

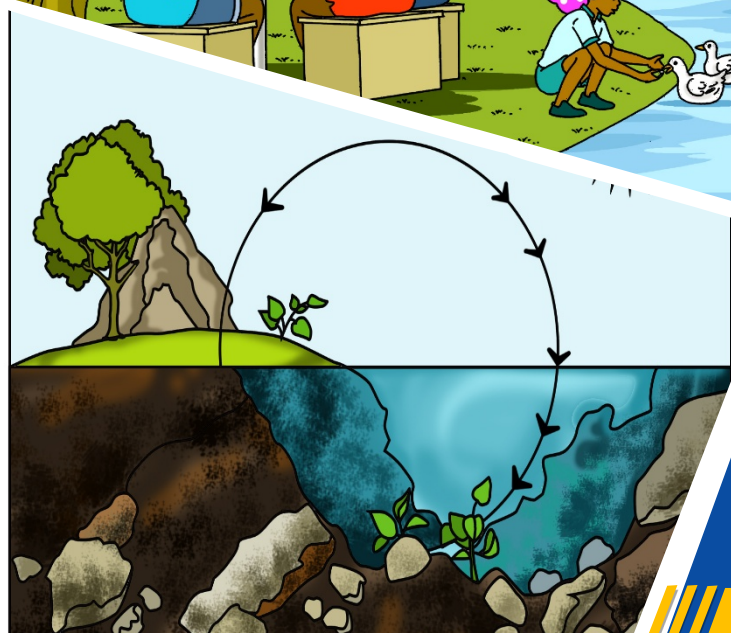


Republic of Rwanda  
Ministry of Education



RTB | RWANDA  
TVET BOARD

## RQF LEVEL 5



## TOURISM

### GENAB 502

### Applied Biology

## TRAINER'S MANUAL

April 2025



Republic of Rwanda  
Ministry of Education



## APPLY BASIC KNOWLEDGE OF ECOLOGY



2025

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## LIST OF ABBREVIATIONS AND ACRONYMS

|              |                                                 |
|--------------|-------------------------------------------------|
| <b>CBET:</b> | Competence Base Education and Training          |
| <b>PPE:</b>  | Personal Protective Equipment                   |
| <b>RQF:</b>  | Rwanda Qualification Framework                  |
| <b>RS:</b>   | Rwandan Standard                                |
| <b>RSB:</b>  | Rwanda Standards Board                          |
| <b>DNA:</b>  | Deoxyribonucleic acid                           |
| <b>RTB:</b>  | Rwanda TVET Board                               |
| <b>GPP:</b>  | Gross Primary Productivity                      |
| <b>NPP:</b>  | Net Primary Productivity                        |
| <b>TVET:</b> | Technical and Vocational Education and Training |
| <b>REMA:</b> | Rwanda Environment Management Authority         |
| <b>MYA:</b>  | Million Years ago                               |

## INTRODUCTION

This Trainer's Manual encompasses all methodologies necessary to guide you to properly deliver the module titled: **Applied Biology**. Students undertaking this module shall be exposed with practical activities that will develop and nurture their competences. The writing process of this training manual embraced competency-based education and training (CBET) philosophy by providing practical opportunities reflecting real life situations.

The Trainer's Manual is subdivided into Learning Outcomes, each learning outcome has got various topics. You will start guiding a self-assessment exercise to help students rate themselves on their level of skills, knowledge and attitudes about the unit.

The Trainer's Manual will give you the information about the objectives, learning hours, didactic materials, proposed methodologies and crosscutting issues.

A discovery activity is followed to help students discover what they already know about the unit.

This manual will give you tips, methodologies and techniques about how to facilitate students to undertake different activities as proposed in their Trainee's Manuals. The activities in this training manual are prepared such that they give opportunities to students to work individually and in groups.

After going through all activities, you shall help students to undertake progressive assessments known as formative and finally facilitate them to do their self-reflection to identify your strengths, weaknesses and areas for improvements.

Remind them to read the point to remember section which provides the overall key points and takeaways of the unit

## APPLIED BIOLOGY

| Learning Outcomes                                             | Learning Hours | Topic                                                        |
|---------------------------------------------------------------|----------------|--------------------------------------------------------------|
| <b>1. Discuss theories of evolution and their evidence.</b>   | 10             | 1.1 Explanation of the origin of life                        |
|                                                               |                | 1.2 Description of Human evolution and Present-day evolution |
| <b>2. Describe ecosystems</b>                                 | 10             | 2.1 Explanation of ecological factors                        |
|                                                               |                | 2.2 Description of ecosystems                                |
|                                                               |                | 2.3 Explanation of relationship between living organisms     |
| <b>3. Illustrate mechanisms of environmental conservation</b> | 10             | 3.1 Description of biogeochemical cycles                     |
|                                                               |                | 3.2 Explanation of ecosystem degradation                     |
|                                                               |                | 3.3 Application of environmental protection Strategies.      |

# Theory of Evolution



## Learning outcome 1: Self-Assessment

1. Ask trainees to look at the unit illustration in their Trainee's Manuals and together discuss:
  - a. What do the illustrations show?
  - b. What topics do you think will be covered under this unit based on the illustration?
2. After the discussion, inform students that this unit is intended to provide them with the knowledge, skills and attitudes to **discuss theories of evolution and their evidence**.
3. Ask trainees to fill out the self-assessment at the beginning of the unit in their Trainee's Manuals. Explain that:
  - a. The purpose of the self-assessment is to become familiar with the topics in the unit and for them to see what they know or do not know at the beginning.
  - b. There are no right or wrong ways to answer this assessment. It is for their own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
  - c. They should think about themselves: do they think they have the knowledge, skills or attitudes to do this? How well?
  - d. They read the statements across the top and put a check in column that best represents their level of knowledge, skills or attitudes.



## Key Competencies:

| Knowledge                                                    | Skills                                                                   | Attitudes                                                         |
|--------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------|
| 1. Explain scientific theories and evolution basics.         | 1. Communicating scientific ideas                                        | 1. Open-mindedness                                                |
| 2. Describe the origin of life                               | 2. Evaluate origin of life and Seeking evidence to support claims.       | 2. Analytical reasoning                                           |
| 3. Explain history of the human evolution,                   | 3. Develop bipedalism, tool use, and language use.                       | 3. Empathetic and Responsible to global citizens.                 |
| 4. Describe development in technology and innovations trend  | 4. Apply research technology proficiency.                                | 4. Adaptability                                                   |
| 5. Demonstrate scientific evidence,                          | 5. Conducting research using various sources,                            | 5. Change management on environmental dynamics                    |
| 6. Explain the limitations of scientific knowledge           | 6. Illustrate Factors influencing present day evolution                  | 6. A willingness to change one's beliefs in light of new evidence |
| 7. Describe Mechanisms of present-day evolution              | 7. Collect information from multiple sources to form a coherent argument | 7. Environmental friendly attitude                                |
| 8. Explain common Ancestry.                                  | 8. Tracing the evolutionary relationships between different organisms.   | 8. Appreciation of biodiversity                                   |
| 9. Compare the complexity and the diversity of life on Earth | 9. Analyzing complex ecological relationships                            | 9. Being loyal to vastness of the natural world                   |

 **Steps:** **Discovery Activity** **Task 1**

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to read the scenario and answer questions under the task 1 in their Trainee's Manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are given.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class.
3. Encourage all students to give their views.
4. After the presentations/sharing session, inform students that this activity was not intended for them to give the right answers but to give them a picture of what they will cover in the unit.

