asking what artificial selection is and whether they have seen species produced by natural selection. If so, ask them some examples. Ask them to describe how the species obtained by artificial selection.

b)Teaching resources

Surroundings of students either at home or school, internet, textbooks.

c) Learning activity 16.2

Take students outside the classroom so that they can observe individuals resulting from artificial selection and invite them for:

- Working on questions given in activity 16.2 in their respective groups
- Share the ideas in small groups and then in large groups
- Consolidate their ideas and also challenge them.
- Conclude the lesson and also extend the lesson by addressing issue of finance education

Answers for activity 16.2

1)Artificial selection means the breeding two species that display desired characteristics

2) Inbreeding selection is a selective crossing between individuals that have the same genotype or are more closely related e.g. siblings whereas outbreeding is a selective breeding between distinct individuals or different varieties of species.

3) Selective breeding or artificial selection has been used to improve the yield or production by:

- Producing species of high quantity and quality
- Producing species that resist to diseases, pesticides and or herbicides
- Producing species that grow faster and quickly produce
- Producing species that are tolerant to harsh environment
- Producing species for ornamentation such as koi fish, orchids etc

Answers for self-assessment 16.2

1) Artificial selection is beneficial to humans from what breeders have produced. Among their production, there are species with various characters that fit to environment and produce more as humans need.

2) Even though both inbreeding and out breeding contributes to different results needed by human being, inbreeding presents some negative effects such as producing sterile species whereas in most cases the out breeding brings again variation which increases selective adaptive features.

Lesson 3: Allele frequency and its causes

a) Prerequisites/Revision/Introduction:

Introduce the lesson by asking students to describe and illustrate what allele means. Ask also them to distinguish phenotype from genotypes with clear examples.

b) Teaching resources

Simulations, illustrations, students' textbooks and internet.

c) Learning activity 16.3

Invite students to use available school resources such as internet, library, and teachers; search information about allele frequency, selection, the founder effect and genetic drift. You have also to use pictures which are related to this lesson or use bean seeds of different colour and then facilitate the smooth going of this learning activity by:

- Asking students to observe pictures or playing game
- Ask them to analyse pictures or what they observe from the game
- Facilitating the discussions through questions like what is gene pool, allele frequency, founder effect, and genetic drift
- Helping the presentation and clarifying the concepts
- Concluding and asking questions for deeper understanding

Instructions for the game

a) Take 15 bean seeds and then put all in one plastic bottle such as the one of mineral water or power soap

b) Take other three empty bottles

c) Shake the bottle containing bean seeds and randomly distribute seeds into the three bottles. Record and discuss the observations

d) Repeat events in step c) at least three times.

e) Draw the conclusion by linking the discussion to what they have read on allele frequency, founder effect, and genetic drift

Answers for activity 16.3

1) Allele frequency is the rate at which a specific allele appears within a population. Allele frequency ranges from 0, present in no individuals, to 1, present in all individuals. The gene pool is the sum of all the alleles at all genes in an interbreeding population.

2) Forces of natural selection/mutation, the founder effect and genetic drift affect the allele frequencies in populations in the following ways:

- Selection causes variations or mutations
- By a founder effect, parts of a population are established from a common larger population. The new populations have their own allele frequencies
- Genetic drift or change occurs by an overall shift of allele distribution in an isolated population. By such change, individual's alleles change whereby new characteristics appear when the existing ones disappear.

3) Change in allele frequency in a population can be used to measure evolution since the number and type of allele in initial population has

changed by either selection, founder effect, genetic drift or gene flow.

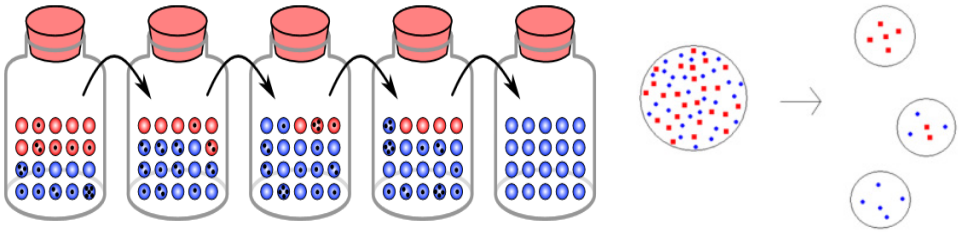
Answers for self-assessment 16.3

1) Allele frequency is the rate at which a specific allele appears within a population.

