BIOLOGY

TEACHER'S GUIDE

GRADE 12

2023

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF EDUCATION

BIOLOGY TEACHER'S GUIDE GRADE 12

BIOLOGY

TEACHER'S GUIDE
GRADE 12

2023

ISBN 978-99990-0-015-4

Biology

TEACHER'S GUIDE

GRADE 12

Writers:

Anbessa Dabassa (PhD)

Eba Alemayehu (PhD)

Pedagogical Editor:

Meskerem Cheru (MSc)

Content Editor:

Destaw Damtie (PhD)

Language Editor:

Yenus Nurie (PhD)

Illustrator:

Nega Tassie (PhD)

Designer:

Ali Seid (PhD)

Evaluators:

Berhanu Tesfaye (MA & MEd)

Gebrehana Zeleke (MSc)

Samuel Desalegn (MSc)

Bekele Geleta (MSc)

First Published August 2023 by the Federal Democratic Republic of Ethiopia, Ministry of Education.

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

Printed by:

GRAVITY GROUP IND LLC

13th Industrial Area,

Sharjah, UNITED ARAB EMIRATES

Under Ministry of Education Contract no. MOE/GEQIP-E/LICB/G-01/23

ISBN: 978-99990-0-015-4

Table of Contents

I. Introduction

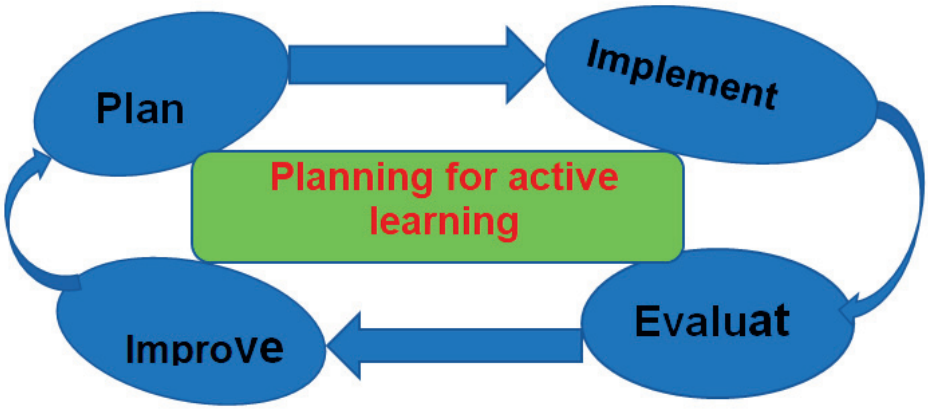
The purpose of Grade 12 biology teacher's guide is desined to provide useful and informative insructions for grade 12 biology teachers and students and introduce the contents, teaching-learning strategies, activities, assessments and related support materials. It also aims to help teachers reinforce the teaching learning process by explicitly communicating the conceptual goals of contents with suggested strategies, activities and assessments. This guide also aims to equip the teacher with relevant pedagogical and content knowledge that will enable him/her how to plan, organize lesson and activities, teach a lesson and assess their students' learning in an effective way while teaching.

This teacher's guide focuses on active learning methods (activity based learning, critical thinking, multidirectional, collaboration, and cooperation, change in the role of teacher (facilitator)); formative continuous assessment (aligned with the on-going and frequent learning objectives, providing useful feedback to students (peer and self-assessment)); and principle of talular (Teaching and learning using locally available resources).

Grade 12 biology teacher's guide was developed based on important documents such as grade 12 biology syllabuses, which contain relevant contents, minimum learning competencies and learning and assessment strategies. This guide is the most important resource for the teaching learning process. Therefore, the teacher will need to have a copy of it as well as the syllabus to support effective instructional practices and improve the learning outcomes.

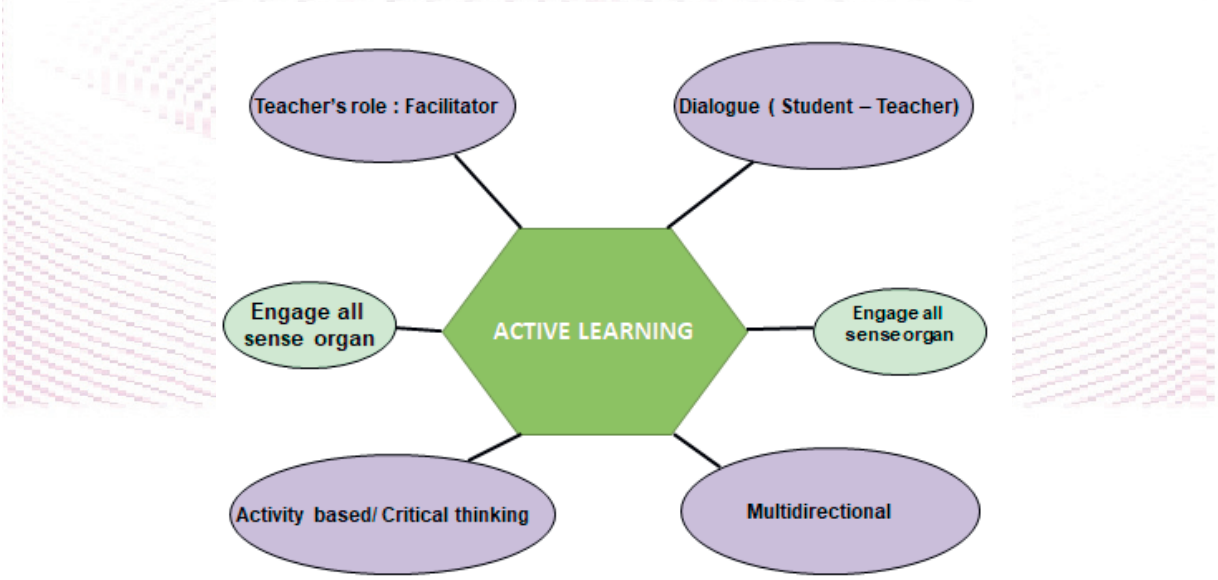
II. Planning

Lesson plan is the instructor's road map that provides the teacher with what students need to learn and how it will be done effectively during the class time. Before you plan your lesson, you will first need to identify the expected learning objectives for the lesson. Then, you can design appropriate learning activities and develop strategies that will help you to obtain feedback on student learning. Therefore, lesson plan addresses and integrates these three key components: Objectives for student learning, Teaching/learning activities, Strategies to check student understanding. **Annual, Unit and Lesson Plan** would be the road map for the teacher.



III. Active learning

Active learning methods require students to fully participate in their learning by thinking, discussing, investigating, and creating. In active learning classrooms, students may be asked to practice skills, solve problems, struggle with complex questions, propose solutions, and explain ideas in their own words through writing and discussion. Therefore, active learning reinforces important material, concepts, and skills, provides more frequent and immediate feedback to students, provides students with an opportunity to think about, talk about, and process course material, and Creates personal connections to the material for students, which increases their motivation to learn.



IV. Activities

Different activities are included in the student textbook to support the goal of teaching students to be responsible and give them opportunities that develop character, critical thinking, problem-solving, team building, and leadership skills. Furthermore, some of the activities are designed in such a way that will enable students to search for information from different sources and present their findings to the class. For some of these activities, this guide provides you with some brief information as a hint so as to help you extend more investigation. While other activities that need to be are designed to be addressed in the class are left out for you, you can use the information that is given in the textbook.The teacher needs to actively engage students while they are doing the activities.

V. Assessment

Student assessment is one of the components of the daily lesson plan. Assessment is the systematic basis for making inferences about the learning and development of students. It is the process of defining, selecting, designing, collecting, analysing, interpreting and using information to increase students' learning and development.

Formative assessment is an assessment during the course of instruction rather than before it is started or after it is completed. It helps to observe and monitor student learning and check that students understand the lesson, thereby improve instruction.

Summative assessment is an assessment to be conducted after a lesson, or unit is completed. It is usually conducted usually to document the student scores or marks and check whether competencies are achieved.

The teacher can use assessment techniques for different competencies. She/he needs to involve the students in the assessment process although they can come to see themselves as competent learners. A good classroom assessment plan gathers evidence of student learning and informs teachers' instructional decisions. For instance, you can use observation, reflection, presentation, concept map, tests / quizzes, lab reports, examinations, classroom discussions, exercises, assignments, group works, projects, interviews, group discussions, questionnaires and field reports.

UNIT 1

The Applications of Biology in a day to day life (11 PERIODS)

Unit learning out come

Learning Outcomes: After the successful completion of this unit, the learner will be able to:

- Appreciate nature as a source of biological knowledge
- Explain the application of biological knowledge in different areas in their environment
- Discuss the role of biology in enhancing their livelihood
- Value the contribution of biologists and promises biology will have for the society.

Unit minimum learning competency

- Explain the relation between nature and biology
- Describe ways to appreciate nature
- Discuss the role of Biology in the conservation of natural resources
- Practice school-based gardening as one strategy of addressing food security.
- Realize the significance of biology in social, cultural, and economic development in a different context
- Apply Biological knowledge to support their lives (career, health and wellbeing)
- Explore Biological applications in their surroundings (agriculture, industry, medicine, waste treatment plants, etc.)
- Define Biotechnology
- Discuss how Biotechnology is traditionally applied in their localities

- Interview a Biologist and search through the internet to come up with a possible list of the promises of Biology to the society

Learning strategies

- Let students observe their environment critically and relate it with the knowledge used in the development of technology (e.g. critically observe how birds fly and relate it with technology in the development of an airplane etc.). Then, students can realize the relationship between nature and biology.
- Allow students to reflect on what natural resources are by mentioning examples and whether they are limited or infinitely available in the environment. Then, introduce them the meaning and importance of conservation of these natural resources and the role of biology in the conservation of natural resources
- Form groups and grow different vegetables in the school compound on the ground/in pots to easily demonstrate how one can secure food in a small area.
- Ask students about how they can relate biology to social and cultural context; economy and job opportunity. List some examples and discuss them in class.
- Students in pairs undergo role plays to show the application of biological knowledge in everyday life for example for income generation and means of living.
- Let students read their textbook first and then prepare an activity for students to ask professionals about the applications of biology in agriculture, industry, medicine, waste treatment plants, etc., and prepare notes. They peer review each other's notes and come up with some sort of generalization. The teacher will summarize it at the end.
- Allow students to undergo reciprocal questioning to understand biotechnology and its traditional applications in Ethiopia (competencies (7-8)
- Let students first imagine what promises biology will have for the society and then they will read the textbook and supplementary books or undergo an internet search/ask a biologist to get knowledge about the promises of biology to the society.

1. Applications of Biology

1.1. Application in Conservation of natural resources

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate learning from food security. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lessons about food security and factors that affect food security, you can use questions in the textbook and encourage them participate actively.

III. Tasks

Support learners to understand better, let them share their ideas with one another, and answer the self-assessment question.

Q1. Do you agree with the following argument: We should conserve natural resources? Why? Yes.

Natural resources are very important for living things. Humans, plants, animals, and microorganism need natural resources to survive. That is why we say conserving natural resources, which means protecting natural resources is important. Imagine what would happen if we could not conserve water and clean air? So, how can we conserve our natural resources? Some natural resources cannot be renewed or replaced. Those resources may run out due to overuse by humans. It is our responsibility to conserve our natural resources. By doing this, we can balance the amount of resources we have and the amount we consume. It is important to reduce, reuse, and recycle the materials we obtain from our natural resources. For example,

- Walk or ride a bike instead of using car
- Use less water (reduce use of water by turning off tap water)
- Use a washbasin to wash materials instead of running water
- Turn off electricity when not using it.
- Use sun light instead of electricity when we read
- Use worn-out plastic bottle as planting pot or pencil holders

Fossil fuels are typical examples of natural resources that cannot be replaced. Conserving fossil fuels will have to anchor that we have enough for our future generation. The burning fuel causes air pollutions, which is one of the environmental problems we have today. We can reduce the amount of air pollution by using fewer fuels.

Q2. Explain the concept that human should practice sustainable management of natural resources.

The Earth's natural resources include soil, air, water, plants, animals, light, stone, minerals and fossil fuels. We/human beings have to conserve our natural resources since many of them are limited. To conserve means to protect something from harm or destruction. Many people are committed to taking care of the earth's natural resources. (The jotted answers in **Q1-** well explains the ways we need to practice conservation)

Q3. How the knowledge and application of conservation is critical to the survival of our people?
Conservation is the act of protecting Earth's natural resources for current and future generations. They are important for the cash economy, for creating energy, for providing shelter, for food and medicine, and for spiritual well being. By protecting and conserving natural resources we help to ensure that they are available for use not only today, but in the future as well.

Activity 1.1 and 1.2: Natural resources of Ethiopia

Starter activity: Have a brainstorming session and tell them to think of as many natural resources of Ethiopia as they can. Tell them that resources can be divided into renewable resources and non-renewable resources.

Main activity: The student should make a poster or collage to show these natural resources. They should divide the poster into renewable and non-renewable resources. They can draw living or non-living things, cut pictures from different sources and stick them on, collect fur or feathers from animals use their imagination to make their poster as interesting as possible to show people the great variety of our natural resources.

Concluding activity: The teacher observes the students activity and gives the final summer for further students understanding.

Assessment method

- Ask students questions related to the lesson and give them a chance to answer the question. For example:
  - What do we mean by natural resources?
  - What are the differences between renewable and non-renewable natural resources of Ethiopia?
- Evaluate their awareness based on their responses to resources in Ethiopia

1.2. Food and nutrition security

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate learning from food security. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lessons about food security and factors that affect food security, you can use questions in the textbook and encourage them participate actively.

III. Tasks

Support learners to understand better, let them share their ideas with one another, and answer the self-assessment question.

Q1. Which biological application is important for maintaining food security?

❖ **Answer:** biotechnological application

Biotechnological application can:-1) increase crop yields through introducing high-yielding varieties resistant to biotic and abiotic stresses; 2) reduce pest– associated losses; and 3) increase the nutritional values of foods which is a very important factor in rural areas or developing countries.

Activity 1. 3a: Group work:

- **Starter activity**: Form a food security committee among students who will be assigned to coordinate garden /pot vegetables at school. A food security committee makes decisions about how a school's garden will look like, what it will be used for, and how it will operate. (The committee can also include the school's administration, teaching staff, students, parents, and community volunteers)
- **Main activity**: Teach the committee member and the students to monitor the practical activity and the importance of garden vegetables for food security.
- **Concluding activity**: Support the school cafeteria or tea club with the vegetable produced in the school garden by food security committee members.

Aditional note

Food security: refers to a situation whereby all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for active and healthy living. Nutrition security

Nutrition security is a situation whereby individuals have access to sufficient, safe and nutritious foods, safe water and adequate sanitation, the ability to access health care services, and knowledge of sound household and community practices in child care, food storage and preparation and hygiene

Bio fortification is a strategy for increasing micronutrient levels in food groups through the use of modern biotechnology techniques or traditional plant breeding and agronomic practices. It is a one-time investment that provides a cost-effective, long-term, and sustainable strategy for combating hidden hunger. Bio fortification can be accomplished in three ways: 1. Transgenic using modern biotechnology, 2. Conventional breeding, and 3. Agronomy through fertilizer Micronutrients fortificated on selected

Activity 1.3b. Individual work.

Starter activity: Before the class, inform students to Google or read an additional book on food availability, food security, and food insecurity.

Main activity: The students present what they read to the class during the class session.

Concluding activity: Observe their presentation and give a summary for further understanding of the students.

Nutritional security is different from food security as it is about a community's access to essential nutrients, not just calories. Food security refers to the causes and effects of food availability whereas nut riti on security refers to the entire relati onships among food availability, caring capacity, health services, environmental conditions, food intake, health status and, ultimately, nutritional status. However, both food security and nutrition security go in tandem. Nutrition security is overarching and contains food security within it. The conceptual framework below shows the relationships as well as the difference().

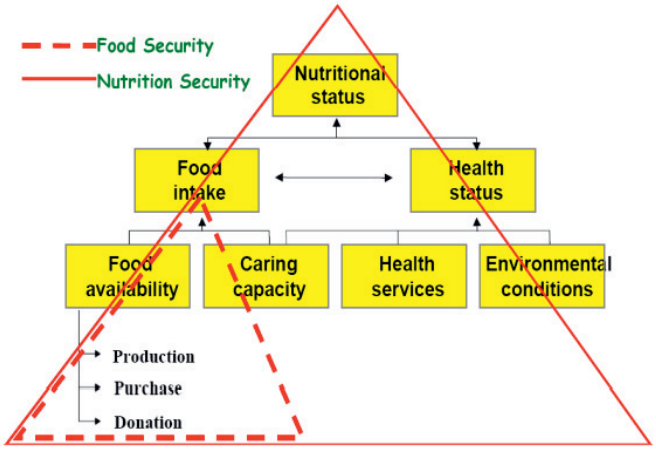


Figure 1.1. conceptual framework of nutritional security

Biofortification is **the process of breeding staple crops to have higher levels of essential nutrients either through selective breeding or genetic modifications**. For example, biofortification of wheat with zinc, golden rice.

The major aim of biofortification is to;

- Improved protein content and quality,
- Improved oil content and quality,
- Improved vitamin content
- Improved micronutrient and mineral content of the food items.

Table 1: List of biofortified food items released by Ethiopia

Food items	bio fortified by:-	Status
Maize -vitamin A fortified maize	vitamin A	Released
Rice	Zinc, β-carotene (vitam A)	Released
Pearl millet	Iron and zinc	Released
Orange flesh sweet potato	Vitamin A	Released
Oats	Zinc	Released
Maize-quality protein mainze	Protein	Released
Iron and zincs beans	Zinc and iron	Released

Assessment method

- ❖ Ask students questions related to the lesson and give them chance to answer the question.
- ❖ Evaluate their awareness of food availability, food security, and food

Global food supply is not evenly distributed. Some places produce more food than others. **Physical factors** (such as climate, soil quality and gradient) and **human factors** (such as technology) have historically controlled the quantity and type of food produced in any location.

Impact of food insecurity

Food security is when the entire population of a country has access to enough safe and nutritious food to maintain an active life. The opposite is food insecurity, which is a problem for lots of different countries. Countries that do not have enough food to feed their citizens usually have other associated issues to overcome. Some impacts of food insecurity include:

Famine - the World Food Program classifies three hunger conditions:

- **Undernourishment** is when people do not consume enough calories. Over 800 million people in the world are undernourished.
- **Malnutrition** is when people do not eat enough of the right kind of foods to keep them healthy.
- **Wasting** is the most serious type of hunger. It is severe weight loss due to acute malnutrition resulting from starvation.

- **What is the difference between food security and food insecurity?**

Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Food insecurity is defined as the disruption of food intake or eating patterns because of lack of money and other resources. Low food security refers to "Reports of reduced quality, variety, or desirability of diet. Food insecurity debilitates society by increasing mortality, disease and disability. It inflates the direct economic costs that are used to cope with the health impacts and enormous reduction in human potential and economic productivity, brought about by hunger and malnutrition (See **Figure 1.1**).

- **What are the effects of food insecurity?**

Poverty, unemployment/under-employment, and inconsistent access to enough healthy food are sources for food insecurity.Food security is also caused by the following factors

- War & conflict

- Climate change
- Poor nutrition
- Poor public Policy
- Economy
- Food waste
- Gender inequality
- Forced Migration

Hunger is usually understood as an uncomfortable or painful sensation caused by insufficient food energy consumption. Scientifically, hunger refers to food deprivation. To put it simply, all hungry people are food insecure, but not all food insecure people are hungry, as there are other causes of food insecurity, including those due to poor intake of micro-nutrients.

Malnutrition results from deficiencies, excesses or imbalances in the consumption of macro- and/or micronutrients. Malnutrition may be an outcome of food insecurity, or it may relate to non-food factors, such as:

- inadequate care practices for children,
- insufficient health services; and
- an unhealthy environment.

While **poverty** is undoubtedly the cause of hunger, lack of adequate and proper nutrition itself is also an underlying cause of poverty.

"**Poverty** encompasses different dimensions of deprivation that are related to human capabilities including consumption and food security, health, education, rights, voice, security, dignity and decent work."

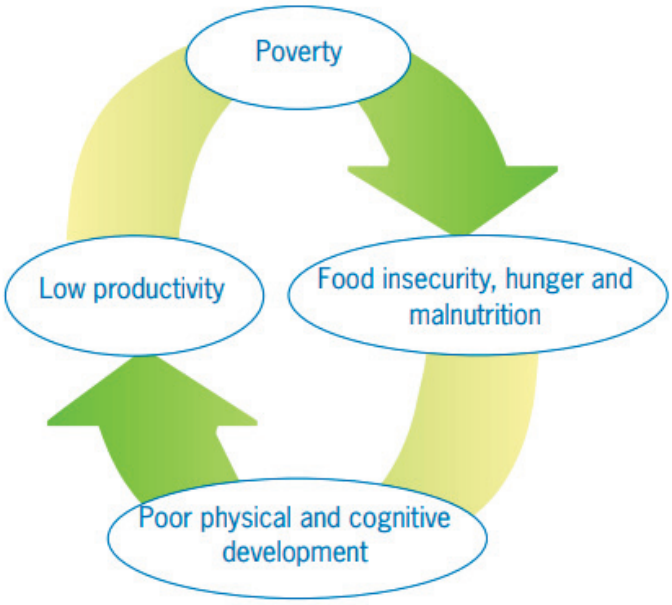


Figure 1:1. Food insecurity, malnutrition and poverty are deeply interrelated phenomena

1.3. Creating conscious citizens and ensuring sustainable development

- **Q1. What do we need to be conscious global citizens?**

As people who live in this world, we should all want to be a **conscious global citizen**. A global citizen is someone who is aware of what's happening in the world and how they personally as well as how other global citizens can impact the world with their actions.

A conscious citizen is one who places value on being fully human while connecting with a higher purpose; one who values human life and the relationship among all living things, and takes responsibility for transforming skill into action, through ethical decision making, to ultimately improve life and living.

Therefore, a global conscious citizen is someone who is aware of and understands the wider world and the places in it. They take an active role in their community and work with others to make our planet more peaceful, sustainable and fairer. Global citizenship helps young people tobuild their own understanding of world events. Besides, a global conscious citizen is respectful of cultural diversity and human rights. They are empathetic to the causes and suffering around the world and feel responsible for their impact on it and strive to make change. They see themselves as citizens of the world rather than a single country.

- **Q2. How do we become a conscientious citizen?**

A conscientious citizen remains alive to his own **responsibilities** and **duties**. He becomes eager to take any step for the **development of the state**. To the conscientious citizen, the right and the unjust depend on judgment and conscience. Social welfare and patriotism give rise to the sense of conscience.

A conscious citizen of the world sees the interconnection of one's actions and their consequences. When young students become successful adults who contribute to a better world as conscious citizens, we really begin to realizethe results of our education.

Civic consciousness is also a form of social consciousness that co-exists with the concept of citizen. In a narrow sense, in contrast to servant consciousness characterized by analysis, civic consciousness mainly refers to the cognition of a citizen's qualification or status with equal civic rights and obligations.

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

- Define conscious citizen.
- Explain the role of education in creating a conscious citizen.
- Describe the meaning of a conscious global citizen.

- **Q3. How do we promote responsible citizenship?**

A **responsible citizen** has knowledge about his/her role in the community, state and the world. A responsible citizen has a role in making the world a better place to live in (for every component in biosphere). A responsible citizen is a change agent that acts out against injustice in social, economic, and environmental sectors.

Dear Teacher, **activity 1.3c on student book is related to this question (the Q3 above)**

A good citizen is patriotic citizen who practices responsible citizenship including.

- Brushing up on your country's history.
- Reading up on social studies.
- Obeying the rule of law.
- Paying your taxes.
- Learning the national anthem.
- Hoisting your country's flag.
- Avoiding in litter or engaging in acts of vandalism that deface your environment.
- Traveling around your country and talkin to your fellow citizens.

1.4. Applications in biotechnology

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate learning from health and wellbeing. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about health and wellbeing, you can use question in the textbook and encourage them toparticipate actively.**III. Tasks**

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Activity 1.4: Group work

1. **Starter activity:** Before the class, group the student into 5-10 members and direct them to ask from their family or neighbours or the experts from their surrounding the ingredients, recipe, and biotechnology of the following traditional fermentation products.

- Making "Injera"
- Making "Areki"
- Making "Tej"
- Making "Tella"
- Making yogurt

2. Main activity: The students prepare their own note and discuss in their group at class room

3. Concluding activity: By observing the student presentation, the teacher will give them summary of the presentation for further understanding of the students.

Assessment method:

- Correct their paper after the presentation and record the results.
- Observe the discussions and comment on important issues.
- Evaluate the presentation techniques of the groups.

- **Q1. List microorganisms used in each fermentation products and explain why microorganisms are important for fermentation?**

Many fermentative and non-fermentative microorganisms are common to traditional fermented foods

For example: **1 Yeasts**

- *Candida humilis*
- *Meyerozyme guilliermondii*
- *Pichia kudriavzevii and*
- *Saccharomyces servisiae,* are common to all traditional fermented food and beverage of Ethiopia

Q2. What types of metabolites or bio-products are produced by those microorganisms?

- **Primary metabolites**

Differences between Primary and Secondary metabolites

Primary Metabolites	**Secondary Metabolites**
Ae the same in every species.	Are different in every species.
Perform physiological functions in the body.	Are derivatives of primarymetabolites.
e.g., carbohydrates, vitamins, ethanol, lactic acid.	E.g., Phenolics, steroids, antibiotics, pigments.

A primary metabolite is a kind of metabolite that is directly involved in the normal growth, development, and reproduction. A secondary metabolite is typically available in a taxonomically restricted set of organisms or cells (plants, fungi, bacteria, etc.).

Q3. What is backslopping traditional food fermentation? Give an example?

Back-slopping method is carried out by adding a small amount of fermented products into fresh ingredient and then is left to be fermented in room temperature. Finally, a stable microbial community is formed after a few cycles. (**For example absit (raacatii)**)

Activity 1.5 Group work

Starter activity: Guide the students to make a group and discuss the role of biosensor and differenciate the characterestics and areas of application of biosensor.

Main activity: Motivate a student to represent the group and present their discussion.

Conclusive activity: The teacher gives the summary for their presentation for further understanding of the students.

Forensic Science

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures and videos to teach and demonstrate learning from biological warfare. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods
Use student-centered strategy and learning by doing. In delivering the lesson topic about biological warfare, and you can use question in the textbook and encourage them toparticipate actively.

III. Tasks
Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Activity 1.6.

- **Q1. Where do we apply forensic science?**

  Ans. Forensic science can beapplied not only in investigation and prosecution of crimes such as rape, murder, and drug trafficking but also in matters in which a crime has not been committed but in which someone is charged with a civil wrong, such as willful pollution of air or water or causing industrial injuries.
- Q2. Why is forensic science more reliable than other types of investigative approaches?
  Ans. DNA fingerprints are used to differenciate a criminal and are considered the most accurate or among the most accurate forensic techniques.
- **Q3. What tools are used in forensic science?**
- Ans. Forensic laboratory equipment such as, Thermocyclers, or thermal cyclers, microscopes, fume hoods, chromatographs and spectrometers, to equipment used for specific forensic analysis, like cyanoacrylate fuming chambers for lifting of latent fingerprints.

Activity 1.7.
Make a group and discuss the role of biological knowledge in forensic science.

Ans. Forensic biologists analyze cellular and tissue samples, as well as physiological fluids that are relevant to a legal investigation. These techniques can also definitively identify paternity/ kinship relationships and are used to determine the manner, mechanism, cause and time of death.

(Vi). Application in the Environment

Activity 1.8

1. Describe how biofuel is produced?

Ans. The most basic way to do this is through fermentation of crops that are high in sugar (starch) or fat into ethanol, which can be mixed directly with gasoline to power cars. In the Northwest, oilseed crops like canola or sunflowers are used to make biofuels.

2. Distinguish between biodegradable and non-biodegrdable substances.

   Ans. Biodegradable wastes are those substances that degrade or break down naturally. Non-biodegradable wastes are those substances that do not degrade easily. Materials like plants, animals, their waste, paper, fruits, vegetables fall under the category of biodegradable substances.

3. Explain the importance of microorganisms in wastewater treatment.

Ans. The role of microorganisms in wastewater treatment helps to treat and purify wastewater and make it less harmful to the environment. While there are many different microbes used in sewage treatment, there are three well-known microbes that play an instrumental role in keeping sewage clean.

Q1. What are the three stages of wastewater treatment?

Ans. There are three main stages of the wastewater treatment process, aptly known as primary, secondary and tertiary water treatment.

Viii. Biological warfare

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures and videos to teach and demonstrate learning from biological warfare. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about biological warfare, and you can use question in the textbook and encourage them toparticipate actively.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

- **What is biological warfare?**

Biological warfare, also known as germ warfare, is the use of biological toxins or infectious agents such as bacteria, viruses, insects, and fungi with the intent to kill, harm or incapacitate humans, animals or plants as an act of war. Biological weapons are living organisms or replicating entities.

- **Biological warfare: an emerging threat in the 21st century**
- **Why the use of biological warfare is prohibited?**

  Biological weapons disseminate disease-causing organisms or toxins to harm or kill humans, animals or plants. They can be deadly and highly contagious. Diseases caused by such weapons would not confine themselves to national borders and could spread rapidly around the world.

The Biological Weapons Convention (BWC) effectively prohibits the development, production, acquisition, transfer, stockpiling and use of biological and toxin weapons. It was the first multilateral disarmament treaty banning an entire category of weapons of mass destruction (WMD).

The international community banned the use of chemical and biological weapons after World War I and reinforced the ban in 1972 and 1993 by prohibiting their development, stockpiling and transfer. Advances in science and technology raise concerns that restraints on their use may be ignored or eroded.

Review Questions

Answer

1. Genetic engineering is a process that uses laboratory-based technologies to alter the DNA makeup of an organism**.**
2. Gene cloning and gene therapy are two different processes that involve manipulating the DNA of an organism. Here are some of the main differences between them:
   - Gene cloning is the process of making copies of a specific gene or segment of DNA, usually for research or biotechnology purposes. Gene therapy is the process of introducing a normal gene into an individual's genome in order to repair a mutation that causes a genetic disease
   - Gene cloning uses a carrier called a vector, such as a bacterium or a virus, to insert the gene of interest into another DNA molecule. Gene therapy uses various methods of gene delivery, such as transformation, transfection, transduction, or electroporation, to insert the normal gene into the cells or tissues of the patient
   - Gene cloning can produce multiple copies of the same gene in a laboratory setting. Gene therapy can modify the genes of a single individual in vivo (in the body) or ex vivo (outside the body)
   - Gene cloning can be used to study the function and expression of genes, to produce useful substances, such as proteins or hormones, or to create transgenic organisms, such as plants or animals. Gene therapy can be used to treat genetic diseases, such as cystic fibrosis or hemophilia, or to enhance the immune system against infections or cancers

3. Some of the properties that have been acquired by crop plants via genetic engineering are:

- **Herbicide tolerance**: This property allows the crop plants to survive the application of herbicides that kill weeds. For example, some soybean, maize, canola and cotton varieties have been genetically modified to tolerate glyphosate, a widely used herbicide
- **Insect resistance**: This property enables the crop plants to produce toxins that kill or deter insect pests. For example, some maize, cotton and eggplant varieties have been genetically modified to express genes from the bacterium Bacillus thuringiensis (Bt), which produces proteins that are toxic to certain insects
- **Abiotic stress tolerance**: This property enhances the crop plants' ability to cope with environmental stresses, such as drought, salinity, cold or heat. For example, some rice, wheat and potato varieties have been genetically modified to improve their water use efficiency, salt tolerance, frost tolerance or heat tolerance
- **Disease resistance**: This property confers the crop plants with immunity or resistance to viral, bacterial or fungal diseases. For example, some papaya, squash and plum varieties have been genetically modified to resist specific viruses, such as the papaya ringspot virus, the cucumber mosaic virus and the plum pox virus
- **Nutritional improvement**: This property modifies the crop plants' composition or quality to increase their nutritional value or health benefits. For example, some rice, banana and cassava varieties have been genetically modified to increase their content of vitamin A, iron or zinc, respectively

4. **Single-cell protein** is a term that refers to the protein derived from microorganisms, such as algae, bacteria, fungi, or yeast. These microorganisms can be grown in large quantities in culture media, using different sources of carbon and energy, such as sugar, starch, molasses, methane, or sunlight. Single-cell protein can be used as a food supplement for humans or animals, especially in situations where there is a shortage of conventional protein sources.
5. DNA technology is the manipulation of DNA molecules to achieve a desired outcome, such as producing useful substances, modifying organisms, or diagnosing diseases. Some of the medical applications of DNA technology are:

    - **Diagnosis of genetic diseases**: DNA technology can be used to detect mutations or variations in the genes that are associated with certain genetic diseases, such as cystic fibrosis, sickle cell anemia, or Huntington's disease. This can help in early diagnosis, prognosis, and treatment of these diseases. For example, DNA technology can be used to perform prenatal testing, newborn screening, carrier testing, or predictive testing for genetic diseases.
    - **DNA typing (DNA fingerprinting):** DNA technology can be used to identify individuals based on their unique DNA sequences. This can help in forensic investigations, paternity testing, organ transplantation, or ancestry tracing. For example, DNA technology can be used to match crime scene evidence with suspects or victims, determine the biological father of a child, find compatible donors for organ recipients, or trace the origin and migration of human populations.
    - **Gene therapy:** DNA technology can be used to introduce normal or modified genes into the cells or tissues of a patient to treat a genetic disease or enhance a desired trait.

This can help in correcting defective genes, replacing missing genes, or adding new genes. For example, DNA technology can be used to deliver genes that produce insulin for diabetic patients, clotting factors for hemophilia patients, or immune cells for cancer patients.

- **Recombinant DNA technology in the synthesis of human insulin:** DNA technology can be used to produce human insulin by inserting the human insulin gene into a bacterial plasmid and transferring it into a bacterial cell. The bacterial cell then produces human insulin that can be purified and used for treating diabetic patients. This method is more efficient and safer than using animal insulin or synthetic insulin.
- **Hepatitis B vaccine:** DNA technology can be used to produce a vaccine against hepatitis B virus by inserting the gene that codes for the surface antigen of the virus into a yeast plasmid and transferring it into a yeast cell. The yeast cell then produces the surface antigen that can be purified and used as a vaccine. This vaccine stimulates the immune system to produce antibodies against the virus and prevent infection.

6. Biogas production is a complex process that involves different communities of anaerobic microbes that work together to degrade organic matter and produce methane and carbon dioxide. The main groups of anaerobic microbes involved in biogas production are:
   - Hydrolytic bacteria: These bacteria break down complex organic molecules, such as carbohydrates, proteins, and fats, into simpler compounds, such as sugars, amino acids, and fatty acids. Hydrolytic bacteria include species from the genera Clostridium, Bacteroides, Ruminococcus, and others.
   - Fermentative bacteria: These bacteria ferment the products of hydrolysis into volatile fatty acids (VFAs), such as acetic acid, propionic acid, butyric acid, and others. Fermentative bacteria also produce hydrogen, carbon dioxide, and other gases. Fermentative bacteria include species from the genera Acetobacterium, Propionibacterium, Butyribacterium, and others.
   - Acetogenic bacteria: These bacteria convert the VFAs (except acetic acid) and hydrogen into acetic acid and carbon dioxide. Acetogenic bacteria also convert other compounds, such as alcohols, lactate, and methanol, into acetic acid and carbon dioxide. Acetogenic bacteria include species from the genera Syntrophobacter, Syntrophomonas, Syntrophus, and others.
   - Methanogenic archaea: These archaea produce methane from acetic acid or hydrogen and carbon dioxide. Methanogenic archaea are the final and most important group of anaerobic microbes in biogas production, as they generate the main component of biogas. Methanogenic archaea include species from the genera Methanosarcina, Methanobacterium, Methanococcus, and others.
   - These four groups of anaerobic microbes form a syntrophic relationship, meaning that they depend on each other for their growth and survival. The products of one group serve as the substrates for another group, and the energy flow is balanced by the exchange of electrons and protons. The optimal conditions for biogas production depend on the type and composition of the organic matter, the temperature, the pH, the retention time, and the mixing of the reactor.

7. Bioremediation is helpful to humans in many ways. Bioremediation is the use of living organisms, such as bacteria, fungi, algae, or plants, to remove or reduce pollutants from the environment12 Some of the benefits of bioremediation are:

   - It is a natural and eco-friendly process that does not harm the ecosystems or create harmful byproducts
   - It is a cost-effective and scalable process that can treat large areas of contamination without requiring excavation or transportation of materials
   - It can degrade or transform a wide range of organic pollutants, such as oil, solvents, pesticides, and explosives, into harmless substances, such as water and carbon dioxide
   - It can also remove or immobilize some heavy metals, such as mercury, lead, arsenic, and cadmium, by biosorption, bioaccumulation, or bioprecipitation
   - It can improve the quality of soil, water, and air for human health and well-being
   - It can provide useful products, such as biofuels, bioplastics, enzymes, and antibiotics, from the metabolic activities of the microorganisms

   Bioremediation is a promising technology that can help humans to cope with the environmental challenges caused by pollution and waste. Bioremediation can also contribute to the sustainable development goals of reducing poverty, ensuring clean water and sanitation, promoting responsible consumption and production, and protecting life on land and below water

8. The practical application of DNA-based biotechnology affects human lives in many ways. Some of the examples are:

- In medicine, DNA technology can be used to diagnose genetic diseases, produce vaccines and drugs, and perform gene therapy. For instance, DNA technology can create insulin and growth hormones from genetically modified bacteria, which can help treat diabetes and growth disorders. DNA technology can also introduce normal or modified genes into patients' cells to correct genetic defects or enhance immunity.
- In forensics, DNA technology can be used to identify individuals based on their unique DNA fingerprints. This can help solve crimes, determine paternity, or trace ancestry. For example, DNA technology can match crime scene evidence with suspects or victims, or find compatible donors for organ transplantation.
- In agriculture, DNA technology can be used to create genetically modified crops that have improved traits, such as resistance to pests, diseases, or herbicides, or enhanced nutritional value or shelf life. This can help increase crop yield, reduce environmental impact, and support farmers. For example, DNA technology can create rice varieties that have increased vitamin A content, which can prevent blindness and malnutrition.