Introduce Topic 1.1: **Explanation of the origin of life**

## Topic 1.1: Explanation of the origin of life

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>Objectives:</b><br>By the end of the topic, trainees will be able to: <ul style="list-style-type: none"><li>a. Explain how Evolution is an ongoing process that continues to shape life on Earth.</li><li>b. Demonstrate how Human activities, such as climate change and pollution, can accelerate evolutionary change.</li><li>c. Describe how Understanding evolution is crucial for addressing global challenges, such as disease, climate change, and biodiversity loss.</li><li>d. Analyze how by studying evolution, we can gain insights into the past, present, and future of life on Earth.</li></ul> |
|  <b>Time Required: 5 hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|  <b>Learning Methodology:</b> Group discussion, Trainer guided, Videos, brainstorming and demonstration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|  <b>Materials, Tools and Equipment Needed:</b><br>Computer, projector, white board/chalkboard<br>Flipcharts, papers, wall charts, pictures<br>Markers, chalks, tutorial videos                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|  <b>Preparation:</b><br>Brainstorming, demonstration and simulation, individual and group work, group discussion, documentary research<br>Written assessment, oral presentation                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|  <b>Cross Cutting Issues:</b><br>Climate change and environment protection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|  <b>Prerequisites:</b><br>General Biology (botany and zoology)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |



## Activity 1: Problem-Solving



### Task 2:

1. Using various methodologies like individual work, pair-share, or small group discussions, guide trainees to read the scenario provided in the trainee's manual and answer questions on task 2 in their trainee manuals. Ensure that scenario is clear and understood, and that each student actively participates in the activity.
2. Provide necessary materials and tools for the task.
3. Employing suitable methodologies such as question and answer sessions in large groups, or pair and small group presentations, prompt students to share their answers with the class. As they present, write down their responses for future reference. Encourage all students to contribute their perspectives and ideas during the sharing session.
4. After the sharing session, refer students to **Key facts 1.1** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.



## Activity 2: Guided Practice



### Task 3:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees and field visit to answer the questions provided under task 3 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.

3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.
4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 1.2** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.
6. Use the following Checklist in evaluating the readiness of the business start-up requirements.

### **Understanding the Origin of Life and Evolutionary Theories (Exploring the Mystery of Life's Beginnings)**

**Activity:** Form Group of 3-5 Students

**Step 1 Plan the Presentation:** Storyboard the use of textual, Images, and potential activities to foreground the key concepts. For instance, to differentiate complex ideas, construct an essay that includes typical examples.

**Step 2 Answer the Following Questions in conclusion:**

- i. What does the evidence say that would make one be convinced by evolution?
- ii. How, in public education, can misconceptions about evolution be addressed?
- iii. Why does it matter to understand the origin of life and evolution in the modern world?

**Possible answers:**

- I. **What does the evidence say that would make one be convinced by evolution?**
  - a. **Fossil Record:** The progressive series of fossils showing transitional forms between different species demonstrates gradual change over time. For example, the fossil record of horses shows a clear progression from small, multi-toed ancestors to the large, single-toed horses of today.
  - b. **Comparative Anatomy:** Homologous structures, like the forelimbs of vertebrates, reveal common ancestry despite different functions. Analogous structures, while having similar functions, have different underlying structures, demonstrating convergent evolution.

- c. **Comparative Embryology:** Similarities in the early embryonic development of different species suggest a shared ancestry.
- d. **Molecular Biology (DNA):** The similarity of DNA sequences between different species reflects their evolutionary relationships. The more similar the DNA, the more closely related the species.
- e. **Biogeography:** The distribution of species across the globe is consistent with evolutionary theory. Species on islands often resemble those on the nearest mainland, but with unique adaptations.
- f. **Direct Observation:** Evolution can be directly observed in organisms with short generation times, such as bacteria developing antibiotic resistance or insects developing pesticide resistance.
- g. **Vestigial Structures:** The presence of vestigial structures, like the human appendix or whale pelvic bones, indicates that these structures were functional in ancestral organisms.

## II. How, in public education, can misconceptions about evolution be addressed?

- a. **Present Evolution as a Scientific Consensus:** Emphasize that evolution is a well-supported scientific theory, not just a hypothesis.
- b. **Focus on Evidence-Based Learning:** Teach students to analyze and interpret scientific data, including fossil records, DNA evidence, and comparative anatomy.
- c. **Address Common Misconceptions Directly:** Acknowledge and debunk common misconceptions, such as the idea that evolution is "just a theory" or that it contradicts religious beliefs.
- d. **Use Visual Aids and Interactive Activities:** Engage students with visual representations of evolutionary processes and hands-on activities that demonstrate key concepts.
- e. **Promote Critical Thinking:** Encourage students to ask questions and evaluate evidence critically.
- f. **Provide Context:** Explain the role of evolution in various fields, such as medicine, agriculture, and conservation.
- g. **Separate Science from Religion:** Clearly distinguish between scientific explanations and religious beliefs, emphasizing that they address different questions.

- h. **Educate Teachers:** Ensure that teachers have a strong understanding of evolutionary theory and effective teaching strategies.
- i. **Community Engagement:** Engage with parents and community members to address concerns and provide accurate information.

**III. Why does it matter to understand the origin of life and evolution in the modern world?**

- a. **Medicine:** Understanding evolution is crucial for developing effective treatments for diseases, such as antibiotic resistance and cancer.
- b. **Agriculture:** Evolutionary principles are used to improve crop yields and develop pest-resistant varieties.
- c. **Conservation Biology:** Understanding evolution is essential for protecting endangered species and managing ecosystems.
- d. **Understanding our place in the universe:** Evolution provides a framework for understanding our relationship to other living things and the history of life on Earth.
- e. **Scientific Literacy:** Understanding evolution is a fundamental component of scientific literacy, which is essential for informed decision-making in a technologically advanced society.
- f. **Predicting and responding to change:** Evolution helps us to understand how populations adapt to changing environments, which is crucial for addressing challenges such as climate change.
- g. **Developing new technologies:** Biomimicry, the process of designing technologies based on biological systems, relies heavily on understanding evolutionary principles.



### Activity 3: Application



#### Task 4:

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
3. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
4. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regarding their work. Support those who may carry out remedial activities.
5. Make a summary of **topic 1.1** by asking students to mention the main key points discussed.
6. You may follow the steps below to assess their work

#### Activity 2: Analyzing Evidence

In small groups, pairs or individual, students will analyze samples of "evidence for evolution," such as diagrams fossil records. Each group will present how their evidence supports the theory of evolution.

**Possible answers:**

**1. What is the significance of homologous structures in understanding evolution?**

- a. Homologous structures are anatomical features in different species that share a common ancestry, even if their functions have diverged. They provide strong evidence for evolution by demonstrating that different species evolved from a common ancestor. The underlying similarity in their structure, despite differences in function, points to a shared developmental origin. This showcases the concept of divergent evolution.

**2. How does the fossil record provide evidence for the theory of evolution?**

- a. The fossil record provides a chronological sequence of life's history, showing how organisms have changed over time. It reveals:
  - i. Transitional fossils: These show intermediate forms between ancestral and modern species, demonstrating gradual evolutionary change.
  - ii. The appearance and disappearance of species: This shows how life on Earth has changed over geological time scales.
  - iii. The progression of complexity: Fossils reveal a general trend from simpler to more complex life forms.
  - iv. It allows scientists to reconstruct evolutionary lineages, tracing the descent of modern species from their ancestors.

**3. Why is the universal genetic code considered strong evidence for a common origin of life?**

- a. The universal genetic code refers to the fact that virtually all living organisms use the same DNA codons to specify the same amino acids. This remarkable similarity strongly suggests that all life on Earth shares a common ancestor. It is highly improbable that such a complex system would have evolved independently multiple times.

**4. Describe how natural selection drives evolutionary change in populations.**

- a. Natural selection is the process by which organisms with traits better suited to their environment survive and reproduce more successfully. It works as follows:
  - i. Variation: Individuals within a population exhibit variation in their traits.