2) Both mutation and natural selection causes phenotypic and genetic variation by change which starts at gene level thus affect change in gene pool thus evolution occurs.

3) There is only 0.5 allele form in a gene for a non-dominating or recessive character.

4) Illustration of genetic drift and founder effect



Lesson 4: Study of population genetic variation by Hard-Weinberg principle

a) Prerequisites/Revision/Introduction

Introduce the lesson by asking students to describe how the ratio of genotypes and phenotypes is obtained. Ask also them to predict how genetic variation in a population is calculated.

b) Teaching resources

Internet, library, and pictures or diagrams.

c) Learning activity 16.4

Help learners to calculate allele frequencies by:

- Asking students to do a research on Hardy-Weinberg principle and ask them to explain what is it.
- Enhance their understanding on the Hardy-Weinberg principle by reinforcing their explanations
- Giving them exercises so that they can calculate allele, genotypes and phenotypes in populations.

Answers for activity 16.4

1) Hardy-Weinberg principle is a mathematical way used to estimate the frequency of alleles, genotypes and phenotypes in a population. Frequency of allele is expressed by P+Q=1 Frequency of genotypes is calculated by $p^2+2pq+q^2=1$

Whereby P represents a dominant allele/genotype whereas Q represents recessive allele/Genotype

2) The frequency of dominant allele is 0.8 which is obtained from P=1-Q

3) By using a Punnet square, the obtained phenotype is yellow pea seeds. Genotypes obtained are 4 Yy or 100% Yy. For allele frequencies are 0.6 for the dominant allele and 0.4 for the recessive allele. Genotypic frequencies are $(0.6)^2+ 2(0.6)(0.4) + (0.4)^2=1$. Thus, it gives 0.36 YY, 0.52Yy and 0.16 yy. Phenotypes are 88 yellow seeds against 12 green seeds.

Answers for self-assessment 16.4

1) The allelic, genotypic and phenotypic frequencies:

   a) Allelic frequency of dominant allele is 0.8; genotypic frequencies are 100% Tall plants; 100 % Tt.

   b) Allelic frequency is also 0.8; genotypic frequencies are 0.64 TT, 0.32 Tt and 0.4 tt; and 75% versus 25% phenotypic frequencies tall and short plants respectively.

   c) Allelic frequency of dominant allele is equal to 0.8; 0.64 TT, 0.32 Tt and 0.4 tt; and 100% tall plants.

2) Phenotypes, Genotype and allele frequencies of hybrids obtained when the crossing is done between YY and Yy individuals are:

   - Allele frequencies are 0.7 and 0.3 for dominant and recessive respectively.
   - By $p^2+2pq+q^2=1$, the genotype frequencies are: $(0.7)^2+2(0.7)(0.3)+(0.3)^2=1$. This gives 0.49 YY, 0.58 Yy and 0.9 yy. Phenotypes are 91 yellow seeds against 9 green seeds

16.6 Summary of the unit

This unit consists of four lessons as detailed in student textbook. Those lessons are: natural selection, artificial selection, allele frequency and its causes, and calculation of allelic, genotypic and phenotypic frequencies in populations.

In the first lesson, types of natural selections are described. It also emphasizes natural selection with examples to antibiotic resistance, pesticides resistant in insects as well as industrial melanism. In the second lesson, types of artificial selections are provided

with their both positive and negative effects. The third lesson describes concepts of allele frequency, founder effect and genetic drift. In the fourth lesson, Hardy-Weinberg principle is applied in solving different exercises.

For each lesson, introduction, resources, learning activities and self-assessment questions have been provided. At the end of unit, end unit assessment tasks are provided.

16.7 Additional information

For effective facilitation of the learning, you need to be equipped with knowledge, skills, attitudes and values that are related to evolution.

16.8 Answers for end of unit assessment 16

1) Comparison between natural selection from artificial selection is summarised in the table below

Natural selection	Artificial selection
The process whereby organisms better adapted to their environment tend to survive and produce more offspring	Process by which plants and animals are chosen by breeders to produce desirable and inheritable characters in the successive generationsMan-made selection process
Nature-made selection process	Produces organisms with selected traits
Produce a huge biological diversity	Mainly occurs in domestic populations
Occurs in natural populations	Allows only selected traits to be inherited over successive generations
Only allows favourable characters to be inherited over the successive generations	A rapid process
A slow process	Does not facilitate evolution
Facilitates evolution through generating biological diversity	Examples: breeding of small dogs such as Chihuahua, and cattle which can produce more milk
Examples: selection of long-necked giraffes, and change in size and shape of beaks of birds upon the available food	

2) In relation to individuals of the swallowtail butterfly scientifically known as Papilio Machaon:

   a) Such kind of selection is disruptive or diversifying

   b) The intermediate colour forms would be at selective disadvantage because they display unfavorable characteristics.