9. The production of human insulin by recombinant DNA methods has had significant medical advantages for diabetics for several reasons. Some of them are:

- Recombinant human insulin is identical to the natural hormone produced by the human body, unlike animal insulins, which have slight differences in their amino acid sequences. This reduces the risk of allergic reactions, immune responses, or insulin resistance that some diabetics may experience with animal insulins.

- Recombinant human insulin can be produced in large quantities and at a lower cost than animal insulins, which require extraction and purification from animal pancreases. This increases the availability and affordability of insulin for diabetics around the world.
- Recombinant human insulin can be modified to create insulin analogs that have improved pharmacokinetic and pharmacodynamic properties, such as faster onset, shorter duration, or longer action. This allows for more flexible and individualized dosing and better glycemic control for diabetics. For example, insulin lispro, insulin aspart, and insulin glargine are some of the insulin analogs that have been developed using recombinant DNA technology.

10. The two fusion proteins that are used to make human insulin are:

    - A fusion protein that consists of the A-chain of insulin attached to the Fc-domain of an immunoglobulin. This fusion protein is produced by using the 'knob-into-hole' technique, which forces the Fc-domain to form a heterodimer. The A-chain of insulin is then cleaved from the Fc-domain by cyanogen bromide.
    - A fusion protein that consists of the B-chain of insulin attached to the molecular chaperone αB-crystallin. This fusion protein is produced by using a plasmid that contains the gene for the B-chain of insulin joined with the gene for αB-crystallin. The B-chain of insulin is then released from αB-crystallin by cyanogen bromide.

    The two fusion proteins are then combined under oxidative conditions to form the disulfide bonds between the A-chain and B-chain of insulin. The resulting human insulin is then purified by phenyl sepharose hydrophobic interaction chromatography.

11. Some of the benefits of biofuels are:

    - Biofuels can reduce greenhouse gas emissions, which contribute to global warming and climate change. Biofuels are derived from biomass, which absorbs carbon dioxide from the atmosphere during photosynthesis. When biofuels are burned, they release the same amount of carbon dioxide that they absorbed, creating a closed carbon cycle. In contrast, fossil fuels release carbon dioxide that was stored underground for millions of years, increasing the net amount of carbon dioxide in the atmosphere. According to some studies, biofuels can reduce greenhouse gas emissions by up to 87% compared with fossil fuels.
    - Biofuels can enhance energy security and diversity, as they can be produced from a variety of feed-stocks that are available in different regions and seasons. Biofuels can reduce the dependence on imported oil and gas, which are subject to price fluctuations and geopolitical uncertainties. Biofuels can also provide a backup source of energy in case of supply disruptions or emergencies. Biofuels can be blended with fossil fuels or used as pure fuels in existing vehicles and infrastructure, increasing the flexibility and resilience of the energy system.
    - Biofuels can support economic development and rural livelihoods, as they can create new markets and jobs for farmers, workers, and entrepreneurs. Biofuels can increase the income and food security of smallholders and rural communities, especially in developing countries, where biomass is often abundant and underutilized. Biofuels can also stimulate innovation and investment in research and development,

biotechnology, and engineering. Biofuels can generate revenues and taxes for governments, which can be used to fund public services and infrastructure.

12. Plant biotechnology is the application of biotechnology techniques, such as genetic engineering, tissue culture, molecular markers, and genome editing, to improve the quality and productivity of plants. Plant biotechnology can be used for enhancing the nutritive qualities of foods by introducing or modifying genes that are related to the biosynthesis, accumulation, or bioavailability of nutrients, such as vitamins, minerals, proteins, carbohydrates, lipids, and phytochemicals. Some examples of how plant biotechnology can be used for enhancing the nutritive qualities of foods are:

- Increasing the content of vitamin A in rice, banana, and cassava by introducing genes that encode enzymes involved in the carotenoid pathway. Vitamin A is essential for vision, immunity, and growth. Vitamin A deficiency is a major public health problem that affects millions of people worldwide, especially children and pregnant women.
- Increasing the content of iron and zinc in rice, wheat, and potato by introducing genes that encode metal transporters or chelators that enhance the uptake, translocation, or storage of these minerals. Iron and zinc are important for hemoglobin synthesis, oxygen transport, enzyme activity, and immune function. Iron and zinc deficiency are common forms of micronutrient malnutrition that affect billions of people worldwide, causing anemia, impaired cognitive development, and increased susceptibility to infections.
- Increasing the content of essential amino acids in cereals, millets, pulses, and oilseeds by introducing genes that encode enzymes involved in the amino acid biosynthesis or degradation pathways. Essential amino acids are those that cannot be synthesized by the human body and must be obtained from dietary sources. Essential amino acids are important for protein synthesis, tissue repair, and metabolic regulation. Essential amino acid deficiency can lead to protein-energy malnutrition, growth retardation, and impaired immune response.
- Increasing the content of omega-3 fatty acids in oilseeds by introducing genes that encode desaturases and elongases involved in the fatty acid metabolism pathway. Omega-3 fatty acids are polyunsaturated fatty acids that have beneficial effects on cardiovascular health, brain function, and inflammation. Omega-3 fatty acids are mainly found in fish oils and some plant sources, such as flaxseed and walnuts. However, the consumption of fish oils is limited by availability, cost, and environmental concerns. Plant-based sources of omega-3 fatty acids can provide an alternative and sustainable source of this nutrient.
- Increasing the content of phytochemicals in fruits, vegetables, spices, and medicinal plants by introducing or modifying genes that encode enzymes involved in the secondary metabolite pathways. Phytochemicals are bioactive compounds that have various health benefits, such as antioxidant, anti-inflammatory, anti-cancer, anti-diabetic, anti-microbial, or anti-hypertensive effects. Phytochemicals include flavonoids, carotenoids, glucosinolates, terpenoids, alkaloids, phenolics, and others. Phytochemicals can modulate various cellular processes and signaling pathways involved in disease prevention and treatment.

- These are some of the ways that plant biotechnology can be used for enhancing the nutritive qualities of foods. However, there are also some challenges and limitations associated with plant biotechnology, such as biosafety regulations, public acceptance, gene flow risks, environmental impacts, ethical issues, and intellectual property rights. Therefore, plant biotechnology should be used in a responsible and sustainable manner to ensure its benefits for human health and well-being.

13. Some of the strategies adopted for creating transgenic plants with the following traits are:

    (a) Disease resistance: One strategy is to introduce genes that encode proteins that can recognize and respond to specific pathogen effectors, such as resistance ® genes or pattern recognition receptors (PRRs). These proteins can trigger defense responses, such as hypersensitive cell death, production of reactive oxygen species, or expression of pathogenesis-related (PR) genes. Another strategy is to introduce genes that encode proteins that can interfere with the pathogen infection process, such as antimicrobial peptides, lytic enzymes, or inhibitors of pathogen enzymes. A third strategy is to introduce genes that encode proteins that can enhance the plant's tolerance or resilience to biotic stress, such as heat shock proteins, transcription factors, or phytohormones.

    (b) Herbicide tolerance: One strategy is to introduce genes that encode proteins that can degrade or detoxify the herbicide, such as cytochrome P450 monooxygenases, glutathione S-transferases, or phosphinothricin acetyltransferases. Another strategy is to introduce genes that encode proteins that can confer resistance to the herbicide's mode of action, such as mutant forms of acetolactate synthase (ALS), 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), or protoporphyrinogen oxidase (PPO). A third strategy is to introduce genes that encode proteins that can reduce the uptake or translocation of the herbicide, such as ABC transporters, aquaporins, or lipid transfer proteins.

    (c) Insect resistance: One strategy is to introduce genes that encode proteins that can kill or harm the insect pests, such as Bacillus thuringiensis (Bt) toxins, lectins, protease inhibitors, or ribosome-inactivating proteins. Another strategy is to introduce genes that encode proteins that can repel or deter the insect pests, such as volatile organic compounds, trichomes, or phytoalexins. A third strategy is to introduce genes that encode proteins that can enhance the plant's tolerance or resilience to insect damage, such as wound-inducible genes, transcription factors, or phytohormones.

14. Plant genetic engineering is the manipulation of plant genes to create or modify traits, such as disease resistance, herbicide tolerance, or insect resistance. However, this technology also raises some social and ethical problems, such as:

- The potential risks to human health and the environment from the release of genetically modified (GM) plants. For example, GM plants may have unintended effects on non-target organisms, such as beneficial insects, soil microbes, or wild relatives. GM plants may also transfer their genes to other plants through cross-pollination or gene flow,

creating new weeds or reducing genetic diversity. GM plants may also affect human health by causing allergies, toxicity, or antibiotic resistance.

- The social and economic impacts of GM crops on farmers and consumers. For example, GM crops may create dependency on multinational corporations that own the patents and seeds of GM crops. GM crops may also increase the gap between rich and poor farmers, as some farmers may not have access to or afford the GM seeds and the associated inputs, such as herbicides. GM crops may also reduce consumer choice and autonomy, as some consumers may not have the option or information to avoid GM foods.
- The ethical and moral implications of modifying life forms. For example, some people may consider GM plants as unnatural or unnatural interference with God's creation. Some people may also question the ownership and patenting of life forms, as they may regard plants as common heritage or public goods. Some people may also challenge the values and assumptions behind GM crops, such as the need for increased production, efficiency, or uniformity.

These social and ethical problems can be addressed by various strategies, such as:

- Developing and implementing appropriate biosafety regulations and guidelines to assess and monitor the risks and benefits of GM crops. For example, GM crops should undergo rigorous testing and evaluation before approval and release. GM crops should also be labeled and traced to ensure transparency and accountability. GM crops should also be managed to prevent or minimize gene flow or environmental impacts.
- Promoting public participation and dialogue among different stakeholders, such as scientists, farmers, consumers, policy makers, and civil society groups. For example, public consultation and engagement should be conducted to inform and involve the public in the decision-making process of GM crops. Public education and awareness should also be enhanced to increase the public's understanding and acceptance of GM crops. Public debate and deliberation should also be encouraged to reflect on the social and ethical issues of GM crops.
- Respecting the diversity of views and values regarding GM crops. For example, different cultural, religious, or philosophical perspectives should be acknowledged and respected in the discussion of GM crops. Different preferences and needs of different regions or communities should also be considered and accommodated in the development and deployment of GM crops. Different alternatives or options to GM crops should also be explored and supported in the pursuit of sustainable agriculture and food security.

15. Genetic engineering is a technology that involves the manipulation of the genetic material of living organisms to create new or modified traits. Genetic engineering has various implications for the society, the economy, and the environment. Some of these implications are:

- Social implications: Genetic engineering can affect the social aspects of human life, such as health, ethics, culture, and human rights. For example, genetic engineering can be used to diagnose and treat genetic diseases, improve human capabilities, or create designer babies. However, these applications may also raise ethical and moral dilemmas, such as the safety and efficacy of gene therapy, the potential misuse or abuse of genetic

information, the respect for human dignity and diversity, and the regulation and oversight of genetic engineering. Genetic engineering can also affect the social aspects of animal and plant life, such as animal welfare, food security, and biodiversity. For example, genetic engineering can be used to create transgenic animals and plants that have improved traits, such as disease resistance, herbicide tolerance, or insect resistance. However, these applications may also pose social risks, such as the impact on animal rights and welfare, the loss of traditional knowledge and practices, the threat to food sovereignty and quality, and the disruption of natural ecosystems and balance.

- Economic implications: Genetic engineering can affect the economic aspects of human life, such as innovation, productivity, and competitiveness. For example, genetic engineering can be used to create new products and services that can benefit various sectors and industries, such as biotechnology, medicine, agriculture, and energy. However, these applications may also create economic challenges, such as the cost and accessibility of genetic engineering technologies, the distribution and equity of benefits and risks, the ownership and patenting of genetic resources and products, and the trade and market implications of genetically modified organisms (GMOs). Genetic engineering can also affect the economic aspects of animal and plant life, such as profitability, efficiency, and sustainability. For example, genetic engineering can be used to increase the yield and quality of animal and plant products, reduce the input and output costs of production, and enhance the adaptation and resilience of animal and plant systems. However, these applications may also entail economic costs, such as the dependence on external inputs and technologies, the vulnerability to biotic and abiotic stresses, the loss of genetic diversity and variability, and the externalities and unintended consequences of genetic engineering.

- Environmental implications: Genetic engineering can affect the environmental aspects of human life, such as pollution, climate change, and resource management. For example, genetic engineering can be used to reduce greenhouse gas emissions by creating biofuels from microorganisms or plants. However, these applications may also have environmental impacts, such as the contamination or displacement of native species by GMOs, the alteration or disruption of ecological processes and functions, the depletion or degradation of natural resources, and the generation or accumulation of wastes or toxins. Genetic engineering can also affect the environmental aspects of animal and plant life, such as adaptation, evolution, and coexistence. For example, genetic engineering can be used to enhance the fitness and diversity of animal and plant species by introducing or modifying genes that confer resistance or tolerance to environmental stresses. However, these applications may also affect the natural balance and dynamics of animal and plant populations by creating or altering the interactions and relationships among species, the gene flow and migration of species, the selection pressure and mutation rate of species, and the emergence or spread of diseases or pests.

UNIT 2:
MICROORGANISMS (15 periods)

Unit Learning Outcomes: After the successful completion of this unit, the learner will be able to:

- State the characteristics of microorganisms
- Explain different groups of microorganisms
- Discuss the importance of microorganisms in industry and the environment
- Explain diseases caused by microorganisms and viruses
- Describe prevention and treatment mechanisms of diseases caused by

Learning competencies

By the end of this section, the student will be able to:

- Define microorganisms
- Classify microorganisms
- Describe characteristics of bacteria, fungi, protozoa and viruses
- Classify bacteria based on their common characteristics
- Explain the reproduction mechanisms of microorganisms
- Discuss the roles of bacteria in the ecosystem, industry, medicine, and genetic engineering with examples
- Explain the food, medicine, ecosystem, and industrial roles of fungi
- Appreciate the contribution of bacteria and fungi in the preparation of cultural foods and drinks in Ethiopia
- Discuss the economic importance of protozoa
- Discuss common viral diseases and their preventive mechanisms
- Discuss the biology of common disease-causing bacteria, fungi, protozoa (malaria, amoeba, giardia), and viruses in Ethiopia
- Appreciate the works of renowned microbiologists/ parasitologists in Ethiopia

Unit learning strategies

1. Let students tell you the meaning of micro and organism and ask them to define microorganism.. After defining microorganisms, they will need to identify bacteria as one group of microorganisms list their characteristics as much as they can individually and then share with each other. They can use student pictures to make their discussion concrete and classify bacteria based on the common characteristics they listed and shared.
2. Let students identify and discuss on the characteristics of fungi using the Brain Drain Approach.
3. Use picture prompt to study the characteristics of virus and differentiate the structures of RNA viruses and DNA viruses
4. Ask students to tell you if they know how microorganisms reproduce. If their answer is yes, let them explain how. and which method they use. (Hint-Asexually, sexually .....). Do bacteria, fungi, protozoa, and viruses use the same method? Then guide them to use an internet search about the mechanisms of reproduction of microorganisms and ask them to present their findings to the class.
5. Let students reflect on what happens to the body of an animal when it dies and ask them to explain why it happens so. After answering this question concerning the role of bacteria in the ecosystem, guide them to read from textbook/internet or ask a microbiologist/biologist to understand the role of bacteria in the ecosystem, industry, medicine, and genetic engineering with examples and ask them to share their findings to the whole-class.
6. Let students discuss in groups on the role of fungi in medicine, industry and ecosystem
7. Students will list down those cultural foods and drinks in their locality which are results of bacteria and fungi. Then, ask them the role of bacteria and fungi in preparing such foods and drinks. They are expected to identify how local people sustain such bacteria and fungi and use them consistently (Hint "ersho").
8. Tell them to be in a group of 5 students, select a group leader and read their textbook and ask the leader to tell you her/his understanding and finally discuss together the characteristics and economic importance of some common protozoa. Explain to them that they can invite their teacher for clarification if they have any difficulties.
9. Make six groups in a classroom and take one group of organisms among bacteria, fungi, protozoa (malaria, amoeba, and giardia), and virus for each group to study their life cycles using the Jigsaw method. Tell them to use your textbook and picture prompt for each group of organisms. Students can also use drama method or role play (Hint-some students

can act as doctor and others as patients) to learn about the cause, symptom, prevention, and treatment methods of disease).

10. Search for and study the works of a renowned microbiologist/parasitologist in Ethiopia and evaluate the applications of his/her works to everyday life.

2.1. What is microorganisms?

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate microorganisms. Design a strategic plan to deliver the lessonsand conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about microorganisms and types microorganisms, and you can use question in the textbook and encourage them to participate actively and then, you summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Q1. How do you define Microorganism?

Microorganisms are all single-celled microscopic organisms that include viruses, which are microscopic but not cellular (See Figure 2.1).

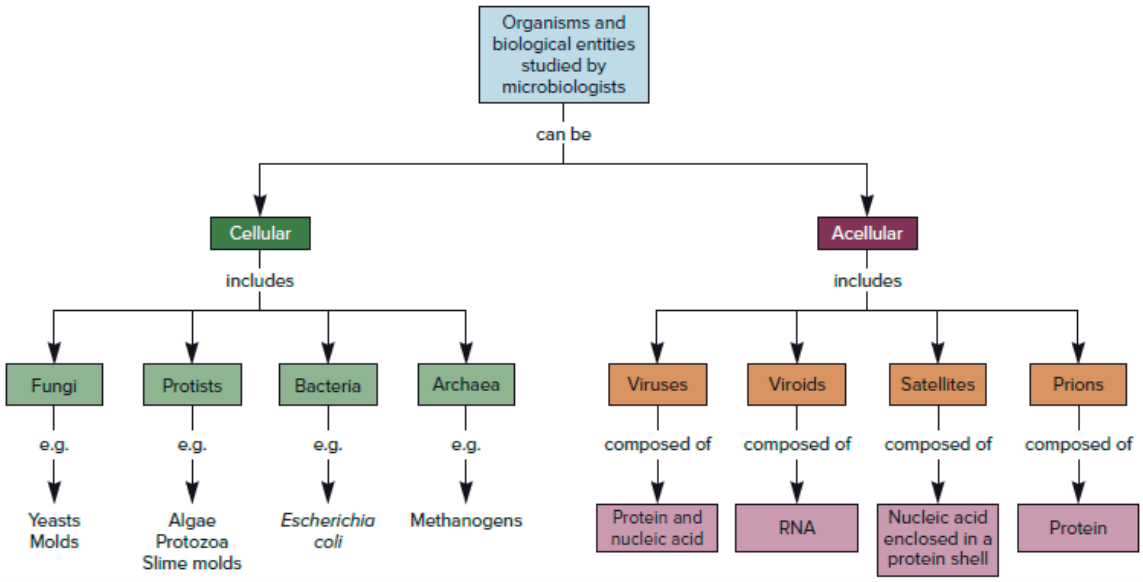


Figure 2.1 Concept Map Showing the Types of microorganisms Studied by Microbiologists.

- **Q2. Why is microscopic life vital for all life on earth?**

The earth is an amazingly nurturing environment for microorganisms. Although it has been fancifully nicknamed the "blue planet" or the "water planet," the earth is truly the "planet of the microbes." They are the dominant organisms living in most of the natural environments, and they are woven tightly through the cycles of all living things.

- Clearly, microorganisms pervade our lives in both an everyday, mundane sense and in a far wider view.
- We wash our clothes with detergents containing microbe-produced enzymes,
- We eat food that derives flavor from microbial action,
- We even eat microorganisms themselves.
- We are vaccinated with altered microbes to prevent diseases that are caused by those very same microbes.
- We treat various medical conditions with drugs produced by microbes;
- we dust plants with insecticides of microbial origin; and
- We use microorganisms as tiny factories to churn out various industrial chemicals and plastics.
- We depend on microbes for many facets of life—one might say even for life itself.

Q3. Where do microorganisms live?

Microorganisms are ubiquitous (we can get them everywhere)

- Microbes are tiny living things that are found all around us and are too small to be seen by the naked eye. They live in water, soil, and in the air. The human body is home to millions of these microbes too called microorganisms.

Q4. Why is it important to study microbiology?

Microorganisms matter because they affect every aspect of our lives. They are in us, on us, and around us. Microorganisms are most famous for causing disease, however, microorganisms are also vital to agriculture, industry and ecology. Therefore, we have to know the genotype,

phenotype, physiology, biochemistry, and every nature of that organism to use for different purposes. In fact, life on earth would not survive without microorganisms.

2.1.1. Eubacteria

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the Eubacteria, staining techniques, and different bacterial structures. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about eubacteria and the general characteristics of bacteria, and you can use question in the textbook and encourage them toparticipate actively and you summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Q1. What are Eubacteria and what do they do?

Bacteria (singular: bacterium) are prokaryotes, which are single-celled organisms with a simple internal structure that lacks a nucleus, and contains DNA that either floats freely in a twisted, thread-like mass called the nucleoid, or in separate, circular pieces called plasmids. Ribosomes are the spherical units in the bacterial cell where proteins are assembled from individual amino acids using the information encoded in ribosomal RNA. (Microorganisms are the oldest forms of life). They are important in nutrient production and energy flow, production of foods, decomposition (bioremediation). Without certain microorganisms, life could not exist as they produce O_2 and N_2, drugs and vaccines through genetic engineering Microorganisms have killed more people than have ever been killed in war.)

Q2. Where can we get microorganisms?

Bacteria are ubiquitous or omnipresent in their distribution. They are found in all the natural habitats i.e. soil, water, and air. They occur in all situations except in pits of **volcanoes, deep strata or rock and rainwater, distilled water, in deep wells, blood of normal animal**s. They constitute the major part of the soil microflora and intestine of animals. Viz. E. *coli* in the

intestine of human beings. Some species have been found in extreme hot spring as well as extreme cold condition, these are referred to as thermophilic (survive > 40 ^{O}C*)* and psychrophilic (on-190°C) respectively. They can tolerate and remain alive at a pH lower than 1 at one end and 13 at another end. Generally, 1 gm. soil contains about 1000-10 million bacteria.

A bacterium also occurs in a variety of foods and food products such as fruit, vegetables, milk, butter, and cheese and milk beverages.

Q3. What is the difference between eukaryotes and prokaryotes?

Both **prokaryotes and eukaryotes** contain nucleic acids, proteins, lipids and carbohydrates. They use the same kinds of chemical reactions to metabolize food, build proteins, and store energy. The structure of cell walls and membranes, and the absence of organelles (specialized cellular structures that have specific functions)primarily distinguish prokaryotes from eukaryotes.

The chief distinguishing characteristics of prokaryotes (has no true nucleus) are as follows:

1. Typically their DNA is not enclosed within a membrane and is usually a singular, circularly arranged chromosome. Gemma obscuriglobus has a double membrane around its nucleus. (Some bacteria, such as Vibrio cholerae have two chromosomes, and some bacteria have a linearly arranged chromosome.)
2. Their DNA is not associated with histones (special chromosomal proteins found in eukaryotes); other proteins are associated with the DNA.
3. They generally lack organelles. Advances in microscopy reveal a few membrane-enclosed organelles (for example, some inclusions). However, prokaryotes lack other membrane enclosed organelles such as nuclei, mitochondria, and chloroplasts.
4. Their cell walls almost always contain the complex polysaccharide peptidoglycan.
5. They usually divide by binary fission, where DNA is copied, and the cell splits into two cells. This involves fewer structures and processes than eukaryotic cell division.

Eukaryotes (meaning true nucleus) have the following distinguishing characteristics:

1. Their DNA is found in the cell's nucleus, which is separated from the cytoplasm by a nuclear membrane, and the DNA is found in multiple chromosomes.
2. Their DNA is consistently associated with chromosomal proteins called histones and with non-histones.
3. They have a number of membrane-enclosed organelles including mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, and sometimes chloroplasts.
4. Their cell walls (if there is any) are chemically simple.

5. Cell division usually involves mitosis, in which chromosomes replicate and an identical set is distributed into each of two nuclei. Division of the cytoplasm and other organelles follows so that the two cells produced are identical to each other.

Q4. What characteristics are common to all bacteria?

The following are the general characteristics of bacteria.

- They are omnipresent i.e. present in soil, air and water.
- They are unicellular, prokaryotic microorganism.
- The cell bears a thick rigid cell wall outside the plasma membrane (because of this characteristic, they are kept in plant kingdom).
- They have great variation in the mode of nutrition i.e. may be autotrophic and heterotrophic. In heterotrophism mode of nutrition they may be parasite saprophyte or symbiotic in nature.
- With the exception of few photosynthetic bacteria that have a special type of chlorophyll called bacterio-chlorophyll, they lack true chlorophyll.
- Because of the prokaryotic nature they lack true nucleus (lacking nuclear membrane and nucleolus), genetic material is in the form of composite structure known as genophore/ nucleoid/ incipient nucleus.
- Unlike the cell wall of plants, which is made up of cellulose, the cell wall of bacteria is made up of mucopeptide,
- They lack mitochondria, Golgi apparatus, plastid and endoplasmic reticulum.
- They lack basic protein histone in their DNA.
- Ribosomes are of 70s type.
- At some places, the plasma membrane invigilates in folds to form mesosomes.
- All the enzymes required for respiration are found in the cell membrane.
- Both DNA and RNA are available in the bacterial cell. DNA is in the form of single circular chromosome (therefore the ce.il is haploid)
- Vegetative reproduction generally takes place by binary fission, cyst, budding and gonidia.
- Asexual reproduction occurs through conidia, motile spores and endospore.

- True sexual reproduction is absent in bacteria but there are examples of genetic recombination which may be of following types viz. conjugation, transduction and transformation.

Activity 2.1. The structure and function of flagella and pili in bacteria

- **Starter activity**: Students tackle activity 2.1 to work out what they understand on the structure flagella and pili: the teacher should read out the text of the activity and encourage responses from the class.
- **Main Activity**: Students draw the table and list different parts of flagella and pili in the table and compare the function of the two structures.
- **Conclusive Activity**: Compare presentations of all groups give an overall summary of their discussion.

Assessment method:

- Correct their paper after the presentation and record the results.
- Observe the discussions and comment on important issues.
- Evaluate the presentation techniques of the groups.

Structure of Bacterial cells

For the self-assessment questions under the title "structure of Bacterial Cell" on the student book, the following shot note helps you get some information that guides you before you start teaching the topic.

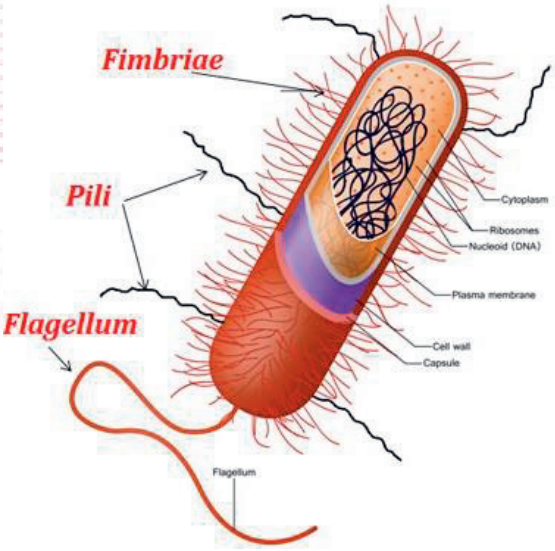


Figure 2.2. Internal structure cell surface appendages of bacterial cells

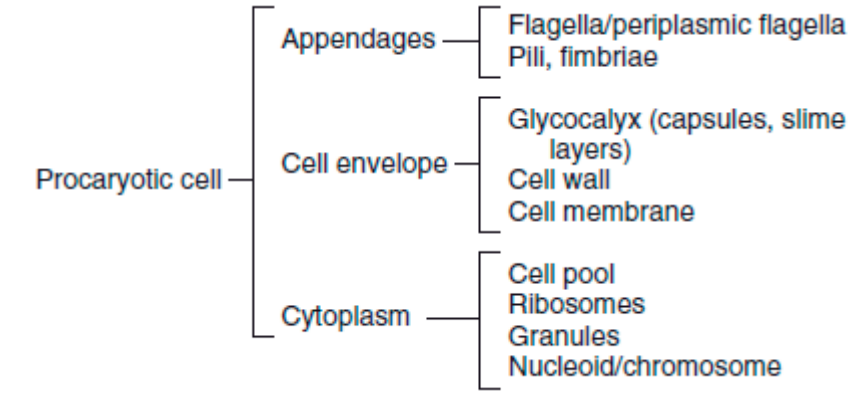
Pili are short, hair-like structures on the cell surface of prokaryotic cells (See Figure 2.2). They can have a role in movement, but are more often involved in adherence to surfaces, which facilitates infection, and is a key virulence characteristic structure of a bacterial cell.

Flagella are long thin appendages free at one end and attached to the cell at the other end. Flagella actually extend from the interior of the cell body. Pili are short, thick straight hair like surface appendages. Flagella and fimbriae are important for the attachment of pathogens to fresh production . Flagella are long, thin surface appendages that extend up to 20μm and which are important for motility and chemotaxis.

Q5. What are the functions of bacterial structure?

All bacterial cells invariably have a cell membrane, cytoplasm, ribosomes, and a chromosome where the majority has a cell wall and some form of surface coating or glycocalyx. Specific structures that are found in some, but not all, bacteria are flagella, pili, fimbriae, capsules, slime layers, and granules.

The general cellular organization of a prokaryotic cell can be represented with the following flowchart and cellular structures are presented in Figure 2.3 and a representative bacterial cell is presented in Fig 2.4a.



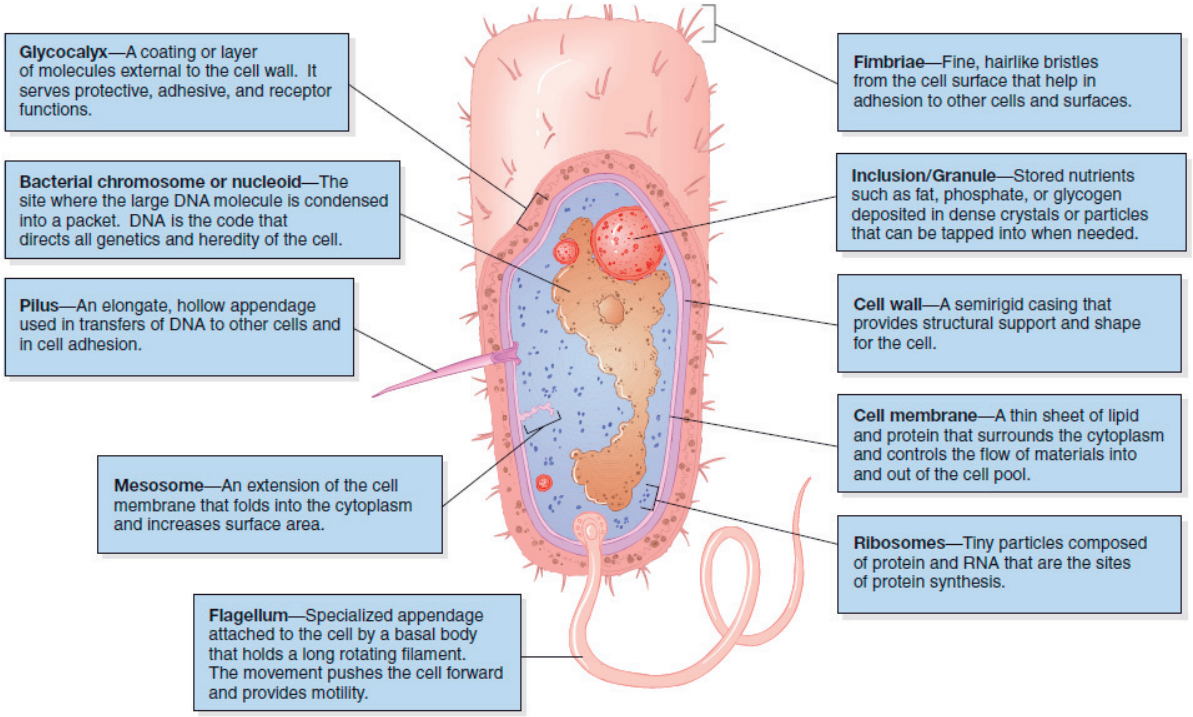


Figure 2.3: Structure of a prokaryotic cell. Cutaway view of a typical rod-shaped bacterium, showing the major structural features. Note that not all components are found in all cells.

Q6. Draw and explain the structural difference between prokaryote and eukaryote cells.

Table 2.1. Principal differences between prokaryotic and eukaryotic cells

Characteristic	Prokaryotic	Eukaryotic
Size of Cell	Typically 0.2–2.0 μm in diameter	Typically 10–100 μm in diameter
Nucleus	Typically no nuclear membrane or nucleoli except *Gemmata* (see Figure 11.23)	True nucleus, consisting of nuclear membrane and nucleoli
Membrane-Enclosed Organelles	Relatively few	Present; examples include nuclei, lysosomes, Golgi complex, endoplasmic reticulum, mitochondria, and chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell Wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple (includes cellulose and chitin)
Plasma Membrane	Carbohydrates and generally lacks sterols	Sterols and carbohydrates that serve as receptors
Cytoplasm	Cytoskeleton (MreB and ParM, cresetin, and FtsZ proteins); no cytoplasmic streaming	Cytoskeleton (microfilaments, intermediate filaments, and microtubules); cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA)	Usually single circular chromosome; typically lacks histones	Multiple linear chromosomes with histones
Cell Division	Binary fission	Involves mitosis
Sexual Recombination	None; transfer of DNA only	Involves meiosis

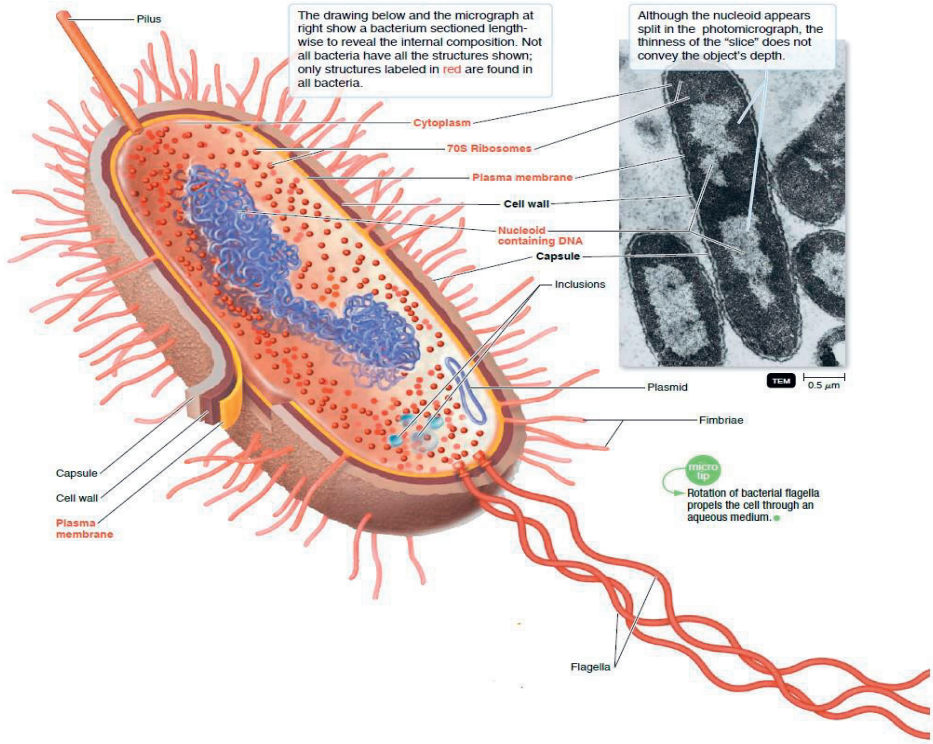


Figure 2.4. Bacterial cell structure

Compared to the prokaryotic cells, Eukaryotic cells are complex in which the genetic material is organized into membrane-bound nuclei (**Figure 2.5**).