- ii. Inheritance: These variations can be passed on from parents to offspring.
- iii. Selection: Some variations provide a survival or reproductive advantage in a particular environment.
- iv. Differential reproduction: Individuals with advantageous traits are more likely to survive and reproduce, passing those traits to their offspring.
- v. Over time, the frequency of advantageous traits increases in the population, leading to evolutionary change.

**5. What role did endosymbiosis play in the development of complex cells?**

- a. Endosymbiosis is the process by which one organism lives inside another. It played a crucial role in the development of complex eukaryotic cells. Specifically:
  - i. Mitochondria: These organelles, responsible for cellular respiration, are thought to have originated from aerobic bacteria that were engulfed by ancestral eukaryotic cells.
  - ii. Chloroplasts: These organelles, responsible for photosynthesis in plants and algae, are thought to have originated from photosynthetic bacteria that were engulfed by ancestral eukaryotic cells.
- b. The endosymbiotic theory proposes that these engulfed bacteria established a symbiotic relationship with their host cells, eventually evolving into the organelles we see today. This process allowed for the development of more complex and efficient cells.

## Topic 1.2: Explanation of Human evolution and Present-day evolution

|                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>Explain Present-Day Evolution concept in line with the relevance of present-day evolution</li> <li>Describe how traditional and modern factors influencing present-day evolution</li> <li>Interpret the mechanisms of present-day evolution</li> </ol> |
|    | <p><b>Time Required: 5 hours</b></p>                                                                                                                                                                                                                                                                                                                                              |
|    | <p><b>Learning Methodology:</b> Group discussion, Trainer guided, Site visit, brainstorming and demonstration.</p>                                                                                                                                                                                                                                                                |
|  | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/chalkboard</p> <p>Flipcharts, papers, wall charts, pictures</p> <p>Markers, chinks, tutorial videos</p>                                                                                                                                                                                  |
|  | <p><b>Preparation:</b></p> <p>Brainstorming, demonstration and simulation, individual and group work, group discussion, documentary research</p> <p>Written assessment, oral presentation</p>                                                                                                                                                                                     |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Climate change and environment change</li> </ul>                                                                                                                                                                                                                                                     |
|  | <p><b>Prerequisites:</b></p> <p>Theory of origin of life</p>                                                                                                                                                                                                                                                                                                                      |



## Activity 1: Problem-Solving



### Task 5:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to analyze the paragraph and answer the questions provided under task 5 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 1.2 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 6: Group work activity

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees analyze the case study and answer the questions provided under task 6 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 1.1** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.
6. You can follow the steps below to perform the activity/task:

**Procedure:**

**Step: Case Study Analysis (20 minutes)**

- ✓ Divide the class into groups of 4-5 students.
- ✓ Provide each group with a case study related to present-day evolution, such as:
  -  The evolution of antibiotic resistance in bacteria
  -  The impact of climate change on species distribution and behaviour
  -  The role of genetic engineering in agriculture
- ✓ Ask each group to identify the key evolutionary mechanisms at play.
- ✓ Have groups present their findings to the class, explaining how the concepts of natural selection, Technology and mutation apply to the specific case.

**Step: Relevance of Present-Day Evolution (20 minutes)**

- ✓ Facilitate a class discussion on the relevance of present-day evolution, focusing on the following questions:
  -  How does the understanding of evolution impact human health and medicine?
  -  What are the implications of genetic engineering for human evolution?
  -  How can evolutionary principles be applied to conservation efforts?
  -  What are the ethical considerations of human-induced evolutionary change?



### Activity 3: Application



#### Task 7:

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regarding their work. Support those who may carry out remedial activities.
6. Make a summary of **topic 1.2** by asking students to mention the main key points discussed.
7. You may follow the steps below to assess their work

#### Activity 2: Evolutionary Timeline

##### Procedure:

1. Form groups.
2. By using a specific hominid species of your choice.
3. Make group search on species and create a poster with key information:
  - a. Name of the species
  - b. Time period
  - c. Physical characteristics
  - d. Important tools or behaviors

4. Groups arrange the posters in chronological order on the timeline.
5. Together, discuss the major trends in human evolution and the role of natural selection in shaping our species.



## Formative Assessment

### Section A: Short Answer Questions:

1. Define the following terms:
  - a. Natural selection
  - b. Genetic drift
  - c. Gene flow
  - d. Mutation
2. Explain the role of technology in influencing present-day evolution.
3. List three mechanisms of present-day evolution.
4. Describe the relevance of present-day evolution for human health and medicine.
5. Discuss the impact of climate change on species evolution.
6. Explain how genetic engineering can accelerate evolutionary change.
7. Define the concept of evolutionary fitness.
8. Describe the role of mutation in generating genetic variation.
9. Explain the concept of adaptive radiation.
10. Discuss the ethical implications of human-induced evolution.

### Section B: Long Answer Questions.

1. Compare and contrast natural selection and genetic drift.
2. Explain the role of gene flow in maintaining genetic diversity within a population.
3. Discuss the impact of human activities on the rate of evolution.
4. Evaluate the potential benefits and risks of genetic engineering.
5. Explain how evolutionary theory can be applied to conservation biology.
6. Critically analyse the concept of biological determinism.
7. Discuss the future implications of emerging technologies, such as artificial intelligence, on human evolution.

8. Explain the concept of coevolution and provide examples.
9. Evaluate the role of chance in evolutionary processes.
10. Discuss the concept of punctuated equilibrium and its implications for understanding the pace of evolution.

**Answers:**

**Section A:**

**1. Define the following terms:**

- a. **Natural selection:** The process by which organisms with traits better suited to their environment survive and reproduce more successfully, passing those traits to their offspring.
- b. **Genetic drift:** Random fluctuations in allele frequencies within a population, especially in small populations, due to chance events.
- c. **Gene flow:** The transfer of genetic material from one population to another, often through migration.
- d. **Mutation:** A change in the DNA sequence of an organism, which can create new alleles.

**2. Explain the role of technology in influencing present-day evolution.**

- a. Technology, such as antibiotics, pesticides, and genetic engineering, creates selective pressures that drive rapid evolution in organisms like bacteria, insects, and crops.

**3. List three mechanisms of present-day evolution.**

- a. Antibiotic resistance in bacteria
- b. Pesticide resistance in insects
- c. Evolution of viruses (e.g., influenza, COVID-19)

**4. Describe the relevance of present-day evolution for human health and medicine.**

- a. Understanding present-day evolution is crucial for combating antibiotic resistance, developing new vaccines, and understanding the evolution of diseases.

**7. Discuss the impact of climate change on species evolution.**

- a. Climate change creates new selective pressures, leading to adaptations like changes in migration patterns, altered breeding times, and shifts in species distribution.

8. **Explain how genetic engineering can accelerate evolutionary change.**
  - a. Genetic engineering allows for the direct manipulation of an organism's genome, introducing new traits and accelerating the pace of evolutionary change compared to natural processes.
9. **Define the concept of evolutionary fitness.**
  - a. Evolutionary fitness refers to an organism's ability to survive and reproduce successfully in its environment, measured by its contribution to the next generation's gene pool.
10. **Describe the role of mutation in generating genetic variation.**
  - a. Mutations are the ultimate source of new genetic variation, introducing new alleles into a population that can be acted upon by natural selection or genetic drift.
11. **Explain the concept of adaptive radiation.**
  - a. Adaptive radiation is the rapid diversification of a lineage into many new species, each adapted to a different ecological niche.
12. **Discuss the ethical implications of human-induced evolution.**
  - a. Human-induced evolution raises ethical concerns about unintended consequences, the potential for misuse, and the alteration of natural ecosystems.