3) Heavy metal tolerant plants e.g. horsetails are less competitive (have a selective disadvantage) in unpolluted areas and rarely survive there. Tolerance to heavy metal is inherited and appears to have evolved by directional selection. However, tolerant individuals flourish in polluted areas as the heavy metals kill their rivals/ competitors, and they pass on their tolerance to their offspring. Or simply heavy-metal tolerant plants are less completive in unpolluted areas and rarely survive

4) Industrial pollution has an effect on the frequency of the melanic allele within a population of peppered moths by enabling them to camouflage in dark places as CC and Cc genotypes give them the melanic colour. Or an increase in the frequency of the C allele.

5) In malaria infested areas, heterozygotes $Hb^A Hb^S$ are fitter than either homozygote.

They are much less likely to suffer malaria than those homozygous for the normal allele (Hb^AHb^A genotypes) and they do not suffer sickle-cell anaemia like the Hb^SHb^S genotypes.

16.9 Additional activities

16.9.1 Remedial Activities

1) Choose the correct answer: in the diversifying selection

   a) An average phenotype is favored

   b) Two or more extreme phenotypes are selected

   c) One new or fit extreme phenotype is obtained

2) What do you understand by a gene pool?

3) What are the types of natural selections?

4) Describe how out breeding selection is advantageous for human being

5) If the frequency of dominant allele is 0.65. What is the frequency of a recessive allele?

6) Describe how natural selection is important for the organisms.

Answers

1) b

2) The gene pool is the sum of all the alleles at all genes in an interbreeding population.

3) There is stabilizing, directional and disruptive selection

4) By out breeding, hybrids are new with superior phenotypes that have greater potential to adapt to environmental changes. They are vigour, healthier and larger by increased heterozygosity and new opportunities for gene interaction. By out breeding, harmful recessive alleles are masked by dominant alleles.

5) The frequency of a recessive allele is 0.35

6) Answer: it enables them the fitness as well as survival adaptability.

16.9.2 Consolidated activities

1)Under what conditions can changes in allele frequency be used to measure evolution by natural selection.

2) If one in 2200 people in a population has cystic fibrosis, an inherited disorder caused by a single recessive allele, what is the frequency of carriers?

3) What effect does of inbreeding and out breeding have on the genetic diversity of a population?

4) Give two possible explanations of hybrid vigour in plants produced by a cross between two different strains of pure breeding plants.

Answers

1) When the population is large, mating is random, no mutations occur, there is no net immigration into or out of the area.

2) The frequency of carriers is 4.17%

3) inbreeding reduces genetic diversity whereas out breeding increases genetic diversity

4) Harmful recessive alleles maybe less likely to be present in the homozygous condition and some allele combinations may interact positively.

16.10.3. Extended activities

1) The pepped moth, Biston betularia, produces a black variety from time to time. The mutation causing this black variety results in 1848 in Manchester, but by 1895 it had increased to 95% of the population in the city.

   a) What was the frequency of the dominant allele B in the 1895 population of the moth? Show your calculations

   b) Explain why there were always some light-coloured forms of the moth present in urban populations after 1895?

   c) Explain why in the rural populations, the black form of the moth remains very rare?

2) In relation to natural selection with an example related to resistance:

   a) Describe with the use of examples, the genetic basis of resistance

   b) Discuss the development of resistance in a named organism

Answers

1) The answers are:

a) If 96% of the population is black moths, then 4% must be light-coloured moths. Light moths are homozygous recessive, bb, as black is the dominant allele for colour.

The frequency of homozygous recessive is given by q2 in the Hardy-Weinberg principle, therefore, q2= 4% or 4 in 100=0.04; if q2 =0.04, then q is equal to 0.2

The frequency of alleles, p+q=1, where p represents a dominant allele which is B. Therefore, P which represents the dominant allele is = 0.8

b) Some black moths were heterozygous, so two heterozygous moths breeding together would have a 1 in 4 probabilities of producing the recessive light coloured form.

c) In rural populations, the light-coloured moths that predominates in homozygous recessive; the dominant allele that produces black forms cannot occur in the population unless a new mutation arises or stray moths from the urban population migrate into rural population.