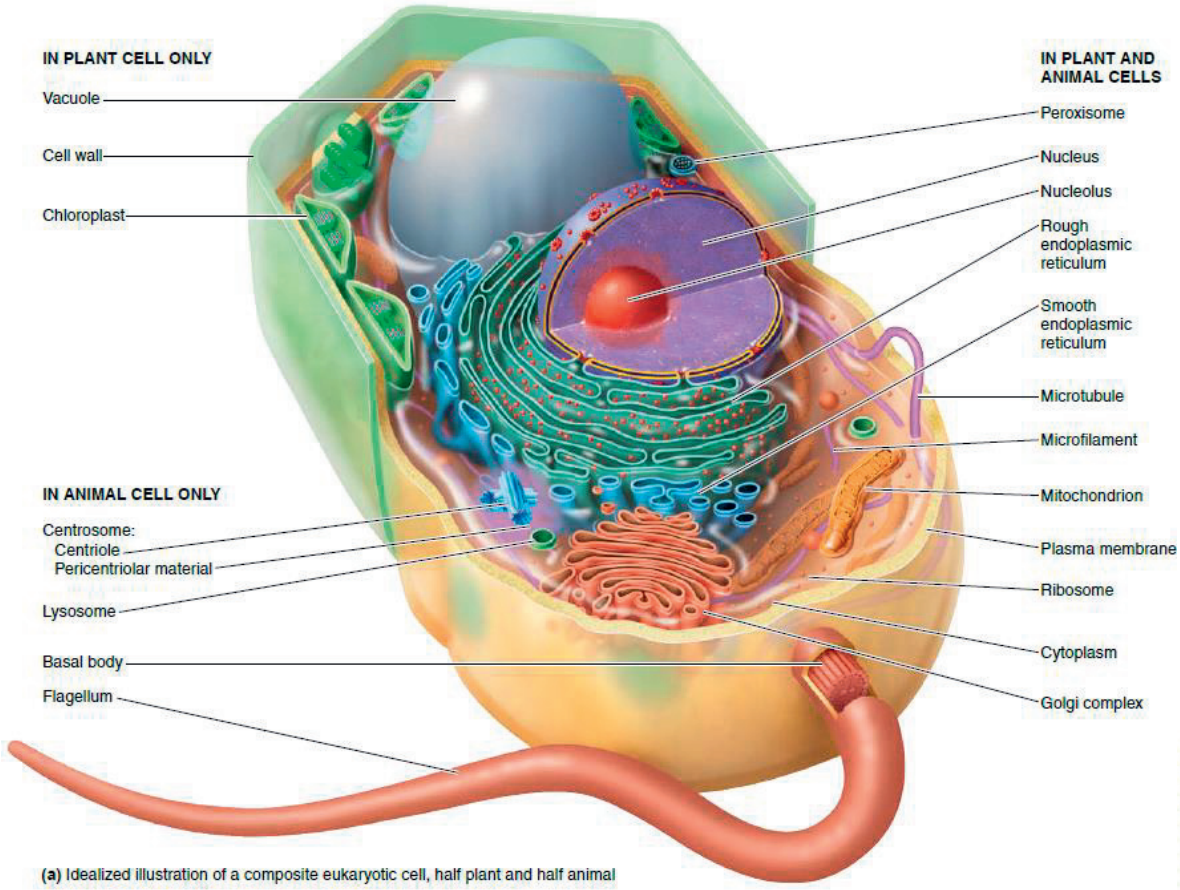


Figure 2.5. Idealized illustration of a complete eukaryotic cell half plant and half animal cells

Q7. What are the major differences among bacteria, archaea, and Eukaryia?

The differences between the three domains of life are indicated in the table below:

Table2.2. Major Characteristics of Bacteria, Archaea, and Eukarya

Property	Bacteria	Archaea	Eukarya
Organization of Genetic material			
True membrane Bound Nucleus	no	No	yes
DNA complexed with histones	no	Some	yes
Chromosomes	Usually one circular chromosome	One circular chromosome	More than one; chromosome are linear
Plasmids	Very common	Very common	Rare
Introns in genes	Rare	Rare	Yes
Nucleolus	No	No	Yes
Mitochondria	No	No	Yes
Chloroplast	No	No	Yes
Plasma Membrane lipids	Ester-linked phosphor; lipids and hopanoids; some have sterols	Glycerol diethers and diglycerol tetraethers	Ester-Linked phospholipids and sterols
Flagella	Submicroscopic in size; composed of one protein fiber	Submicroscopic in size; composed of a fiber made from multiple different flagellain proteins	Microscoic in size; mmembrane bound; usually 20 microtinbules in 9=2 pattern
Endoplasmic reticulum	No	No	Yes
Golgi Apparatus	No	No	Yes
Peptido Glycan in cell walls	Yes	No	No
Ribosome size	70S	70S	80S
Lysosomes	No	No	Yes
Cytoskeleton	Rudimentary	Rudimentary	Yes
Gas Vesicle	Yes	Yes	No
Nitrification (ammonia oxidation)	Yes	Yes	No
Chlorophyll-based photosynthesis	Yes	No	Yes
Denitrification	Yes	Yes	No
Nitrogen fixation	Yes	Yes	No
Rhodopsin-based energy metabolism	Yes	Yes	No

Activity 2.2.

Work in small groups and brainstorm all the differences you can think of between eukaryotic and prokaryotic cells. Make a table comparing the two different types of cells and share your ideas with the rest of the whole class.

The answer for this activity is ths same as the answer given for question # 6 below**.**

Bacterial Shapes

Q1. Do all bacteria have the same shapes? No! Different bacteria have different shapes.

Common Prokaryotic Cell Shapes

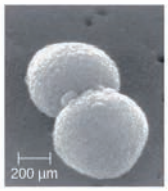
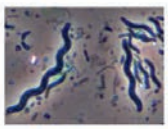
Name	Description	Illustration	Image
Coccus (pl. cocci)	Round		
Bacillus (pl. bacilli)	Rod		
Vibrio (pl. vibrios)	Curved rod		
Coccobacillus (pl. coccobacilli)	Short rod		
Spirillum (pl. spirilla)	Spiral		
Spirochete (pl. spirochetes)	Long, loose, helical spiral		

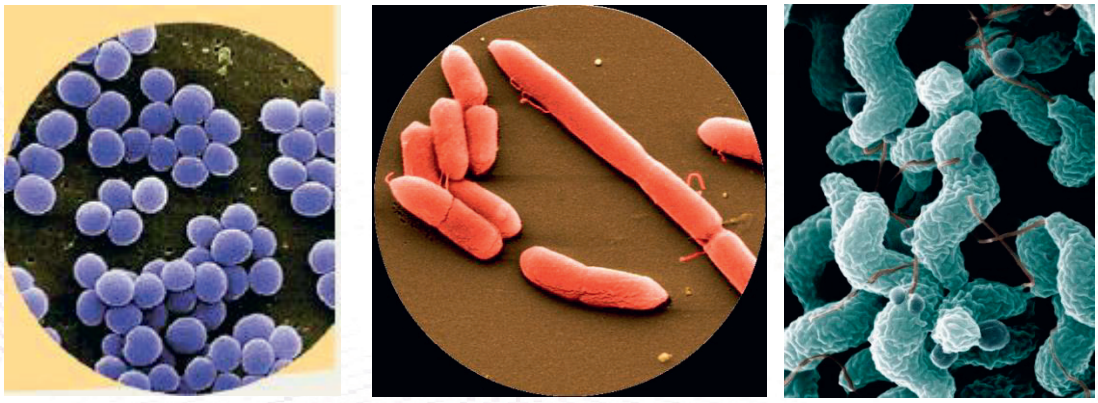
Figure 2.6. Common prokaryotic cell shape

Q2. What are the three basic shapes of bacteria?

Is there any other more shapes? **Yes!**

Most bacteria come in one of three basic shapes: coccus, rod or bacillus, and spiral (See **Figure 2.6**).

- Cocci (singular, coccus) – spherical bacteria
- Bacilli (singular, bacillus) – rod-shaped bacteria
- Spirochaetes – spiral or corkscrew-shaped bacteria



Cocci Bacilli Spirochaetes

Q3. How do the bacterial cells cluster together?

The different types of bacterial cell arrangement result from the cell division at different planes (See **Figure 2.7**)

Figure 2. 7. The three basic bacterial shapes

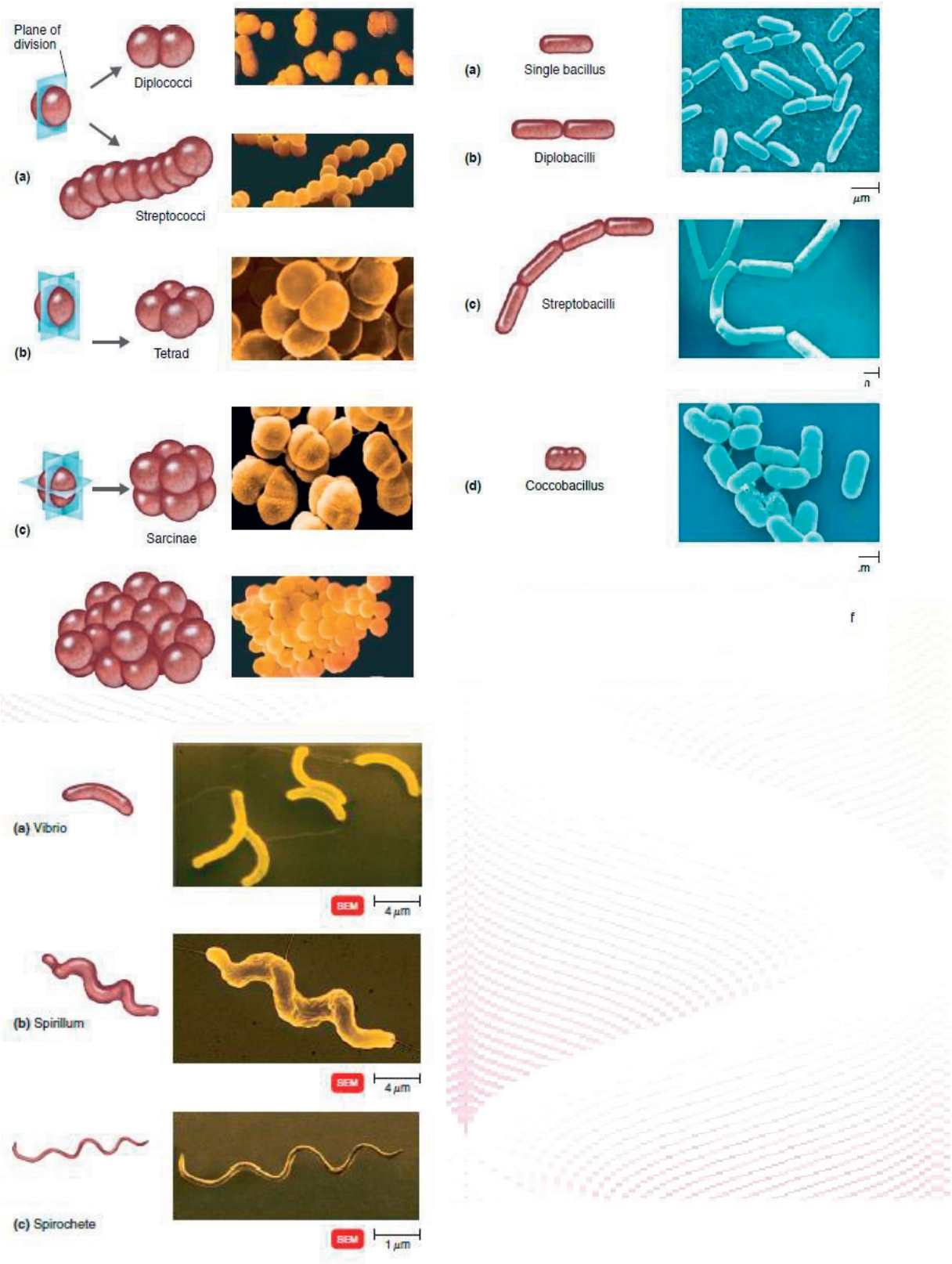


Figure 2.8. Bacterial cell arrangements

Activity 2.3: Finding out more about bacteria

- **Starter activity**: Before you begin the lesson, encourage students to Google search and read additional books on *streptococcus* and *lactobacillus* bacterial species. Tell them to identify the shapes and arrangements of the two bacteria and why they are so important to us. Also, tell them to find two diseases caused by spiral-shaped bacteria.
- **Main Activity**: The students' should draw the table, list the characteristics, ecology, and importance of the two bacteria found in food fermentation. Each student presents their finding to the class.
- **Conclusive Activity**: The teacher gives the summary of their presentation.

The following is a short note for activity 2.3 above. Lactobacillus, (genus Lactobacillus) are any of the group of rod-shaped, aerotolerant anaerobes or microaerophilic, gram-positive, non-spore-forming bacteria of the family Lactobacillaceae. Similar to other genera in the family, Lactobacillus are characterized by their ability to produce lactic acid as a by-product of glucose metabolism. The organisms are widely distributed in animal feeds, silage, manure, and milk and milk products. Various species of Lactobacillus are used commercially for the production of sour milks, cheeses, and yogurt, and they have an important role in the manufacture of fermented vegetables (pickles and sauerkraut), beverages (wine and juices), sourdough breads, and some sausages. **Streptococci** are Gram-positive, nonmotile, nonsporeforming, catalase-negative cocci that occur in pairs or chains. Older cultures may lose their Gram-positive character. Most streptococci are facultative anaerobes, and some are obligate (strict) anaerobes. Most require enriched media (blood agar). Group A streptococci have a hyaluronic acid capsule.

For the answer for the self-assessment questions under the title "bacterial shape" what structures are found outside the cell of bacteria? Why cilia and flagella are important for bacteria? What is the structural parts of flagella?, check the answer given for activity 2.1 and for question number five under the title *Eubacteria.*

Bacterial Cell wall

Depending on the characteristic being studied, bacterial species may be further categorized into broad groups. One such useful classification is based on if a bacterium is Gram positive or Gram negative. In other words, it is based on the structure of bacterial cell walls. The procedure for

this classification is called Gram staining (See Figure 2.8). The structure of bacterial cell wall of the two groups is presented in Figure 2.9.

Q1. Are there other ways of classifying bacteria?

- **Yes! Gram staining**

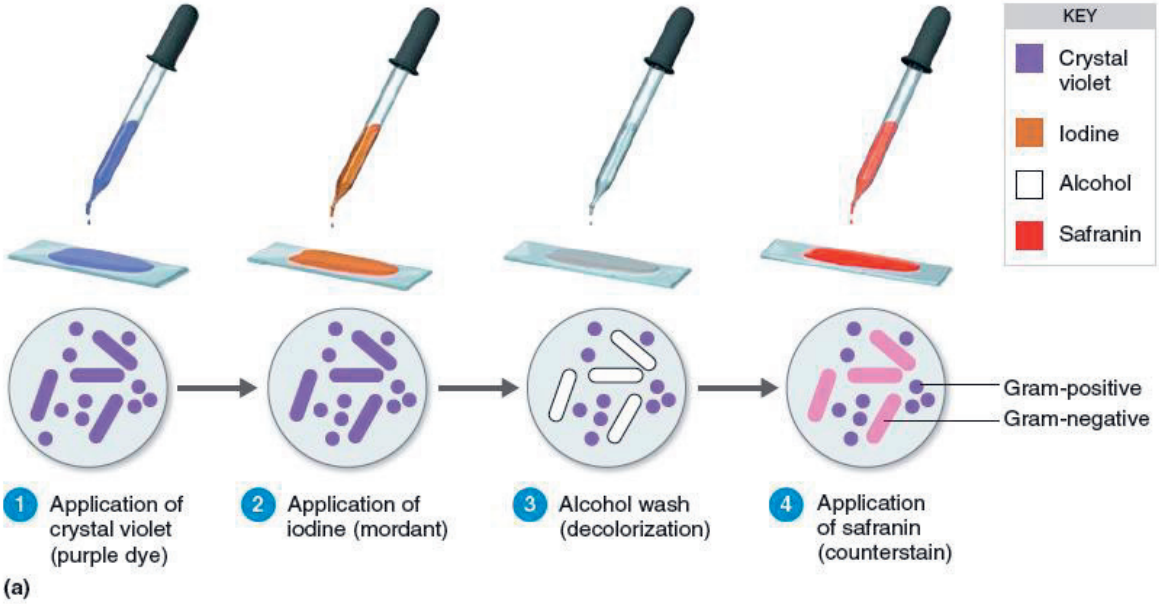


Figure 2.9. Steps in gram staining

Microorganisms are identified and classified based on the following critieria:

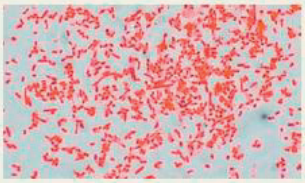
- Morphology
- Mode of reproduction
- Nutrition and metabolism
- Gas requirement
- Temperature requirement
- Acidity Vs Alkalinity or pH Requirements
- Osmotic Pressure Requirements
- Environmental Relationships
- Biochemical and molecular analysis

- Explain the functions of each structures of bacteria

Structure	Characteristics
Extracellular	
Filamentous appendages	Composed of protein subunits that form a helical chain.
Flagella	Provide the most common mechanism of motility.
Pili	Different types of pili have different functions. The common types, often called fimbriae, allow cells to adhere to surfaces. A few types are used for twitching or gliding motility. Sex pili join cells in preparation for DNA transfer.
Capsules and slime layers	Layers outside the cell wall, usually made of polysaccharide.
Capsule	Distinct and gelatinous. Allows bacteria to adhere to specific surfaces; allows some organisms to evade innate defense systems and thus cause disease.
Slime layer	Diffuse and irregular. Allows bacteria to adhere to specific surfaces.
Cell wall	Peptidoglycan provides rigidity to bacterial cell walls, preventing the cells from lysing.
Gram-positive	Thick layer of peptidoglycan that contains teichoic acids and lipoteichoic acids.
Gram-negative	Thin layer of peptidoglycan surrounded by an outer membrane. The outer layer of the outer membrane is lipopolysaccharide.
Cell Boundary	
Cytoplasmic membrane	Phospholipid bilayer embedded with proteins. Surrounds the cytoplasm, separating it from the outside environment. Also transmits information about the external environment to the inside of the cell.
Intracellular	
DNA	Contains the genetic information of the cell.
Chromosomal	Carries the genetic information required by a cell. Typically a single, circular, double-stranded DNA molecule.
Plasmid	Extrachromosomal DNA molecule. Generally carries only genetic information that may be advantageous to a cell in certain situations.
Endospore	A type of dormant cell. Generally extraordinarily resistant to heat, desiccation, ultraviolet light, and toxic chemicals.
Cytoskeleton	Involved in cell division and control of cell shape.
Gas vesicles	Small, rigid structures that provide buoyancy to a cell.
Granules	Accumulations of high-molecular-weight polymers, synthesized from a nutrient available in relative excess.
Ribosomes	Involved in protein synthesis. Two subunits, 30S and 50S, join to form the 70S ribosome.

Q2. Describe in detail the structure and composition of peptidoglycan of, gram-positive and gram-negative cell walls.

Table. The difference between Gram Negative and Positive bacteria

Characteristic	Gram-Positive	Gram-Negative
	 LM 12 μm	 LM 15 μm
Gram Reaction	Retain crystal violet dye and stain blue or purple	Can be decolorized to accept counterstain (safranin) and stain pink or red
Peptidoglycan Layer	Thick (multilayered)	Thin (single-layered)
Teichoic Acids	Present in many	Absent
Periplasmic Space	Granular layer	Periplasm
Outer Membrane	Absent	Present
Lipopolysaccharide (LPS) Content	Virtually none	High
Lipid and Lipoprotein Content	Low (acid-fast bacteria have lipids linked to peptidoglycan)	High (because of presence of outer membrane)
Flagellar Structure	2 rings in basal body	4 rings in basal body
Toxins Produced	Exotoxins	Endotoxin and exotoxins
Resistance to Physical Disruption	High	Low
Cell Wall Disruption by Lysozyme	High	Low (requires pretreatment to destabilize outer membrane)
Susceptibility to Penicillin and Sulfonamide	High	Low
Susceptibility to Streptomycin, Chloramphenicol, and Tetracycline	Low	High
Inhibition by Basic Dyes	High	Low
Susceptibility to Anionic Detergents	High	Low

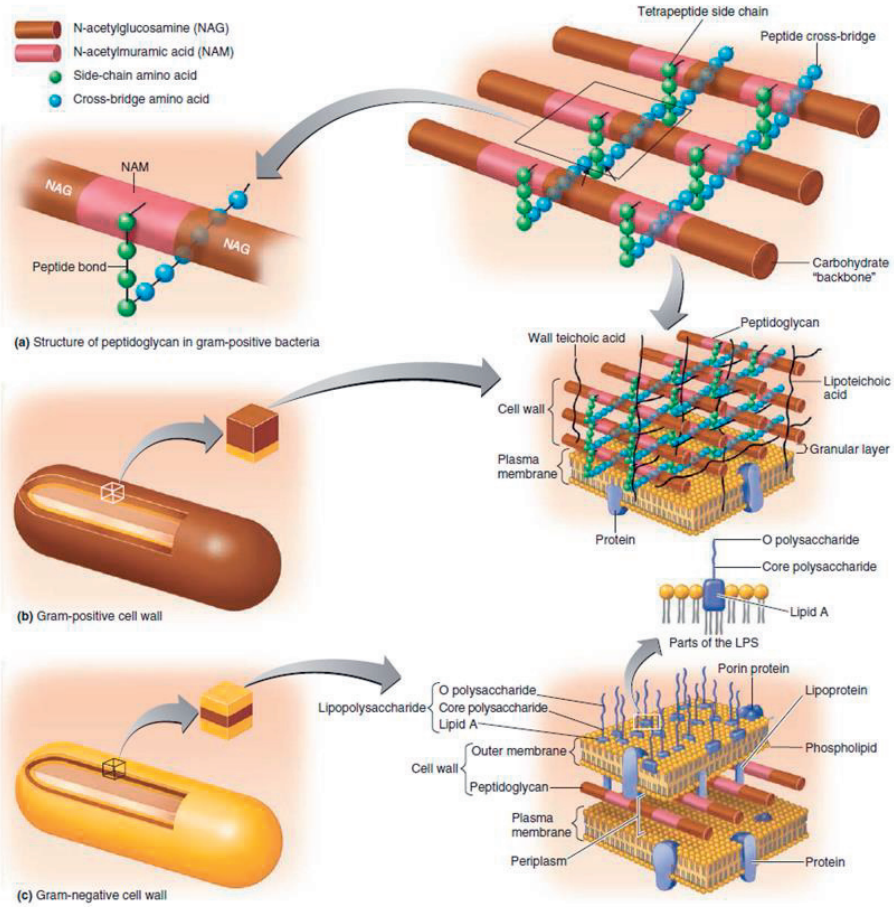


Figure 2.10. Bacterial cell walls (a) The structure of peptidoglycan in gram-positive bacteria. The carbohydrate backbone (glycan portion) and tetra peptide side chains (peptide portion) together make up peptidoglycan. The frequency of peptide cross-bridges and the number of amino acids in these bridges vary with species of bacteria. The small arrows indicate where penicillin interferes with the linkage of peptidoglycan rows by peptide cross-bridges. (b) A gram-positive cell wall. (c) A gram-negative cell wall.

Define or describe the following: outer membrane, periplasmic space, envelope, teichoic acid, adhesion site, lipopolysaccharide, and porin protein.

- The bacterial outer membrane is found in gram-negative bacteria. Its composition is distinct from that of the inner cytoplasmic cell membrane - among other things, the outer leaflet of the outer membrane
- The **periplasmic space** is a concentrated gel-like matrix in the space between the inner cytoplasmic membrane and the bacterial outer membrane called the periplasmic space in gram-negative bacteria.
- The bacteria **cell envelope** is a complex multilayered structure that serves to protect these organisms from their unpredictable and often hostile environment.
- Teichoic acids (TA) are anionic polymers found in Gram-positive bacteria CW and are made of polyglycerol phosphate units (approximately 20–30 repeats). They are involved, among others, in the regulation of cell morphology as well as in cell division. They can represent up to 50% of the dry-weight of the CW.
- Adhesion site-bacterial attachment structures (e.g. Pili)
- Lipopolysaccharides are large molecules consisting of a lipid and a polysaccharide composed of O-antigen, outer core and inner core joined by a covalent bond. They are found in the outer membrane of Gram-negative bacteria.
- Porins are beta barrel proteins that cross a cellular membrane and act as a pore, through which molecules can diffuse. Unlike other membrane transport proteins, porins are large enough to allow passive diffusion, i.e., they act as channels that are specific to different types of molecules.

Explain the role of a cell wall in protecting against lysis and illustrate how this role may be experimentally demonstrated.

The bacterial cell wall is made of thick, rigid **peptidoglycan** that maintains the shape of the cell, protects the cell interior, and **prevents the cell from bursting during osmosis**. In most prokaryotic cells, the cell wall provides support and helps cells resist mechanical pressures, but

they are not solid so that materials can pass through rather easily. Cells that have a cell wall are better able to withstand subtle changes in osmotic pressure and maintain their shape. In hypertonic environments, cells can become dehydrated, causing crenation or shrivelling of the cell.

In contrast, cells that possess a cell wall undergo plasmolysis rather than crenation. In plasmolysis, the plasma membrane contracts and detaches from the cell wall. There is a decrease in interior volume, thus allowing the cell to maintain some shape and integrity for a while.

Likewise, cells that lack a cell wall are more prone to lysis in hypotonic environments (See Figure 2.11).

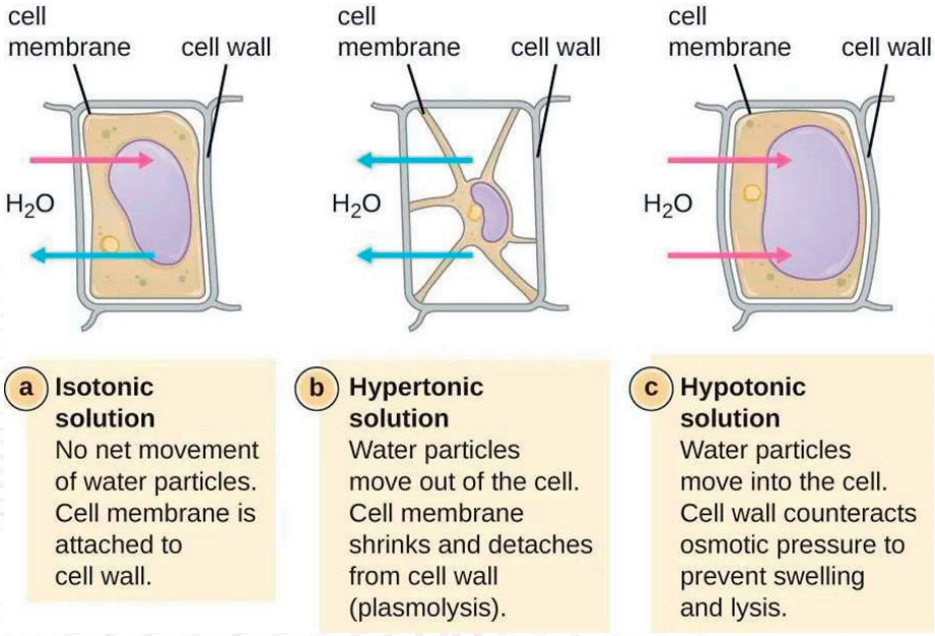


Figure 2. 11. Bacterial cell wall against cell lysis

In prokaryotic cells, the cell wall provides some protection against changes in osmotic pressure, allowing it to maintain its shape longer. The cell membrane is typically attached to the cell wall in an isotonic medium (Left). In a hypertonic medium, the cell membrane detaches from the cell wall and contracts (plasmolysis) as water leaves the cell. In a hypotonic medium (right), the cell wall prevents the cell membrane from expanding to the point of bursting although Lysis will eventually occur if too much water is absorbed.

Penicillin can be used to break down the peptidoglycan wall as it inhibits the construction of the bacterial cell wall making the bacteria more prone to bursting.

Distinguish the difference between protoplasts and spheroplasts.

Both **protoplasts** and **spheroplasts** are altered forms of plant, bacterial or fungal cells from which the cell wall has been partially or completely removed. **Protoplasts are** bounded by a single membrane while **spheroplasts** have two - an inner membrane and an outer membrane.

Activity 2.4: Looking at bacteria/microorganisms in yoghurt

Follow the procedure in the student textbook and show the students the microbial movement under the microscope. Tell them to draw what they observed. The motile organism is a bacterium.

2.1.2. Archaea

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate Archaea. Design a strategic plan to deliver the lessonsand conduct all the activities.

II. Teaching methods

Use student-cantered strategy and learning by doing. In delivering the lesson topic about archaea and the general characteristics of archaea, and you can use question in the textbook and encourage them to participate and you summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Where are archaea bacteria found?

- Archaean's are inhabitants of some of the most extreme environments on the planet. Some live near hydrothermal (rift vents) in the deep sea at temperatures well over 100 ^{O}C. Others live in hot springs, in extremely alkaline or acid waters.

Why are archae-bacterial and other bacterial groups placed together?

- Because both are prokaryotic organisms.

List the general characteristics of archae-bacterial.

- You can refetr to what has lready been provided in the student text book

What do you think, are archae unique?

Unique archaea characteristics include their ability to live in extremely hot or chemically aggressive environments, and they can be found across the Earth wherever bacteria survive. Those archaea that live in extreme habitats such as hot springs and deep-sea vents are called extremophiles.

What are the major differences among the Bacteria, Archaea, and Eukarya?

- Check table 1 of sub title (2.2.1. Eubacteria).

To make a hypothesis about the distribution of methanogenesis in the domain Archaea. When do you think their tolerance to harsh environment? What evolutionary processes have resulted in the distribution of this trait in the archaeal family tree?

- This is because of their membrane made of different chemical components than those bacteria, plants, or animals. It could be what provides protection in extreme habitats.
- SSU rDNA/rRNA.
- *compre bacteria with archaea
- Tg. The comparision between bacteria and archaea

Properties	Eubacteria	Archaea
Meaning	Bacteria are also single-cell but have the complex structure. All types of bacteria except archaea falls under this category.	Archaea are single-cell, simple microorganisms and are capable of surviving under extreme condition. They are considered as the most primitive cells, which originated on the earth 4 billion years ago.
Distribution	They are found everywhere like in the soil, water, living and non-living organisms.	Archaea are found in unusual environment like in hot spring, ocean depth, salt brine.
Cell Wall	The cell wall is made up of peptidoglycan with muramic acid or lipopolysaccharide.	The cell wall is said to be as pseudopeptidoglycan .
Lipid membrane	Eubacteria or bacteria have lipid membrane of ester bonds with fatty acids.	Archaea have ether bonds with the branching of aliphatic acids in their lipid membrane.
Metabolic pathway	Follow glycolysis pathway and Kreb's cycle to break down glucose.	Archaea do not follow glycolysis or Krebs cycle but uses similar pathway.
Types	Gram-positive and gram-negative.	Methanogens, Halophiles, Thermoacidophiles.
Reproduction	Bacteria can produce spores which allow them to live in unfavourable condition.	Archaea reproduce asexually by binary fission, fragmentation, or by the budding process.
Other features	Thymine is present in the tRNA.	Thymine is absent in the tRNA (transferase RNA).
	Introns are absent.	Introns are present.
	RNA polymerase is simple and contains 4 subunits.	RNA polymerase is complex and contains 10 subunits.
	Some bacteria are pathogens.	Archaea are non-pathogens.
Examples	Streptococcus pneumoniae., Yersinia pestis, Escherichia coli (E.coli).	Pyrolobus fumarii, Sulfolobus acidocaldarius, Pyrococcus furiosus.

2.1.3. Fungi

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the fungal structures. Design a strategic plan to deliver the lessonsand conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about eubacteria and the general characteristics of fungi, their economic importance, and role in biotechnology, and you can use question in the textbook and encourage them to participate actively and you summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Table Comparision of fungi with prokaryotes

Properties	Fungi	Bacteria
Nucleus	Eukaryotic; nuclear membrane; more than one chromosome; mitosis	Prokaryotic; no membrane; nucleoid; only one "chromo-some"
Cytoplasm	Mitochondria; endoplasmic reticulum; 80S ribosomes	No mitochondria; no endoplasmic reticulum; 70S ribosomes
Cytoplasmic membrane	Sterols (ergosterol)	No sterols
Cell wall	Glucans, mannans, chitin, chitosan	Murein, teichoic acids (Gram-positive), proteins
Metabolism	Heterotrophic; mostly aerobes; no photosynthesis	Heterotrophic; obligate aerobes and anaerobes, facultative anaerobes
Size, mean diameter	Yeast cells: 3–5–10 µm. Molds: indefinable	1–5 µm
Dimorphism	In some species	None

What are the general Characteristics of True Fungi?

1. **All are eukaryotic**
   - Possess membrane-bound nuclei (containing chromosomes) and a range of membrane bound cytoplasmic organelles (e.g. mitochondria, vacuoles, endoplasmic reticulum).
2. **Most are filamentous**
   - Are composed of individual microscopic filaments called hyphae, which exhibit apical growth and which branch to form a network of hyphae called a mycelium.
3. **Some are unicellular e.g. yeasts.**
4. **Protoplasm of a hypha or cell is surrounded by a rigid wall**
   - Are composed primarily of chitin and glucans, although the walls of some species contain cellulose.
5. Many reproduce both sexually and asexually
   - Both sexual and asexual reproduction often result in the production of spores.
6. Their nuclei are typically haploid and hyphal compartments are often multinucleate
   - However, the Oomycota and some yeasts possess diploid nuclei.
7. All are achlorophyllous
   - They lack chlorophyll pigments and are incapable of photosynthesis.
8. All are chemoheterotrophic (chemo-organotrophic)
   - They utilise pre-existing organic sources of carbon in their environment and the energy from chemical reactions to synthesize the organic compounds they require for growth and energy.
9. Possess characteristic range of storage compounds e.g. trehalose, glycogen, sugar alcohols and lipids.
10. May be free-living or may form intimate relationships with other living organisms

Do fungi have importance for human? If yes, list the importance of fungi.

Fungi are important because they are:

- agents of biodegradation and biodeterioration
- responsible for the majority of plant diseases and several diseases of animals (including humans)
- used in industrial fermentation processes

- used in the commercial production of many biochemical
- cultured commercially to provide us with a direct source of food
- used in bioremediation
- Beneficial in agriculture, horticulture and forestry.

How do hyphae grow?

- Hyphae may initially develop from a **GERM-TUBE** (a short, immature hypha) that emerges from a germinating spore. Spores are the microscopic dispersal or survival propagules produced by many species of fungi. Most fungi are mycelial (filamentous).

Where do representatives of different fungal groups grow in nature? How do different fungi get their nutrients?

- Fungi grow in moist and fertile area. Fungi feed by absorption of nutrients from the environment around them. They produce extra cellular enzyme which degrade the organic materials.

*. Differences among major divisions of fungi

Group and Representative Member(s)	Appearance	Usual Habitat	Some Distinguishing Characteristics	Asexual Reproduction	Sexual Reproduction
Chytridiomycetes *Batrachochytrium dendrobatidis*		Aquatic, guts of herbivores, parasitic	Unicellular and multicellular. Rhizoids with no true mycelium	Motile zoospores from a sporangium	Flagellated gametes in male and female
Zygomycetes *Rhizopus stolonifer* (black bread mold)		Terrestrial	Multicellular, mycelia of continuous hyphae with many haploid nuclei	Asexual spores develop in sporangia on the tips of aerial hyphae	Sexual spores known as zygospores can remain dormant in adverse environment
Ascomycetes *Neurospora, Saccharomyces cerevisiae* (baker's yeast) *Penicillium, Aspergillus*		Terrestrial, on fruit and other organic materials	Unicellular and multicellular with septated mycelia	Is common by budding; conidiospores	Involves the formation of an ascus (sac) on specialized hyphae
Basidiomycetes *Agaricus campestris* (meadow mushroom) *Cryptococcus neoformans*		Terrestrial	Multicellular, uninucleated mycelia; group includes mushrooms, smuts, rusts that affect the food supply	Commonly absent	Produce basidiospores that are borne on club-shaped structures at the tips of the hyphae

What features of fungal species may be interpreted as adaptations to life as a saprobe, a pathogen, or a mutualistic symbiont?

- This is because the virulence gene is available in the cell of the fungi.

Which fungal features permit some fungal species and not others to be pathogenic on humans?

- This is because the virulence gene is available in the organism

What are the ecological roles of different kinds of fungi?

- Fungi are agents of biodegradation and biodeterioration: SAPROTROPHIC fungi utilize dead organic materials as sources of nutrients and are responsible for the biodegradation of organic materials in our environment, particularly plant materials in the form of leaf litter and other plant debris. Such types of fungi play a vital role in recycling essential elements, particularly carbon.

How do different kinds of fungi, including lichenized fungi, reproduce asexually?

- Answer: By producing the sexual and asexual spores.

Why are there several names for the same fungus or fungal group? Provide specific

- Answer: Because of the existence of telomorphic and anamorphic stages in their life cycle.

What are traditional fermented foods?

- Fermented foods that produced at home, not produced by the industry.

List the Ethiopian traditional fermented foods, beverages, and condiments.

- You can refer to the student text book

What do you think is the role of fungi in the production of traditional fermented products?

- Most fermentative yeast and molds play a role in fermenting food beverage and condiments.

What is starter culture?

- A starter culture is defined as a preparation of living microorganisms, which are deliberately used to assist the beginning of fermentation, producing specific changes in the chemical composition and the sensorial properties of the substrate to obtain a more homogeneous product. E.g. Absit (raacatii).