## **Section B:**

1. **Compare and contrast natural selection and genetic drift.**
  - a. **Natural selection** is driven by selective pressures and leads to adaptation, while
  - b. **genetic drift** is driven by random chance and can lead to the fixation of neutral or even maladaptive traits. Both change allele frequencies, but through different mechanisms.
2. **Explain the role of gene flow in maintaining genetic diversity within a population.**
  - a. Gene flow introduces new alleles into a population, increasing genetic diversity and reducing differences between populations, which can counteract the effects of genetic drift and local adaptation.
3. **Discuss the impact of human activities on the rate of evolution.**
  - a. Human activities, such as habitat destruction, pollution, and the use of antibiotics and pesticides, are accelerating the rate of evolution in many species, often leading to rapid adaptation to human-altered environments.

4. **Evaluate the potential benefits and risks of genetic engineering.**
  - a. Benefits include improved crop yields, disease resistance, and medical advancements. Risks include unintended ecological impacts, the potential for misuse, and ethical concerns about altering the human genome.
5. **Explain how evolutionary theory can be applied to conservation biology.**
  - a. Evolutionary theory informs conservation efforts by helping to understand species adaptation, genetic diversity, and the impacts of environmental change, guiding strategies for preserving biodiversity.
6. **Critically analyze the concept of biological determinism.**
  - a. Biological determinism is the idea that genes or biological factors determine human behavior and social traits. It is often criticized for ignoring the role of environmental and social factors and for its potential to justify social inequalities.
7. **Discuss the future implications of emerging technologies, such as artificial intelligence, on human evolution.**
  - a. Emerging technologies may influence human evolution through increased longevity, genetic enhancements, and the potential for human-machine integration, raising ethical and societal questions.
8. **Explain the concept of coevolution and provide examples.**
  - a. Coevolution is the reciprocal evolutionary influence between two or more interacting species. Examples include the relationship between flowering plants and their pollinators, or predator and prey relationships.
9. **Evaluate the role of chance in evolutionary processes.**
  - a. Chance plays a significant role in evolution through genetic drift, mutations, and unpredictable environmental events. These random factors can influence the direction and pace of evolutionary change.
10. **Discuss the concept of punctuated equilibrium and its implications for understanding the pace of evolution.**
  - a. Punctuated equilibrium proposes that evolution is characterized by long periods of stasis punctuated by short bursts of rapid change, challenging the traditional view of gradualism and highlighting the importance of environmental disruptions in driving evolutionary change.



## Points to Remember

Evolution is an ongoing process that continues to shape life on Earth.

Human activities, such as climate change and pollution, can accelerate evolutionary change.

Understanding evolution is crucial for addressing global challenges, such as disease, climate change, and biodiversity loss.

By studying evolution, we can gain insights into the past, present, and future of life on Earth.



## Self-Reflection

1. Ask learners to re-take the self-assessment at the beginning of the unit. They should then fill in the table in their Trainee's Manual to Identify their areas of strength, areas for improvement and actions to take to improve.
2. Discuss trainees' results with them. Identify any areas that are giving many trainees difficulties and plan to give additional support as needed (ex. use class time before you begin the next learning outcome to go through commonly identified difficult concepts).

## LEARNING OUTCOME 2: DESCRIBE ECOSYSTEMS



## Learning outcome 2: Self-Assessment

1. Ask trainees to look at the unit illustration in their Trainee's Manuals and together discuss:
  - a. What do the illustrations show?
  - b. What topics do you think will be covered under this unit based on the illustration?
2. After the discussion, inform students that this unit is intended to provide them with the knowledge; skills and attitudes on describe ecosystems.
3. Ask trainees to fill out the self-assessment at the beginning of the unit in their Trainee's Manuals. Explain that:
  - a. The purpose of the self-assessment is to become familiar with the topics in the unit and for them to see what they know or do not know at the beginning.
  - b. There is no right or wrong way to answer this assessment. It is for their own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
  - c. They should think about themselves: do they think they have the knowledge, skills or attitudes to do this? How well?
  - d. They read the statements across the top and put a check in column that best represents their level of knowledge, skills or attitudes.
4. At the end of the unit, they will do a self-reflection, which includes re-taking the self-assessment and identifying their strengths, areas of improvement and actions to be taken.



## Key Competencies:

| Knowledge                                                            | Skills                                                            | Attitudes                                                                          |
|----------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------------------|
| 1. Describe of the energy flows, nutrient cycles, and habitat types. | 1. Apply environmental science to identify environmental factors  | 1. Environmental awareness and responsibility.                                     |
| 2. Explain interdependencies, and scientific inquiry.                | 2. Interpret interactions (symbiosis, competition)                | 2. Respect for ecological balance,                                                 |
| 3. Define the effects of human activities on ecosystems              | 3. Generate solutions to real-world problems.                     | 3. Having sense of responsibility to use scientific knowledge for the environment. |
| 4. Compare biodiversity and ecosystem                                | 4. Observe, and analyze complex environmental                     | 4. Curiosity and appreciation to the ecosystems' conservation.                     |
| 5. Differentiate biotic and abiotic factors and nutrient cycling.    | 5. Analyze interactions between living and non-living components. | 5. Adaptation to the new concept                                                   |



**Steps:**



### **Discovery Activity**



#### **Task 8**

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to read the scenario and answer questions under the task 8 in their Trainee's Manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are given.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class.
3. Encourage all students to give their views.
4. After the presentations/sharing session, inform students that this activity was not intended for them to give the right answers but to give them a picture of what they will cover in the unit.

Introduce Topic 2.1: **Explanation of ecological factors**

## Topic 2.1: Explanation of ecological factors

|                                                                                     |                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>The learner will be able to identify Ecological factors properly referring to their effects on living organism</li> </ol> |
|    | <p><b>Time Required: 4 hours</b></p>                                                                                                                                                                                                                 |
|    | <p><b>Learning Methodology:</b> Group discussion, Trainer guided, Videos, brainstorming and demonstration</p>                                                                                                                                        |
|    | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/ chalkboard</p> <p>Flipcharts, papers, wall charts</p> <p>Markers, chinks, tutorial videos, pictures</p>                                                    |
|   | <p><b>Preparation:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Brainstorming, demonstration and simulation</li> <li><input type="checkbox"/> Individual and group work, group discussion</li> </ul>                      |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Living together in peace harmony</li> </ul>                                                                                                                             |
|  | <p><b>Prerequisites:</b></p> <ul style="list-style-type: none"> <li>✓ Origin of life</li> <li>✓ Human evolution</li> </ul>                                                                                                                           |



## Activity 1: Problem-Solving



### Task 9:

#### Instructions to the trainer:

1. Introduce Topic 2.1: **Explanation of ecological factors**
2. Using appropriate methodologies such as individual work, pair-share, or small group discussions, guide trainees to read the scenario provided in the trainee's manual and answer questions on task 9 in their trainee manuals. Ensure that scenario is clear and understood, and make sure every trainee is writing down their answers.
3. Using appropriate methodologies such as brainstorming, trainer guided sessions of small groups, or pair and small group presentations, prompt students to share their points of view with the classmates. When they are presenting, write down their key highlights for future reference. Encourage all students to contribute and ask for clarification.



## Activity 2: Guided Practice



### Task 10:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to read the scenario and answering the questions provided under task 10 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 2.1** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.
6. You can follow the steps below to perform the activity/task:

**Materials:**

- ✓ Whiteboard or projector or chalkboard
- ✓ Markers or pens
- ✓ Handouts with images of different hominid species

**Procedure:**

**Step 1: Timeline Creation**

1. Make groups of 4-5 students.
2. Prepare a timeline about human development by including their specific stages:  
In the timeline cultivation process, always include some key features and approximate time frames for each stage. Finally, each group present the timelines to the class, engaging in discussions on their findings or answer questions.

**Step 2: Fossil Analysis**

Handouts containing pictures of various ancient hominids' skulls (Dryopithecus, Australopithecus, Homo erectus, Homo sapiens) distributed to the class. Have observation on differences in the size, shape, and features of the skulls.