2) The answers are:

a) Resistance is any inherited characteristic of an organism which reduces the effect of an adverse environmental factor such as pest/pesticide/salinity etc. adverse factor does not cause the mutations which produce the resistant alleles; alleles for resistance already present in gene pool of population, although at low frequency; or new alleles arise randomly by mutation; presence adverse factor creates strong selection pressures for resistant allele; allele for resistance may initiate production of enzymes to break down drugs, pesticide, virus or induce enzymes that allow other metabolic pathways to be utilized, by passing effect of adverse factor, non-resistant strains destroyed; leaving less competition for resistant strains; resistance can be introduced into organisms by transferring genes from resistant species/from susceptible species; resistance usually under the control of one or two gene loci; credit for other details;

b) Drug resistance: some strains of bacteria have developed resistance to drugs or antibiotics. Staphylococcus aureus for example allow bacteria to survive in the presence of methicillin or any other penicillin called antibiotic. Gene conferring resistance can be transferred to other bacteria making them resistant. Pesticide resistance: some forms of insects such as mosquitoes have developed resistance to insecticides such as DDT. Rats have also developed resistance to warfarin. Herbicides resistance: groundsel/Senecio vulgaris is a major pest as weed, competing with cash crops for resources; triazine herbicides bind to

thylakoid membranes of chloroplasts, prevent photosynthesis; resistant plants may possess genetically controlled mechanisms to prevent herbicide binding. Disease resistance: some rabbits have developed resistance to myxomatosis; virus rendered ineffective by mutated gene in some cases; in others, behaviour of rabbit is altered by mutant gene, causing it to spend more time out of its burrow and therefore less chance of being infected by fleas from other rabbits; resistance to rust in flax; Resistance to heavy metals: heavy metals such as tin/ copper/lead or nickel which are toxic to plants; some varieties of grasses/Festuca ovina/ Agrostis tenuis etc have developed resistance to toxicity thus they can survive in high levels of these metals. By that resistance, they can colonise where other plants cannot.

UNIT 17: EVOLUTION AND SPECIATION

17

17.1 Key Unit Competence

Analyse the relevance of theories of evolution and explain the process of speciation.

17.2 Prerequisite (knowledge, skills, attitudes and values)

To succeed well this unit, make sure that the learners have learned and have understood well previous units that are closely related to variation. The previous units that learners should know before studying are: unit 16, senior five: genetics; unit 17, senior five: mutations; Unit15, senior six, variation; unit 1 6, senior six, natural and artificial selection

17.3 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 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 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.

17.4 Guidance on the introductory activity

Introduce the unit 17 by using the written information in student's book, and do the following:

- Invite the learners to think about the written information of introductory activity

- Give time to think about the given questions
- Allow them to express their ideas
- Consider their ideas and then inform what they will learn in this unit

Expected answers to the introductory activity

1) Original population containing common ancestor shared a gene pool; groups from original population became geographically isolated; by physical barriers such as land masses moving away from each other / oceans; separation of groups stops flow of genes between them; each group/ deme may then evolve in different ways/ adaptive radiation; so that even if re-united, they would not be able to breed successfully; allopatric speciation

2) They have the same origin/ ancestor, differences in habitat and environment, food habit, natural selection

17.5 List of lessons/sub-headings

	Lesson title	Learning objectives	Number of periods
1	Theories of evolution	State the general theory of evolution that organisms have changed over time. Acknowledge that over the years the theories of evolution have undergone modifications as more evidence is collected.	1 period
2	Molecular evidence of evolution	Discuss the molecular evidence that reveals similarities between closely related organisms with reference to mitochondrial DNA and protein sequence data. Observe and interpret mitochondrial, DNA and protein sequence data and investigate the similarities of closely related organisms. Research evidence for evolution Relate diagrams of Darwin's finches to the mechanism of evolution.	3 periods

3	Causes of evolution	Explain how the following processes are the casuses of evoultion Competition changes in the environment. Sexual reproduction. Mutations. Gene recombination. Industrialisation. Effect of drugs or chemical resistance. Artificial selection Explain the causes of present day evolution	3periods
4	Speciation	Explain how speciation may occur as a result of geographical separation (allopatric speciation), and ecological and behavioural separation (sympatric speciation).	2periods
5	Types and roles natural selection in speciation	Appreciate that over prolonged periods of time, some species have remained virtually unchanged, while others have changed significantly and many	1 period
6	Mechanism of speciation	Explain why organisms become extinct, with reference to climate change, competition, habitat loss and killing by humans. Explain large-scale extinctions in earth's history	2 periods
7	Assessment standard	Students can clearly explain theories of evolution	2 Periods