How do local people preserve starter culture for a long-time use?

- They preserve through the process of back sloping methods. By using absit they transfer the organism to the new prepared dough they preserve the starter culture.

Which fungal groups are commonly involved in food fermentation?

- Saccharomyces cervisiae

Activity 2.5b

- **Starter activity**: Before you conduct the lesson, encourage students to Google search and read additional books on fungal species that are common to the Ethiopian traditional fermented Enjera, Kocho, Bulla, Tej, Shameta, and different condiments.
- **Main Activity**: Students should make a discussion and list all the fungi common to Ethiopian traditional fermented food, beverage and condiments. The report to the class.
- **Conclusive Activity**: The teacher gives a summary of their presentation.

Assessment method:

- Correct their paper after the presentation and record the results.
- Observe the discussions and comment on important issues.
- Evaluate the presentation techniques of the groups.

Which funguses are common in food spoilage?

- *Rhizopus stolinfer*, Penicilium, and aspergillus are the common one.

What does a fungal disease mean?

- A fungus that invades the tissue of plant and animals that can cause a disease.

List at least five diseases caused by fungi?

- *Candidiasis.*
- *Cryptococcosis.*
- *Aspergillosis.*
- *Coccidioidomycosis (Valley Fever)*
- *Histoplasmosis.*
- *Blastomycosis.*
- *Pneumocystis pneumonia.*

What are the main human diseases caused by fungi?

- *Black piedra of hair.*
- *Ringworm.*
- *Aspergillosis.*
- *Coccidioidomycosis (Valley Fever)*
- *Histoplasmosis.*
- *Blastomycosis.*
- *Pneumocystis pneumonia.*

What is a plant fungus? List fungi that cause plant diseases.

- Fungi that cause plant diseases
  - *Cochliobolus heterostrophus*, *Cryphonectria parasitica*, *Erysiphe gramminis*, *Puccinia graminis*, etc.
  - Other funguses Clubroot; *Pythium* species; *Fusarium* species; *Rhizoctonia* species; *Sclerotinia* and *Sclerotium* species – are soilborne diseases

What is a probiotic? What does a probiotic do for you?

- **Probiotics** are a combination of living beneficial bacteria and/or yeasts that naturally live in the human body. Bacteria are usually viewed in a negative light as something that makes people sick. However, There are two kinds of bacteria constantly found in and on the human body: Good bacteria and bad bacteria.

Activity 2.6

- **Starter activity**: Before the class, encourage students to Google search and read additional books on the economic importance of some common protozoa.
- **Main Activity**: Students should make a discussion on the economic importance of some common protozoa. Then, report/present to the class.

Assessment method:

- Correct their paper after the presentation and record the results.
- Observe the discussions and comment on important issues.
- Evaluate the presentation techniques of the groups.

2.1.4. Protozoa

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the protozoa structures. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about protozoa, the general characteristics and their health effect on human and animals, and you can use questions in the textbook and encourage to participate actively and you summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Can protozoa reproduce?

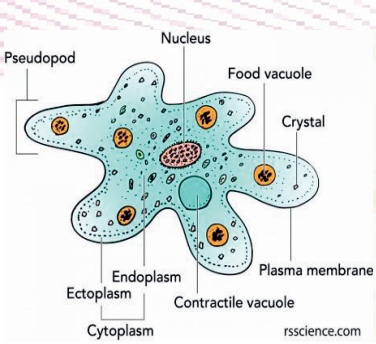
- Yes!

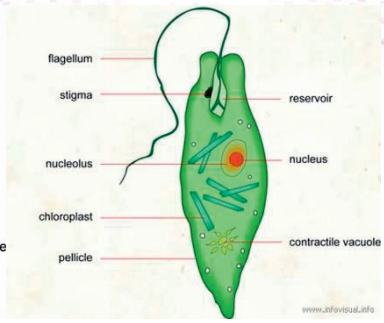
Protozoa is a phylum comprising some of the morphologically simplest organisms of the animal kingdom (See Figure 2.11). Many species are unicellular, eukaryotic, and microscopic in size, and most are free-living and motile, but some have communalistic, mutualistic, or parasitic relationships

How are Amoeba, Euglena and Paramecium reproduced?

- Amoebas are single-celled organisms that reproduce asexually. Reproduction occurs when an amoeba doubles its genetic material, creates two nuclei, and starts to change in shape, forming a narrow "waist" in its middle. This process usually continues until the final separation takes place into two cells.
- Euglena **reproduce asexually by means of longitudinal cell division**, in which they divide down their length, and several species produce dormant cysts that can withstand drying
- Paramecium reproduction is **asexual, by binary fission**, which has been characterized as "the sole mode of reproduction in ciliates" (conjugation being a sexual phenomenon, not directly resulting in increase of numbers). During fission, the macronucleus splits by a type of amitosis, and the micronuclei undergo mitosis.

Draw and label the structure of Amoeba, Euglena, and Paramecium.





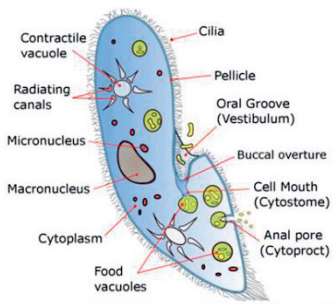


Figure 2.12. Protozoa cell structures

What are Babesia and Theileria?

- Babesia also called Nuttallia is an apicomplexan parasite that infects red blood cells and is transmitted by ticks. Originally discovered by the Romanian bacteriologist Victor Babeș, over 100 species of Babesia have since been identified.
- *Theileria* is a genus of parasites that belongs to the phylum Apicomplexa, and is closely related to Plasmodium. Two *Theileria* species, *T. annulata* and *T. parva*, are important cattle parasites. *T. annulata* causes tropical theileriosis and *T. parva* causes East Coast fever. *Theileria* species are transmitted by ticks.

State the common species of plasmodium found in Ethiopia.

- Among the five Plasmodium species known to infect human beings, *Plasmodium falciparum* and *Plasmodium vivax* malaria are by far the most predominant and widely distributed in Ethiopia.

Explain the causative agent and vector of Nagana (Gandii)/ (Gendi).

- The African trypanosome, *Trypanosoma brucei*, is a unicellular parasite causing African Trypanosomiasis (sleeping sickness in humans and nagana in animals). Due to some of its unique properties, it has emerged as a popular model organism in systems biology.
- tsetse flies are the vector for Nagana diseases

Describe the vector and life cycle of leshimania spp.

- The vector for leshmania is **sandfly (Figure 2.13).**

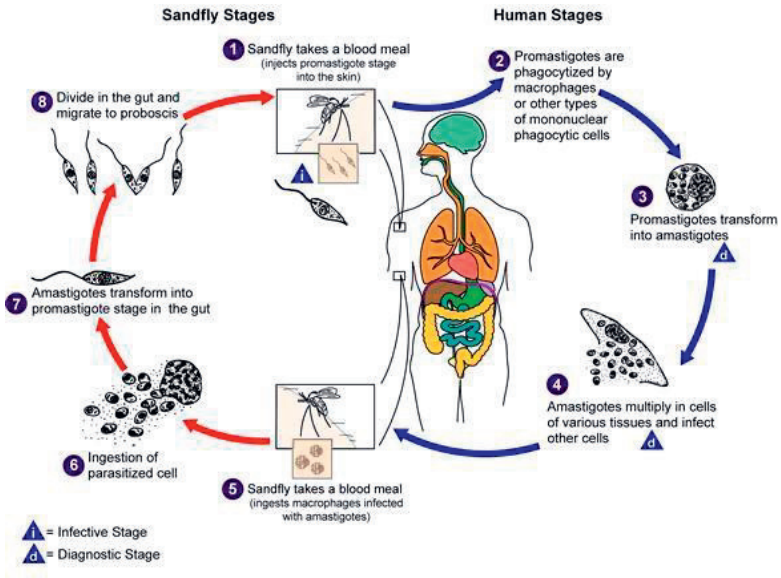


Figure 2.13. Leshmania lifecycle

State the routes of transmission of Giardia and amoeba.

- Answer: The roots for Giardia and amoeba are drinking water and foods

Show the life cycle of plasmodium spp. and describe their ecology.

The malaria parasite life cycle involves **two hosts**. During a blood meal, a malaria-infected female Anopheles mosquito inoculates sporozoites into the human host. Sporozoites infect liver cells and mature into schizonts, which rupture and release merozoites (See **Figure 2.12**) on the student textbook.

2.1.5. Viruses

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the virus structures. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about viruses, general characteristics, their health impact, and role in biotechnology, and you can use questions in the textbook and encourage them toparticipate actively, and then you summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Activity 2.7

- **Starter activity**: Before the class, encourage students to Google search and read additional books on morphology and chemical structure of viruses and write an essay on multiplication of animal viruses, bacteriophage, and its application in biotechnology.
- **Main Activity**: Students should discuss the document they wrote and present it to the class.

Assessment method:

- Correct their paper after the presentation and record the results.
- Observe the discussions and comment on important issues.
- Evaluate the presentation techniques of the groups.

What are the bases for the classification of viruses?

- Their virion morphology
- Physicochemical properties of virion
- Virion genome properties
- Virion proteins
- Replication
- Antigens and biologic properties.

List the different shapes of a virus.

- Spherical
- Rod-shaped
- Brick-shaped
- Tadpole-shaped
- Bullet-shaped
- Filament

Do you think viruses are essential for human beings? If yes, in what way?

- *Phage typing of bacteria*
- Phage typing of bacteria
- Pesticides.
- Pesticides.
- Anti-tumor agent

- Gene vectors for protein production
- Gene vectors for treatment of genetic diseases

Can viruses reproduce? What does it mean by the lytic and lysogenic cycle?

- **V**iruses reproduce through lytic and lysogenic cycles

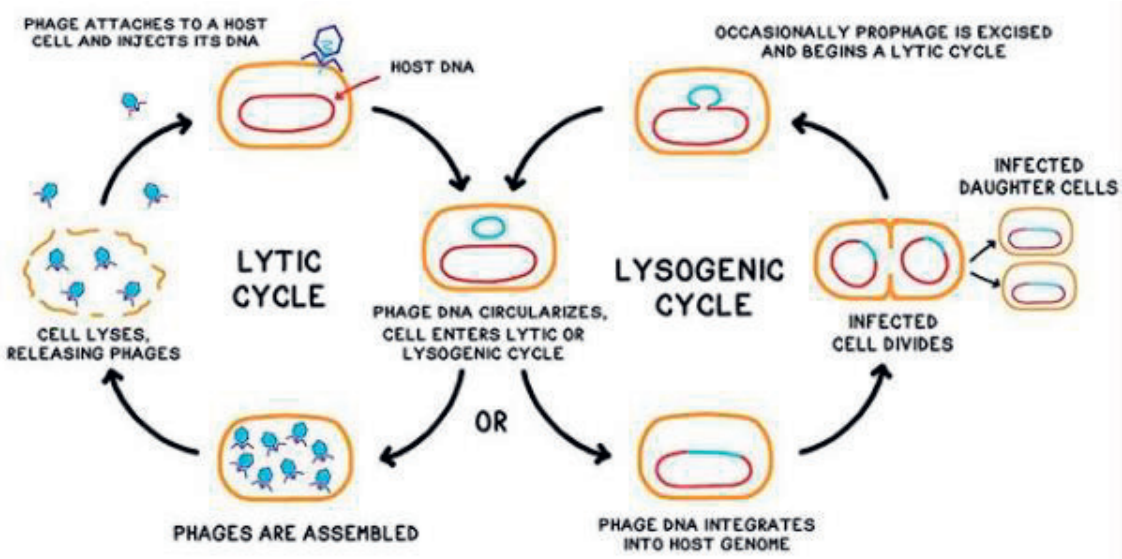


Figure 2.14. The lytic and lysogenic cycle of viral reproduction.

What feature of viruses could be used to characterize them as life forms?

- They show multiplication (only inside the host cell).
- They have genetic material i.e. DNA/RNA.
- They can direct protein synthesis (though they use host machinery for it).
- They show mutation.
- They can be transmitted from the diseased host to the healthy ones or posses the ability to infect.
- They react to heat, chemicals, radiation, and shows irritability, a character of only living organisms.
- They possess genetic continuity and have definite races/strains.
- Similarity between nucleoproteins of viruses with the protein and nucleic acid of living organisms.

What make viruses more similar to lifeless molecules?

- They can be crystallized (Stanley, 1935)
- They behave as inert chemicals outside the host cell.

- A cell wall or cell membrane of any type is absent in viruses.
- They do not show functional autonomy.
    - they do not move
    - they do not grow
- They do not respire or excrete or they do not show any sign of metabolism except reproduction.
- They lack any energy producing enzyme system.

What are Retroviruses?

- A retrovirus is a type of virus that inserts a copy of its RNA genome into the DNA of a host cell where it invades and changes the genome of that cell.

How does HIV reproduce and cause AIDS? Can AIDS be treated?

- The major steps in the HIV replication cycle are; binding and fusion; reverse transcription, integration, transcription, assembly, and budding (See Figure 2.14). A typical structure of the virus is presented in Figure 2.15.

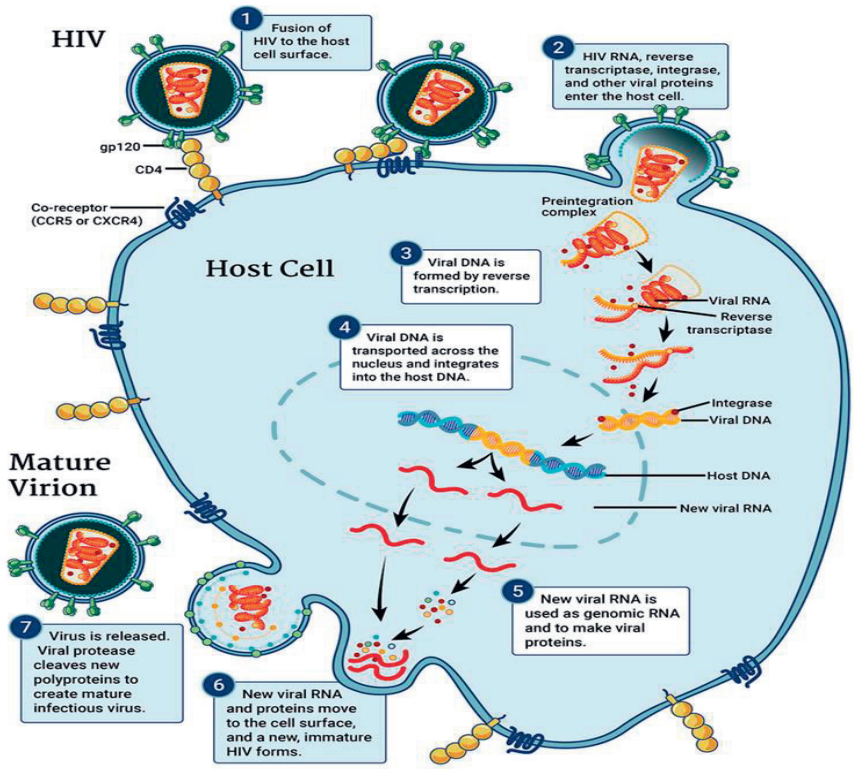


Figure 2.15. The HIV replication cycle

What is the social and economic impact of AIDS?

- HIV/AIDS is a threat to social and economic development. Treatment of HIV/AIDS patients must be accompanied with other social measures to enhance their physical, mental and social wellbeing. HIV/AIDS can lead to poverty, affecting particularly women and young people.

Draw the structure of HIV

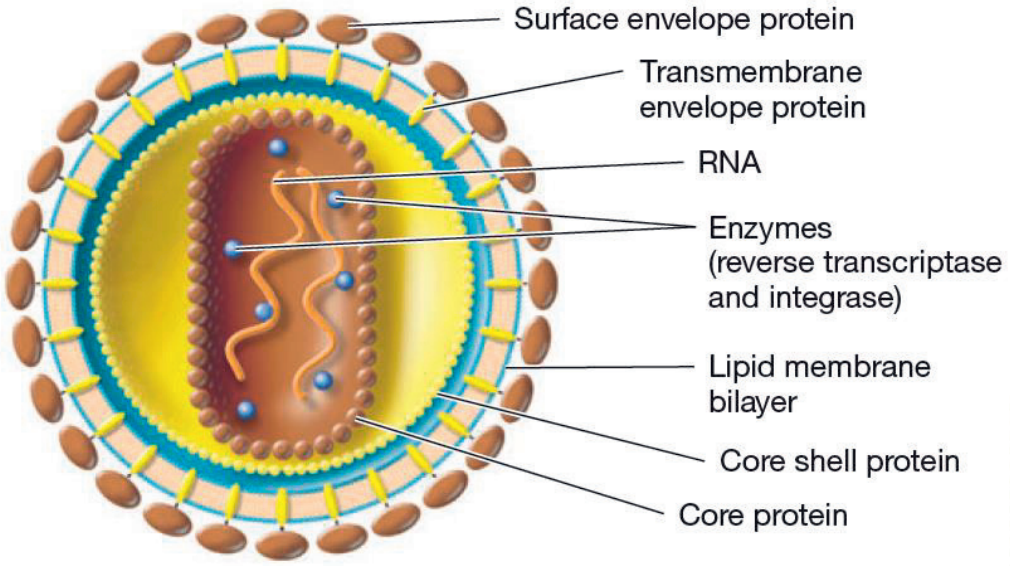


Figure 2.16. HIV virus structure

What is HIV surface spikes made from?

- Glycoprotein

What is the role of HIV spikes?

- The spikes on virus surfaces bind receptors on host cells to propagate infection.

What is the reproductive cycle of bacteriophages?

- Bacteriophages are viruses that only infect bacteria (See Figure 2.16)

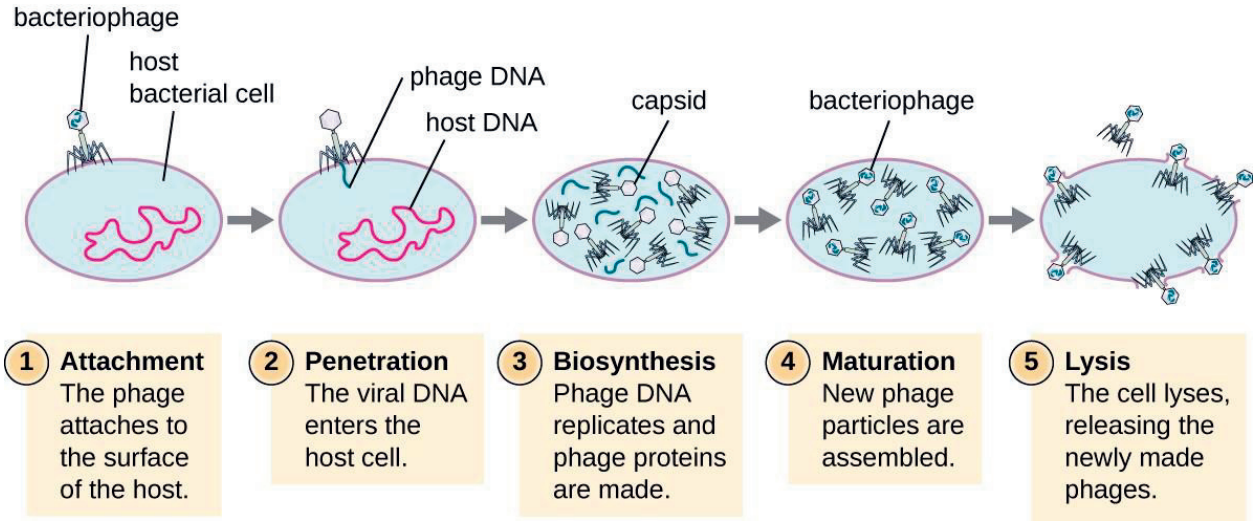


Figure 2.17. Bacteriophage life cycle

What happens to the body of an animal when it dies? Why?

- It decays. The microorganisms act on the dead matter, converting it to the inorganic substances.

What do you think the economic or beneficial uses of microorganisms?

- The beneficial uses of bacteria include the production of traditional foods such as yogurt, cheese, and vinegar. Microbes are also important in agriculture for the production of compost and fertilizer. Bacteria are also used in genetic engineering and for genetic changes.

List all the Ethiopian traditionally fermented food, beverages, and condiments.

- You can refer to the student textbook

Which main types of microorganisms play a role in Ethiopian food fermentation?

- Lactic acid bacteria and yeasts

Which microorganisms are important in the spoilage of foods?

- Both bacteria and fungi

What are the roles of microorganisms in the industry?

- Industrial microorganisms are used to produce many things including food, cosmetics, pharmaceuticals and construction materials. Microorganisms can be genetically modified or engineered to aid in large-scale production.

Activity 2.10

- **Starter activity**: Instruct students to prepare a poster about the industrial uses of microorganisms.
- **Main Activity**: The students present and discuss their papers to the class.
- **Conclusive Activity:** Finally, the teacher gives them the summary of the student presentation with a poster.

What is the role of bacteria and other microorganisms in infectious diseases?

- Pathogen bacteria cause diseases on plant and animals.

How do we benefit from the production of vitamin K by microbes?

Bacteria that live in the human gut also produce small quantities of K-2. Both forms of vitamin K are essential for blood clotting and bone health. However, vitamin K-2 may also protect against certain forms of cancer and heart disease.

What are infectious diseases?

- Infectious diseases are diseases caused by pathogen microorganisms.

How will you prove that microorganisms can cause disease?

- The couch postulate (See Figure 2.18) is the best technique to identify, which microorganisms can cause diseases and additional notes are shown in the figure below.

This is a supplementary note for the Germ Theory of Disease and Koch's Postulates

To prove if diseases are caused by microorganisms, Koch used mice as experimental animals. Using appropriate controls, Koch demonstrated that when a small amount of blood from a diseased mouse was injected into a healthy mouse, the latter quickly developed anthrax. He took blood from this second animal, injected it into another, and again observed the characteristic disease symptoms. However, Koch carried this experiment with a critically important step further. He discovered that the anthrax bacteria could be grown in nutrient fluids outside the host and that even after many transfers in laboratory culture, the bacteria still caused the disease when inoculated into a healthy animal. On the basis of these experiments and others on the causative agent of tuberculosis, Koch formulated a set of

rigorous criteria, now known as **Koch's postulates**, for definitively linking a specific microorganism to a specific disease. Koch's postulates state the following:

1. The disease-causing organism must always be present in animals suffering from the disease but not in healthy animals.

2. The organism must be cultivated in a pure culture away from the animal body.
3. The isolated organism must cause the disease when inoculated into healthy susceptible animals.
4. The organism must be isolated from the newly infected animals and cultured again in the laboratory where it should then be seen to be the same as the original organism

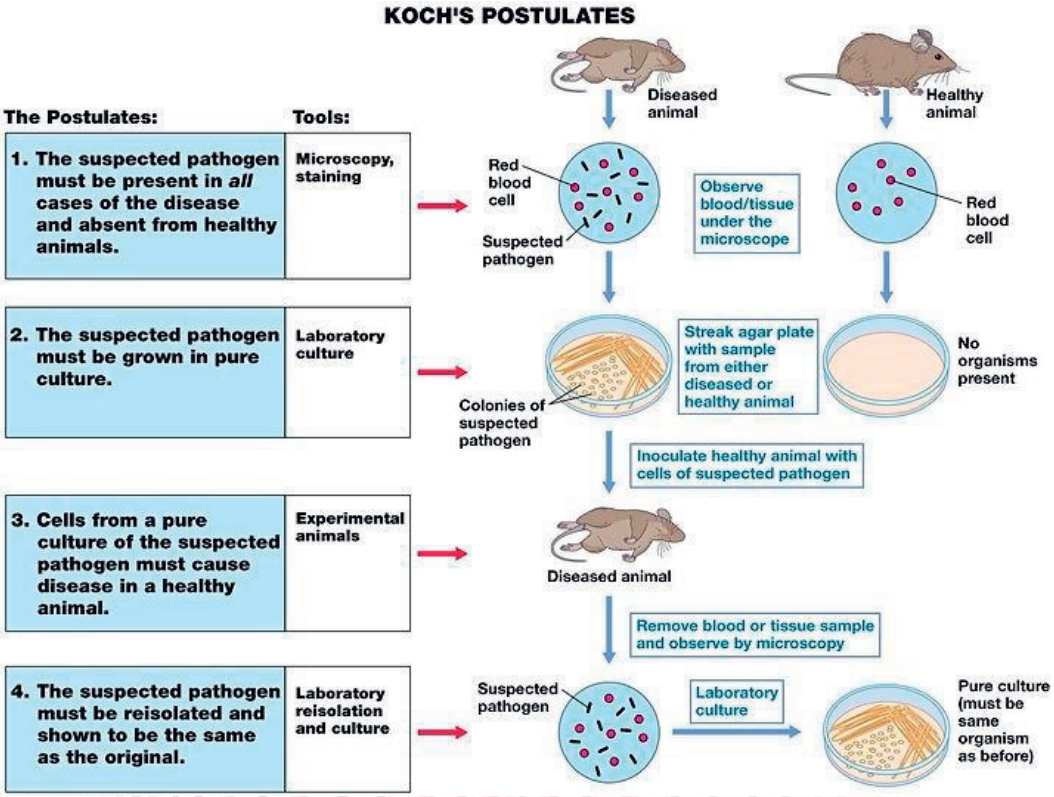


Figure 2.18. Diagrammatic presentation of coach's postulate

How are normal microbiotas beneficial?

- Norma microbiotas are soldiers of the body, they compute for the space and food with the pathogenic microorganisms and they produce different metabolites that the pathogenic microorganisms could not tolerate.

Which are the common disease causing microorganisms?

- Pathogen microorganisms *e.g. Salmonella typhae, Shigella dysentery, Mycobacterium tuberculosis* etc.

Activity 2.8

- **Starter activity**: Arrange the students into six groups; you may assign each group to take one organism among bacteria, fungi, protozoa (malaria, amoeba, and giardia), and virus to study their life cycles and biology using the Jigsaw method. Tell them to read additional books or they can use their textbook and picture prompt for each group of organisms.
- **Main Activity**: Students use drama method or role-play (Hint-some students can act as doctor and others as patients) to learn about the causes, symptoms, preventive and treatment methods.
- **Conclusive Activity**: Finally, the teacher gives them the summary of the dram presented.

Activity 2. 7

- **Starter activity**: Before the class, motivate the students to Google search or read different literature to differentiate between a renowned microbiologist and parasitologist in Ethiopia.
- **Main Activity**: Students will list the microbiologists and parasitologist in Ethiopia and discuss their novel works and their contribution to the country and science.
- **Conclusive Activity**: Finally, the teacher gives them a summary of the discussion

Assessment method:

- Ask the student a question related to the life cycle and biology of microorganisms.
- Observe their discussions and comment on important issues.

List microorganisms that produce the antibiotics and the antibiotics produced by microorganisms.

The following are some examples of antibiotics produced by microorganisms.

Penicillins—produced from genus *Penicillium,* **Cephalosporin**--Derivatives of fermentation products of the mould, *Cephalosporium,* **Carbapenems**—produced by

Streptomyces spp. **Aminocyclitol** ---Produced by *Streptomyces spectabilis,* **Aminoglycosides**--Naturally occurring antibiotics or semisynthetic derivatives from *Micromonospora* spp. Or *Streptomyces* spp.- **Ansamycin**---Semisynthetic antibiotic derived from compounds produced by *Streptomyces mediterranei etc.*

Answer Key for the chapter review questions

Part I: Multiple choice

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

Part II: Fill in the blnk spaces

1. Treponema pallidum
2. purple nonsulfur
3. genus
4. Distance
5. Common ancestor (LUCA)
6. Coenocytic
7. Yeasts
8. Antibiotics
9. Bacteriophage
10. Complex
11. naked or nonenveloped
12. Electron

UNIT 3:
Energy Transformation (26 periods)

Unit Learning Outcomes: After the successful completion of this unit, the learner will be able to:

- Discuss how cells in multi-cellular organisms communicate with each another
- Explain how the process of photosynthesis turns light energy into stored food energy in plants.
- Model how the process of cellular respiration turns energy stored in food into a usable form for physiological activities
- Discuss the process of fermentation and how it differs from photosynthesis

Learning competency for the unit:

At the end of this unit, the student is expected to:

- Enumerate the types of cell communication
- Explain chemical structure of lipids and carbohydrates
- Define metabolism
- List the types of metabolism
- Define photosynthesis
- Discuss the structure and functions of chlorophyll and chloroplast
- Conduct paper chromatography experiment to separate photosynthetic pigments
- Identify the raw materials of photosynthesis
- State the role of light energy in photosynthesis
- Differentiate between light-dependent and light-independent reactions in photosynthesis
- Explain the process and products of the light-independent and light-dependent reactions in photosynthesis
- Demonstrate how the absence of CO_2, chlorophyll, and light affect photosynthesis

- Appreciate the contributions of photosynthesis for the continuity of life and O_2 and CO_2balance
- State the contributions of photosynthesis in reducing global warming
- Discuss cellular respiration
- Describe the structure and functions of mitochondria
- Explain the structure and importance of ATP
- Differentiate between aerobic and anaerobic respirations
- Sketch the process of energy harvest from glucose in the presence and absence of oxygen (Glycolysis, Kreb's cycle, and Electron transport system)
- Appreciate alcoholic and lactate fermentation at home (Tej, Yoghurt)
- Infer the effect of lactate production during physical exercise

Learning strategies

1. Let students reflect on what communication means and how it occurs. Following this reflection, ask them if they know how one cell can communicate with another cell in the organisms' body. Group them into three and assign each group to take one type of cell communication and read from their textbook or make a library search to find the definitions and functions of gap junctions, tight junctions and desmosomes. Then, let them discuss their findings in the class.
2. Let students compare and contrast between chemical structure of lipids and carbohydrates
3. In groups, students will discuss and provide their definitions for cellular metabolism, differentiate between types of metabolism. The teacher will help in giving appropriate definitions and explanation on metabolism and its type. Support this activity using virtual lab (simulation software, animation and video) (competencies 3 & 4).
4. Let students observe plants around them and ask them to reflect why they appear green. Guide them to search for the reason. Then, ask students to reflect on what they know about photosynthesis and what they want to learn in this session using the KWL chart. Indicate where photosynthesis occurs in plants and describe the structure and role of chlorophyll and chloroplast in photosynthesis. . Support this activity using virtual lab (simulation software, animation and video) (Competencies 5 & 6).

5. Form groups and make a paper/chalk chromatography experiment to separate the photosynthetic pigments in the chlorophyll. Then, ask them to tell you what happens to the chromatography. Determine the component pigments in the chlorophyll.
6. Brainstorm students' prior knowledge about the materials required for photosynthesis, the role of each material in photosynthesis. Instruct them to search and read further from the literature
7. Let students differentiate light-dependent and light-independent reactions. Discuss in groups on how and in which reaction ATP and NADPH are produced, how they are used to produce glucose and the role of light energy in photosynthesis. You also need to ask them to draw and label two stages of reactions of photosynthesis with raw materials required and products (Competencies 9-11).
8. Let them conduct experiments to show the importance of light, CO2 and chlorophyll for photosynthesis to consolidate knowledge construction and extend their understanding.
9. Ask students to define what global warming is and list the causes for global warming and the factors that affect the continuity of life. Discuss the role of photosynthesis for the continuity of life, O2, and CO2 balance, and in reducing global warming. To provide additional insight and enhance their understanding on global warming, you can invite a senior Geography teacher to the classroom for more explanation. (Competencies 13 &14).
10. Ask students to reflect on why they feel tiered after working or running. One possible answer might be that we lose energy. Then, keep on asking them to tell you where they can get this energy from. Then, let students brainstorm and reflect on what cellular respiration is.
11. Let students sit in groups and remind them what they learned about the structure and function of mitochondria in grade 9 about a cell. Remind them about the structure and function of ATP from their study in biochemical molecules.(competencies 16 &17).
12. Let students identify the difference between aerobic and anaerobic respiration. Clarify the types of anaerobic respiration (alcoholic fermentation and lactic acid fermentation) by comparing them with aerobic respiration.
13. Students can sit in a group and discuss how cellular respiration produces ATP in mitochondria. Introduce the three phases of cellular respiration (glycolysis, Kreb's

cycle, and Electron transport system).Let them search from the library and use picture prompts/models/videos to study the cycles, end products of each phase/cycle. Collect data of ATP from each phase and discuss how to calculate the total amounts of ATP produced from a single glucose molecule during aerobic and anaerobic respiration.

14. Let students ask their mothers, guardians or anyone about what they use for alcoholic and lactic acid fermentation while making Tej and Yoghurt, respectively.
15. Extend students' knowledge construction by guiding students to predict the cause of experiencing muscle cramps after a physical education class and to imagine what would happen to life if photosynthesis and cellular respiration were limited.

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the cell communication. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about cell communication, types of cell communication and mechanisms of cell communications, and you can use question in the textbook and encourage them to participate actively, and then you summarize their answer.

III. Tasks

Additional teaching notes

3.1. Energy

As one of the most important concepts in biology, energy can be understood in the context of matter, which is anything that has mass and takes up space. Energy is defined as the capacity to do work, which is any change in the state or motion of matter. Technically, mass is a form of energy, which is the basis behind the energy generated by the sun and other stars. More than 4 billion kilograms of matter per second are converted into energy in the sun.

Biologists generally express energy in units of work, or kilojoules (kJ). It can also be expressed in units of heat energy—kilocalories (kcal)—thermal energy that flows from an object with a higher temperature to an object with a lower temperature. One kilocalorie is equal to 4.184 kJ. Heat energy cannot do cell work because a cell is too small to have regions that differ in temperature. For that reason, the unit most biologists prefer today is

the kilojoule. However, we will use both units because references to the kilocalorie are common in the scientific literature.

3.2. Photosynthesis

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the photosynthesis. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about photosynthesis, light and dark reaction, and sites of photosynthesis, and you can use question in the textbook and encourage them toparticipate actively and then you will summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

How are autotrophs different from heterotrophs?

Autotrophs are known as producers because they are able to make their own food from raw materials and energy. Examples include plants, algae, and some types of bacteria. **Heterotrophs** are known as consumers because they consume producers or other consumers. Dogs, birds, fish, and humans are all examples of **heterotrophs**.

Describe photosynthesis in words and show its chemical reaction.

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that, through cellular respiration, can later be released to fuel the organism's activities

The process of photosynthesis is commonly written as: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. This means that the reactants, six carbon dioxide molecules and six water molecules, are converted by light energy captured by chlorophyll (implied by the arrow) into a sugar molecule and six oxygen molecules, the products.

Why is photosynthesis essential to life?

Photosynthesis is important to living organisms because it is the number one source of oxygen in the atmosphere. Green plants and trees use photosynthesis to make food from sunlight, carbon dioxide and water in the atmosphere: It is their primary source of energy.

Table 3.1.The difference between Catabolism and Anabolism

CATABOLISM	ANABOLISM
All the catabolic reactions in a cell	All the anabolic reactions in a cell
Catabolic reactions release	Anabolic reactions require
Catabolic reactions involve the breaking of bonds; whenever chemical bonds ; are broken, energy is released	Anabolic reactions; involve the creation of bonds; it takes energy to create chemical bonds released
Larger molecules are broken down into smaller molecules (sometimes referred to as degradative reactions)	Smaller molecules are bonded together to create larger molecules (sometimes referred to as biosynthetic reactions)

3.2.1. The place/site of photosynthesis

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the sites of photosynthesis. Design a strategic plan to deliver the lessonsand conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about photosynthesis, light and dark reaction, and sites of photosynthesis, and you can use question in the textbookand encourage them to participate actively and then you will summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Where do you think is the site of photosynthesis in plants?

In plants, photosynthesis takes place in **chloroplasts**, which contain the chlorophyll. Chloroplasts are surrounded by a double membrane and contain a third inner membrane, called the **thylakoid membrane**, which forms long folds within the organelle.

3.2.2. Photosynthetic pigments

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the photosynthetic pigments. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about photosynthetic pigments, importance of different colours, and the wave length of different colours, and you can use question in the textbook and encourage them to participate actively and then you will summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

What are the main components of sunlight?

Generally, sunlight is broken down into three major components: (1) visible light, with wavelengths between 0.4 and 0.8 micrometre, (2) ultraviolet light, with wavelengths shorter than 0.4 micrometre, and (3) infrared radiation, with wavelengths longer than 0.8 micrometre.

How does having multiple types of pigments benefit plants?

Multiple pigments absorb different wavelengths of light, allowing plants to capture the maximum amount of energy from the sun. Multiple pigments allow plants to have different colours of leaves, which allow them to capture the maximum amount of energy from the sun.

Activity 3. 4 (Group work)

- **Starter activity**: Before the class, inform students to read their textbooks or Google search and prepare a presentation on, if plants expose to one wavelength of light at a time, 300 nm, 450 nm, or 600 nm, which produce the highest photosynthetic rate?
- **Main Activity**: The students will write a note and discuss it in their group and present to the class.
- **Conclusive Activity**: The teacher will summarize their discussion by giving

Assessment method:

- Ask the student a question related to types of light wave absorption by the leaf.
- Observe their discussions and comment on important issues.
- Evaluate their presentation techniques of the groups.

For activity 3.4, various books have shown that exposing plants to blue light has the highest photosynthetic rate because chlorophyll absorbs blue light the best.. Blue light is between 490–450 nm. 450 nm (closest to green)

3.2.3. Light-dependent and light-independent reactions

What are the two stages at which photosynthesis occurs?