Guide the class in discussing by asking questions like:

1. How do the brains compare?
2. What about the jaws' form - what inference can be derived from it about food eaten?
3. What can we infer about their intelligence and social behavior?



## Activity 1: Problem-Solving



### Task 9:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to analyze the scenario and answer the questions provided under task 9 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class.  
Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 2.1 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 10:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees read the paragraph and answer the questions provided under task 10 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.

3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.
4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 2.1** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.
6. You can follow the steps below to perform the activity/task:

**Form groups of 5 students.**

- i. Instruct the groups to do the practice in the classroom or outdoors (if possible).
- ii. Define biotic and abiotic factors.
- iii. Have groups presentation on their findings to the class, explaining how each factor influences living organisms.
- iv. Explain how these factors interact to shape ecosystems.

**Then after presentation Facilitate a class discussion on the following questions:**

1. How do abiotic and biotic factors interact to create a balanced ecosystem?
2. What happens when an ecosystem is disrupted by human activities or natural disasters?
3. How can we protect and conserve ecosystems?

**Answers:**

**1. How do abiotic and biotic factors interact to create a balanced ecosystem?**

- a. Abiotic factors provide the physical and chemical foundation for life. For example, sunlight provides energy for plants (biotic) to perform photosynthesis. Water and soil nutrients (abiotic) support plant growth, which in turn provides food and habitat for animals (biotic).
- b. Biotic factors, in turn, modify abiotic conditions. Plants, for instance, release oxygen into the atmosphere and their roots stabilize soil. Animals contribute to nutrient cycling through decomposition and waste.
- c. The interaction between these factors creates a dynamic equilibrium. For instance, the availability of sunlight (abiotic) influences plant growth (biotic), which then

affects the population of herbivores (biotic) that feed on the plants. The population of predators (biotic) that feed on the herbivores is then influenced by the herbivore population.

- d. This constant interplay results in a system where energy flows, nutrients cycle, and populations remain relatively stable over time, creating a balanced ecosystem.

## **2. What happens when an ecosystem is disrupted by human activities or natural disasters?**

- a. Disruption of Food Webs: The removal or decline of a key species can cascade through the food web, impacting other organisms.
- b. Loss of Biodiversity: Habitats may be destroyed, leading to the extinction of species and a reduction in overall biodiversity.
- c. Nutrient Cycling Disruption: Soil erosion, pollution, and deforestation can disrupt the natural cycling of nutrients, affecting plant growth and ecosystem productivity.
- d. Changes in Abiotic Factors: Pollution can alter water and soil chemistry. Deforestation can change local climate patterns. Natural disasters can cause extreme changes to the landscape.
- e. Invasive Species: Disruption creates opportunities for invasive species to establish themselves, outcompeting native species and further disrupting the ecosystem.
- f. Reduced Ecosystem Services: Disrupted ecosystems provide fewer ecosystem services, such as clean water, air purification, and pollination.
- g. Instability: A disrupted ecosystem becomes less resilient, and less able to recover from further disturbances.

## **3. How can we protect and conserve ecosystems?**

- a. Establish Protected Areas: Create national parks, wildlife refuges, and marine reserves to safeguard critical habitats.
- b. Reduce Pollution: Implement regulations to control air, water, and soil pollution. Promote the use of sustainable technologies.
- c. Promote Sustainable Resource Use: Practice sustainable forestry, fishing, and agriculture to minimize habitat destruction and resource depletion.
- d. Restore Degraded Habitats: Replant forests, restore wetlands, and remove invasive species to help ecosystems recover.

- e. Control Invasive Species: Implement measures to prevent the introduction and spread of invasive species.
- f. Educate the Public: Raise awareness about the importance of ecosystems and the need for conservation.
- g. Implement Environmental Policies: Enact and enforce laws that protect ecosystems and promote sustainable development.
- h. Reduce Carbon Footprint: Take action to mitigate climate change, which poses a significant threat to ecosystems.
- i. Support Conservation Organizations: Contribute to organizations working to protect and restore ecosystems.
- j. Practice Responsible Consumption: Reduce consumption, reuse materials, and recycle to minimize waste and resource use.



### Activity 3: Application



#### Task 11:

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regarding their work. Support those who may carry out remedial activities.

6. Make a summary of **topic 2.1** by asking students to mention the main key points discussed.
7. You may follow the steps below to assess their work

**Step 1: Identify the Ecosystem**

- a. What type of ecosystem is present in the Gardened area?
- b. What are the dominant plant and animal species in this ecosystem?

**Step 2: Assess Abiotic Factors**

- a. Identify the key abiotic factors that influence the ecosystem.
- b. How might the construction and operation of the classroom affect these factors?

**Step 3: Analyze Biotic Interactions**

- a. Describe the food web and energy flow within the ecosystem.
- b. Identify any keystone species or endangered species that may be affected by the development.
- c. How might the development disrupt the interactions between different species?

**Step 4: Predict Potential Impacts**

- a. What are the potential negative impacts of the classroom blocks on the ecosystem?
- b. How might the development affect the local community and its residents?

**Step 5: Propose Mitigation Strategies**

- a. Suggest ways to minimize the negative impacts of the development.
- b. Consider strategies such as wildlife corridors, noise barriers, and pollution control measures.

## Topic 2.2: Description of ecosystems

|                                                                                     |                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>Distinguish Types of ecosystems clearly based on relationships among living organisms</li> </ol>                                            |
|    | <p><b>Time Required: 3 hours</b></p>                                                                                                                                                                                                                                   |
|    | <p><b>Learning Methodology:</b> Group discussion, Trainer guided, Site visit, brainstorming and demonstration.</p>                                                                                                                                                     |
|    | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/ chalkboard</p> <p>Flipcharts, papers, wall charts</p> <p>Markers, chalks, tutorial videos, pictures</p>                                                                      |
|  | <p><b>Preparation:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Brainstorming, demonstration and simulation, individual and group work, group discussion</li> <li><input type="checkbox"/> Written assessment, oral presentation</li> </ul> |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Climate change and global warming</li> </ul>                                                                                                                                              |
|  | <p><b>Prerequisites:</b></p> <ul style="list-style-type: none"> <li>➤ Origin of life</li> <li>➤ Human evolution</li> <li>➤ Ecological factors</li> </ul>                                                                                                               |



## Activity 1: Problem-Solving



### Task 12:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to read a short description and answer the questions provided under task 12 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 2.2 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 13:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees read the paragraph and answer the questions provided under task 13 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 2.2** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

**Possible answers:**

**1. What role does primary productivity play in an ecosystem?**

- a. Primary productivity is the foundation of energy flow in an ecosystem. It's the rate at which producers (plants, algae, and some bacteria) convert sunlight or chemical energy into organic matter (biomass).
- b. It essentially sets the limit for how much energy is available to support all other organisms in the ecosystem (herbivores, carnivores, and decomposers).
- c. Primary productivity influences the abundance and diversity of life within an ecosystem. A highly productive ecosystem can support more organisms at higher trophic levels.