Lesson 1: Theories of evolution

a) Prerequisites/Revision/Introduction

Ask some questions to check students' understanding. The questions should focus on variation, natural and artificial selection.

b) Teaching resources

- Charts and illustrations indicating the evolution
- Student books and pictures

c) Learning activity 17.1

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 activity 17.1

- The students should write a report on evolution including the definition of evolution, the theories of evolution, and the evidences of evolution
- It helps to understand the biological forces that cause organisms to develop from simple to more complex organisms to the extent of new species emerging
- It helps to know how different organisms relate

Answers for self- assessment 17.1

1) he changeover successive generations of the genetic composition (allele frequency of a population) that may result in the formation of new species from pre-existing species.

2) Neo-Darwinism incorporates new scientific evidence, particularly from genetics and molecular biology

Lesson 2: Molecular evidence of evolution

a) Prerequisites/Revision/Introduction:

You should start this lesson by asking questions on the previous lesson and revise shortly the previous lesson "evolution".

b) Teaching resources

- Charts of types of evolution
- Student textbooks, internet, pictures

c) Learning activity 17.2

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 17.2

The cellular and biochemical details of organisms are quite similar, but any differences can give an idea of how closely different species are related. Species that are closely related would be expected to differ only slightly from each other. Detailed comparisons of DNA, metabolic pathways, key proteins, and organelles such as ribosomes have been used to work out the evolutionary relationships of organisms. For example, ribosomes inside mitochondria and chloroplast are similar to those in bacteria, suggesting that these organelles may have evolved from bacteria.

Mammalian blood proteins can be tested to see how similar they are to human blood proteins: blood serum from the mammal in question is added to rabbit serum containing anti-human antibodies

Answers for self-assessment 17.2

1) Types of evolution are:

a) Convergent evolution

b) Parallel evolution

2) Two forms: the genetic code is almost universal, respiration follows similar metabolic pathways in all organisms, and ATP is the universal energy currency.

Lesson 3: Causes of evolution

a) Prerequisites/Revision/Introduction:

Introduce the lesson by asking the students to describe the types of variation.

b) Teaching resources

- Charts illustrating the causes of evolution
- Student books, pictures, internet.

c) Learning activity 17.3

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

- Facilitate students to do activity 17.3 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 activity 17.3

Competition changes in the environment, sexual reproduction, mutations, gene recombination.

Industrialization, effect of drugs or chemical resistance, artificial selection

Answers for self-assessment 17.3

1) The present day evolution includes:

- Any artificial selection; selective breeding (hybrid of maize)
- Two distinct species of mice are mating and their hybrid mice pups are immune to pesticides

2) Refer to student book where polymorphism or industrial melanism and gene recombination are described.

Lesson 4: Speciation

a) Prerequisites/Revision/Introduction:

You should start this unit by revising the causes of evolution, that revision helps you to teach this lesson effectively

b) Teaching resources

- Student books, pictures, internet
- Projector

c) Learning activity 17.4

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

- Ask students to do activity 17.4 or write it on chalkboard or whiteboard
- Provide different biology books.
- Let groups of learners 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

Expected answers for activity 17.4

1) Evolution occurs whenever the inherited characteristics of a population or of a species change over a period of time. When these changes lead to the formation of one or more new species, speciation has taken place.

2) The process of one species splitting into two begins when a population of that one species enters a new niche or environment, genetically isolated from other populations of the original species. The population adapts to the new niche, while other populations of the original species continue to adapt to their original niche (which often means they don't change much, since they're already well adapted to it). The population in the new niche evolves so as to change into (first) a new subspecies, and (later) a new species.

Answers for self-assessment 17.4

Allopatric speciation occurs in two or more demes which are geographically isolated whereas sympatric speciation occurs in two or more demes living in the same geographical location.