- There are two main stages of photosynthesis: the light-dependent reactions and the Calvin cycle.

What happens in each of the two main stages of photosynthesis?

- The light-dependent reactions use light energy to make two molecules needed for the next stage of photosynthesis: the energy storage molecule or ATP and the reduced electron carrier or NADPH.
- In the dark reaction, plants use carbon dioxide with ATP and NADPH from the light reactions to produce glucose. It takes place in the stroma of the chloroplast.

Where does in the chloroplast each stage occur?

- Light reactions happen in the thylakoid membrane, and the Calvin cycle happens in the stroma.
  A. Light dependent reaction (cyclic and non-cyclic photophosphorylation)
  B. Light-Independent Reactions (Calvin cycle

- Photosynthesis is the process by which green plants prepare their food in the presence of sunlight, water, chlorophyll and carbon dioxide. The complete process bears two reactions in which one occurs in the presence of sunlight, whereas the other occurs in the absence of sunlight.
- **What is the difference between light-dependent and light-independent reactions?**

Light-dependent photosynthesis	Light-independent photosynthesis
It is called light-dependent photosynthesis because it needs light or depends on light to produce organic energy molecules ATP and NADPH.	It is called light-independent photosynthesis because no light is required here to reduce carbon dioxide and glucose by the use of ATP and NADPH.
It occurs in the grana or thylakoid of the chloroplast.	It occurs in the stroma of the chloroplast.
During light-dependent photosynthesis photolysis or splitting of molecules of water takes place into hydrogen and oxygen.	During light-independent photosynthesis reduction of carbon dioxide into glucose molecules takes place through a series of reactions constituting the Calvin cycle.

Here chlorophyll absorbs light energy and loses one electron during this process. The chlorophyll molecule gets back its lost electron from the electron released during photolysis of water.	The carbon dioxide is taken up at night and an intermediate product in the form of malic acid is produced. This acted upon by the energy absorbed through chlorophyll and the ATP produced will reduce malic acid into carbohydrates.
It is also called the photochemical phase of photosynthesis.	It is also called the biochemical phase of photosynthesis.
Photolysis occurs in light-dependent photosynthesis.	Photolysis does not occur in light-independent photosynthesis.
The end product of this reaction is ATP and NADPH.	The end product of this reaction is glucose.

- **Why is the Calvin cycle also called the C3 pathway?**
  - In Calvin cycle, a 3-carbon compound Phosphoglyceric acid (PGA) is the first product of CO_2 fixation. As a result, it is called C3 cycle.
- **How does photorespiration counter photosynthesis?**
  - Photorespiration reduces the efficiency of photosynthesis for a couple of reasons. First, oxygen is added to carbon. In other words, the carbon is oxidized, which is the reverse of photosynthesis—the reduction of carbon to carbohydrate.
- **Describe how a C4 plant minimizes photorespiration.**
  - The light reactions and carbon reactions occur in different cells, so oxygen does not come into contact with rubisco.
- **How is the CAM pathway similar to the C4 metabolism, and how is it different?**
  - The Calvin cycle produces a three-carbon compound from C3 photosynthesis, whereas C4 photosynthesis produces an intermediate four-carbon compound that splits into a three-carbon compound for the Calvin cycle. Plants that use CAM photosynthesis collect sunlight during the day and fix CO2 molecules at night.

Activity 3.3

- **Starter activity**: Group students in a class to discuss, draw, and label the structure of a chloroplast showing where the light dependent and the light-independent reactions take place.
- **Main Activity:** Each student will draw and label the structure of the chloroplast and present it to the class.
- **Conclusive Activity**: The teacher will summarize their discussion for further student understandings.

Assessment method:

- Ask the student a question related to chloroplast, light, and dark reactions.
- Observe their discussions and comment on important issues.
- Evaluate their presentation techniques of the groups.

The following image shows the the structure of a chloroplast and also a site where the light dependent and the light-independent reactions take place.

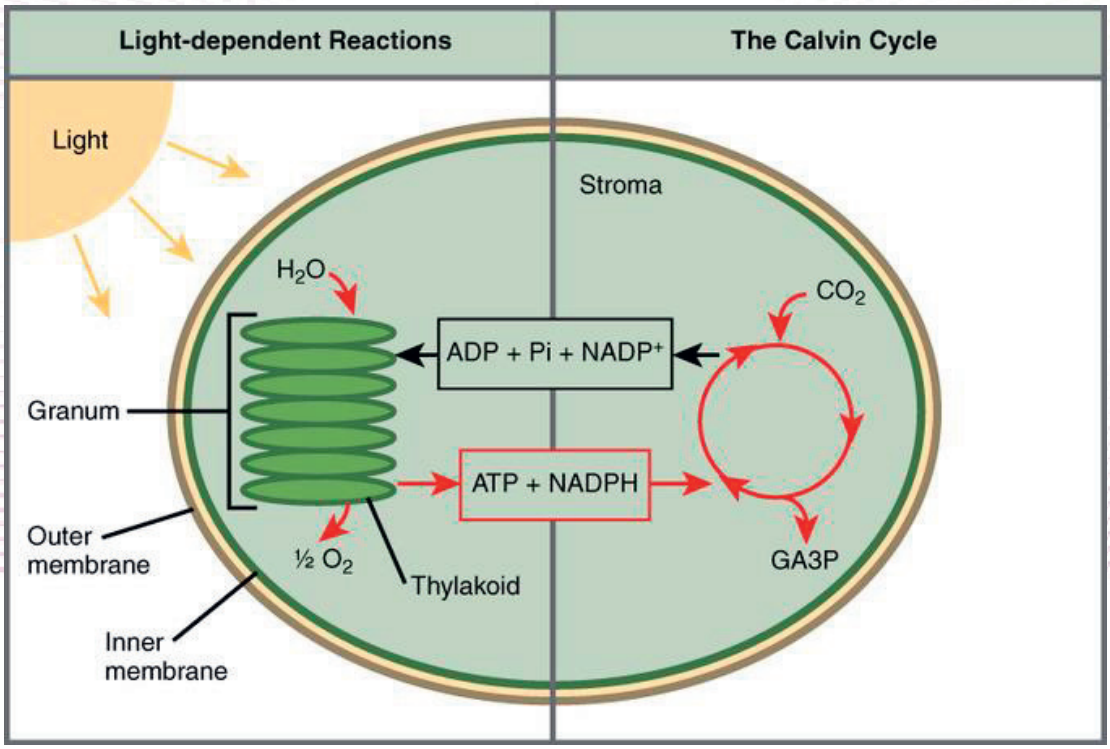


Figure 3.5. the structure of a chloroplast where the light dependent and the light-independent reactions take place.

3.2.4. Contributions of photosynthesis for the continuity of life, for O_2 and CO_2 balance and global warming

Answer key for Review questions

1. C
2. C
3. D
4. A
5. D
6. D
7. B
8. C
9. B
10. A
11. C

3.3. Cellular Respiration

Cellular respiration is the process by which biological fuels are oxidised in the presence of an inorganic electron acceptor such as oxygen to produce large amounts of energy, to drive the bulk production of adenosine triphosphate.

Table 2.4. Comparison between photosynthesis and Respiration

Photosynthesis	**Respiration**
Anabolic process	Cathobolic process
Requires the presence of light.	Does not require the presence of light.
Uses CO_2 and H_2O	Uses $C_6H_{12}O_6$ and O_2
Reduction occurs	Oxidation occurs
Photolysis of water	Formation of water
Produces $C_6H_{12}O_6$ and O_2	Produces CO_2 and H_2O
Occurs in cells that contain chlorophyll	Occurs in all metabolically active cells.
Occurs in chloroplasts	Occurs in cytoplasm and mitochondria.
$NADPH^+$ is formed	$NADH^+$ is formed.
Thylakoid membrane is the location for electron transport system	Inner mitochondrial matrix is the location for electron transport.
ATP production is by means of photophosphorylation	ATP production is by means of substrate level and oxidative phosphorylation.

3.3.1. The site/place of cellular respiration

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the glycolysis, Kreb (Citric acid) cycle, and electron transport chains. Design a strategic plan to deliver the lessonsand conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about glycolysis, Kreb (Citric acid) cycle, and electron transport chains, and you can use question in the textbook and encourage them toparticipate actively and you will summarize their answer.

III. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Where does cellular respiration take place?

- Cellular respiration takes place in the cytoplasm and mitochondria of each cell of the body. Glycolysis occurs inside the cytoplasm, whereas the TCA cycle occurs inside the matrix of the mitochondria. On the other hand, oxidative phosphorylation occurs on the inner mitochondrial membrane, with protons diffusing across the membrane and is later pumped back into the matrix.

Why is cellular respiration important?

- Cellular respiration is used to generate usable ATP energy in order to support many other reactions in the body. ATP is particularly important for energetically unfavorable reactions that would otherwise not occur without an energy input.

- **What is metabolism on a cellular level?**

- Cellular metabolism is the set of chemical reactions that occur in living organisms in order to maintain life. Cellular metabolism involves complex sequences of controlled biochemical reactions called metabolic pathways. These processes allow organisms to grow and reproduce, maintain their structures, and respond to environmental changes.

- **Which reactions require energy input and which release energy?**

- In exothermic reactions, more energy is released when the bonds are formed in the products than is used to break the bonds in the reactants. Exothermic reactions are accompanied by an increase in temperature of the reaction mixture. Chemical reactions that absorb (or use) energy are generally called endothermic.

- **Why oxidation and reduction reactions are always linked?**
  - The oxidation and reduction reactions are usually coupled together because electrons have unique exchanging property which drives the chemical processes to perform both reactions as a coupled reaction.

3.3.2. Stages of respiration

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids (pictures or model), and videos to teach and demonstrate the structure of different macromolecules. Design a strategic plan to deliver the lessons and conduct all the activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about carbohydrates, proteins, and lipids, and you can use question in the textbook and encourage them toparticipate actively and then you will summarize their answer.

II. Tasks

Support the learners to understand, share their ideas with one another, and answer the self-assessment question.

Activity: 3.6. Group work

Let them discuss in your group and prepare a presentation on:

- In comparison, both aerobic and anaerobic respiration involve glucose as a starting material by whichenergy is produced. Therefore, glycolysis occurs in both the presence and absence of oxygen.

- The ultimate electron acceptor in aerobic respiration is molecular oxygen. In contrast, the electron acceptor of anaerobic respiration is not oxygen but different substances such as sulfur, sulfate, and nitrate. Also, the process of the Krebs cycle and oxidative phosphorylation occurs during aerobic respiration..

Activity 3.7. Group work

- **Starter activity**: Group students in a class to discuss, and present it to the lass.
  - In the citric acid cycle shown in **Figure 2.28**, what molecules capture energy from the redox reactions? How is ATP produced?
  - What processes do in your cells produce the CO2 that you exhale?
- **Main Activity**: Each student should participate in group discussion and answer his what he from the discussion
- **Conclusive Activity:** The teacher will summarize their discussion for further student understandings.

Assessment method:

- Ask the student a question related to what molecules capture energy from the redox reactions? How is ATP produced?
- Observe their discussions and comment on important issues.
- Evaluate their presentation techniques of the groups.

- NADH and FADH2; one ATP is produced during substrate-level phosphorylation in step 5.
- The CO2 that we exhale is produced by pyruvate oxidation and the citric acid cycle.

The energy budget of one glucose molecule

What couples the electron transport chain to ATP synthesis?

- The electron transport chain forms a proton gradient across the inner mitochondrial membrane, which drives the synthesis of ATP via chemiosmosis.

Activity 3.8. Group work

- **Starter activity**: Group students in a class to discuss, and answer in group on the following question.
  - What effect would an absence of O_2 have on the process shown in **Figure 3.33** of the textbook? In the absence of O_2, as in question 1, what do you think would happen if you decreased the pH of the intermembrane space of the mitochondrion? Membranes must be fluid to function properly. How does the operation of the electron transport chain support that assertion?
- **Main Activity**: Each student should participate in group discussion and answer his what he from the discussion
- **Conclusive Activity**: The teacher will summarize their discussion for further student understandings.

Assessment method:

- Ask the student a question related to respiration without oxygen.
- Observe their discussions and comment on important issues.
- Evaluate their presentation techniques of the groups.

- Oxidative phosphorylation would eventually stop entirely, resulting in no ATP production by this process. Without oxygen to "pull" electrons down the electron transport chain, H+ would not be pumped into the mitochondrion's intermembrane space and chemiosmosis would not occur.
- Decreasing the pH means the addition of H+. This would establish a proton gradient even without the function of the electron transport chain, and we would expect ATP synthase to function and synthesize ATP. (In fact, it was experiments like this one that provided support for chemiosmosis as an energy-coupling mechanism.)
- One of the components of the electron transport chain, ubiquinone (Q) must be able to diffuse within the membrane. It could not do so if the membrane components were locked rigidly in to place.

Activity 3.9

Make a large annotated wall chart showing glycolysis and Krebs cycle and how they are linked together. Make sure that the student shows the different compounds and a site where ATP is formed. This should be as accurate as possible so that it can form the basis for their revision of this complex topic.

Answer key for Chapter review questions

1. **B**
2. **A**
3. **B**
4. **D**

Fill in the blnk spaces

1. ***Energy; kilojoules,kJ; heat energy; kilocalorie***
2. **Metabolism; metabolic pathways; catabolic; anabolic**
3. **Fermentation; Cellular respiration; Aerobic respiration**
4. **Visible light; wavelengths; ; chlorophyll a**
5. **C3 plants; photorespiration; Rubisco**
6. **C4 plants; bundle-sheath cells**
7. **CAM plants**

Unit 4:
Evolution (23 Periods)

Unit Learning Outcomes: After the successful completion of this unit, the learner will be able to:

- Analyze different views about the origin of life and evaluate from a scientific explanations point of view.
- Describe scientific evidence that supports that modern living things have evolved from a common ancestor.
- Explain major causes of evolution that lead to variation in organisms.
- Appreciate the role of natural selection and survival of the fittest in evolution and day to day life.

Unit minimum learning competency

After the successful completion of this unit, the student is expected to:

1. Define evolution
2. Debate on the different thoughts of the origin of life
3. Compare Lamarck Vs Darwinian theory
4. Explain how comparative anatomy embryology, fossil records, and biochemistry provide evidence for evolution
5. Define natural selection
6. Describe the types of natural selection with examples
7. Apply the theory of natural selection in their day-to-day life (survival of the fittest)
8. Appreciate the struggle among organisms for survival
9. Outline human evolution
10. State the role of paleontological discoveries in Ethiopia in explaining human evolution [e.g. Lucy (*A. afarensis*)]
11. Define mutation
12. Examine the different types of mutations with examples
13. Describe the causes of mutation

14. Appreciate the effects of mutations on living things
15. Discuss Genetic drift and Gene flow
16. Describe the roles of immigration and emigration on gene flow and speciation
17. Explain causes of species extinction
18. Critique the evolution theory based on their taught at the end of the topic
19. Appreciate the works of renowned anthropologists and evolutionists in Ethiopia

Unit learning strategies

1. Let students reflect on what they know about evolution and debate on the different thoughts about the origin of life. Provide historic sources that show how the Theories of Evolution have evolved (Competencies 1&2).
2. Let e students discuss the theories of Lamarck and Darwin in small groups and prepare charts on the main points of Darwin's theory, and let them elaborate the differences and similarities in the explanations of Lamarck and Darwin.
3. Tell students to form groups. Assign one of the pieces of evidence of evolution for each group and instruct them to read from books in library/ the internet about the pieces of evidence of evolution and let them discuss (Comparative anatomy, Embryology, the fossil record, Paleontology and Biochemistry)
4. Let students outline what they know about natural selection. Then, instruct them to discuss the topic using stabilizing, diversifying, disruptive, sexual, and predatory selections as examples. They can further discuss an artificial selection and survival of the fittest in a day to day life.
5. Tell them to go to nearby natural forests or grasslands with prior plan and inquiry questions and observe what happens with plants and animals and come up with concluding remarks on concepts such as natural selection and survival of the fittest.
6. Instruct them to use the internet, pictures, diagrams, and video material on human evolution and list what they know, and finally, define human evolution
7. Arrange a field visit (if possible) to the national museum to get information on *A. afarensis* (Lucy). Let students prepare beforehand a list of queries for experts at the museum and discuss the causes of differences among human races. Then, let students reflect on what they get from the visit in line with the competencies stated in the textbook.
8. Let students reflect on what they know about mutation and then discuss in groups to examine the causes and types of mutations (substitution, Insertion, deletion, and frame shift mutations).
9. Instruct them to use the internet, books, and other relevant sources to describe the causes and

effects of mutation on living things.

10. Let students be in groups of 6-7 members and discuss how genetic drift along with natural selection, mutation, and migration/immigration are the basic mechanisms of evolution (Competencies 15 &16).
11. Let a team of students explore drivers of extinction such as climate change, human activities, greenhouse gases, and natural disasters. Ensure that they seek solutions to mitigate habitat loss and prevent extinction.
12. Let students be grouped into two and tell them to have a debate on the evolutionary theories and pieces of evidence provided for the existence of evolution.
13. Tell students to have a visit or read about the work of renowned anthropologists and evolutionists in Ethiopia and model their work.

Unit assessment strategies

DA: Desired Achievement

E: Evidence

AI: Assessment Instrument

1.DA: Competencies 1 -3

E: Written / verbal

AI: **Written** assignments and tests / presentation / reflection

2. **DA:** Competency 4

E: Written / verbal/diagrams/reports

AI: written assignment and test/reflection /presentation/ drawings/field reports

3. **DA:** Competencies 5-8

E: Written/ verbal/

AI: Written assignment or test/ presentation/ questionnaires/portfolio

4. **DA:** Competencies 9 &10

E: Written/ verbal/diagrams

AI: Written assignment or test/ presentation/drawings/field reports

5. **DA:** Competencies 11-14

E: Written/ verbal/diagrams/practice

AI: Written assignment or test/ presentation/ questionnaire/drawings

6. **DA**: Competencies 15-17

E: Written/ verbal

AI: Written assignment or test/ presentation/

7. **DA:** Competencies 18&19

E: Written/ verbal

AI: questionnaire/ Written assignment or test/ presentation/portfolio

4.1. Evolution (21 periods)

4.1.1. Definition (3 periods)

Minimum learning competency

- Define evolution
- Debate on the different thoughts of the origin of life

Learning strategies

- Let students reflect on what they know about evolution and hold a debate on the different thoughts about the origin of life.

Assessment strategy

E: Evidence
AI: Assessment Instrument

- **E:** Written / verbal
- **AI: Written** assignments and tests / presentation / reflection

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate definition of evolution and the different thoughts of the origin of life. Design a strategic plan to deliver the lessonsand conduct all activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about Evolution and the different thoughts of the origin of life, you will ask question from the textbook, motivate students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students to read about the origin of life. The following description may give you a hint.

Religion mainly focuses on spiritual matters which, by their very nature, cannot be seen, touched or measured effectively. Religion deals with philosophical matters that are related to morality and

concerns humans and their God. Religion is less concerned with empirical observable facts and testable hypotheses but it rather relies on faith, the belief in things that cannot be proven.

Science describes the natural world around us using a means of observation and empirical testing using instruments. These observations then result in the development of scientific theories. There is no room or attempt on the part of science about morality or purpose. Taken together, while science relies on provable events, religion relies on believing in that which cannot be proven. The two views are based on entirely different perspectiveseven though each has a valid worldview in its own context.

Give a task for students to read about the forms of creation (Activity 4.1). The following description may give you a hint.

Special creation states that at some stage, some supreme being created life on earth. There are many different versions of special creation that are linked with different religions. Often, there is a considerable variation as to how rigidly the special creation theory is interpreted among/within a religion.

Young Earth creationism

This form of creationism today suggests that the Earth is only a few thousand years old. Young Earth creationists often believe that the Earth was created in six 24-hour days. While they agree that the Earth is round and moves around the sun, they all interpret geology in light of Noah's flood.

Old Earth creationism

There are several types of creationism that consider Old Earth. They vary in different aspects of how they explain the age of the Earth while still holding to the story found in Genesis. Those who believe in Old Earth creationism accept the evidence that the Earth is very old but still maintain that all life was created by God.

Day-age and gap creationism

Both are similar in that each interprets the beginnings of the creation story as actually having taken much longer than six Earth days. Gap creation discusses a large gap between the formation of the Earth and the creation of all animals and humans. The gap could be millions or billions of years. This gets around the scientific evidence that the Earth is several billion years old without having to believe in the process of evolution itself.

Day-age creationism is similar to the Gap creation in terms of the length of time but talks about each of the six 'days' as really meaning a billion years or so of geologic time, where the 'days' are just symbolic.

Progressive creationism

This type of creationism accepts the Big Bang as the origin of the Universe. It accepts the fossil record of a series of creations for all organisms catalogued. However, it does not accept these as part of a continuing process by which each is seen as a unique creation. In this theory, modern species are not seen as being genetically related to ancient ones.

Theistic evolution/Evolutionary creationism

This view of evolution maintains that God 'invented' evolution and takes some form of an active part in the ongoing process of evolution. It also invokes the role of God in areas not discussed by science, including the creation of the human soul. Theistic evolution is promoted by the Pope of the Catholic Church and is also espoused by most mainline Protestants.

Intelligent design

This is the newest version of creationism and maintains that God's handiwork can be seen in all creation if one knows where to look. Advocates of **intelligent design** offer sophisticated arguments, often based on cell biology and mathematics at the expense of giving the impression of the complex scientific arguments and creating equal stature with mainstream scientific thought. These arguments attack different parts of the evolutionary theory with the idea that if one part of the evolutionary theory can be found to be incorrect, then it follows a premise that all theories of evolution must be incorrect. The term intelligent design is used to mask the theory as if it's a form of creationism cloaked in scientific-sounding ideas.

Spontaneous generation

Spontaneous generation suggests that life can evolve spontaneously' from non-living objects. It was only a few hundred years ago that people still believed this to be true. For example, people believed that rotting meat turned into flies and that wine produced bacteria as it went sour.

Give a task for students to read about spontaneous generation and how spontaneous generation is not possible and does not happen (Activity 4.2). The following description may give you a further hint.

In 1668, Francesco Redi, an Italian scientist, designed a scientific experiment to test the spontaneous creation of maggots by placing fresh meat in jars (See the illustration from the student textbook), While one jar was left open, the others were covered with a cloth. Days later, the open jar contained maggots, whereas the covered jars contained no maggots. He did note that maggots were found on the exterior surface of the cloth that covered the jar. Redi successfully demonstrated that the maggots came from fly eggs and thereby helped to disprove spontaneous generation.

Louis Pasteur, the notable French scientist, showed that broth (or wine) only went sour if micro-organisms were allowed to enter (See the illustration from the student textbook). Also no micro-organisms appeared in the broth unless they were allowed to enter from the outside. Today,

spontaneous generation is generally accepted to have been decisively dispelled during the 19th century by the experiments of Louis Pasteur.

Eternity of life

This theory of life states that there is no beginning and no end to life on earth and so life neither needs special creation nor does it need to be generated from non-living matter. Supporters of this theory believe that life is an inherent property of the Universe where it has always existed as has the Universe.

Cosmozoan theory, Panspermia or Spore broth theory

According to **Cosmozoan theory** life has reached this planet or the Earth from other cosmological structures, such as meteorites, in the form of highly resistant spores. This theory was proposed by Richter (1865). According to this theory, 'protoplasm' reached the earth in the form of spores or germs or other simple particles from some unknown part of the universe with the cosmic dust, which subsequently evolved into various forms of life. Helmholz (1884) speculated that 'protoplasm' in some form reached the earth from falling meteorites.

Give a task for students to read about Cosmozoan theory (panspermia and pseudo-panspermia) (Activity 4.3). The following description may give you a hint.

In the nineteenth century, Hermann Richter put forward the idea that life has always existed in the Universe where it has propagated itself from one place to another by means of '**cozmozoa**' (germs of the cosmos). In this theory, life has existed and will exist for all eternity across the Universe, and so there is no need for an explanation of its origin. Two other eminent scientists of the time – Lord Kelvin and Herman von Helmholtz – also took the same view.

In 1908, the Swedish physical chemist Svante Arrhenius put forward a new version of the cosmozoan theory, and gave it the name panspermia. Arrhenius' contribution was a new theory of the mechanism by which life could have been transported between planets; he proposed that bacterial spores were propelled through an inter-planetary space by radiation pressure. The previous versions of the theory had assumed that the means of transport was meteorites or by comets. However, the very high temperatures that meteorites create on entering the Earth's atmosphere seemed to rule this out. In Arrhenius' version of the theory, spores reaching the Earth (possibly attached to grains of interstellar dust) could fall slowly to the ground without being subjected to high temperatures due to air friction.

Biochemical origin of life

The current ideas we have about how life may have evolved on earth as a result of biochemical reactions (sometimes called abiogenesis) owe much to two biologists working early in the twentieth century.

Give a task for students to read about the theory of biochemical origin of life. Stanley Miller's experiment to support the theory of biochemical origin of life and other scientists work. The following description may give you a hint.

In 1953, Stanley Miller conducted his spark-discharge renown experiment. In this investigation, he passed electric sparks repeatedly through a mixture of gases that were thought to represent the primitive atmosphere of the Earth. These gases were methane (CH_4), ammonia (NH_3), water (H_2O) and hydrogen (H_2). The equipment he used is illustrated in the student text book.

When he analysed the liquid in the water trap, he found that it contained a number of simple organic molecules, out of which hydrogen cyanide (HCN) was one of them. He found that by leaving the equipment for longer periods of time, a larger variety and more complex organic molecules were formed including:

- amino acids – essential to form proteins
- pentose sugars – needed to form nucleic acids
- hexose sugars – needed for respiration and to form starch and cellulose
- hydrogen cyanide –

  But it has been rejected because the nitrogenous bases found in nucleotides can be synthesised in the laboratory using HCN as a starting point.

Autotrophs

These are the first organisms that appeared on earth about 4 billion years ago. They were **prokaryotes** that had no true nucleus. It seems likely also that they had RNA rather than DNA as their genetic material. It seems likely that they gave rise to three distinct lines of evolution leading to:

- **Archaebacteria** – prokaryotes including thermophilic sulphobacteria, methanobacteria and halophilic bacteria
- **Eubacteria** – prokaryotes; ordinary bacteria and cyanobacteria (blue-green bacteria and sometimes known as blue-green algae).
- **Eukaryotes** – eventually evolving into protoctistans, fungi, plants, animals (nearly all are aerobic).

Give a task for students to read about Chemo-autotrophs. The following description may give you a hint.

Other primitive autotrophs that used no light as a source of energy but chemical reactions are called **chemo-autotrophs**. Chemo-autotrophs use the energy from chemical reactions to synthesize all the necessary organic compounds, starting from carbon dioxide. They generally only use inorganic energy sources. Most chemo-autotrophs are bacteria or archaea that live in hostile environments such as deep sea vents and are the primary producers in the ecosystems on the sea beds. Scientists believe that some of first organisms to inhabit earth were chemo-autotrophs.

Give a task for students to debate on the origin of life (Activity 4.5).

Answer key for the review questions

1. Describe the basis of the biochemical theory (abiogenesis) for the origin of life.

Biochemical theory proposed that common gases in the early Earth atmosphere combined to form simple organic chemicals, and these in turn combined to form more complex molecules. Then, the complex molecules became separated from the surrounding medium, and acquired some of the characters of living organisms. They were able to absorb nutrients, to grow, to divide (reproduce), and so on.

2. Explain in detail the contribution of primitive of autotrophs (photoautotrophs and chemoautotrophs) for life on earth.

The fossil record shows that cyanobacteria had been producing oxygen by photosynthesis from about 3.5 billion years ago but that for almost 1 billion years the levels in the atmosphere did not rise because oxygen was absorbed by the vast amount of iron in the Earth – it rusted!! But, by 2.4 billion years ago, the concentration began to rise and the rate of increase accelerated from 2.1 billion years ago.

4.1.2. Theories of evolution: Lamarck Vs Darwin (4 periods)

Minimum learning competency

- Compare Lamarck Vs Darwinian theory

Learning strategies

- Provide historic sources that show how the theories of evolution have evolved.
- Let the students discuss the theories of Lamarck and Darwin in small groups and prepare charts on the main points of Darwin's theory, and let them elaborate the differences and similarities in the explanations of Lamarck and Darwin.

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written / verbal
- **AI: Written** assignments and tests / presentation / reflection

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach theories of evolution: Lamarck Vs Darwin. Design a strategic plan to deliver the lessons and conduct all activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about theories of evolution, you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Lamarckism

Jean-Baptiste De Lamarck (1744 - 1829) was a great French naturalist. Lamarck sought a naturalistic explanation for the diversity of modern organisms and animals seen in the fossil record. ′ He proposed 'the theory of inheritance of acquired characters' in 1809. He postulated:

A) New Needs
B) Use and disuse of organs
C) Inheritance of acquired characters
D) Speciation

Give a task for students to read about Lamark's theory and some of the critics forwarded against this theory (Activity 4.6). The following description may give you a hint.

Evidence:

A) Giraffe - Ancestors of giraffes are supposed to be deer-like quadrupedal grazing grasses in Africa. Due to the disappearance of ground vegetation and the availability of trees, long-necked and long fore-limbed giraffe evolved from short-necked and small fore-limbed deer-like ancestors.

B) Snakes - Ancestors of limbless snakes were lizard-like reptiles with fully developed pentadactyl limbs. Due to the continuous disuse of limbs and stretching of their body to suit their creeping mode of locomotion, limbless snakes evolved.

C) Horse – Ancestors of modern horse (*Equus cabalus*) used to live in the areas with soft ground and were short-legged with more numbers of functional digits. These gradually took it to live in areas with dry ground. This change in habit was accompanied by increase in length of legs and decrease in functional digits for fast running over hard ground.

Criticism of Lamarckism

A) August Weismann, a German biologist proposed the 'Theory of continuity of germplasm' in 1892. This theory states that a multicellular organism is formed of 2 types of cells; **germ cells** (have genes for inheritable characters to the offspring) and **somatic cells** (which have genes of particular organ during one's life time only). ′ Environment affects only somatic cells. As a link between the generations is through germ cells and somatic cells are not transmitted to the next generation, the acquired characters must be lost with the death of an organism, so these should have no role in evolution.

B) Pavlov, a Russian physiologist, trained mice to come for food on hearing a bell. He reported that this training is not inherited and was necessary in each generation.

C) Kellogg and Bell experiment – they fed larva of silk moths on reduced quantity of mulberry leaves. They found decrease in size of larva in the next two generations even though these fed normally. ′

Darwinism (Theory of natural selection)

Postulates of Darwinism

A) Geometric increase
B) Limited food and space
C) Struggle for existence
D) Variations
E) Natural selection or survival of the fittest
F) Inheritance of useful variations

Give a task for students to read about Darwin's theory and the critics against this theory (Activity 4.7). The following description may give you a hint.

What happened to giraffes?

A) Survival of the fittest or natural selection: Natural selection postulated that the giraffes with short necks had less food to eat.

B) Why: the food resources changed to leaves only on the upper branches

C) What happened: short necks could not reach upper branches and did not survive (couldn't pass on genes).

D) Long neck giraffes survived and reproduced because they were able to reach the food.

Evidence in favour of Darwinism

A) Close parallelism between natural selection and artificial selection.

B) The remarkable cases of resemblance e.g. Mimicry and protective colouration.

C) Replacement of earlier giant dinosaurs by small sized carnivorous reptiles due to scarcity of food, space and global cooling.

D) Pedigree of horse and other animals also support Darwinism.

E) Correlation between position of nectars in flower and length of proboscis of pollinating insect which van be developed only gradually.

Evidences against Darwinism

A) Inheritance of vestigial organs.

B) Inheritance of over-specialized organs.

C) He didn't explain the cause of variations and the mode of transmission of variations.

D) It doesn't include the transitional stages which have no fossil record.

E) Darwin did not differentiate between somatic and germinal variations.

F) It doesn't explain the evolution of terrestrial animals from aquatic animals.

Give a task for students to elaborate the differences and similarities between the explanations of the Lamarck's theory and Darwin's theory of natural selection (Activity 4.8). The following table may give you a hint.

Table 4.1 Comparison of Lamarck's theory of use and disuse with Darwin's theory of natural selection

Aspect of theory	Lamarck's theory of use and disuse	Darwin's theory of natural selection
Variation	Environment changes, creating a need for the organism to change	There is a natural variation in features and the variations are heritable
Survival	Development of new features (e.g., longer neck) in order to survive	Environment selects in favor of those traits that adapt the organism to the environment and against those that do not
Inheritance	New features acquired during lifetime of an individual are passed to the Offspring	Individuals with advantageous variations of traits survive in greater numbers and pass on these advantageous variations to their offspring
Evolution	New species over time	New species over time

Give a task for students to read about Neo-Darwinism theory (Activity 4.9). The following description may give you a hint.

Postulates of Neo-Darwinism are;

(1) **Genetic variability** – variability is an opposing force to heredity. In other words, it forms the raw material for evolution. There exist various sources of genetic variability

   a. **Chromosomal aberrations**- Morphological changes in chromosomes without affecting their number. These are the four types of chromosomal aberrations namely; **Deletion** – loss of gene block from chromosome, **Duplication** – presence of some genes more than once, **Translocation**- transfer of gene block from one chromosome to other, **Inversion**- rotation of intercalary gene block through 180 degrees.

   b. **Numerical chromosomal changes**- Can be **Eulpoidy** – gain or loss of one or more genome. It may be Haploidy or polyploidy, **Aneuploidy**- gain or loss of one or two chromosomes. It may be hypoploidy.

   c. **Gene Mutations**- invisible changes in the chemical nature of the gene. These include point mutation, gross mutations, deletion, addition, and substitution.

d. Recombination of genes- new combination of genes are formed due to crossing over, chance arrangement of the bivalents during metaphase and chance fusion of gametes.

e. Hybridization- the interbreeding of two different individuals to produce hybrids. It introduces genes from one species to the gene pool of other species.

f. Mutagens- physical and chemical agents used to induce mutations artificially, chemical mutagens- such as base analogues, methylating agents, acridine dyes etc. and physical mutagens such as temperature, x-rays, uv-rays etc.

g. Genetic Drift- a change in the gene frequency of small breeding population due to bottle neck and founder effect.

h. Immigration- introduces many genes in the existing gene pool by cross breeding between the native individuals and immigrants.

(2) **Natural selection**does not operate on survival of the fittest. It operates through differential reproduction and comparative reproductive success. **Differential Reproduction**- members which are better adapted to the environment reproduce at a high rate and produce more offspring than the members which are less adapted. Due to sexual communication, there is free flow of genes and genetic variability that spread from individuals to deme then to population and finally to most of the members of species. So, natural selection causes progressive changes in the gene frequency. Frequency of more adaptive genes increases and that of less adapted gene decreases.

(3) **Reproductive Isolation**- the inability of living organisms to interbreed. It maintains distinctiveness of characters among species. *Mechanical isolation* occurs due to the difference in the morphology of genitalia or reproductive organs. *Geographical Isolation*- due to physical factors such as sea, mountain, deserts etc. *Spatial isolation*- individuals are isolated by long distances. *Ecological or habitat isolation*- due to differences in their habitat. *Temporal Isolation*- due to difference in the breeding periods in different seasons of the year. *Ethological or Behavioral isolation*- due to behavioral differences between individuals of different species during courtship. *Genetic Isolation* – the inter specific sterility of species due to the accumulation of independent gene mutations for structural and functional characters. *Physiological Isolation*- due to functional incompatibility in their mating or in the production, fertilization and survival of the gametes**.**

Answer key for the review questions

1. Describe in detail Darwin's theory that explains how new species emerge.

*Darwin viewed evolution by **natural selection** as a very gradual mechanism of change within populations, and postulated that new species could be the product of this very same*

process, but over even longer periods of time. He proposed a model whereby lineages form from their ancestors by evolving different characters over relatively long periods of time. Darwin indicated that species could form by the evolution of one species splitting into two, or via a population diverging from its surviving ancestor to the point it was a new species.

2. Explain Lamarck's theory how new species emerge.

   Lamarck believed that living things evolved in a continuously upward direction, from dead matter, through simple to more complex forms, toward human "perfection." Species didn't die out in extinctions, instead, they changed into other species. Since simple organisms exist alongside complex "advanced" animals today, Lamarck thought they must be continually created by spontaneous generation.

3. Explain what Neo-Darwinism theory is.

   ***Neo-Darwinism** is a theory of evolution that represents a synthesis of Charles Darwin's theory in terms of natural selection and modern population genetics. The term was first used after 1896 to describe the theories of August Weismann (1834–1914), who asserted that his germ-plasm theory made impossible the inheritance of acquired characteristics and supported natural selection as the only major process that would account for biological evolution.*

4.1.3. The evidence for evolution (4 periods)

Minimum learning competency

- Explain how comparative anatomy embryology, fossil records, and biochemistry provide evidence for evolution

Learning strategies

- Students can form groups, take one of the pieces of evidence of evolution and discuss after reading from books in library/ internet about the pieces of evidence of evolution (Comparative anatomy, Embryology, the fossil record, Paleontology and Biochemistry).

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written / verbal/diagrams/reports
- **AI:** written assignment and test/reflection /presentation/ drawings/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in the activities.