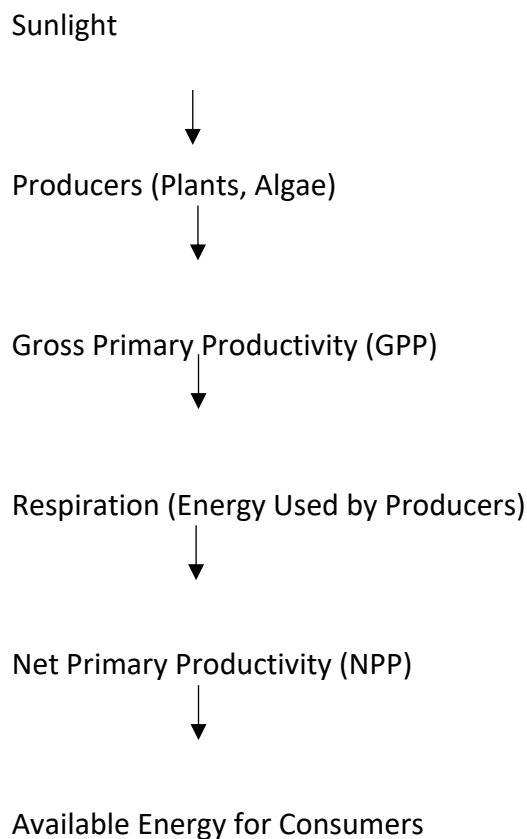
**2. Why does energy decrease as it moves up trophic levels?**

- a. The second law of thermodynamics states that energy conversions are never 100% efficient; some energy is always lost as heat.
- b. When an organism consumes food, only a portion of the energy is converted into its own biomass. The rest is:
  - i. Used for metabolic processes (respiration), which releases heat.
  - ii. Lost as undigested material (feces).
- c. On average, only about 10% of the energy from one trophic level is transferred to the next. This is known as the "10% rule." The other 90% is lost.

**3. How does net productivity affect the energy available for higher levels?**

- a. Net productivity (NPP) is the gross primary productivity (GPP) minus the energy used by producers for respiration. It represents the amount of energy stored as biomass that is available to consumers.
- b. A higher NPP means more energy is available for herbivores, which in turn means more energy is available for carnivores, and so on.

- c. Conversely, a low NPP limits the energy available for higher trophic levels, potentially leading to lower populations or fewer species at those levels.
  - d. Essentially NPP is the energy that is actually "available" to move up the food chain.
4. **Why are there fewer apex predators than primary consumers?**
- a. Due to the 10% rule of energy transfer, there is significantly less energy available at higher trophic levels.
  - b. Apex predators are at the top of the food chain, so they rely on energy that has passed through multiple trophic levels.
  - c. Because of the energy loss at each level, there is simply not enough energy to support a large population of apex predators.
  - d. Therefore, ecosystems typically have a pyramid-shaped structure, with a wide base of producers and progressively smaller levels of consumers, culminating in a relatively small population of apex predators.
5. **A diagram of ecosystem productivity (showing primary productivity, gross productivity, and net productivity)**



- a. **Gross Primary Productivity (GPP):** The total amount of energy captured by producers through photosynthesis.

- b. **Respiration:** The energy used by producers for their own metabolic processes (growth, maintenance, etc.).
- c. **Net Primary Productivity (NPP):** The remaining energy after respiration, which is stored as biomass and available to consumers.



### Activity 3: Application



#### Task 14: Exploring Ecosystems and Ecological Principles

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree aof independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regrading their work. Support those who may carry out remedial activities.
6. Make a summary of **topic 2.2** by asking students to mention the main key points discussed.
7. You may follow the steps below to assess their work

#### 1. Observing the School Environment:

- **Identifying Biotic Factors:**
  - ✓ Plants (grass, trees, shrubs)

- ✓ Insects (ants, bees, butterflies)
- ✓ Birds (pigeons, sparrows)
- ✓ Small mammals (squirrels, rodents)
- ✓ Microorganisms in the soil
- **Identifying Abiotic Factors:**
  - ✓ Sunlight
  - ✓ Temperature
  - ✓ Rainfall/water availability
  - ✓ Soil type and pH
  - ✓ Air quality
  - ✓ Wind
- **Interactions:**
  - ✓ Plants use sunlight for photosynthesis.
  - ✓ Insects pollinate flowers.
  - ✓ Birds eat insects.
  - ✓ Rainfall affects plant growth.
  - ✓ The temperature of the area impacts what plants can grow there.
- **Ecosystem Type:**
  - ✓ Likely a terrestrial ecosystem, potentially a small urban/suburban ecosystem.
- **Ecosystem Components:**
  - ✓ Producers (plants)
  - ✓ Consumers (insects, birds, mammals)
  - ✓ Decomposers (bacteria, fungi in soil)

## 2. Creating a Food Chain/Web:

- **Example Food Chain:**
  - ✓ Grass (producer) → Grasshopper (primary consumer) → Sparrow (secondary consumer) → Hawk (apex predator)
- **Energy Flow:**
  - ✓ Energy flows from the sun to the grass (photosynthesis).
  - ✓ Energy is transferred to each consumer as they eat.
- **Energy Loss:**
  - ✓ Approximately 90% of energy is lost as heat at each trophic level (10% rule).

- ✓ Energy is used for metabolism, movement, and heat production.

### **3. Gross and Net Productivity:**

- Gross Productivity: The total amount of energy captured by producers.
- Net Productivity: The energy remaining after producers use some for respiration.
- Factors Affecting Productivity:
  - ✓ Sunlight availability
  - ✓ Water availability
  - ✓ Soil nutrient content
  - ✓ Temperature

### **4. Biological Relationships:**

- Predation: A sparrow eating a grasshopper.
- Competition: Grass competing for sunlight and nutrients.
- Symbiosis:
  - ✓ Mutualism: Bees pollinating flowers, both benefit.
  - ✓ Commensalism: Birds nesting in trees, birds benefit, tree unaffected.
  - ✓ Parasitism: Fleas on a rodent, the flea benefits, and the rodent is harmed.
- Cooperation: Ants working together to gather food.

### **5. Human Impacts:**

- Positive Impacts:
  - ✓ Planting trees and creating green spaces.
  - ✓ Recycling and waste management.
  - ✓ Maintaining gardens.
- **Negative Impacts:**
  - ✓ Littering and pollution.
  - ✓ Use of pesticides and herbicides.
  - ✓ Habitat destruction from construction.
  - ✓ Excessive noise.
- **Sustainable Solutions:**
  - ✓ Promote recycling and composting.
  - ✓ Plant native species.
  - ✓ Reduce pesticide and herbicide use.
  - ✓ Create wildlife habitats.

- ✓ Use less single use plastics.
- ✓ Use more public transport or walk/bike.

#### **6. Report Components:**

- Introduction: Defining key terms and outlining the task.
- Observation Section: Detailing observations of the school environment, including biotic and abiotic factors.
- Analysis Section: Describing the ecosystem type, food chain/web, energy flow, and biological relationships.
- Discussion Section: Analyzing human impacts and proposing sustainable solutions.
- Conclusion: Summarizing findings and reflecting on the importance of ecological understanding.
- Diagrams: Visual representations of the food chain/web, energy flow, and ecosystem components.
- Examples: specific instances observed in the school environment.

## Topic 2.3: Explanation of relationship between living organisms

|                                                                                     |                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>Discuss Relationship between living organisms effectively in reference with their biological community</li> </ol>                           |
|    | <p><b>Time Required 3 hours.</b></p>                                                                                                                                                                                                                                   |
|    | <p><b>Learning Methodology:</b> Group discussion, trainer guided, site visit, brainstorming and demonstration.</p>                                                                                                                                                     |
|    | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/ chalkboard</p> <p>Flipcharts, papers, wall charts</p> <p>Markers, chalks, tutorial videos, pictures</p>                                                                      |
|  | <p><b>Preparation:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Brainstorming, demonstration and simulation, individual and group work, group discussion</li> <li><input type="checkbox"/> Written assessment, oral presentation</li> </ul> |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Influence of Abiotic Factors</li> <li>✓ Evolutionary History and Constraint</li> <li>✓ Interconnectedness Across Trophic Levels</li> </ul>                                                |
|  | <p><b>Prerequisites:</b></p> <ul style="list-style-type: none"> <li>➤ Basic biological classification</li> <li>➤ Types of species interactions</li> <li>➤ Understanding of evolutionary principles</li> </ul>                                                          |



## Activity 1: Problem Solving



### Task 15:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to analyze the paragraph and answer the questions provided under task 15 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 2.3 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 16:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees read the scenario and perform tasks required the questions provided under task 16 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 2.3** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.