Lesson 5: Types and roles natural selection in speciation

a) Prerequisites/Revision/Introduction:

You should start this unit by revising the speciation, that revision of speciation helps you to teach this lesson effectively

b) Teaching resources

- Student books, pictures, internet
- Projector

c) Learning activity 17.5

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

- Ask students to do activity 17.5 or write it on chalkboard or whiteboard
- Provide different biology books.
- Let groups of learners 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

Expected answers for activity 17.5

Answers of this activity refer to the students' book

Answers for self-assessment 17.5

1) The Intermediates would be at a selective disadvantage because they would be easy seen against either a green or brown background

2) Natural selection leads to evolutionary change when individuals with certain characteristics have a greater survival or reproductive rate than other individuals in a population and pass on these inheritable genetic characteristics to their offspring

Lesson 6: Mechanism of speciation

a) Prerequisites/Revision/Introduction

You should start this unit by revising the speciation types, that revision of speciation helps you to teach this lesson effectively

b) Teaching resources

- Student books, pictures, internet
- Projector

c) Learning activity 17.6

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

- Ask students to do activity 17.6 or write it on chalkboard or whiteboard
- Provide different biology books.
- Let groups of learners 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

Expected answers for activity 17.6

- Different mechanisms of speciation are: Continental drift
- Migration, Adaptive radiation, Divergent and convergent evolution, Isolation i.e. ecological, reproductive and genetic, Extinction

Answers for self-assessment 17.6

1) The continents which now exist have not always appeared as they do today. At one time, the earth had a single large land mass called Pangaea. This is thought to have broken up into two parts, a northern Laurasia and a southern Gondwanaland. Over millions of years, the two great land masses split up and moved by a process called continental drift to form our present continents. The theory that these land masses were once joined is supported by the discovery in Australia, South Africa, South America, and Antarctica of fossils belonging to the same extinct species. Fossils in North and South America show differences between the species, suggesting that these two continents have only joined together relatively recently

2) The following are the answers:

a) To protect the endangered species (e.g. mountain gorilla)

b) Develop and implement detailed species management strategies and plans for key stone and indicator species;

c) Establish and regularly update an effective framework for identifying and listing endangered and threatened species

d) Develop recovery plans for the conservation and survival of endangered and threatened species

e) Develop an effective mechanism for designating critical habitats concurrently with listing of species of conservation concern;

f) Develop measures for the conservation and management of species shared with neighbouring countries.

2) The two species may not normally interbreed because, for example, they have different courtship dances

17.6 Summary of the unit

Theories of evolution include those of Darwin and Lamarck. Darwin proposed that new species evolve by natural selection; Lamarck suggested that new species evolve by inheritance of acquired characteristics. Evidence for evolution comes from the study of fossils, comparative biochemistry, comparative anatomy, cell biology and adaptive radiation of geographically isolated organisms.

Natural selection results from selection pressures that keep populations in check. There are three types of natural selection: stabilizing selection, directional selection and disruptive selection. Industrial melanism, antibiotic resistance in strains of bacteria, and pesticide resistance in insects are examples of evolution in action. Natural selection can lead to a change in allele frequency; it can also result in alleles, such as that for sickle cell anaemia, being retained. Artificial selection by selective breeding has been carried out by farmers for thousands of years.

Speciation is the formation of new species. Isolation mechanisms which can lead to reproductive isolation and speciation include geographical isolation, temporal isolation, ecological isolation, behavioural isolation, mechanical isolation, gametic isolation and hybrid isolation. Allopatric speciation occurs in geographically isolated populations; sympatric speciation (for example, in the cord grass spartina) occurs among individuals living in the same area.

17.7 Additional Information for teachers

To teach this unit effectively, you should know the following other theories of evolution:

1. Francesco Red (1626 -1697), Italian biologist

He carried out a series of controlled experiments to investigate if meat could give rise to maggots

Experiment 1: Meat was placed in an unsealed jar, he observed that flies laid eggs on the meat and maggots emerged.

Experiment 2: Meat was placed in a sealed jar, he observed that flies could not enter the seal jar and therefore, the maggots did not form on the meat.

Experiment 3: Meat was placed in a jar covered with gauze, he observed that the gauze prevented flies from entering jar and therefore, the maggots did not form on the meat.

Conclusion: -Maggots arise from the eggs laid by flies. (All life arises from other life)

-Red disapproved Aristotlee from the eggs laid by flies. (All life arises from other life) e

2) Antony Van Leeuwenhoek (1632 -1723)

- He discovered microscopes
- He used microscope and discovered very little living creatures, he called "animalcules" (little animals). He discovered many small life forms including: bacteria, protozoa and nematodes.