Additional teaching notes

Give a task for students to read about embryology and evolution (Activity 4.10).

The following description may give you a hint.

All terrestrial animals have non-functional gill slits (pharyngeal slits) as early embryos (indicating an aquatic origin). Many vertebrates (including humans) demonstrate a primitive tail at certain stages of embryonic development. The embryonic tail does not develop into a tail in all species. In humans, it is reduced during development to the coccyx, or tailbone. The more similar the pattern of embryonic development, the more closely related species are assumed to be. The similarity in the pattern of development of vertebrates suggests, again, a common ancestor. However, you must be careful when describing what comparative embryology shows. This is because although there is misunderstanding among some people, it does not show that an embryo is retracing its evolutionary history.

Give a task for students to read about dating rocks and half-life time (Activity 4.11). The following description may give you a hint.

Biologists use two techniques to date fossils. These are;

1. Radiocarbon dating, or
2. Potassium–argon dating.

Both these techniques rely on the principle that radioactive atoms gradually decay into other atoms. Radioactive carbon atoms (C14) decay into non-radioactive nitrogen atoms (N). Radioactive potassium atoms (K40) decay into argon atoms (A40). Each has what is known as a **half-life**. During this period, half of the radioactive atoms decay. So, starting with a certain number of radioactive potassium atoms, 50% will still be radioactive after one half-life. After a second half-life, 50% of this will decay and 25% of the original number will still be radioactive.

The ratio of carbon 14 (radioactive carbon) to carbon 12 (ordinary carbon) in living things is about 1 to 1 trillion and we believe that this ratio has always been the same. During their lives, living things lose carbon 14 (as carbon dioxide and other excretory products) and also gain it in the food they eat (or make in the case of autotrophs).

But when living things die, the carbon 14 starts to decay into non-radioactive nitrogen and, clearly, is not replaced. So after 5730 years (one half-life of carbon 14), only 50% of the original carbon 14 atoms will remain and the ratio of carbon 14 to carbon 12 will be 1 to 2 trillion (or 0.5 to 1 trillion). After 11 460 years, 25% of the original carbon 14 atoms remain and the ratio is 1 to 4 trillion (or 0.25 to 1 trillion). The percentage of carbon 14 atoms and the ratio of carbon 14 to carbon 12 keeps halving with each half-life that passes.

Give a task for students to read about fossils found in Ethiopia and their importance. Encourage them to write a report and present to the class (Activity 4.12).

Dear teacher, give a task for students to read about evidence for evolution and, guide and encourage them for the poster presentation of their work (Activity 4.13).

Answer key for the review questions

1. How can fossils provide evidence for evolution?

Fossils are preserved remains or traces of animals, plants, and other organisms from the past. Fossils are important evidence for evolution because they show that life on earth was once different from the existence of life on earth today. Usually only a portion of an organism is preserved as a fossil, such as body fossils (bones and exoskeletons), trace fossils (feces and footprints), and chemofossils (biochemical signals). Paleontologists can determine the age of fossils using various methods including radiometric dating and categorize them to determine the evolutionary relationships between organisms.

2. Explain in detail how embryology provides evidence for evolution.

Embryology *is a branch of comparative anatomy which studies the development of vertebrate animals before birth or hatching. Like adults, embryos show similarities which can support common ancestry. For example, all vertebrate embryos have gill slits and tails. The "gill slits" are not gills, however. They connect the throat to the outside early in development but eventually close in many species; only gill slits in fish and larval amphibians contribute to the development of gills. In mammals, the tissue between the first gill slits forms part of the lower jaw and the bones of the inner ear. The embryonic tail*

does not develop into a tail in all species; in humans, it is reduced during development to the coccyx, or tailbone.

3. How does comparative biochemistry support the theory of evolution?

A common definition of comparative biochemistry is the study of evolutionary relationships between organisms. All living organisms share a common genetic code in the form of DNA, which provides information for making the protein machines that do the day-to-day work of cells. Comparative biochemistry studies protein machines and enzymes, but both are encoded by DNA sequences. By comparing similarities and differences in these genes, scientists can piece together and explain evolutionary relationships between organisms.

4.1.4. Natural selection: Definition, Types & Examples (2 periods)

Minimum learning competency

- Define natural selection
- Describe the types of natural selection with examples
- Apply the theory of natural selection in their day-to-day life (survival of the fittest)
- Appreciate the struggle among organisms for survival

Learning strategies

- Let students outline what they know about natural selection and discuss using stabilizing, diversifying, disruptive, sexual, and predatory selections as examples. Further, they can discuss an artificial selection, survival of the fittest in day to day life.
- Let students go to the nearby natural forests or grasslands with prior plan and inquiry questions and observe what happens with the plants and animals and come up with concluding remarks on concepts like natural selection and survival of the fittest.

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written / verbal/diagrams/reports
- **AI:** written assignment and test/reflection /presentation/ drawings/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate natural selection: Definition, Types & Examples. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about natural selection**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students to read about natural selection (Activity 4.14). The following description may give you a hint.

Example of directional selection is mentioned below:

Darwin's Finches: Also known as Galapagos finches, these little birds where of particular interest to Darwin while he was on his famous discovery expedition. Darwin noticed that the species on different islands where remarkably varied, while undeniably coming from the same source. In recent years, scientist Peter and Rosemary Grant have been studying the finches. In the past thirty years, they have witness all sorts of selection on the finches and the evolution that ensued.

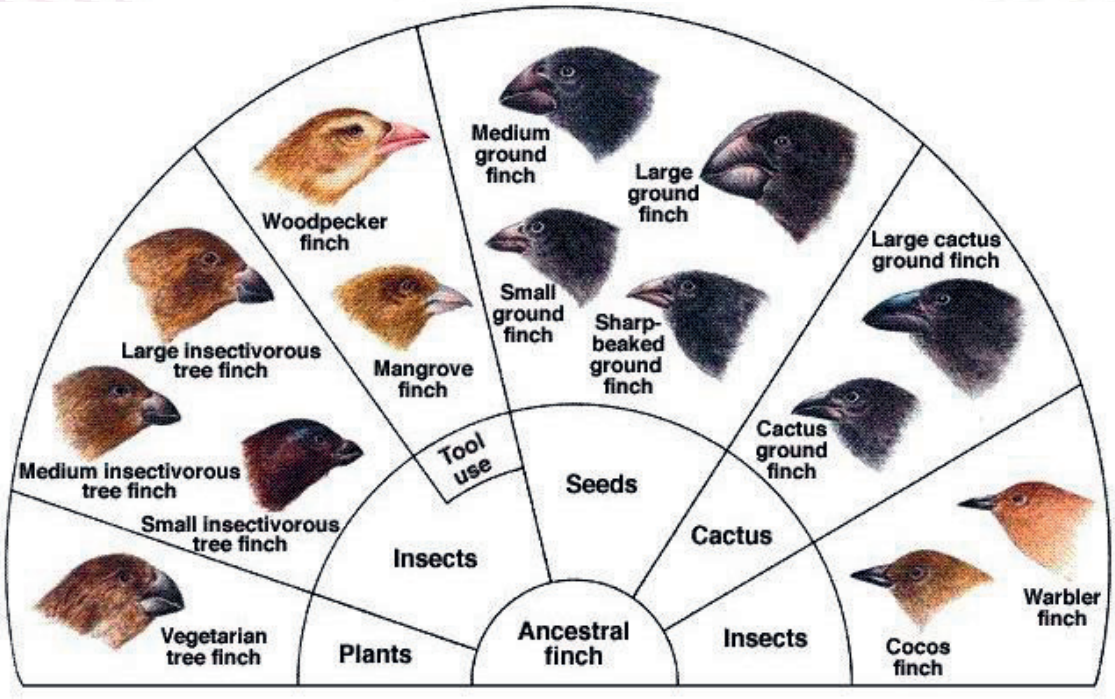


Figure 4.1: Fourteen species of Darwin's finches arranged to show similarities and differences among beak morphology

In one very drastic example of directional selection, the Grants observed selected birds with larger beaks after only one season of an extremely drastic form of directional selection. In the Galapagos, certain plant species that produced seeds relied on a very wet rainy season to supply their many seeds with water. In drought years, the plants produced fewer, larger and tougher seeds. During a drought in 1977, the Grants were actively studying the finches on one of the island. The drought indeed caused the seeds to become larger and stronger. In the population of finches before the drought, beak sizes ranged from very large to very small. Birds with small beaks were apt at handling small seeds, but larger seeds faced a challenge. The drought and the resulting increase in seed size and strength, put a directional selection on the finches. Birds with small beaks were no longer able to eat, whereas birds with large beaks could survive on the large, tough seeds. This directional selection caused the resulting population of finches to have a much larger average beak size than the population before the drought. The Grants have documented many cases such as the finches' and have effectively shown evolution happening at a population level, from year to year.

Lead students to visit nearby natural forests or grasslands (Activity 4.15). Remind them to plan and inquire questions and observe what happens with the plants and animals and come up with concluding remarks on concepts like natural selection and survival of the fittest.

Give a task for students to read about the types of speciation (Activity 4.16). The following description may give you a hint.

Table 4.2 Difference between allopatric and sympatric speciation

BASIS OF COMPARISON	**ALLOPATRIC SPECIATION**	**SYMPATRIC SPECIATION**
Description	**Allopatric speciation** is the physical isolation of a biological population by an extrinsic/geographical barrier such as mountains, rivers, lakes or due to changes in land topography.	**Sympatric speciation** is speciation that occurs when one or two groups of the same species live in the same geographical area, but they evolve differently until they can no longer interbreed and are considered different species.
Cause	Geographical isolation leads to reproductive isolation and speciation.	Indistinct/unknown factors could be attributed to be main reason behind sympatric speciation.

BASIS OF COMPARISON	ALLOPATRIC SPECIATION	SYMPATRIC SPECIATION
Speed of Evolution	Speed of evolution of new species is slow.	Speed of the emergence of new species is fast with autopolyploidy and slow with allopolyploidy.
Geographical Isolation	The populations are geographically separated.	The populations are not geographically separated.
Common	Common in nature.	Common in plants.
Major Differentiation Mechanism	Major differentiation mechanism is natural selection.	Major differentiation is polyploidy.
Examples	Some examples include: Darwin's finches Squirrels in the Grand Canyon.	Some examples include: Cultivated wheat Corn Tobacco African tilapia
Entails	Allopatric speciation involves one population.	Sympatric speciation involves two or more populations.

Give a task for students to work on the activities listed under Activity 4.17 and 4.18.

Answer key for the review questions

1. Explain the similarities and differences between allopatric and sympatric speciation.
   Table 4.2 can be used to elicit student response to this question
2. Compare and contrast divergent and convergent evolution.
   *The development of similar structures within different species that live in the same environment is known as **convergent evolution**.*
   For example, the wing is an adaptation to flight. Wings can be found in bats as well as insects. The wings of bats and the wings of insects are evolved from completely different original structures. Thus, the convergent evolution causes similar structures in different lineages of organisms.

   ***Divergent evolution** is a process of developing two or more species from a common ancestor. The branching begins with the selective breeding of naturally or artificially chosen traits, which occurs gradually. Thus, divergent evolution is a process of*

macroevolution that creates more diversity of species in the biosphere. Divergent evolution produces important changes within individuals for their survival within a changing environment.

3. Explain the different types of natural selection and how they can impact the distribution of phenotypes within a population.

Additional notes presented under 4.1.4 can be used as starter to answer this question.

4.1.5. Human evolution (2 periods)

Minimum learning competency

- Outline human evolution
- State the role of paleontological discoveries in Ethiopia in explaining human evolution [e.g. Lucy (*A. afarensis*)]

Learning strategies

- Tell them to use the internet, pictures, diagrams, and video material on human evolution and list what they know, and finally, define what do we mean by human evolution
- Arrange a field visit (if possible) to the national museum to get information on *A. afarensis* (Lucy). Let students prepare beforehand a list of queries for experts at the museum and discuss the causes of differences among human races and let students reflect on what they get from the visit in line with the competencies stated in the textbook.

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written/ verbal/
- **AI:** Written assignment or test/ presentation/ questionnaires/portfolio

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate human evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about human evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional notes

Give a task for students to discuss who are we and where have we come from (Activity 4.19). The following description may give you a hint.

The emergence of humans

Approximately 70,000,000 years ago, the dinosaurs disappeared completely. At that time, monkey-like animals appeared from more or less similar to the modern lemurs. Tail of these monkey-like animals disappeared about 40,000,000 years ago. Due to the enlargement of brain and improvement in their hands, ape-like animals evolved and then later they evolved into gibbon and orangutan. From gibbon and orangutan, gorilla and chimpanzee evolved about 25, 000,000 years ago. About 20,000,000 years ago, the first human-like animals evolved who had erect posture and who was able to use their hands. Ramapithecus ape was recorded as the first human-like animal. Afterwards, this ape grew up in size and became more intelligent. About 2, 000,000 years ago, skilled human developed and about 1,500,000 years ago, human with erect posture and walking ability evolved. Neanderthal man was considered as the first wise-man. About 50 thousand years ago, the Cro-Magnon man evolved and afterwards, this evolution had been faster than the earlier (You can also see the illustration from the text book).

Give a task for students to read about the emergence of *Homo sapiens* (Activity 4.20). The following description may give you a hint.

The emergence of Homo sapiens

The relationships among *Australopithecus, K. platyops, Paranthropus,* and the direct ancestors of *Homo* are unknown. Because of its early date and geographic location, *A. anamensis* may be the common ancestor of *A. afarensis, A. garhi, K. platyops,* and perhaps the Laetoli Pliocene hominins of eastern Africa, *A. bahrelghazali* of central Africa, and *A. africanus* of southern Africa. *A. afarensis* in turn may be ancestral to *P. aethiopicus,* which begot *P. boisei* in eastern Africa and *P. robustus* in southern Africa.

Give a task for students to read about human races and disagreements (Activity 4.21). The following description may give you a hint.

Human beings have evolved into different 'races' for thousands of years. The classification of these races is difficult as there is some disagreement about their exact nature. One classification is given below. In this classification, there are three main races with several subdivisions. This is based on a recent genetic analysis of the different races.

- **African** (Negroid), 100 million people from Africa and Melanesians of the South Pacific.
- **Eurasian** (Caucasoid), 1000 million people with variable skin colours ranging from white to dark brown. Under Eurasian classification, three subdivisions exist:

A. **Nordic** – often tall, blonde and narrow-headed; includes people from Scandinavian and Baltic countries, Germany, France, Britain

B. **Mediterranean** – usually lighter in body build, dark and narrow-headed; includes people from Southern France, Spain, Italy, Wales, Egypt, Jews, Arabs, Afghanistan, Pakistan, India.

C. **Alpine** – usually broad-headed, square jaws, olive skin, brown hair; includes people from countries from the Mediterranean to Asia.

- **East Asian** (Mongoloid), most numerous of the present-day populations and split into three groups:
  – Eastern Siberians, Eskimos and the Northern American Indians
  – Japanese, Koreans and Chinese
  – Indonesians and Malays

Give a task for students to read about the central role of Ethiopia in human evolution (Lucy, Ardi and Selam) (Activity 4.22). Additional notes for activity 4.12 can be used as starter for this activity. You can also guide them to use the following links

http://www.talkorigins.org
http://iho.asu.edu/ **http://www.time.**

Answer key for the review questions

1. Explain why the human races are now less likely to evolve into separate species.
   As a starter to answer this question, you can use the additional notes provided for activity 4.21.
2. Describe how brain size evolved in hominid.

   As early humans faced new environmental challenges and evolved with bigger bodies, they evolved larger and more complex brains. Large, complex brains can process and store a lot of information. That was a big advantage to the early humans who faced with

unfamiliar habitats in their social interactions.. Over the course of human evolution, brain size tripled. The modern human brain is the largest and most complex of any living primate.

- **Brain size increases slowly**

  From 6–2 million years ago

  During this time period, the early humans began to walk upright and make simple tools. Brain size increased, but only slightly.

- **Brain and body size increase**

  From 2 million–800,000 years ago

  During this time period, the early humans spread around the globe, encountering many new environments in different continents. These challenges, along with an increase in body size, led to an increase in brain size.

- **Brain size increases rapidly**

  From 800,000–200,000 years ago

  The human brain size evolved most rapidly during a time of dramatic climate change. Larger, more complex brains enabled early humans of this time to interact with each other and with their surroundings in new and different ways. As the environment became more unpredictable, bigger brains helped our ancestors to survive.

3. Explain how modern human evolved.

   You can use the additional notes for activity 4.20 as a starter to answer this question.

4.2. Mutations (2 periods)

Minimum learning competency

20. Define mutation
21. Examine the different types of mutations with examples
22. Describe the causes of mutation
23. Appreciate the effects of mutations on living things

Learning strategies

- Let students reflect on what they know about mutation and then tell them to discuss in groups to examine the causes and types of mutations (substitution, Insertion, deletion, and frame shift mutations).
- Tell them to use the internet, books, and other relevant sources to describe the causes and effects of mutation on living things.

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written/ verbal/diagrams
- **AI:** Written assignment or test/ presentation/drawings/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate mutations. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about mutations**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional notes

A **mutation** is any spontaneous change in the genetic material of an organism. There can be large structural changes involving the whole chromosomes or parts of the chromosomes, or changes that involve only a single base. The changes involving only a single base are called point mutations, and it is these types of mutation that we are mainly concerned with.

There are several types of point mutation, in which one of the bases in the DNA sequence of a gene is altered, usually by being copied wrongly when the DNA replicates. The different point mutations are:

- substitution
- addition
- deletions

These mutations occur quite randomly during DNA replication by which each involves a change to just one base. However, the change to the gene can be dramatic and the result can be that the protein that the gene should code for is not made at all or a different protein is made.

Give a task for students to read about the types, causes and effects of mutation (Activity 4.23). The following description may give you a hint.

What causes point mutations?

Mutations occur spontaneously and randomly. They are accidents that mistakenly occur when DNA is replicating. Mutations are rare events, which are quite surprising when you consider that each cell contains 6 × 109 (six billion) base pairs that might mutate! Biologists estimate that mutations arise at the rate of 1 in 50 × 106 (one in fifty million) base pairs. This means that each new cell will have, on average 120 mutations. This sounds rather worrying, but you should remember two things:

- most of these mistakes (mutations) are detected and repaired, and
- Because, 95% of our DNA is non-coding, so most mutations are unlikely to affect coding genes.

The rate of mutation can be increased by a number of factors including

- Carcinogenic chemicals, for example, those in tobacco smoke
- High-energy radiation, for example, ultraviolet radiation, X-rays.

What are the consequences of gene mutations?

Although the answer to this depends on a number of factors, there are really two important questions that we need to answer.

- Which cells, and
- Which genes?

Mutations that occur in a normal body cell (a non-sex cell) will have one of the following four possible consequences:

- It will be completely harmless.
- It will damage the cell.
- It will kill the cell.
- It will make the cell cancerous, which might kill the person.

If a person is not affected by either of these cases, mutation will not be passed on to the next generation. However, if the mutation occurs in a sex cell or a cell that will divide to give rise to a sex cell, then it may be passed on to the next generation.

Can mutations benefit an organism?

When a mutated allele gives an organism an advantage, the frequency of that allele increases with successive generations due to natural selection. As a result, the numbers of the organism with the mutated allele will also increase at the expense of those without it. Mutations in the DNA of bacteria can give them resistance to a specific antibiotic, such as penicillin or ampicillin. Similar to all mutations, these mutations arise spontaneously. They only give the bacterium an advantage

if the particular antibiotic is actually being used. Being resistant to streptomycin has no advantage if penicillin is being used. In contrast, being resistant to penicillin in an environment where penicillin is widely used confers a considerable advantage to the organisms.

In 1947, just four years after penicillin was used widely in the USA, the first penicillin-resistant bacterium called *Staphylococcus aureus* was discovered. . Today, over half the infections caused by *Staphylococcus aureus* are caused by penicillin-resistant types.

Chromosome mutations

Chromosome mutations occur when there is any change in the arrangement or structure of the chromosomes. They mostly occur during meiosis at crossing over in prophase 1. There are several different mutation types that result in a change in the structure of a chromosome. They are much bigger events than point mutations and usually result in the death of a cell. They may also affect the whole organism. For example, if essential parts of the DNA are affected by chromosomal mutations, a foetus may be aborted.

Give a task for students to read about the benefits and adverse effects of mutation (Activity 4.24).

As a starter, you can also use additional notes provided above. Moreover, the following points are also important to provide detail examples.

- **Beneficial Mutations (see the description above)**
- **Harmful Mutations**

Imagine making a random change in a complicated machine such as a car engine. The chance that the random change would improve the functioning of the car is very small. The change is far more likely to result in a car that does not run well or perhaps does not run at all. By the same token, any random change in a gene's DNA is likely to result in a protein that does not function normally or may not function at all. While such mutations are likely to be harmful, other damaging mutations may cause genetic disorders or cancer.

- A **genetic disorder** is a disease caused by a mutation in one or a few genes. A human example is cystic fibrosis. A mutation in a single gene causes the body to produce thick, sticky mucus that clogs the lungs and blocks ducts in the digestive organs.
- **Cancer** is a disease in which cells grow out of control and form abnormal masses of cells. It is generally caused by mutations in genes that regulate the cell cycle. Because of the mutations, cells with damaged DNA are allowed to divide without limits.

Answer key for the review questions

1. Explain in detail the causes and consequences of mutation.

   You can use additional notes provided under causes and consequences of mutations.

2. Explain what happens if a substitution occurs in the DNA of an organism.

   You can use additional notes provided under the sub-topic: consequences of mutations

3. Describe how sickle cell anaemia occurs.

Sickle cell anemia is caused by a mutation in the gene that encodes information to your body to make the iron-rich compound. This iron-rich compound makes blood red and enables red blood cells to carry oxygen from your lungs throughout your body (hemoglobin). In sickle cell anemia, the abnormal hemoglobin causes red blood cells to become rigid, sticky and deformed. For a child to be affected, both the mother and father must pass the defective form of the gene.If only one parent passes the sickle cell gene to the child that a child will have the sickle cell trait. With one normal hemoglobin gene and one defective form of the gene, people with the sickle cell trait make both normal hemoglobin and sickle cell hemoglobin. Their blood might contain some sickle cells, but they generally don't show symptoms. They are carriers of the disease indicating that they can pass the gene to their children.

4.3. Genetic Drift (1 period)

Minimum learning competency

24. Discuss Genetic drift

Learning strategies

25. Let students be in groups of 6-7 members and discuss how genetic drift is the basic mechanism of evolution.

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written/ verbal
- **AI:** Written assignment or test/ presentation/

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate genetic drift. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about genetic drift**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

What is genetic drift?

Allele frequencies can change due to chance alone. This is called genetic drift. Drift is a binomial sampling error of the gene pool. In other words, the alleles that form the next generation's gene pool are a sample of the alleles from the current generation. When a population is sampled, the frequency of alleles differs slightly due to chance alone.

Alleles can increase or decrease in frequency due to drift. The average expected change in allele frequency is zero since increasing or decreasing in frequency is equally probable. A small percentage of alleles may continually change the frequency in a single direction for several generations just as flipping a fair coin may, on occasion, result in a string of heads or tails. A very few new mutant alleles can drift to fixation in this manner.

Give a task for students to read about genetic drift (Activity 4.25). The following description may give you a hint

Allele benefit or harm doesn't matter

Unlike natural selection, genetic drift does not take into account an allele's benefit (or harm) to the individual that carries it. In simple terms, a beneficial allele may be lost or a slightly harmful allele may become fixed purely by chance. A beneficial or harmful allele would be subject to selection as well as drift, but strong drift (for example, in a very small population) might still cause fixation of a harmful allele or loss of a beneficial one.

The bottleneck effect

The **bottleneck effect** is an extreme example of genetic drift that happens when the size of a population is severely reduced. Events such as natural disasters (earthquakes, floods, fires) can decimate a population, killing most individuals and leaving a small, random assortment of survivors behind.

The allele frequencies in this group may be very different from those of the population prior to the event and some alleles may be missing entirely. The smaller population will also be more susceptible to the effects of genetic drift for generations (until its numbers return to normal), potentially causing even more alleles to be lost.

Give a task for students to discuss about a bottleneck event that reduce genetic diversity (Activity 4.26). The following description may give you a hint

Imagine a bottle filled with marbles where the marbles represent the individuals in a population. If a bottleneck event occurs, a small, random assortment of individuals survive the event and pass through the bottleneck (and into the cup), whereas the vast majority of the population is killed off (remains in the bottle). The genetic composition of the random survivors (see the illustration from the student textbook) is now the genetic composition of the entire population. A population bottleneck yields a limited and random assortment of individuals. As a result, this small population will now be under the influence of genetic drift for several generations.

The founder effect

The **founder effect** is another extreme example of drift that occurs when a small group of individuals breaks off from a larger population to establish a colony. While the new colony is isolated from the original population, the founding individuals may not represent the full genetic diversity of the original population. Specifically, alleles in the founding population may be present at different frequencies than in the original population, and some alleles may be missing at all. The founder effect is similar in concept to the bottleneck effect, but it occurs via a different mechanism (colonization rather than catastrophe).

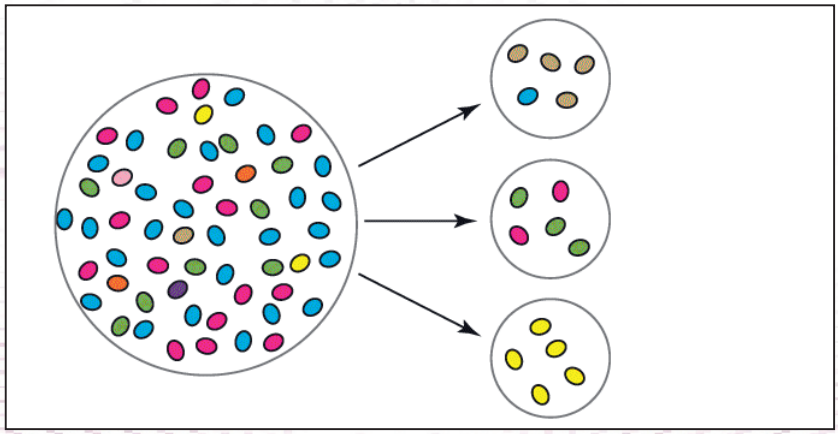


Figure 4.2 Simplified illustration of the founder effect.

Give a task for students to read about Ellis-Van Creveld syndrome (whose symptoms include polydactyly, or extra fingers, and other physical abnormalities) (Activity 4.27). The following description may give you a hint.

Ellis-Van Creveld syndrome is associated with abnormalities (mutations) in two genes on number 4 chromosome called EVC and EVC2. These gene mutations result in the production of abnormally small EVC and EVC2 proteins. Some affected individuals do not have mutations in these genes, so it is likely that other unknown genes are also responsible for the EVC chromosome.

Ellis-Van Creveld syndrome is inherited as an autosomal recessive genetic condition. Recessive genetic disorders occur when an individual inherits two copies of an abnormal gene for the same trait, one from each parent. If an individual receives one normal gene and one gene for the disease, the person will be a carrier for the disease. Some individuals carry one copy of the EVC or EVC2 gene. The chance for two carrier parents to both pass the defective gene and have an affected child with each pregnancy is 25 %. The risk of having a child who is a carrier like the parents is 50% with each pregnancy. The chance for a child to receive normal genes from both parents and be genetically normal for that particular trait is 25%. The risk is the same for males and females.

Answer key for the review questions

As a starter, you can use the keywords and concepts in the text and the teacher's guide to answer the following questions.

1. genetic drift
2. bottle neck effect.
3. founder effect.

4.4. Gene flow (1 period)

Minimum learning competency

- Discuss gene flow
- Describe the roles of immigration and emigration on gene flow and speciation

Learning strategies

Let students be in groups of 6-7 members and discuss how gene flow along with natural selection, mutation, and migration/immigration are the basic mechanisms of evolution

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written/ verbal
- **AI:** Written assignment or test/ presentation/

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate gene flow, immigration and emigration on gene flow and speciation. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about gene flow, immigration and emigration on gene flow and speciation**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional notes

Guide students to read about gene flow (Activity 4.28). Guide and follow students to properly work the activity

Answer key for the review questions

Dear teacher, as a starter you can use the keywords and concepts in the text and teachers guide to answer the questions.

1. Describe gene flow.
2. Explain the role of immigration and emigration on gene flow and speciation.

4.5. Causes of species extinction (2 periods)

Minimum learning competency

- Explain causes of species extinction
- Critique the evolution theory based on their taught at the end of the topic

Learning strategies

- Assign teams of students to explore drivers of extinction including climate change, human activities, greenhouse gases, and natural disasters. Tell them that they should seek solutions to mitigate habitat loss and prevent extinction.
- Let students be grouped into two and have a debate on evolutionary theories and pieces of evidence provided for the existence of evolution.

Assessment strategies

E: Evidence

AI: Assessment Instrument

- **E:** Written/ verbal
- **AI:** Written assignment or test/ presentation/

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate causes of species extinction. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic causes of species extinction, you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional notes

Evidence to date suggests that anthropogenic effects and natural disaster played significant role for direct and indirect cause of species extinction.

Give a task for students to read about drivers of extinction like climate change, human activities, greenhouse gases, and natural disasters (Activity 4.29). The following description may give you a hint.

Extinction occurs when the last existing member of a given species dies. In other words, there aren't any more left. It is a scientific certainty when there are not any surviving individuals left to reproduce.

Causes of Extinction

Genetics and Demographics

- Small populations = increased risk
- Mutations
    - Causes a flux in natural selection
    - Beneficial genetic traits are overruled
- Loss of Genetic Diversity
    - Shallow gene pools promote massive inbreeding

Habitat Degradation

- One of the most influential issue that might be caused by many factors mainly due to humans
- Some due to other factors
- Toxicity
    - Kills off species directly through food/water
    - Indirectly via sterilization
    - Can occur in short spans (a single generation)
    - Can occur over several generations
- Destruction of Habitat
    - Elimination of living space
    - Change in habitat
    - Volcanoes, floods, drought, etc
- Predation
- Competition
- Disease

Climatic Heating and Cooling

- Changes in Sea Level or Currents
- Asteroids
- Acid rains
- Spread of invasive species

Increased human population

- Pollution
- Climate change/Global warming
- Destruction/Fragmentation of habitat

4.6. Renowned anthropologists in Ethiopia (1 period)

By the end of this section, the student will be able to:

- Appreciate the works of renowned anthropologists in Ethiopia.

Guide students to read about the work of renowned anthropologists such as Dr. Yohannes H/ Silassie and Dr. Zeresenay Alemseged (Activity 4.30). Encourage students to review their work and prepare a report and present it to the class.

4.7. Renowned evolutionists in Ethiopia

Guide students to read about the work of renowned evolutionists (Activity 4.31). Encourage them to review their work and prepare a report and present it to the class.

Answer key to the unit summary review questions

1. List at least one point in favour and one point against the theories on the origin of life listed here under.
    a. Special creation

    The theory tried to explain formation of life on earth may have been taken place due to supernatural or divine forces.

    Special creation theory mainly focuses on spiritual matters which cannot be seen, touched or measured effectively by their very nature.

    b. Spontaneous generation

    Spontaneous generation is a hypothetical process by which living organisms develop from nonliving matter.

    The theory could not experimentally prove how living organisms developed from a nonliving matter.

    c. Eternity of life

    This theory state there is no beginning and no end to life on earth.

    However, evidence support the formation of the earth before the existence of life on the earth.

    d. Cosmozoan (panspermia)

    This theory assumes that life was present in the form of resistant spores and appeared on earth from another planet.

    However, no mechanism has been revealed about the transfer of spores from another planet or whether these spores could survive the journey in space. It states the absence of life forms on any planet except on the earth, but no detail was provided about the spores, its origin and mechanism of crossing interplanetary space and reaching the earth.

    e. Biochemical (abiogenesis)

This theory was supported by considerable experimental evidence. However, purines (adenine and guanine) were not synthesized under the same conditions as pyrimidines (thymine, uracil and cytosine). This is quite a serious problem for the theory.

2. (a) Explain what is meant by each of the following terms:

i. *Evolution - The theory of evolution describes how the various forms of life on earth (including humans) emerged and developed*

ii. Convergent evolution- is the evolution of similar 'types' with similar adaptations from several different original 'types'

iii. Divergent evolution- the development of dissimilar traits or features (as of body structure or behavior) in closely related populations, species, or lineages of common ancestry that typically occupy dissimilar environments or ecological niches.

(b) How does fossil record provide evidence for evolution?

Fossils are important evidence for evolution because they show that life on earth was once different from life that exists on earth today. Paleontologists can determine the age of fossils using methods such as radiometric dating and categorize them to determine the evolutionary relationships between organisms.

(c). Explain how neo-Darwinism has modified Darwin's original theory of natural selection.

Neo-Darwinism, the modern version of Charles Darwin's theory of evolution by natural selection, incorporates the laws of Mendelian genetics and emphasizes the role of natural selection as the main force of evolutionary change.

. (a) In each of the following examples of natural selection, identify:

- the selection pressure (feature of the environment that is selective for some types and against others), and the type within the population that is best adapted.

i. Bacteria in a hospital where penicillin is widely used

If the bacteria is resistant to penicillin, the bacteria gains considerable advantage to flourish.

(b) Allopatric speciation and sympatric speciation are two processes by which new species can evolve. *Use the additional notes and the description in the student textbook to answer the following questions.*

- One similarity between the two processes
- One difference between the two processes

4. The amino acid sequences of one of the polypeptide chains of haemoglobin from nine animals were determined.

The results are shown in the following table.

Type of haemoglobin	Number of amino acids different from human haemoglobin
Human	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Horse	25
Chicken	45
Frog	67
Sea slug	127

(a) Use the information to draw a phylogenetic tree of the organisms.

(b) Is it possible to use DNA hybridisation to suggest relationships between species? Explain why

5. Explain the importance of each of the following in speciation:

- Isolation of different populations
- Mutation
- Selection pressures
- Reproductive isolation

6. Describe how Redi and Pasteur were able to disprove the theory of spontaneous generation in their experiments.

7. Describe (a) the Oparin/Haldane theory of abiogenesis (the biochemical origin of life).

(b) Three pieces of evidence that support this theory.

8. Write a short essay on human evolution. Include the following aspects of human evolution in the essay:

- The idea of a common ancestor with chimpanzees
- Some of the characteristics of the early humans
- The importance of bipedalism and large brain size
- The significance of the discovery of Lucy, Ardi and Selam fossils.

Unit 5
The Human body systems
(31 Periods)

Learning Outcomes:

After the successful completion of this unit, the learner will be able to:

- Explain the structure and its functions of nervous system
- Discuss how the nervous and endocrine system works
- Explain how the organs of each organ system work together
- Explain what homeostasis is and how the human nervous and endocrine system helps maintain homeostasis
- Describe the effects of drug abuse on the normal functioning of the

Unit minimum learning competency

- Define the nervous system
- Identify types of the nervous system
- Describe the structure and function of neurons
- Explain nerve impulse and transmission
- Define reflex action
- State the types of reflexes with examples
- Explain the effects of drug abuse on nervous systems with local and international examples
- Discuss the structure and function of skin
- Draw and indicate taste sites on the tongue
- Explain the structure and functions of nose
- Draw and label the structure of the human eye
- Explain the functions of the human eye

- Explain the way the eye sees things
- Identify common eye defects and their causes in humans
- Draw and label the structures of the human ear
- Describe the functions of the human ear
- Define glands and hormones
- Identify the location and function of principal endocrine glands, including pituitary
- thyroid, parathyroid, adrenal, and pancreas
- Compare and contrast exocrine and endocrine glands
- Explain the function of glands and hormones
- Define homeostasis
- Explain the regulatory mechanisms of body temperature, sugar level, water balance
- Discuss the structures and functions of the human kidney
- Investigate traditional mechanisms in your locality used to regulate body homeostasis
- Examine the side effects of drugs (smoking, alcohol use, chewing khat, cannabis) on the normal functioning of nervous and endocrine systems

Unit learning strategies

1. Ask students what the nervous system is. Draw the analogy between a computer and the nervous system. Let students define the nervous system and identify the types of nervous system. Ask students what they know about nerves and how they are organized to work in a system. Then, instruct them to read books, use the internet, watch videos and come up with what they have learned about the nervous system and finally define what the nervous system is and how they work.
2. Let students discuss the types of the nervous systems (central, peripheral, sympathetic, and parasympathetic) using diagrams, models and books. Ask students to describe the four requirements that are necessary for a nervous response to occur: sensory receptors to detect a stimulus (skin, eye, ear); a system for impulse transmission (neurons); the capacity to interpret and analyze impulses (brain, spinal cord); and an effector (muscle, gland) to carry out the response. Support them to do this activity using virtual lab (simulation software, animation and video) (Competencies 2 &3).
3. Let students draw a typical nerve cell and explain that the nervous system is made up of neurons and communicate by synapse. While the nervous system collects and distributes information, all cells maintain an electrical potential across their plasma membranes. A nerve impulse is an action potential that propagates itself along an axon and a myelinated nerve can carry impulse

rapidly. Finally, define the reflex action demonstrating knee jerk, eye reflex (iris and light), and blinking of an eye as an example (Competencies 4- 6).