### Activity 3: Application



#### Task 17: Case Study Analysis

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree aof independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regrading their work. Support those who may carry out remedial activities.
6. Make a summary of **topic 2.3** by asking students to mention the main key points discussed.

**Instructions:** Answer the following questions to the best of your ability.

1. Define:
  - a. Species
  - b. Population
  - c. Community
  - d. Niche
  - e. Biome
  - f. Biosphere
2. List Three different types of Ecology.
3. Define Abiotic and Biotic factors. Give two examples of each.
4. Define Ecosystem.
5. List Five different types of Ecosystems.
6. Define Producer, Primary Consumer, Secondary Consumer, Tertiary Consumer.
7. Define Productivity in an ecosystem.
8. List Two types of productivity in an ecosystem.
9. Define Predation, Competition, Symbiosis.
10. Define Parasitism, Mutualism, Commensalism, Amensalism.
11. Explain The concept of energy flow in an ecosystem.
12. Describe The difference between a food chain and a food web.
13. List Three major human impacts on the ecosystem.
14. Imagine a pond ecosystem List three biotic factors and three abiotic factors that might influence the organisms living in that pond.
15. You observe a bird building its nest in a tree. Identify the type of symbiotic relationship.
16. A lion hunts and kills a gazelle. Identify the type of relationship.
17. Two species of squirrels compete for the same food source in a forest. Identify the type of relationship.
18. A farmer plants a field of corn. Explain how this activity might impact the local ecosystem.
19. Explain How do abiotic factors influence the distribution and abundance of organisms in an ecosystem?
20. Why is biodiversity important for the stability of an ecosystem?
21. How does the loss of a top predator affect the rest of the food web?

22. Evaluate The impact of deforestation on biodiversity and ecosystem function.
23. Evaluate The effectiveness of different conservation strategies in protecting ecosystems.
24. How do the concepts of competition and niche relate to the distribution of species in a community?
25. Explain how human activities can disrupt the balance of energy flow in an ecosystem.
26. Design a simple experiment to investigate the impact of a specific abiotic factor on plant growth.
27. Design A poster illustrating the different trophic levels in a marine ecosystem.
28. Develop A short story or poem that depicts the interconnectedness of living organisms in an ecosystem.
29. Propose A solution to a local environmental problem based on your understanding of ecological principles.
30. Develop A presentation on the importance of protecting endangered species and their habitats.

**Answer:**

**1. Define:**

- a. Species: A group of living organisms capable of interbreeding and producing fertile offspring.
- b. Population: A group of individuals of the same species living in the same area at the same time.
- c. Community: All the different populations of organisms living together in a particular area.
- d. Niche: The role an organism plays in its environment, including its habitat, resources, and interactions with other species.
- e. Biome: A large naturally occurring community of flora and fauna occupying a major habitat, e.g., forest or tundra.
- f. Biosphere: The part of Earth inhabited by living organisms, encompassing all ecosystems.

**2. List Three different types of Ecology:**

- a. Population ecology
- b. Community ecology

- c. Ecosystem ecology

**3. Define Abiotic and Biotic factors. Give two examples of each.**

1. Abiotic factors: Non-living physical and chemical components of an ecosystem.
  - a. Examples: Temperature, sunlight.
2. Biotic factors: Living components of an ecosystem.
  - a. Examples: Plants, animals.

**4. Define Ecosystem.**

- a. An ecosystem is a community of living organisms (biotic factors) and their non-living environment (abiotic factors) interacting as a system.

**5. List Five different types of Ecosystems.**

- a. Forest ecosystems
- b. Grassland ecosystems
- c. Desert ecosystems
- d. Freshwater ecosystems (lakes, rivers)
- e. Marine ecosystems (oceans, coral reefs)

**6. Define: Producer, Primary Consumer, Secondary Consumer, Tertiary Consumer.**

- a. Producer: An organism that produces its own food through photosynthesis or chemosynthesis (e.g., plants).
- b. Primary Consumer: An herbivore that eats producers (e.g., rabbits).
- c. Secondary Consumer: A carnivore that eats primary consumers (e.g., snakes).
- d. Tertiary Consumer: A carnivore that eats secondary consumers (e.g., hawks).

**7. Define Productivity in an ecosystem.**

- a. Productivity is the rate at which biomass (organic matter) is produced in an ecosystem.

**8. List Two types of productivity in an ecosystem.**

- a. Gross primary productivity (GPP)
- b. Net primary productivity (NPP)

**9. Define Predation, Competition, Symbiosis.**

- a. Predation: One organism (predator) kills and consumes another (prey).
- b. Competition: Organisms vie for the same limited resources.
- c. Symbiosis: A close and long-term interaction between two different species.

**10. Define: Parasitism, Mutualism, Commensalism, Amensalism.**

- a. Parasitism: One organism benefits, and the other is harmed.
- b. Mutualism: Both organisms benefit.
- c. Commensalism: One organism benefits, and the other is neither harmed nor helped.
- d. Amensalism: One organism is harmed, and the other is unaffected.

**11. Explain The concept of energy flow in an ecosystem.**

- a. Energy flows through an ecosystem in a one-way direction, starting with producers (converting sunlight to chemical energy), then moving through consumers (herbivores, carnivores), and finally to decomposers. Energy is lost as heat at each trophic level.

**12. Describe The difference between a food chain and a food web.**

- a. Food chain: A linear sequence of organisms showing the transfer of energy from one trophic level to the next.
- b. Food web: A complex network of interconnected food chains, showing the multiple feeding relationships in an ecosystem.

**13. List Three major human impacts on the ecosystem.**

- a. Habitat destruction/fragmentation
- b. Pollution (air, water, soil)
- c. Climate change

**14. Imagine a pond ecosystem List three biotic factors and three abiotic factors that might influence the organisms living in that pond.**

- a. Biotic factors: Fish, algae, insects.
- b. Abiotic factors: Water temperature, sunlight, dissolved oxygen.

**15. You observe a bird building its nest in a tree. Identify the type of symbiotic relationship.**

- a. Commensalism.

**16. a lion hunts and kills a gazelle. Identify the type of relationship.**

- a. Predation.

**17. Two species of squirrels compete for the same food source in a forest. Identify the type of relationship.**

- a. Competition.

**18. a farmer plants a field of corn. Explain how this activity might impact the local ecosystem.**

- a. Reduces biodiversity, may increase erosion, can add chemical pollution through fertilizers and pesticides, can alter water runoff.

**19. Explain How do abiotic factors influence the distribution and abundance of organisms in an ecosystem?**

- a. Abiotic factors (temperature, water, sunlight, etc.) determine which organisms can survive and reproduce in a given area, thus influencing their distribution and abundance.

**20. Why is biodiversity important for the stability of an ecosystem?**

- a. Biodiversity increases ecosystem resilience, provides ecosystem services, and enhances the ability of the ecosystem to adapt to change.

**21. How does the loss of a top predator affect the rest of the food web?**

- a. It can lead to an increase in prey populations, which can then overgraze producers, disrupting the balance of the ecosystem.

**22. Evaluate The impact of deforestation on biodiversity and ecosystem function.**

- a. Deforestation leads to habitat loss, decreased biodiversity, increased erosion, disrupted water cycles, and contributes to climate change.

**23. Evaluate The effectiveness of different conservation strategies in protecting ecosystems.**

- a. Effectiveness varies: Protected areas are effective but can be limited by funding and enforcement. Sustainable resource management and community involvement are crucial.

**24. How do the concepts of competition and niche relate to the distribution of species in a community?**

- a. Competition can lead to niche differentiation, where species evolve to occupy different niches, reducing competition and allowing for coexistence.

**25. Explain how human activities can disrupt the balance of energy flow in an ecosystem.**

- a. Pollution, deforestation, and habitat destruction can reduce primary productivity, altering energy flow and impacting higher trophic levels.