Conclusion:

- Air contains the living things (animalcules).
- Living things are not arisen from non-livings (organic matter).

3) Louis Joblot (1645 -1723), a French microscopist.

He carried out an experiment to investigate if the animalcules observed by Antony really dropped from the air or not. He confirmed that animalcules did not arise spontaneous **but were floating in the air**, thus disapproving the theory of spontaneous generation

4) Louis Pasteur (1822 -1895), a French biochemist and microbiologist.

Louis Pasteur showed that the living organisms grew in **broths come from outside** and were not spontaneously generated within the broth. This was one of the last and most important experiments disapproving the theory of spontaneous generation.

5) Big bang theory

- There was the moment of nothing, then after that moment there was something: our **universe**.
- The importance of the Big Bang theory is to explain what happened during and after that moment.

13.7 billion years ago, our universe sprang into existence as **singularity** (Zone of **intense gravitational pressure**, Zone of i**nfinite density** and Are thought to exist at the core of **black hole**)

- Our universe is thought to have begun as an infinitesimally small, infinitely hot, and infinitely dense

17.8 Answers for end unit assessment 17

Answers of multiple choice questions

1) b

2) a

Short answers

3) Pentadactyl limb in mammals, Australian marsupials or Darwin's finches

4) a) An increase in the frequency of the C allele

b) No change in the rate of mutation

5) In malaria-infested areas, heterozygotes HbAHbS are fitter than either homozygote: they are much less likely to suffer malaria than those homozygous for the normal allele (HbAHbA genotypes) and they do not suffer sickle-cell anaemia like the HbSHbS genotypes.

6) The following are the answers:

a) Homologous structures come from common ancestors, analogous structures evolve not from common ancestors but due to the things like changes in the environment

b) Similar structures amongst different species help scientist figure out the history of evolution. This is known as homologous structure. Human arms, cat forelegs, whale flippers, and bat wings all have the same basic bone structure. While the function of each of these is different, they are all variations of a common ancestor that has simply adapted to different functions.

Answers for essay questions

7) Fossil evidence: preserved parts either in form actual organisms, impressions and fragments of the body parts given on ideas of their external appearance.

Geographical distribution: fossil records and living things along a given zone usually show similarities, which show possibility of a common ancestry.

8) Comparative embryology: the development of vertebrate's embryo resembles one another show that the vertebrates have a common origin (ancestor). Even though the adults vary in many aspects.

Comparative anatomy or morphology: homologous structure are observed in vertebrates, but are diverged and modified for a particular role.

The environment or nature selects the individual with variations that are favoured by the environment. These compete with the others and able to reach sexual maturity, reproduce and pass over the favorable characteristics to their offsprings.

9) **Lamarckism**; An organism can pass on characteristic that it acquired to its offspring. Organisms evolve overtime due to the environmental factors that act up on that organism. E.g: A giraffend pass over the favorable characteristics to their desire for treetop leaves.

Darwinism: The term Darwinism has been applied to the evolutionary theories of Charles Darwin. Organisms evolve overtime due to the environmental factors the origin of species; his theory has been further supported by evidence from many different branches of science. In this spread we shall consider briefly some of the evidence which, in the minds of most scientists, has confirmed evolution as the central process in biology

10) The following are the answers:

i) There are still new mutants being formed in various populations resulting to new organisms.

ii) New hybrids of both plants+ animals.

iii) Formation of new strains of diseases causing microorganisms due to resistance to antibiotics, fungicides and drugs.

11) The following are the answers:

a) Lamarck was able to show that the environment influences the cause of evolution and characteristics are passed from parents to their off springs through reproduction.

b) Darwin on the other hand observed that species change with changes in the immediate environment as cited by Lamarck.

c) It shows that only those individuals with favourable added variations are acted upon by natural selection to form new species.

d) They said that the characteristics in an organism; we and we know today as genes undergo changes (mutations) that can be selected by the environment to form a different phenotype.