4. Assign students to be in groups of 6-7 members and let them discuss factors (diet, sleep, exercise, substance abuse, reading, playing video games, etc.) that affect how well the brain works.
5. Divide students in to three groups and let them discuss and come up with picture, drawings and model of skin, tongue and nose and present their report to the class. Label the five areas of taste (salt, sweet, sour, bitter, and umami) (competencies 8-10).
6. Let students draw the structure of the eye from books/internet and prepare eye model from locally available materials and finally ask them to explain the way the eye sees and common eye defects such as cataract, glaucoma, short, and long-sightedness. Instruct them to collect an eye from a recently slaughtered sheep/Got/Cow at nearby butcheries and dissect it and demonstrate the external and internal structure of the eye (Competencies 11-14).
7. Ask them to draw the structure of a human ear, label it, and using prepared models explain the functions and defects of a human ear (deafness) (Competencies 15&16).
8. Let students use the diagram of a human body showing the main endocrine glands and write a text describing the function of these glands
9. Let students discuss the function of glands and hormones. Assign them to be in groups to carry out a case study on goiter and discuss emphasizing the cause and treatment of goiter.
10. Ask students what they know about homeostasis and explain why dogs pant during sunny days. Tell them to be in groups and discuss different body condition regulation mechanisms (Thermoregulation, Osmoregulation, and Chemical regulation).
11. Let students use text and diagrams that give information on the function of kidneys and the liver and instruct them to dissect a kidney of sheep/goat/ cow and draw and label the structures in their exercise books. Let them also draw the nephron and its structures by copying from other books and indicate their functions
12. Let students investigate traditional mechanism of regulating body homeostasis
13. Let students investigate the effects of drugs on nervous and endocrine glands by interviewing drug users and health professionals or health center.

Unit Assessment strategies

DA: Desired achievement

E: Evidence

AI: Assessment Instrument

1. DA: Competencies 1 -4

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

2. **DA:** Competencies 5& 6

E: Written / verbal/ diagrams/practice

AI: written assignment and test/reflection /presentation/ drawings/observation

3. **DA**: Competency 7

E: Written/ verbal/ records

AI: Written assignment or test/ presentation/ field report/interview

4. **DA**: Competencies 8-16

E: Written/ verbal/diagrams

AI: Written assignment or test/ presentation/drawings

5. **DA**: Competencies 17-20

E: Written/ verbal/diagrams

AI: Written assignment or test/ presentation/ drawings

6. **DA**: Competencies 21-24

E: Written/ verbal/diagram

AI: Written assignment or test/ presentation/drawings

7. **DA:** Competency 25

E: Written/ verbal

AI: questionnaire/ Written assignment or test/ presentation/portfolio

5.1. The Nervous System (11 periods)

Minimum learning competency

- Define the nervous system
- Identify types of the nervous system
- Describe the structure and function of neurons
- Explain nerve impulse and transmission
- Define reflex action
- State the types of reflexes with examples
- Explain the effects of drug abuse on nervous systems with local and international examples

Learning strategies

1. Ask students the question what is the nervous system? Draw the analogy between a computer and the nervous system. Let them define the nervous system and identify the types of nervous system. Ask students what they know about nerves and how they are organized to work in a system. Then instruct them to read books, use the internet, watch videos and come up with what they have learned about the nervous system and finally define what the nervous system is and how they work.
2. Let students discuss the types of the nervous systems (central, peripheral, sympathetic, and parasympathetic) using diagrams, models, and books. Ask students to describe the four requirements that are necessary for a nervous response to occur: sensory receptors to detect a stimulus (skin, eye, ear); a system for impulse transmission (neurons); the capacity to interpret and analyze impulses (brain, spinal cord); and an effector (muscle, gland) to carry out the response. Support them to do this activity using virtual lab (simulation software, animation and video) (Competencies 2 &3).
3. Let the students draw a typical nerve cell and explain that a nervous system is made up of neurons and communicate by synapse. While a nervous system collects and distributes information, all cells maintain an electrical potential across their plasma membranes, a nerve impulse is an action potential that propagates itself along an axon and a myelinated nerve can carry impulse rapidly. Finally, define the reflex action demonstrating knee jerk, eye reflex (iris and light), and blinking of an eye as an example (Competencies 4- 6).
4. Assign students to be in groups of 6-7 members and let them discuss factors (diet, sleep, exercise, substance abuse, reading, playing video games, etc.) that affect how well the brain works.

Assessment strategies

DA: Competencies 1 -4

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

DA: Competencies 5& 6

E: Written / verbal/ diagrams/practice

AI: written assignment and test/reflection /presentation/ drawings/observation

DA: Competency 7

E: Written/ verbal/ records

AI: Written assignment or test/ presentation/ field report/interview

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Definition of the nervous system

Additional teaching notes

Give a task for students to discuss how a computerized machine works (Activity 5.1) and tell them to provide answer for the question: Which parts of human body get involved for coordination and rapid responses to the changes in the environment?

As human beings, not only we control our own bodies, but we also expect our co-ordination systems to control fast and complicated machines as well. In large and complex organisms such as human beings, it is very important for us that the different systems within our body are coordinated and work together. We need to pick up all sorts of changes in the environment, and respond to them.

5.1.1. Types of the nervous system (3 periods)

Minimum learning competency

- Identify types of the nervous system

Learning strategies

- Let students discuss the types of the nervous systems (central, peripheral, sympathetic, and parasympathetic) using diagrams, models, and books.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 1

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students to read about cranial and spinal nerves; the names of the different types of the cranial and spinal nerves and the role of these nerves in the human nervous system. Moreover, let them understand the opposite sides of the brain (the right and left hemispheres of the brain), their basic difference in function and how they work and control the human body (Activity 5.2). The following description may give you a hint.

The 12 Cranial Nerves

Table 5.1 Summary of cranial nerves and their function

Number	Name	Exit	Modality	Function
1 (CNI)	Olfactory	Cribriform plate	Sensory *(SVS)*	Smell
2 (CNII)	Optic	Optic canal	Sensory *(SSS)*	Vision
3 (CNIII)	Oculomotor	Superior orbital fissure	Motor *(GSM & GVM)*	GSM: 4 extrinsic eye muscles and levator palpebrae superioris. GVM: pupillary sphincter
4 (CNIV)	Trochlear	Superior orbital fissure	Motor *(GSM)*	Superior oblique
5 (CNV)	Trigeminal:			
	Ophthalmic	*Superior orbital fissure*	*GSS*	Scalp, forehead and nose.

Number	Name	Exit	Modality	Function
	Maxillary	*F. rotundum*	*GSS*	Cheeks, lower eye lid, nasal mucosa, upper lip, upper teeth and palate.
	Mandibular	*F. ovale*	*GSS* *SVM*	GSS: anterior 2/3 tongue, skin over mandible and lower teeth. SVM: muscles of mastication.
6 (CNVI)	Abducens	Superior orbital fissure	Motor *(GSM)*	Lateral rectus
7 (CNVII)	Facial	Internal acoustic meatus > stylomastoid f.	Both: *GSS* *SVS* *SVM* *GVM*	GSS: sensation to part of ext. ear. SVS: taste from ant. 2/3 tongue, hard and soft palate. SVM: muscles of facial expression. GVM: lacrimal, submandibular, sublingual glands and mucous glands of mouth and nose.
8 (CNVIII)	Vestibulocochlear	Internal acoustic meatus	Sensory *(SSS)*	Hearing and balance
9 (CNIX)	Glossopharyngeal	Jugular f.	Both: *GSS* *GVS* *SVS* *GVM* *SVM*	GSS: post. 1/3 tongue, ext. ear, and middle ear cavity. GVS: carotid body and sinus. SVS: taste from post. 1/3 tongue. GVM: parotid gland. SVM: stylopharyngeus
10(CNX)	Vagus	Jugular f.	Both: *GSS* *GVS* *SVS* *GVM*	GSS: ext. ear, larynx and pharynx. GVS: larynx, pharynx and, thoracic & abdominal viscera. SVS: taste from epiglottis region of tongue

Number	Name	Exit	Modality	Function
			SVM	GVM: smooth muscles of pharynx, larynx and most of the GIT. SVM: most muscles of pharynx and larynx.
11 (CNXI)	Spinal accessory	Jugular f.	Motor *(GSM & SVM)*	GSM: trapezius and sternocleidomastoid. SVM: a few fibres run with CNX to viscera.
12 (CNXII)	Hypoglossal	Hypoglossal canal	Motor *(GSM)*	Intrinsic and extrinsic tongue muscles (except the palatoglossus).

Spinal nerves

In human beings, there are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal (see the illustration from the student textbook). Each pair connects the spinal cord with a specific region of the body.

Two Hemispheres

The left hemisphere of the human brain controls the right half of the body, and the right hemisphere controls the left half of the body. For example, the left hemisphere has been shown to be superior for forming associations in memory, selective attention and positive emotions. The right hemisphere, on the other hand, has been shown to be superior in pitch perception, arousal and negative emotions.

The two hemispheres are connected by a thick band of neural fibers known as the **corpus callosum** that consists of about 200 million axons. The corpus callosum allows the two hemispheres to communicate with each other and allows for information being processed on one side to be shared with the other side of the brain.

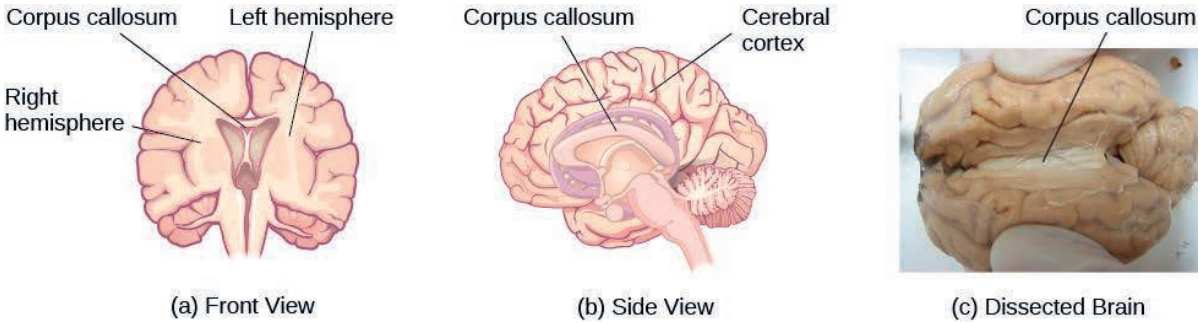


Figure 5.1 (a,b) The corpus callosum connevts the left and right hemisphere of the brain. © A scien tist spreads this dissected sheep brain apart to show the corps callosum between the hemispheres.

5.1.2. Neurons and their functions (2 periods)

Minimum learning competency

- Describe the structure and function of neurons

Learning strategies

- Let students describe the four requirements that are necessary for a nervous response to occur: sensory receptors to detect a stimulus (skin, eye, ear); a system for impulse transmission (neurons); the capacity to interpret and analyze impulses (brain, spinal cord); and an effector (muscle, gland) to carry out the response.
- Support them to do this activity using virtual lab (simulation software, animation and video)

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 2

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students to read how nervous co-ordination works (Activity 5.3). The following description may give you a hint and supplement the note presented in the student textbook.

How nervous co-ordination works

Once a stimulus is picked up by a sensory receptor, the information is passed along special nerve cells, **affector** or **afferent** neurons, to the central nervous system (CNS) or your brain and spinal cord. Once the information has been processed in the CNS, instructions are sent out to the body along more neurons called **effector** or **efferent** neurons. These stimulate the effector organ, usually muscles or a gland.

Sense organ → afferent neurons → central nervous system → efferent neurons → muscles

With millions of them working together in our body, these neurons are the basic unit of our nervous system. Neurons are extremely specialized for the transmission of electrical impulses.

They have a cell body that contains the cell nucleus, mitochondria, and other organelles. They also have slender finger-like processes called **dendrites** that connect to neighboring nerve cells. The most distinctive feature of all nerve cells is the **axon** or nerve fiber, which is extremely long and thin. The axon membrane changes its permeability to sodium ions to create an electrical impulse, whereas the **myelin sheath** provides a layer of insulating material so the nerve impulse travels as fast as possible.

Guide students to draw a typical nerve cell and label the parts, and explain how it functions (Activity 5.4) and discuss whether a neuron is continuous like a wire. The following description may give you a hint.

Neurons are not continuous 'wires' running throughout the human body. Whenever one neuron ends and another begins, there is a gap known as a **synapse**. The electrical impulses that travel along neurons have to cross these synapses, but an electrical impulse cannot leap the gap. Thus, when an impulse arrives at the end of a neuron, chemicals are released. These chemical transmitters (**neurotransmitters**) cross the synapse and are picked up by special receptor cells in the end of the next neuron. In turn, this starts up an electrical impulse, which then travels along

the next neuron. This is how impulses pass from one neuron to another throughout the human body.

5.1.3. Nerve impulse and transmission (1 period)

Minimum learning competency

- Explain nerve impulse and transmission

Learning strategies

- Let students draw a typical nerve cell and explain that a nervous system is made up of neurons and communicate by synapse. While a nervous system collects and distributes information**,** all cells maintain an electrical potential across their plasma membranes,
- Let students describe a nerve impulse, which is an action potential that propagates itself along an axon and a myelinated nerve can carry impulse rapidly.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 3

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students to read about synapses and special types of synapses (Activity 5.5). The following description may give you a hint.

Synapses are very important for the co-ordination of information in the human central nervous system and information that is coming in from many different areas of human body. There are special synapses between effector neurons and the muscles they stimulate. These are known as **neuromuscular junctions** and they work in the same way as a normal synapse, except the chemical crossing in which the gap causes the muscles to contract.

5.1.4. Neurotransmitters (1 period)

Minimum learning competency

- Explain neurotransmitters and their role in the nervous system

Learning strategies

- Let students describe neurotransmitters and their role in the nervous system.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 4

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students to read about the various types of neurotransmitters and their role in the nervous system (Activity 5.6). The following description may give you a hint.

Some of the key neurotransmitters

The first neurotransmitter to be discovered was a small molecule called **acetylcholine**. It plays a major role in the peripheral nervous system, where it is released by motor neurons and neurons of the autonomic nervous system. It also plays an important role in the central nervous system in maintaining cognitive function.

Glutamate is the primary excitatory transmitter in the central nervous system. Conversely, a major inhibitory transmitter is its derivative γ-aminobutyric acid (GABA), whereas another inhibitory neurotransmitter is the amino acid called glycine, which is mainly found in the spinal cord.

Noradrenaline (or norepinephrine) is another monoamine, and is the primary neurotransmitter in the sympathetic nervous system where it works on the activity of various organs in the body to control blood pressure, heart rate, liver function and many other functions.

Answer key to the review questions

1. What are the differences between a neuron and a nerve?

The main difference between a nerve and a neuron is that

- *Nerve is a group of neurons, whereas a neuron is an individual specialized cell.*
- *A nerve transmits information to the various parts of the body. But a neuron conducts electrochemical signaling ornerve impulses.*
- *Nerves are found in the peripheral nervous system. But neurons are found in the brain, spinal cord and the peripheral nerves.*
- *A nerve constitutes different types of axons, with each nerve covered by three layers (endoneurium, perineurium and epineurium). A neuron constitutes four parts (soma, nucleus, dendrite tree and axons.*

2. Figure out the constituents of the central nervous system and the peripheral nervous system.

You can use the additional notes and the note presented in the student textbook to answer this question.

3. How do synapses work?

You can use the additional notes provided earlier in this guide to answer this question.

5.1.5. Reflexes (2 periods)

Minimum learning competency

- Define reflex action
- State the types of reflexes with examples

Learning strategies

- Let students describe define the reflex action demonstrating knee jerk, eye reflex (iris and light), and blinking of an eye as an example

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 5-6

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Guide and give a task for students to investigate reaction time of a reflex action (Activity 5. 7) and knee jerk reflex (Activity 5. 8). The following description may give you hint.

The length of time it takes to recognise a stimulus and react to it is the reaction time. This is very important in many situations – for example, when you are driving, or at the start of a race. Some

people react more quickly than others – and can train themselves to speed up. In this investigation, students will be looking at reaction times by measuring how quickly their partner catches a metre ruler when they let it fall. If they collect all the data for the class, they can produce a graph to show the range of reaction times for their science group, and also do some statistical analysis to find the average median and mean reaction times for the class.

A reflex action, also known as a reflex, is an involuntary and nearly instantaneous movement in response to a stimulus. For example, when a person accidentally touches a hot object, they automatically jerk their hand away without thinking. A reflex does not require any thought input.

The path taken by the nerve impulses in a reflex is called a reflex arc. In higher animals, most sensory neurons do not pass directly into the brain, but via a synapse in the spinal cord. This characteristic allows reflex actions to occur relatively quickly by activating spinal motor neurons without the delay of routing signals through the brain although the brain will receive sensory input while the reflex action occurs.

Give the following tasks for students (Activity 5. 9).

1. Read about Ivan Pavlov's experiment on dog, and encourage them to write a report and present it to the class.

2. Take one example of a reflex action. Facilitate a small group discussion, draw and label a diagram of a reflex arc. The following descriptions may give you hint.

Pavlov's famous Classical Conditioning experiments became one of the first learning theories and contributed to the notion of psychology as an objective science. As a physiologist, not a psychologist (In fact, he was very emphatic about this), Pavlov sought to provide a scientific explanation of why dogs' would start salivating before they have seen food. It was found that almost any stimulus could have the same effect on producing salivation if it was often paired with the presentation of the original stimulus.It was this discovery that gave Pavlov the Nobel Prize award in 1904. This theory may seem to be complicated. Pavlov noticed that the sight of the dog's handler alone was enough to make the dog salivate.

A few examples of reflex action are:

- When light acts as a stimulus, the pupil of the eye changes in size.
- Sudden jerky withdrawal of hand or leg when pricked by a pin.

- Coughing or sneezing, because of irritants in the nasal passages.
- Knees jerk in response to a blow or someone stamping the leg.
- The sudden removal of the hand from a sharp object.
- Sudden blinking when an insect comes very near to the eyes.

Answer key to the review questions

1. Explain why reflexes can happen so quickly.

   Most reflexes don't have to travel up to your brain to be processed, and hence they take place so quickly. A reflex action often involves a very simple nervous pathway called a reflex arc. A reflex arc starts off with receptors being excited. They then send signals along a sensory neuron to your spinal cord where the signals are passed on to a motor neuron. As a result, one of your muscles or glands is stimulated.

2. Do you think that all reflexes are simple?

   There are many different reflexes in the body. Some of them are complicated and involve multiple interneurons and synapses. When there are many synapses, the reflex is called polysynaptic ("poly" means many). These reflexes, just like the simple monosynaptic reflex, exist in living beings, especially in human beings, to keep us safe!

3. How are reflexes so important for keeping us safe and helping us to learn?

   A reflex is an involuntary movement executed in response to a stimulus transmitted to the nerve center in the brain or spinal cord. Naturally, if a movement results, the brain will become aware of such movement and can regulate it somewhat, but the brain cannot control it. For example, when you trip and fall, reflexes automatically command your hands and arms to reach out and handle your fall, and your muscles will contract throughout your body to minimize injury. Reflexes perform many essential jobs for our central nervous system. They protect us from danger, help us to move our body and see. They are intended to help prevent injury to our bodies, but they are not always entirely effective in totally preventing injuries. An example of this is when you reflexively put your hands out to prevent a fall, you may injure your wrist in the process. Having good reflexes aids performance in sports, exercise, and everyday physical activities such as crossing the street, driving and working, whereas poor reflexes can be an underlying reason for faulty

movement and injury. Reflexes and reaction time do have a surprisingly large bearing on our ability to avoid any undue injury.

5.1.6. Drug abuse (2 periods)

Minimum learning competency

- Explain the effects of drug abuse on nervous systems with local and international examples.

Learning strategies

- Let students be in groups of 6-7 membes and let them discuss factors (diet, sleep, exercise, substance abuse, reading, playing video games, etc.) that affect how well the brain works **Assessment strategies**

  E: Evidence

  AI: Assessment Instrument

  DA: Competencies 7

  E: Written / verbal /diagram

  AI: Written assignments and tests/ field report/interview / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Guide and give a task for students to investigate about drug addiction, drug dependence and withdrawal symptom (Activity 5. 10). The following description may give you hint.

What is drug addiction?

Addiction is a disease that affects your brain and behaviour. When you are addicted to drugs, you can't resist the urge to use them no matter how much harm the drugs may cause. The earlier you get the treatment for drug addiction, the more **likely** you are to avoid some of the more dire consequences of the disease.

Drug addiction isn't just about just heroin, cocaine, or other illegal drugs. You can also get addicted to alcohol, nicotine, sleep and anti-anxiety medications, and other legal substances.

Addiction vs. Abuse and Tolerance

Drug abuse is when you use legal or illegal substances in ways you shouldn't do. You might take more than the regular dose of pills or use someone else's prescription. You may abuse drugs to feel good, ease stress or avoid reality. But, you can usually change your unhealthy habits or stop using at all.

Addiction is a difficult situation when you can't stop it. I is not only when it puts your health in danger I is also when it causes financial, emotional, and other problems for you or your loved ones. It is also that urges you to get and use drugs can fill up every minute of the day even if you want to quit.

What is withdrawal?

Withdrawal is the combination of physical and mental effects that a person experiences after they stop using or reduce their intake of a substance such as alcohol and prescription or recreational drugs.

If you have been using a substance with a high potential for dependency and you stop suddenly or abruptly or you cut down your use drastically, it means that you are experiencing a variety of withdrawal symptoms.

Symptoms

Some symptoms commonly associated with withdrawal include:

- Changes in appetite, changes in mood, congestion, fatigue, irritability, muscle pain, nausea, restlessness, runny nose, shakiness, sleeping difficulties, sweeting, tremors, vomiting etc.

Give a task for students to discuss the three most commonly abused substances by young people in Ethiopia (Activity 5. 11). The following description may give you hint.

Studies revealed that khat, alcohol, and cigarette are commonly abused substances used by many people. They are also widely used substances by high school and university students in Ethiopia. Let your students discuss what they know and observe from their surroundings.

Give a task for students to discuss harmful chemicals found in cigarettes and diseases that are caused as a result of smoking (Activity 5. 12). The following description may give you hint.

Harmful Chemicals in Tobacco Products

- All types of tobacco products contain chemicals that can be harmful to your health. Cigarettes, cigars, and pipe tobacco are made from dried tobacco leaves. Other substances are added for flavor and to make smoking more pleasant. The smoke from these products is a complex mixture of chemicals produced by burning tobacco and its additives. Tobacco smoke is made up of thousands of chemicals, including at least 70 known chemicals that cause cancer. These cancer-causing chemicals are referred to as *carcinogens*. Some of the chemicals found in tobacco smoke include: Nicotine is the addictive drug that produces affects the brain. People are looking for), hydrogen cyanide, formaldehyde, lead, arsenic, ammonia, carbon monoxide, tobacco-specific nitrosamines etc.

Many of these substances cause cancer. Some can cause heart disease, lung disease, or other serious health problems, too. Most of the substances come from the burning tobacco leaves themselves, not from additives included in cigarettes (or other tobacco products).

Smoking increases risk of the following diseases:

• Coronary Heart Disease.

• Strokes

• Lung Disease

• Cancers (lip, mouth, throat, pancreas, bladder and kidney) -

Give a task for students to discuss about how alcohol can directly and/or indirectly affect the health of young people (Activity 5. 13). The following description may give you hint.

If you drink large amounts of alcohol such as a whole bottle of spirits, your liver simply cannot cope. You suffer from alcohol poisoning. This can quickly lead to unconsciousness, coma and death. Some people who drink heavily for many years become **alcoholics**. They are addicted to the drug. Their liver and brain suffer long-term damage and eventually the drink may kill them. They may develop **cirrhosis of the liver**. This disease destroys your liver tissue. They can also get liver cancer, which spreads quickly and can be fatal. The brain of some heavy drinkers can be so damaged (it becomes soft and pulpy) that it can't work any longer. This causes death. It is also an established fact that those addicted (dependent) to alcohol are more likely to develop **Korsakoff's syndrome** (chronic memory disorder) as a result of damage to the neurons.

Give the following tasks for students (Activity 5. 14).

1. The economic importance of khat and its negative effect in damaging the economy.
2. Some of the relationship between unprotected sex, HIV/AIDS infection and Khat

The following description may give you hint.

Chewing khat has been a part of our Ethiopian culture for centuries, but now there are growing concerns about its use although it is an important part of our economy. Khat is relatively easy to grow and it creates jobs in the harvesting, packing and transporting of it as well as in selling it. What is more, it stops you feeling hungry. In other words, if people have little food to eat, it helps them to cope if they can chew leaves which make them feel good and stop them feeling hungry. But the negative effects of the drug outweigh its advantage as it may damage the economy even more. People spend hours chewing and dreaming when they could be working. If people spent less time chewing khat and more time cultivating the fields there might be more food to eat. Khat affects the health of the population directly and indirectly by the behaviour it causes. For many young people, khat is destroying their chances in life. Many people in Ethiopia need to work together to find the best way to deal with the problem of khat. It might seem impossible, but smoking widespread in the UK 50 years ago. Hundreds of thousands died from smoking-related diseases. Some people still smoke in the UK, but numbers have fallen dramatically and it is now against the law to smoke in public buildings. The numbers of people dying from smoking-related diseases has fallen steadily. This shows that it is possible to reduce the use of familiar local drugs.

Khat use is linked to unprotected sex, which put young people at risk of pregnancy and HIV/AIDS infection. Young men who used khat were found to be more likely to use a sex worker, and more likely to have many different sexual partners. All of these behaviours increase their risk of becoming infected with HIV/AIDS and of passing that infection on to someone else. Using khat also makes people more likely to be injured in accidents, more likely to be involved in crime, less likely to have a job and more likely to have problems in their family lives.

Give the following tasks for students about the health and social effects of drug abuse on individuals, families and communities (Activity 5. 15). Guide them to gather information from various sectors and stakeholders.

.

5.2. Sense organs (8 periods)

5.2.1. Skin (Structure and function) (2 periods)

Minimum learning competency

- Discuss the structure and function of skin

Learning strategies

- Divide students in to three groups and let them to come up with picture, drawings and model of skin and present in class. Label the parts of a skin.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 8

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give the following tasks for students to discuss about the function of human skin, the average weight of a human skin, how much area a human skin can cover and to label parts of human skin (Activity 5.16). Use the notes provided in the text book.

The following description is important to guide students for Activity 5.17

Pigmentation

The colour of skin is influenced by a number of pigments, including melanin, carotene, and hemoglobin. Melanin is produced by cells called melanocytes, which are found scattered throughout the stratum basale of the epidermis. The melanin is transferred into the keratinocytes via a cellular organelle called a **melanosome.** The relative coloration of the skin depends on the amount of melanin produced by melanocytes in the stratum basale and taken up by keratinocytes.

Melanin occurs in two primary forms. Eumelanin exists as black and brown, whereas pheomelanin provides a red colour. Dark-skinned individuals produce more melanin than those with pale skin. Exposure to the ultraviolet (UV) rays of the sun causes melanin to be manufactured and built up in keratinocytes, as the sun exposure stimulates keratinocytes to secrete chemicals that stimulate melanocytes. The accumulation of melanin in keratinocytes results in the darkening of the skin. This increased melanin accumulation protects the DNA of epidermal cells from UV ray damage and the breakdown of folic acid, a nutrient necessary for our health and well-being. In contrast, too much melanin can interfere with the production of vitamin D, an important nutrient involved in calcium absorption. Thus, the amount of melanin present in our skin is dependent on the balance between available sunlight and folic acid destruction, and protection from UV radiation and vitamin D production.

Some skin disorders

Vitiligo is a long-term condition where pale white patches develop on the skin. It's caused by the lack of melanin, which is the pigment in skin Vitiligo can affect any area of skin, but it commonly appears on the face, neck and hands, and in skin creases.

Vitiligo is caused by the lack of a pigment called melanin in the skin. Melanin is produced by skin cells called melanocytes, and it gives your skin its colour.

Figure 5.2 Figure showing vitiligo.

Acne, Cold sore and Eczema are also some of the skin disorders.

Give tasks (Activity 5.18 and 5.19) to students and guide them to perform the activities properly.

5.2.2. Tongue (1 period)

Minimum learning competency

- Draw and indicate taste sites on the tongue

Learning strategies

- Divide students into three groups and let them to come up with picture, drawings and model of tongue. Let students discuss in each group and present it to the class.
- Label the five areas of taste (salt, sweet, sour, bitter, and umami).

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 9

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give tasks for students (Activity 5. 20) about the tongue and why we see variation in some people in response to the same stimulus. The following description may give you hint.

For many years, it was thought that receptors for the four known senses had their areas of greatest concentration on different parts of the tongue. It has now been clearly shown that in fact all of the five different taste organs are spread out all over the tongue although some of them may seem to be in a greater concentration in certain places. while a few substances stimulate only one of the five types of receptors, most stimulate two, three, four or five types to varying degrees. The taste sensations you experience are produced by a blending of the five basic sensations in different relative intensities along with the input of smell from your nose. The sensation experienced by different people in response to the same stimulus may not be the same. The same substance can give rise to a sensation of sweet in one person if it stimulates primarily the sweet receptors. It can give rise to a sensation of bitter in a second person if it stimulates primarily the bitter receptors. There can be no sensation at all to a third person if it fails to stimulate any of the receptors. That is why the same food can taste delicious to one person and disgusting to another!

5.2.3. Nose (1 period)

Minimum learning competency

- Explain the structure and functions of nose

Learning strategies

- Divide students in to three groups and let them to come up with picture, drawings and model of nose.
- Let students discuss in each group and present in class.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 10

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task to students why they cannot 'taste' foods well when catch a common cold (Activity 5. 21). The following description may give you hint.

The reason why you cannot 'taste' foods well when suffering from a cold is as your nasal passages are inflamed and coated with mucus, your smell receptors cannot work. In other words, much of what is called taste is really smell.

5.2.4. The eye structure, function, and defects (2 periods)

Minimum learning competency

- Draw and label the structure of the human eye
- Explain the functions of the human eye
- Explain the way the eye sees things

Learning strategies

- Let students draw the structure of the eye from books/internet and prepare eye model from locally available materials and finally explain the way the eye sees and common eye defects such as cataract, glaucoma, short, and long-sightedness.
- Tell them to collect animal eye of the sheep/got/Cow from nearby butcheries, dissect and demonstrate the external and internal structure of the eye

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 11-14

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessons and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give tasks (Activity 5.22, 5.23 and 5.24) for students and guide them to perform the activities properly.

Give tasks for students (Activity 5.25) on how the retina works? What is colour blindness? What do you think is the cause of colour blindness? The following description may give you hint.

The light energy that falls on retina is changed into electrical energy by the light-sensitive cells known as the rods and cones that make up retina. Rods and cones contain chemicals that change when the light falls on them. This change triggers an impulse in the affector neurons that make up the optic nerve. The impulses travel along the optic nerve to the visual areas of the brain. The rods and cones then use energy to restore the chemicals to their original form. Rods respond to relatively low light levels, but they do not give a very clear image and they do not respond to different colours. This explains why colour drains away and everything looks black and grey when light levels fall in the evening. Rods spread across human retina except over the fovea (the small area of your retina which contains ONLY cones). Cones only work properly in bright light, but they respond to colours and give very clear, defined images. There are fewer cones than rods, and there are very few of them around the edges of the retina. That is why the edges of your visual field are blurred, although it is very sensitive to movement. The closer you get to the fovea the more cones there are, and the fovea itself has only cone cells. When light falls on your fovea, you see clearly and in colour. Each cone responds to red, green or blue light. The colours you see depend on which combination of cones is stimulated. If all the three are stimulated equally, you see white. Some people cannot see all the colours because they are missing one or more type of cone. This is known as colour blindness. It is not a major problem although there are a few jobs you can't do easily if you are colour-blind.

Give tasks for students (Activity 5.26 and 5.27) and guide them to perform the activities properly.

Give tasks for students (Activity 5.28) about eye defects and how these defects can be resolved. The following description may give you hint.

Common eye defects

Short sight: A short-sighted person can focus clearly on things that are close to them but has much more difficulty with objects in the distance, which appear blurred. This may be as a result of a lens that is effectively 'too strong'. It is too curved even when the ciliary muscles are fully relaxed and so the light from distant objects is focused in front of the retina, making the image that actually lands on the retina spread out again and blurry. Another cause of short sightedness is when the lens is normal but the eyeball is particularly long and again this means light is focused in front of the retina.

This problem can be corrected using concave (diverging) lenses that spread the light out more before it gets into your eye. This means that the thicker lens can bring the rays of light into perfect focus on the retina, or there is room in the long eyeball for the light rays to be focused on the correct point.

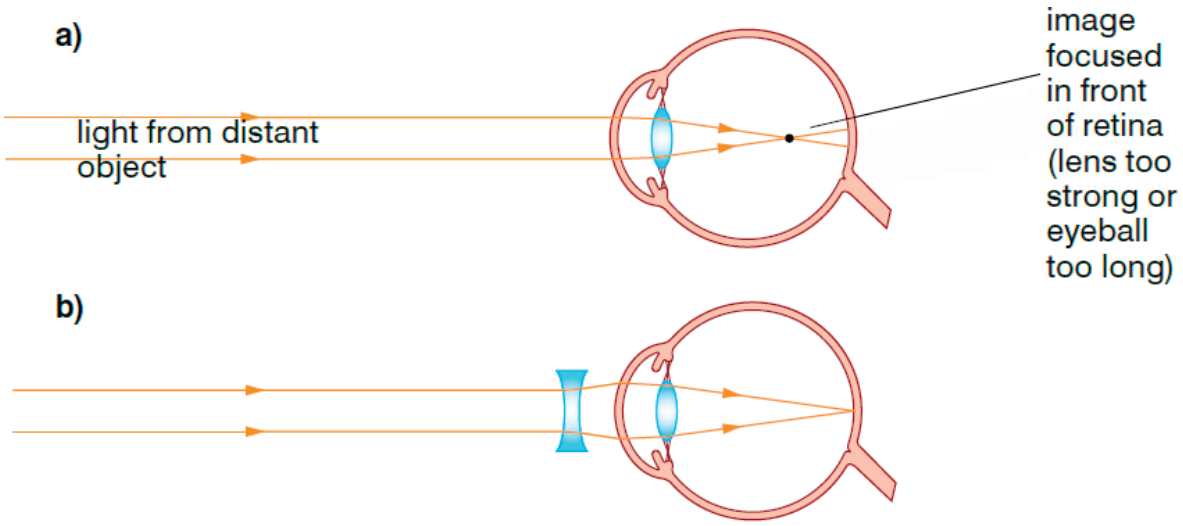


Figure 5.3 The eyes of short-sighted people easily corrected by a simple concave lens eye glass.

Long sight: A long-sighted person can focus clearly on things that are at a distance but has much more difficulty with objects close to them, which appear blurred. This may be as a result of a lens that is effectively 'too weak'. It is too flat even when the ciliary muscles are fully contracted and so the light from close objects is focused behind the retina. Consequently, the image that actually lands on the retina spreads out and becomes blurry. Another cause of long sightedness is that when the lens is normal although the eyeball is particularly short and again this means light is focused behind the retina. This problem can be corrected using convex (converging) lenses that bring the light rays together more before they reach your eye. Now the thinner lens can bring the rays of light into perfect focus on the retina – or the short eyeball becomes the right length for the light rays to be focused on the correct point.

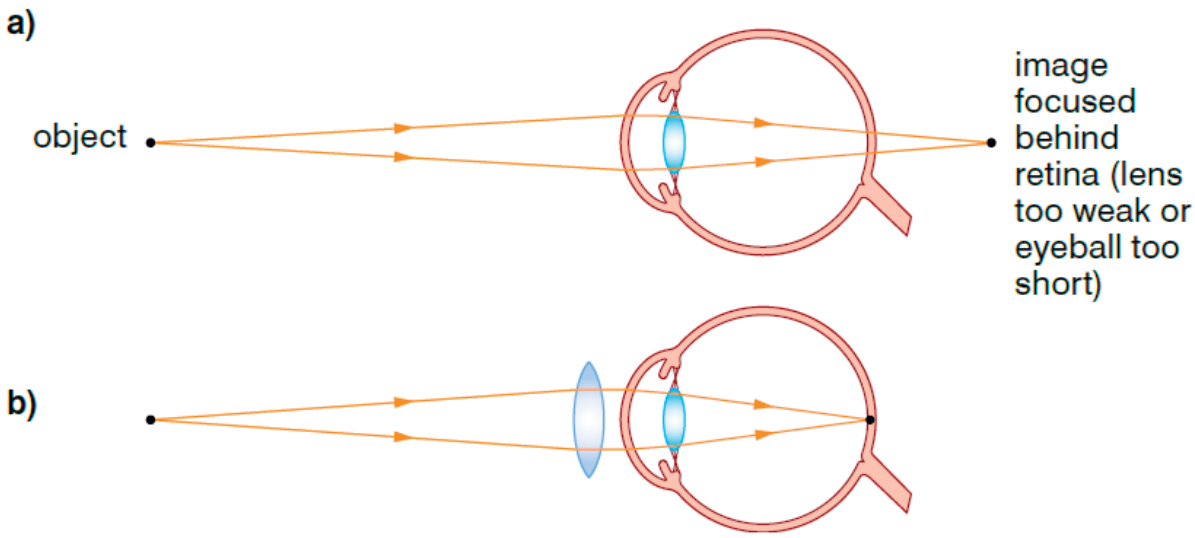


Figure 5.4 The eyes of long sighted people easily corrected by a simple convex lens eye glass.