12) Knowledge about the chromosome and gene as the unity of inheritance; allows to understand handling of characteristics (now genes) from parents to their offsprings through reproduction. Genes are in DNA or RNA > Proteins > phenotypes

13) The following are the answers:

a) a)Resistance: any inherited characteristic of an organism which reduces the effect of an adverse environmental factor/ named example such as pest/pesticide/ salinity/ etc.; adverse factor does not cause the mutations which produce the resistant alleles; alleles for resistance already present in gene pool of population, although at low frequency; or new alleles arise randomly by mutation; presence of adverse factor creates strong selection pressures for resistance alleles; allele for resistance may initiate production of enzyme to break down drug/ pesticide/ virus/

b) Drug resistance: some strains of bacteria have been developed resistance to drugs/ antibiotics; Staphylococcus aureus/ allow bacteria to survive in the presence of methycillin/ penicillin/other named antibiotic; gene conferring resistance can be transferred to other bacteria making them resistant;

c) Pesticide resistance: Some forms of insects such as mosquitoes/Anopheles/aedes/ other named example have developed resistance to insecticides such as DDT

d) Herbicide resistance: groundsel/Senecio vulgaris/ other named example; is a major pest as a weed, competing with crash crops for resources; triazine herbicides bind to thylakoid membranes of chloroplasts prevent photosynthesis; resistant plants may possess genetically controlled mechanisms to prevent herbicide binding.

e) Disease resistance: Some rabbits have developed resistance to myxomatosis; virus rended ineffective by mutated gene in some cases; in others behaviuor of rabbit is altered by mutant gene, causing it to spend more time out of its burrow and therefore less chance of being infected by fleas from other rabbits; resistance to rust in flax

f) Resistance to heavy metals: heavy metals/tin/ copper/ lead/ nickel toxic to most plants; some varieties of grasses/ festuca ovina/ agrostis tenuis/ other named example have developed resistance to toxicity/ can survive high levels of these metals; so can colonise where other plants can't

17.9 Additional activities

17.9.1 Remedial activities

Multiple choice questions: choose the best answer

1) A species of finch living on an isolated island shows variation in beak size. Birds with larger beaks can eat larger seeds. After a period of drought on the island, large seeds were more plentiful than small seeds and the average size of the finches' beaks increased. What explains this increase in size of beak?

   a) Artificial selection acting against finches with small beaks

   b) Directional selection acting against finches with small beaks

   c) Increased rate of mutation resulting in finches with larger beaks

   d) Stabilizing selection acting against finches with the smallest and largest beaks

2) Which effect of natural selection is likely to lead to speciation?

   a) Differences between populations are increased.

   b) B. The range of genetic variation is reduced.

   c) C. The range of phenotypic variation is reduced.

   d) D. Favourable alleles are maintained in the population.

Answers

1. c

2. b

17.9.2 Consolidated activities

The wings of butterflies are covered with microscopic scales that give them their colour and also provide waterproofing. The wings of some species have large transparent areas through which the colour of the vegetation on which the butterfly has settled can be seen. Because they lack scales, these areas have poor waterproofing. The butterflies are eaten by birds.

1) Describe two selection pressures that are likely to control the size of the transparent areas of the wings of these butterflies

2) In what circumstances might there be selection for larger transparent areas in the wings?

Answers

1) predation by birds, tending to increase the size of the transparent areas of the wings as they increase camouflage; rainfall, because smaller transparent areas give an advantage

2) increased predation / drier conditions;

17.9.3 Extended activities

1) Rearrange the order of the following statements to give a flow diagram showing the evolution of resistance to the antibiotic streptomycin by the bacterium Escherichia coli.

a) Most of the population of E. coli is resistant to streptomycin.

b) A mutation in a DNA triplet of a plasmid, changing TTT to TTG, gives an E. coli bacterium resistance to streptomycin.

b) The resistant bacterium divides and passes copies of the R plasmid (plasmid with gene for resistance to antibiotic) to its off spring

c) Sensitive bacteria die in the presence of streptomycin as a selective agent.

d) The frequency of the mutated gene in the population increases.

e) The resistant bacterium has a selective advantage and survives.

2) Pale and dark peppered moths were collected and placed on pale and dark areas of bark on trees in Akagera Park, Rwanda. Some of the moths were predated by birds. The results of the investigations are shown in the table.

Colour of moth	Percentage of moths taken by birds	
	From pale bark	From dark bark
Pale	20	44
Dark	40	15

a) 40 dark moths were placed on dark bark. Calculate the number of moths taken by birds. Show your working. Suggest an explanation for the differences in the numbers of moths taken by birds.

Answers

1) b, d, f, c, e, a

2) The following are the answers:

a) 40 × 40 ÷ 100 = 16

b) pale moths are camouflaged on pale bark, and dark moths on dark bark; predators / birds, hunt by sight; fewer moths taken that match bark; refer to figures: 20% v. 44% of pale moths / 15% v. 40% of dark moths;

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