Astigmatism: Astigmatism is another fairly common eye defect. The shape of the eye is irregular, more egg-shaped than round, so the cornea is curved asymmetrically and this affects the way light is focused on your retina. In some people, it is the lens rather than the eyeball itself that is an unusual shape, but the end result is the same. Astigmatism can also be corrected by using lenses, but the situation is more complex than for long and short sight.

Give a task for students (Activity 5.29) and guide them to perform the activity properly. The following description may give you hint.

Glaucoma and cataracts are physical conditions which cause loss of vision. Cataracts are gradual and painless conditions manifested by a loss of transparency. On the other hand, glaucoma can be either quick and painful or slow and subtle. A cataract is a change in the lens of the eyewhere the result is cloudiness as light is prevented from entering the eye properly. Glaucoma is a condition in which a build-up of pressure in the eye causes damage to the optic nerve. It is the vital link of the eye to the brain which processes visual information. Unlike glaucoma that can cause irreversible blindness and must be treated, cataracts are unlikely to be the cause of blindness. Glaucoma and cataracts are more prevalent in people who suffer from diabetes.

5.2.5. The structure and function of an ear (2 periods)

Minimum learning competency

- Draw and label the structures of the human ear
- Describe the functions of the human ear

Learning strategies

- Let students draw the structure of a human ear, label it, and using prepared models explain the functions and defects of the human ear (deafness)

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 15-16

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students (Activity 5.30) and guide them to perform the activity properly. Give a task for students (Activity 5.31) to discuss on the possible causes of deafness (hearing loss). The following description may give you a hint.

Deafness, or an inability to hear, is one of the most common disorders of the ear. Deafness may be temporary or permanent. It can be caused in many ways. If the eardrum is damaged by a blow or by a very loud noise, deafness will result. This may be temporary or, if the eardrum fails to heal, it can be permanent. If the tiny bones of the middle ear become damaged or fused by infection, or crumble away with age or disease, you will be permanently deaf.

Damage to the auditory nerve is another cause of deafness, and once the nerve is damaged it cannot be restored. Hearing loss can also be the result of infection when the middle ear becomes full of thick infected mucus. This type of hearing loss can be reversed if the infection is cleared with antibiotics. However, if the infection lasts too long, permanent hearing loss may result.

Answer key to the review questions

1. Explain some of the eye disorders with their possible corrections.

Refer to the additional notes under common eye defects to answer this question

2. Briefly explain how you can use your ears to hear a sounds.

Hearing depends on a series of complex steps that change sound waves in the air into electrical signals. Our auditory nerve then carries these signals to the brain.

- *Sound waves enter the outer ear and travel through a narrow passageway called the ear canal, which leads to the eardrum.*
- *The eardrum vibrates from the incoming sound waves and sends these vibrations tothree tiny bones in the middle ear. These bones are called the malleus, incus, and stapes.*
- *The bones in the middle ear amplify, or increase the sound vibrations and send them to the cochlea, a snail-shaped structure filled with fluid, in the inner ear. An elastic partition runs from the beginning to the end of the cochlea, splitting it into an upper and lower part. This partition is called the basilar membrane because it serves as the base, on which key hearing structures are situated.*
- *Once the vibrations cause the fluid inside the cochlea to ripple, a traveling wave forms along the basilar membrane. Hair cells,sensory cells situated on top of the basilar membraneride the wave. Hair cells near the wide end of the snail-shaped cochlea detect higher-pitched sounds, such as an infant crying. Those closer to the center detect lower-pitched sounds, such as a large dog barking.*
- *As the hair cells move up and down, microscopic hair-like projections (known as stereocilia) that perch on the top of the hair cells bump against an overlying structure and bend. Bending causes pore-like channels, which are at the tips of the stereocilia, to open up. When that happens, chemicals rush into the cells, creating an electrical signal.*
- *The auditory nerve carries this electrical signal to the brain, which turns it into a sound that we recognize and understand.*

3. Describe the role of some of the pigments that are found in your skin.

You can refer to the additional note given under 5.2.1 and note from the text book to answer this question.

5.3. The endocrine system (4 periods)

5.3.1 Endocrine glands (3 periods)

5.3.2 Exocrine glands (1 periods)

Minimum learning competency

- Define glands and hormones
- Identify the location and function of principal endocrine glands, including pituitary, thyroid, parathyroid, adrenal, and pancreas

- Compare and contrast exocrine and endocrine glands
- Explain the function of glands and hormones

Learning strategies

- Let students use the diagram of a human body showing principal endocrine glands and a text describing the function of these glands.
- Let students discuss the function of glands and hormones.
- Let students be in groups and carry out a case study on goiter and discuss emphasizing the cause and treatment of goiter.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 17-20

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students (Activity 5.32) about how hormones production is regulated in human body. The following description may give you hint.

Hormone production and release are primarily controlled by negative feedback. In negative feedback systems, a stimulus elicits the release of a substance. Once the substance reaches a certain level, it sends a signal that stops further release of the substance. In this way, the concentration of hormones in the blood is maintained within a narrow range. For example, the anterior pituitary signals the thyroid to release thyroid hormones. The increasing levels of these hormones in the blood then give feedback to the hypothalamus and anterior pituitary to inhibit further signaling to the thyroid gland.

Give a task for students (Activity 5.33) about the different types of hormones produced (released) by the anterior pituitary and posterior pituitary gland. The following description may give you hint.

The anterior pituitary often is referred to as the "master gland". This is because the anterior pituitary together with the hypothalamus orchestrates the complex regulatory functions of many other endocrine glands. The anterior pituitary gland produces six major hormones: (1) prolactin (PRL), (2) growth hormone (GH), (3) adrenocorticotropic hormone (ACTH), (4) luteinizing hormone (LH), (5) follicle-stimulating hormone (FSH), and (6) thyroid-stimulating hormone (TSH).

Hormones released from the posterior lobe of the pituitary include arginine vasopressin (AVP) and oxytocin. These two protein hormones are actually produced in the hypothalamus by specialized bundles of nerves.

Give tasks for students (Activity 5.34) about:

- **Thyroxine**
- **The current situation of goiter cases in Ethiopia?**
- **Why women and children are more affected by iodine deficiency than men? The following description may give you hint.**

The thyroid gland in your neck uses iodine from your diet to produce a hormone called **thyroxine**. Thyroxine is one of the hormones involved in the long-term chemical control of your body. It controls the metabolic rate of your body regarding how quickly substances are built up and broken down, how much oxygen your tissues use and how the brain of a growing child develops. If someone has an overactive thyroid that makes too much thyroxine, their metabolism starts to go very fast. The symptoms include losing a lot of weight, sweating a lot and becoming irritable. If the thyroid doesn't make enough thyroxine, people feel tired and lack energy. They may gain weight.

Low levels of thyroxine can cause problems in getting pregnant, results in miscarriages and still births. If small children do not make enough thyroxine, their growth is stunted and they do not develop normally, and this damage can be permanent. They have difficulties in learning. This is called cretinism.

The most common reason for not making enough thyroxine is related to a lack of iodine in the diet. Without iodine, the thyroid gland works very hard to try and make enough thyroxine although it cannot do it. The gland will grow and enlarge in an attempt to make the right amount of thyroxine. This is known as goitre. The enlarged gland can be felt in the neck. Eventually, the goitre gets so big that it can be seen as a swelling in the neck. Many people do not like the appearance of goitre in their neck.

Iodine deficiency disorders such as goitres are very common in Ethiopia. Several scientific studies have shown that between 30 and 40% of our population are affected by iodine deficiency to some extent. Women and children tend to be more affected than men. This may be because women have big demands on their bodies with pregnancy and breastfeeding, whereas children need to have more for growth. The problem is worse in rural areas, particularly in the mountainous regions where any iodine tends to be washed away out of the

soil. In some areas up to 90% of school children show some level of iodine deficiency. Iodine deficiency affects the health of millions of people in Ethiopia. A simple solution for most of the problems of iodine deficiency and goitre is to include more iodine in our diet.

There is a simple way to do this. Iodine can be added easily to the salt we use to season our food. It is important to note that tiny amount of extra iodine is all we need to overcome all the problems that goitre and IDD (iodine deficiency disease) can bring! In areas where the iodine levels are very low, special iodised capsules can be used to help people overcome the deficiency. Our women would suffer from the far fewer losses of iodine during pregnancy and birth. Our children would not fail to develop and become cretins. Every child would benefit and be able to learn more effectively. People would have more energy and be able to work more effectively. Adding more iodine to our diet in this simple way can have major effects on the wellbeing of millions of people in our country. As it has worked elsewhere in the world, it is now our chance to overcome this simple but devastating disease

Give a task for students (Activity 5.35) about the types of hormones secreted by Zona glomerulosa, Zona fasciculate and Zona reticularis and the role of each hormone. The following description may give you hint.

Zona Glomerulosa: the outermost layer: zona glomerulosa is the main site for the production of mineralocorticoids, mainly aldosterone. Mineralocorticoids are largely responsible for the long-term regulation of blood pressure. Aldosterone exerts its effects on the distal convoluted tubule collecting duct of the kidney where it causes increased reabsorption of sodium and increased excretion of both potassium (by principal cells) and hydrogen ions (by intercalated cells of the collecting duct). The major stimulus to produce aldosterone is angiotensin II, as ACTH from the pituitary only produces a transient effect. Angiotensin is stimulated by the juxtaglomerular cells when renal blood pressure drops below 90 mmHg.

Zona fasciculata is the layer situated between the glomerulosa and reticularis. This layer is responsible for producing glucocorticoids, such as 11-deoxycorticosterone, corticosterone and cortisol in humans. Cortisol enhances the activity of other hormones including glucagon and catecholamines.

Zona reticularis is the innermost cortical layer, and it produces androgens, mainly dehydroepiandrosterone (DHEA), DHEA sulfate (DHEA-S), and androstenedione (the precursor to testosterone) in humans.

Give a task for students (Activity 5.36) about the role of adrenaline. The following description may give you hint.

Adrenaline makes your heart beat faster and your lungs breathe more efficiently. It causes the blood vessels to send more blood to the brain and muscles, increases your blood pressure, makes your brain more alert, and raises sugar levels in the blood to give you energy. Your pupils grow larger and you sweat.

Give a task for students (Activity 5.37) about the difference between Type I and Type II diabetes. The following description may give you hint.

Both types of diabetes are chronic diseases that affect the way your body regulates blood sugar, or glucose. Glucose is the fuel that feeds your body's cells. For glucose to enter your cells, it needs a key calledInsulin. People with type 1 diabetes don't produce insulin. You can think of the state as not having a key. People with type 2 diabetes don't respond to insulin. Although they should respond to insulin, they often don't make enough insulin later in the disease. You can think of it as having a broken key. Both types of diabetes can lead to chronically high blood sugar levels that increase the risk of diabetes complications.

Give a task for students (Activity 5.38) about the hormones that have effect on the female reproductive system, control of the menstrual cycle and female fertility. The following description may give you hint.

The hormones of the menstrual cycle

Remember that there are four main hormones which have an effect on the female reproductive system. and between them control the menstrual cycle and female fertility. Produced by the pituitary gland in the brain, FSH (follicle stimulating hormone) stimulates the development of a follicle in the ovary, and within the follicle the egg matures and ripens. FSH stimulates the ovaries to produce hormones, particularly oestrogen. LH (luteinising hormone) stimulates the release of an egg from the ovary in the middle of the menstrual cycle and also affects the ovary so that it produces another hormone (progesterone) to keep the uterus lining in place. Produced by the ovaries, oestrogen stimulates the lining of the uterus to build up in preparation for pregnancy. It also affects the pituitary gland. As the oestrogen levels rise, the production of FSH by the pituitary gradually falls. This, in turn, means the oestrogen levels fall. The rise in oestrogen levels has the

opposite effect on the levels of the other pituitary hormone, LH. As oestrogen rises, the production of LH goes up. When the LH reaches its peak in the middle of the menstrual cycle, it stimulates the release of a ripe egg from the ovary. Progesterone maintains the thickened lining of the uterus and stimulates the growth of blood vessels in the lining to prepare for a pregnancy. Further, if a fertilised ovum arrives in the uterus, progesterone helps to maintain the pregnancy. By the end of the cycle, when the menstrual bleeding is about to start, all of the hormones are at a low ebb. Because the ovaries only contain a limited number of ova, women do not have periods throughout their lives. Eventually, the ova in the ovaries run out. As a result, the hormone levels drop, the ovaries and uterus shrink and the woman stops having periods. In other words, she is no longer fertile. This change, which takes place around the age of fifty, is known as the **menopause**.

Give a task for students (Activity 5.39) about the difference between endocrine and exocrine glands. **The following description may give you hint.**

The key difference between the two types of glands is that exocrine glands secrete substances into a ductal system to an epithelial surface, whereas endocrine glands secrete products directly into the bloodstream.

Answer key to the review questions

1. Compare and contrast the endocrine and exocrine glands

please refer the text book and the additional note provided here in the teaching guide to answer this question.

2. Describe the main differences of communication methods used by the endocrine system and the nervous system.

The body coordinates its functions through the two major types of communication: neural and endocrine. Neural communication includes both electrical and chemical signaling between neurons and the target cells. Endocrine communication involves chemical signaling via the release of hormones which travel through the bloodstream, where they elicit a response in the target cells. Endocrine glands are ductless glands that secrete hormones. Many organs of the body with other functions—such as the heart, stomach, and kidneys—also have endocrine activity.

3. Compare and contrast the anatomical relationship of the anterior and posterior lobes of the pituitary gland and the hypothalamus.

The hypothalamus–pituitary complex is located in the diencephalon of the brain. The hypothalamus and the pituitary gland are connected by a structure called the infundibulum, which contains vasculature and nerve axons. The pituitary gland is divided into two distinct structures with different embryonic origins. The posterior lobe houses the axon terminals of hypothalamic neurons. It stores and releases two hypothalamic hormones: oxytocin and antidiuretic hormone (ADH) into the bloodstream. The anterior lobe is connected to the hypothalamus by vasculature in the infundibulum and produces and secretes six hormones. Their secretion is regulated, however, by releasing and inhibiting hormones from the hypothalamus. The six anterior pituitary hormones are: growth hormone (GH), thyroid-stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), and prolactin (PRL).

5.4. Homeostasis in the human body (8 periods)

Minimum learning competency

- Define homeostasis
- Explain the regulatory mechanisms of body temperature, sugar level, water balance

Learning strategies

- Ask students what they know about homeostasis and to explain why dogs pant during sunny days. Then, you will define homeostasis.
- Guide them to form a group and discuss the different body condition regulation mechanisms (Thermoregulation, Osmoregulation, and Chemical regulation).

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 21-22

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students how kidneys control the levels of water and ions in the human body. The following description may give you hint.

One way the kidneys can directly control the volume of bodily fluids is by conserving or getting rid of the amount of water in the body. Either the kidneys can conserve water by producing urine that is concentrated relative to the plasma, or they can rid the body of excess water by producing urine that is dilute relative to the plasma. The direct control of water excretion in the kidneys is exercised by vasopressin or anti-diuretic hormone

(ADH), a peptide hormone is secreted by the hypothalamus. ADH causes the insertion of water channels into the membranes of cells lining the collecting ducts, allowing water reabsorption to occur. Without ADH, little water is reabsorbed in the collecting ducts and dilute urine is excreted.

Give a task for students on kidney dissection (Activity 5.40). Guide the students to properly work on the activities.

5.4.1 Structures and functions of the human kidney (2 periods)

Minimum learning competency

- Discuss the structures and functions of the human kidney

Learning strategies

- Instruct students to use text and diagrams that give information on the function of kidneys and the liver and to collect a kidney from a slaughtered sheep/goat/ cow and dissect and draw and label the structures in their exercise books.
- Let them also draw the nephron and its structures by copying from other books and indicate their functions.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 23

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students (Activity 5.41) about homeostasis in action by considering the type of urine produced when someone drinks a lot of water and small volume of water. The following description may give you hint.

On a typical day, the average adult will take in about 2500 mL (almost 3 quarts) of aqueous fluids. Although most of the intake comes through the digestive tract, about 230 mL (8 ounces) per day is generated metabolically through the last steps of aerobic respiration. Additionally, each day about the same volume (2500 mL) of water leaves the body via different routeswhere most of this lost water is removed as urine. The kidneys can also adjust blood volume though mechanisms that draw water out of the filtrate and urine. The kidneys can regulate water levels in the body in two major ways. They conserve water if you are dehydrated, and they can make urine more dilute to expel excess water if it is necessary.

5.4.1. Thermoregulation (1 period)

Minimum learning competency

- Investigate traditional mechanisms in your locality used to regulate body homeostasis

Learning strategies

- Let students investigate traditional mechanism of regulating body homeostasis

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 24

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students (Activity 5.42) about the different types of physiological and behavioral methods of temperature regulation in the human body. The following description may give you hint.

Physiological methods of temperature regulation

- **Sweating** – when you are getting hot, sweat oozes out of the sweat glands and spreads over the surface of the skin. Sweat consists of mainly of water and salt but it also contains a small amount of nitrogenous waste. As the water evaporates it cools the skin, taking heat from the body.. It is important to remember that sweat itself is not cool, but it can only cool you down when it evaporates. In hot, humid conditions, you may sweat a lot but it won't cool you down because the water can't evaporate! In cold weather, little or no sweat is formed so that as little heat as possible is lost by evaporation.
- **Vasodilation** – if the body temperature starts to go up, the blood vessels supplying the capillaries in your skin dilate so that more blood flows through the capillaries. Your skin flushes and more heat is lost through radiation from the surface. This is known as vasodilation

and it is particularly obvious in pale-skinned people. As a result, less blood flows through the slightly deeper vessels in your skin.

- **Vasoconstriction** – if your core temperature begins to fall the blood vessels which supply your skin, capillaries constrict (close up) to reduce the flow of blood through the capillaries. This reduces the heat lost through the surface of the skin, and makes you look paler. This is known as vasoconstriction and it works to keep you as warm as possible. As a result, more blood flows through the deeper blood vessels of your skin.

- **Piloerection (pulling the hairs upright)**.
- **Shivering and metabolic responses**

Behavioural methods of temperature regulation

- **Clothing** – We choose suitable clothes for the various types of weather as we do not have fur or feathers to keep us warm. We wear warm clothes when the weather is cold and fewer, cooler clothes when the external temperature is hot.
- **Seeking shade or shelter**
- **Burning fires, central heating, air conditioning, etc.**

5.4.2. Osmoregulation (2 periods)

Minimum learning competency

- Discuss the structures used for osmoregulation in human body.

Learning strategies

- Let students discuss structures used for osmoregulation.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 24

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Guide students to discuss on traditional mechanisms used to regulate body homeostasis in their locality (Activity 5.43).

5.4.3. Chemical regulation (2 periods)

Minimum learning competency

- Discuss the structures used to regulate chemicals in the human body.

Learning strategies

- Let students discuss structures used to regulate chemicals.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 24

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Give a task for students (Activity 5.44) to further read about other types of chemical regulation that takes place in the human body.

5.4.4. The side effects of drugs on the normal functioning of nervous and endocrine systems (1 period)

Minimum learning competency

- Examine the side effects of drugs (smoking, alcohol use, chewing khat, cannabis) on the normal functioning of nervous and endocrine systems.

Learning strategies

- Let students investigate the effects of drugs on nervous and endocrine glands by interviewing drug users and health professionals or health center.

Assessment strategies

E: Evidence

AI: Assessment Instrument

DA: Competencies 24

E: Written / verbal /diagram

AI: Written assignments and tests / presentation / reflection/drawings

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Guide students to do research on the effects of drugs (smoking, alcohol use, chewing khat and cannabis) on the normal functioning of the nervous system and endocrine system (Activity 5.44). Guide the students to properly work the activity.

Answer Key to the unit summary questions

Multiple choice part

1. C	**6. B**
2. C	**7. D**
3. A	**8. B**
4. C	**9. D**
5. D	**10. B**

Essay part

1. *Neurotransmitters are often referred to as the body's chemical messengers. They are molecules used by the nervous system to transmit messages between neurons, or from neurons to muscles.*

Communication between two neurons happens in the synaptic cleft (the small gap between the synapses of neurons). Here, electrical signals that have travelled along the axon are briefly converted into chemical ones through the release of neurotransmitters, causing a specific response in the receiving neuron.

A neurotransmitter influences a neuron in one of the three ways: excitatory, inhibitory or modulatory. An excitatory transmitter promotes the generation of an electrical signal called an action potential in receiving neuron, whereas an inhibitory transmitter prevents it. Whether a neurotransmitter is excitatory or inhibitory depends on the receptor it binds to.

2. *The parathyroid glands produce and secrete parathyroid hormone (PTH), a peptide hormone, in response to low blood calcium levels. PTH secretion causes the release of calcium from the bones by stimulating osteoclasts, which secrete enzymes. These enzymes degrade bone and release calcium into the interstitial fluid. PTH also inhibits osteoblasts, the cells involved in bone deposition, thereby sparing blood calcium. PTH causes increased reabsorption of calcium (and magnesium) in the kidney tubules from the urine filtrate. In addition, PTH initiates the production of the steroid hormone calcitriol (also known as 1,25-dihydroxyvitamin D), which is the active form of vitamin D_3, in the kidneys. Calcitriol then stimulates increased absorption of dietary calcium by the intestines. A negative feedback loop regulates the levels of PTH, with rising blood calcium levels inhibiting further release of PTH.*

3. *The three regions of the adrenal cortex are Zona glomerulosa, Zona fasciculate and Zona reticularis.*

Zona Glomerulosa: The outermost layeror the zona glomerulosa is the main site for production of mineralocorticoids, mainly aldosterone, that are largely responsible for the long-term regulation of blood pressure.

Zona fasciculata is the layer situated between the glomerulosa and reticularis. This layer is responsible for producing glucocorticoids, such as 11-deoxycorticosterone, corticosterone, and cortisol in humans.

Zona reticularis is the innermost cortical layer whereit produces androgens, mainly dehydroepiandrosterone (DHEA), DHEA sulfate (DHEA-S), and androstenedione (the precursor to testosterone) in human beings.

4. *The major hormones produced by the anterior pituitary gland are:*

- *ACTH: Adrenocorticotrophic hormone. Stimulates the production of cortisol, a "stress hormone" that maintains blood pressure and blood sugar levels.*
- *FSH: Follicle-stimulating hormone. Promotes sperm production and stimulates the ovaries to produce estrogen.*
- *LH: Luteinizing hormone. Stimulates ovulation in women and testosterone production in men.*
- *GH: Growth hormone helps to maintain healthy muscles and bones and manage fat distribution.*
- *PRL: Prolactin stimulates breast to produce milk after childbirth. It also affects hormones that control the ovaries and testes, which can affect menstrual periods, sexual functions and fertility.*
- *TSH: Thyroid-stimulating hormone stimulates the thyroid gland, which regulates metabolism, energy and the nervous system.*

5. *Feedback loops are used extensively to regulate the secretion of hormones in the hypothalamic-pituitary axis. An important example of a negative feedback loop is the control of thyroid in hormone secretion. The thyroid hormones thyroxine and triiodothyronine ("T4 and T3") are*

synthesized and secreted by thyroid glands and affect metabolism throughout the body. The basic mechanisms for control in this system are:

- *Neurons in the hypothalamus secrete thyroid releasing hormone (TRH), which stimulates cells in the anterior pituitary to secrete thyroid-stimulating hormone (TSH).*
- *TSH binds to receptors on epithelial cells in the thyroid gland, stimulating synthesis and secretion of thyroid hormones, which affect probably all cells in the body.*
- *When blood concentrations of thyroid hormones increase above a certain threshold, TRH-secreting neurons in the hypothalamus are inhibited and stop secreting TRH.*
- *Inhibition of TRH secretion leads to shut-off of TSH secretion, which leads to shut-off of thyroid hormone secretion.*

As thyroid hormone levels decay below the threshold, negative feedback is relieved, TRH secretion starts again, leading to the TSH secretion.

Unit 6.
Climate change (11 Periods)

Unit learning outcome:

Learning Outcomes: After the successful completion of this unit, the learner will be able to:

- Explore the key scientific concepts of climate change.
- Analyze the causes of climate change and how human activities affect the climate.
- Discuss the effects of climate change on living things
- Elaborate the measures to combat climate change
- Analyze implementation practice of international conventions to mitigate

Unit minimum learning competency

- Define climate change
- Explain the causes of climate change
- Discuss the effects of climate change on biodiversity, agricultural productivity, and human being
- Relate climate change and natural disasters
- Excise safety rules/ precautions during natural disaster
- Discuss international conventions regarding climate change
- Discuss the implementation status of international conventions in Ethiopia
- States measures Ethiopia has taken to combat climate change
- Consider an environmental action that addresses climate change in your community.
- Explain the role of the green legacy in Ethiopia to combat climate change
- Show a willingness to participate in the green legacy project by tree planting

Learning strategies

- Ask students to write down some ideas they have about climate change and let them define climate change. If they cannot define correctly, ask them to complete a a gap fill exercise. .
- Have students come up with questions to ask one another about climate change, cause and effect on our planet. Then let them be in groups and discuss their responses. Let students collect information from the internet/books/video about climate change and form in groups of 6-7 members and discuss the causes and effects of climate change on human beings and biodiversity (loss of species), agriculture (drought, soil degradation, low productivity), and forest productivity (drought, bushfire, etc.). The teacher may divide the lesson into sections corresponding to each group..
- Let students discuss the causes and effects of natural disasters such as flood, land slide and ice melt and describe what they know about safety rules/ precautions to take during natural disasters. (Competencies 4 & 5).
- Let students collect international convention frameworks from the internet or nearby responsible offices and discuss whether these conventions are being implemented as intended in the world and Ethiopia or not (competencies 6 & 7).
- Let students discuss the measures Ethiopia has taken to combat climate change in line withthe international conventions, (competencies8&11)
- Let students participate in tree planting to help them relate what they learned on the importance of planting trees with carbon sequestration and carbon trading.

Assessment strategies

DA: Desired Achievement

E: Evidence

AI: Assessment Instrument

1. **DA:** Competencies 1 -5

   E: Written / verbal /reports

   AI: Written assignments and tests / presentation / reflection/field reports
2. **DA:** Competencies 6-9

   E: Written / verbal/diagrams/reports

   AI: written assignment and test/reflection /presentation/ drawings/field reports

3. **DA:** Competencies 10&11

E: Written/ verbal/practice

AI: questionnaire/ Written assignment or test/ presentation/portfolio/observation

6.1. Climate change: causes and effects (2 periods)

Minimum learning competency

- Define climate change

Learning strategies

- Ask students write down some ideas they have about climate change and let them define climate change. If they cannot define correctly, ask them to complete a a gap fill exercise.

Assessment strategies

DA: Competencies 1

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessons.and conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

Give a task for students (Activity 6.1) to further read about differences between weather, climate, climate variability and climate change. The following description may give you hint.

Weather is the mix of events that happen in our atmosphere each day. Even though there is only one atmosphere on earth, the weather isn't the same all around the world. Weather is different in different parts of the world where it changes over minutes, hours, days, and weeks. Most weather happens in the part of the Earth's atmosphere that is closest to the groundcalled the troposphere. And, there are many different factors that can change the atmosphere in a certain area including air pressure, temperature, humidity, wind speed and direction, and lots of other things. All these togetherdetermine what the weather is like at a particular time and location.

Climate describes what the weather is like in a specific area for a long period of time. Different regions can have different climates. To describe the climate of a place, we might say what the temperatures are like during different seasons, how windy it usually is, or how much rain or snow typically falls.

When scientists talk about climate, they are often looking at averages of precipitation, temperature, humidity, sunshine, wind and other measures of weather that occur in a particular place for a long period of time. Climate is the average weather in a place for many years. Climate change is a state of shift in those average conditions.

6.1.1. Causes of climate change (3 periods)

Minimum learning competency

- Explain the causes of climate change

Learning strategies

- Have students come up with questions to ask one another about climate change, the causes and effects of climate change on our planet. Then, let them be in groups and discuss their responses.

Assessment strategies

DA: Competencies 2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Give tasks for students (Activity 6.2 and 6.3) to further read about types of natural and human activities that causes climate change. The following description may give you hint.

Humans are increasingly influencing the climate and the earth's temperature by burning fossil fuels, cutting down forests for farming and livestock production. Together with those naturally occurring in the atmosphere, this adds enormous amounts of greenhouse gases, increasing the greenhouse effect and global warming.

- **What are greenhouse gases?**

A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone.

- **What is the difference between global warming and climate change?**

Global warming refers only to the Earth's rising surface temperature, whereas climate change includes warming and the “side effects” of warming such as melting glaciers, heavier rainstorms, or more frequent drought. ... Global warming is just one symptom of the much larger effect of climate change.

- **Is the sun a major driver of recent changes in the climate?**

No! The Sun can influence the Earth's climate, but it isn't responsible for the warming trend we've seen for the last recent decades. The sun is a giver of life on earth where it helps keep the planet

warm enough for us to survive. We know that the subtle changes in the Earth's orbit around the sun are responsible for the comings and goings of the ice ages

- **What happens to carbon dioxide after it is emitted into the atmosphere?**

After it is emitted into the atmosphere, carbon dioxide (CO_2) is firstly rapidly distributed between atmosphere, the Upper Ocean and vegetation. Subsequently, the carbon continues to be moved between the different reservoirs of the global carbon cycle, such as soils, the deeper ocean and rocks.

- **Is climate always changing?**

Yes! Because of the natural phenomenon (such as, Solar Cycles, Volcanic Sulphur, Short-Term Climate Fluctuation, Orbital Wobbles, Carbon Dioxide and the Weathering Thermostat, Plate Tectonics, Asteroid Impacts, Evolutionary Changes, and Large Igneous Provinces) the climate is always changing.

6.1.2 Effects of climate change on Biodiversity, Agriculture and forest productivity (2 periods)

Minimum learning competency

- Discuss the effects of climate change on biodiversity, agricultural productivity, and human beings.

Learning strategies

- Let students collect information from the internet/books/video about climate change and form groups of 6-7 students and discuss the causes and effects of climate change on human beings and biodiversity (loss of species), agriculture (drought, soil degradation, low productivity), and forest productivity (drought, bushfire, etc.). The teacher may divide the assignment corresponding to each group.

Assessment strategies

DA: Competencies 3

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities **and answer questions.**

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Additional teaching notes

6.2. Climate change and natural disasters (1 period)

Minimum learning competency

- Relate climate change and natural disasters

Learning strategies

- Let students discuss that cause and effects of natural disasters such as flood, land slide and ice melt.

Assessment strategies

DA: Competencies 1-2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

I. **Tasks**

Support the learners to understand and answer the self-assessment questions and participate in activities.

Give a task for students (Activity 6.4) to further read the cause and effects of natural disasters such as flood, land slide and ice melt and the safety rules/ precautions to take during these natural disasters. Guide them to reflect their idea to the class.

6.3. Safety rules/ precautions during natural disaster (1 period)

Minimum learning competency

- Exercise safety rules/ precautions during natural disaster

Learning strategies

- Let students discuss on the safety rules/ precautions to take during natural disaster.

Assessment strategies

DA: Competencies 1-2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Give a task for students (Activity 6.5) to further read about international conventions from the internet or collect from nearby responsible offices and discuss whether these conventions are being implemented as intended in the world and Ethiopia in particular. Guide them to write a report and reflect in the class.

6.4. International conventions (2 periods)

Minimum learning competency

- Discuss international conventions regarding climate change
- Discuss the implementation status of international conventions in Ethiopia
- States measures Ethiopia has taken to combat climate change
- Consider an environmental action that addresses climate change in Ethiopia
- Explain the role of the green legacy in Ethiopia to combat climate change
- Show a willingness to participate in the green legacy project by tree planting

Learning strategies

- Let students collect international conventions from the internet or nearby responsible offices and discuss whether these conventions are being implemented as intended in the world and Ethiopia or not.
- Let students discuss the measures Ethiopia has taken to combat climate change in line with the international conventions.
- Let students participate in tree planting and associate the importance of planting trees with carbon sequestration and carbon trading.

Assessment strategies

DA: Competencies 1-2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

6.4.1. The United Nations Framework Convention

Minimum learning competency

- Define climate change
- Explain the causes of climate change

Learning strategies

- Ask students to write down some ideas they have about climate change and let them define climate change. If they cannot define correctly, ask them to complete a a gap fill exercise.

Assessment strategies

DA: Competencies 1-2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

6.4.2 Kyoto Protocol on Climate Change

Minimum learning competency

- Define climate change
- Explain the causes of climate change

Learning strategies

- Ask students to write down some ideas they have about climate change and let them define climate change. If they cannot define correctly, ask them to complete a a gap fill exercise.

Assessment strategies

DA: Competencies 1-2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

6.4.2. International and national practices of Implementation of conventions

Minimum learning competency

- Define climate change
- Explain the causes of climate change

Learning strategies

Ask students to write down some ideas they have about climate change and let them define climate change. If they cannot define correctly, ask them to complete a a gap fill exercise.

Assessment strategies

DA: Competencies 1-2

E: Written / verbal /reports

AI: Written assignments and tests / presentation / reflection/field reports

I. Instructional designs

Prepare instructional materials including daily lesson plan, teaching aids and pictures to teach and demonstrate the evidence for evolution. Design a strategic plan to deliver the lessonsand conduct all practical activities.

II. Teaching methods

Use student-centered strategy and learning by doing. In delivering the lesson topic about the evidence for evolution**,** you will ask question from the textbook, encourage students to participate in activities and answer questions.

III. Tasks

Support the learners to understand and answer the self-assessment questions and participate in activities.

Give a task for students (Activity 6.6) to discuss the importance of the Ethiopian green legacy initiative campaign which was launched in 2019 in terms of international protocol implementations. Guide them to gather information, write a report and reflect in the class.

Answer key to the unit summary questions

1. **What is climate change? Explain how it differs from global warming.**

   Global warming refers only to the Earth's rising surface temperature, whereas climate change includes warming and the "side effects" of warming such asmelting glaciers, heavier rainstorms, or more frequent drought.

2. **How does climate change affect human health?**

In some cases, there can be health benefits, but in the clear majority of observed and predicted cases, the health impacts of climate change are negative. Climate change can lead to increased infectious diseases such as malaria and dengue fever, and can have significant impacts on mental health.

3. **How is agricultural productivity related to climate change?**

Climate change can disrupt food availability, reduce access to food and affect food quality. For example, key global projections showed increasing in temperatures, changing in precipitation patterns, changing in extreme weather events, and reductions in water availability, which may all result in reduced agricultural productivity.

4. **Describe some of the climate change conventions**

The United Nations Climate Change Conferences are yearly conferences held in the framework of the United Nations Framework Convention on Climate Change (UNFCCC). They serve as the formal meeting of the UNFCCC Parties (Conference of the Parties, COP) to assess the progress in dealing with climate change., and beginning in the mid-1990s, it has seved to negotiate the Kyoto Protocol to establish legally binding obligations for developed countries to reduce their greenhouse gas emissions. Since 2005, the "Conference of the Parties Serving as the Meeting of Parties to the Kyoto Protocol" (CMP)accepted parties that are not parties to the Protocol to join to the Convention, but. to participate in the Protocol-related meetings as observers. Since 2011, the meetings have also been used to negotiate the Paris Agreement as part of the Durban platform activities until its conclusion in 2015, which created a general path towards climate action.

1. 1995: COP 1, Berlin, Germany

2. 1996: COP 2, Geneva, Switzerland

3. 1997: COP 3, Kyoto, Japan

4. 1998: COP 4, Buenos Aires, Argentina

5. 1999: COP 5, Bonn, Germany

6. 2000: COP 6, The Hague, Netherlands

7. 2001: COP 6, Bonn, Germany

8. 2001: COP 7, Marrakech, Morocco

9. 2002: COP 8, New Delhi, India

10. 2003: COP 9, Milan, Italy

11. 2004: COP 10, Buenos Aires, Argentina

12. 2005: COP 11/CMP 1, Montreal, Canada

13. 2006: COP 12/CMP 2, Nairobi, Kenya

14. 2007: COP 13/CMP 3, Bali, Indonesia

15. 2008: COP 14/CMP 4, Poznań, Poland

16. 2009: COP 15/CMP 5, Copenhagen, Denmark

17. 2010: COP 16/CMP 6, Cancún, Mexico

18. 2011: COP 17/CMP 7, Durban, South Africa

19. 2012: COP 18/CMP 8, Doha, Qatar

20. 2013: COP 19/CMP 9, Warsaw, Poland

21. 2014: COP 20/CMP 10, Lima, Peru

22. 2015: COP 21/CMP 11, Paris, France

23. 2016: COP 22/CMP 12/CMA 1, Marrakech, Morocco

24. 2017: COP 23/CMP 13/CMA 1-2, Bonn, Germany

25. 2018: COP 24/CMP 14/CMA 1-3, Katowice, Poland

26. 2019: SB50, Bonn, Germany

27. 2019: COP 25/CMP 15/CMA 2, Madrid, Spain

28. 2021: COP 26/CMP 16/CMA 3, Glasgow, United Kingdom

5. What is climate change mitigation?

Climate change mitigation means the practices of avoiding and reducing emissions of heat-trapping greenhouse gases into the atmosphere to prevent the planet from warming to more extreme temperatures.

The End