**26. Design a simple experiment to investigate the impact of a specific abiotic factor on plant growth.**

- a. Experiment: Investigate the effect of light intensity on plant growth.
  - i. Setup: Grow identical plants under varying light intensities (e.g., different distances from a light source).
  - ii. Measure: Plant height, leaf count, and biomass over a set period.

**27. Design A poster illustrating the different trophic levels in a marine ecosystem.**

- a. Poster: Show phytoplankton (producers), zooplankton (primary consumers), small fish (secondary consumers), and sharks (tertiary consumers). Include arrows showing energy flow.

**28. Develop A short story or poem that depicts the interconnectedness of living organisms in an ecosystem.**

- a. This would be a creative writing task.

**29. Propose A solution to a local environmental problem based on your understanding of ecological principles.**

- a. Example: If litter is a local problem, propose a community recycling and education program.

**30. Develop A presentation on the importance of protecting endangered species and their habitats.**

- a. Presentation: Cover topics like the role of endangered species in ecosystems, threats to their survival, and conservation efforts.



**Points to Remember**

- ✓ Species: A group of organisms that can interbreed and produce fertile offspring.
- ✓ Population: A group of individuals of the same species living in the same area at the same time.
- ✓ Community: All the different populations of organisms living and interacting in a particular area.
- ✓ Niche: The role and position of an organism within its environment, including its habitat, food sources, and interactions with other organisms.

- ✓ Biomes: Large-scale ecological regions characterized by distinct climates, vegetation, and animal life.
- ✓ Biosphere: The global sum of all ecosystems, encompassing all life on Earth and the physical environment that supports it.
- **Types of Ecology**
  - ✓ Population Ecology: Focuses on the dynamics of populations.
  - ✓ Community Ecology: Studies the interactions between different species within a community.
  - ✓ Ecosystem Ecology: Examines the flow of energy and nutrients through ecosystems.
  - ✓ Landscape Ecology: Investigates the spatial patterns and processes across different landscapes.
- **Ecological Factors**
  - ✓ Biotic Factors: Living components of the environment (e.g., plants, animals, microorganisms).
  - ✓ Abiotic Factors: Non-living components of the environment (e.g., temperature, light, water, soil).
- **Types of Ecosystems**
  - ✓ Forest Ecosystems
  - ✓ Tundra Ecosystems
  - ✓ Desert Ecosystems
  - ✓ Freshwater Ecosystems
  - ✓ Ocean Ecosystems
  - ✓ Grassland Ecosystems
  - ✓ Alpine Ecosystems
  - ✓ Trophic Levels
  - ✓ Producers: Autotrophs that convert sunlight into chemical energy.
  - ✓ Primary Consumers: Herbivores that eat producers.
  - ✓ Secondary Consumers: Carnivores that eat primary consumers.
  - ✓ Tertiary Consumers: Top predators that eat secondary consumers.
  - ✓ Factors Affecting Productivity: Sunlight, temperature, water, nutrients, grazing pressure.

- ✓ Relationships Among Living Organisms
- ✓ Predation: One organism hunts and kills another for food.
- ✓ Competition: Organisms compete for limited resources.
- ✓ Symbiosis: Close and long-term interactions:
- ✓ Mutualism: Both organism's benefit.
- ✓ Commensalism: One benefits, the other is unaffected.
- ✓ Parasitism: One benefits (parasite), the other is harmed (host).
- ✓ Cooperation: Organisms work together for mutual benefit.
- ✓ Amensalism: One organism is harmed; the other is unaffected.
- **Energy Flow in Ecosystem**
  - ✓ Energy flows through ecosystems in a linear fashion.
  - ✓ Food chains and food webs illustrate the transfer of energy from producers to consumers.
- **Human Impact on the Ecosystem**
  - ✓ Habitat destruction
  - ✓ Pollution
  - ✓ Climate change
  - ✓ Overexploitation of resources
  - ✓ Invasive species



### Self-Reflection

1. Ask learners to re-take the self-assessment at the beginning of the unit. They should then fill in the table in their Trainee's Manual to Identify their areas of strength, areas for improvement and actions to take to improve.
2. Discuss trainees' results with them. Identify any areas that are giving many trainees difficulties and plan to give additional support as needed (ex. use class time before you begin the next learning outcome to go through commonly identified difficult concepts).

## LEARNING OUTCOME 3: ILLUSTRATE MECHANISMS OF ENVIRONMENTAL CONSERVATION



### Learning outcome 3: Self-Assessment

1. Ask trainees to look at the unit illustration in their Trainee's Manuals and together discuss:
  - a. What do the illustrations show?
  - b. What topics do you think will be covered under this unit based on the illustration?
2. After the discussion, inform students that this unit is intended to provide them with the knowledge, skills and attitudes to **illustrate mechanisms of environmental conservation**
3. Ask trainees to fill out the self-assessment at the beginning of the unit in their Trainee's Manuals. Explain that:
  - a. The purpose of the self-assessment is to become familiar with the topics in the unit and for them to see what they know or do not know at the beginning.
  - b. There are no right or wrong ways to answer this assessment. It is for their own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
  - c. They should think about themselves: do they think they have the knowledge, skills or attitudes to do this? How well?
  - d. They read the statements across the top and put a check in column that best represents their level of knowledge, skills or attitudes.
4. At the end of the unit, they will do a self-reflection, which includes re-taking the self-assessment and identifying their strengths, areas of improvement and actions to be taken.



## Key Competencies:

| Knowledge                                                                                       | Skills                                                                                        | Attitudes                                                           |
|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 1. Describe biogeochemical cycles and involve the elements                                      | 1. Analyze causes of biodiversity Loss                                                        | 1. Awareness of environmental balance.                              |
| 2. Explain ecological balance                                                                   | 2. Identifying the causes of bio-degradation                                                  | 2. Awareness on ecosystem degradation and environment restorations. |
| 3. Identify practices, policy regulations, conservation methods, and climate change adaptation. | 3. Apply sustainability compliance/legislation practices, environmental protection strategies | 3. Active role toward the conservation of resources and ecosystems. |



Steps:



### Discovery Activity



#### Task 18

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to share their prior experience and read the scenario and answer questions under the task 18 in their Trainee's Manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are given.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class.
3. Encourage all students to give their views.
4. After the presentations/sharing session, inform students that this activity was not intended for them to give the right answers but to give them a picture of what they will cover in the unit.
5. Introduce Topic 3.1: **Description of biogeochemical cycles**

## Topic 3.1: Description of biogeochemical cycles

|                                                                                     |                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>Describe Biogeochemical cycles appropriately based on their nature</li> </ol>                                                                                     |
|    | <p><b>Time Required: 5 hours</b></p>                                                                                                                                                                                                                                                         |
|    | <p><b>Learning Methodology:</b> Group discussion, Trainer guided, Videos, brainstorming and demonstration</p>                                                                                                                                                                                |
|    | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/chalkboard</p> <p>Flipcharts, papers, wall charts, pictures</p> <p>Markers, chalks, tutorial videos</p>                                                                                             |
|  | <p><b>Preparation:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Brainstorming, demonstration and simulation, individual and group work, group discussion, documentary research</li> <li><input type="checkbox"/> Written assessment, oral presentation</li> </ul> |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Climate feedback loops driven by nutrient availability.</li> <li>✓ Human disruption of interconnected elemental fluxes.</li> <li>✓ Scale-dependent impacts of biodiversity on cycle resilience.</li> </ul>      |
|  | <p><b>Prerequisites:</b></p> <ul style="list-style-type: none"> <li>✓ Understanding basic chemical cycling</li> <li>✓ Knowledge of ecosystem structure and function</li> <li>✓ Familiarity with fundamental ecological principles</li> </ul>                                                 |



## Activity 1: Problem-Solving



### Task 19:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to read and answer the questions provided under task 19 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 3.1 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 20:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees read the scenario and answer the questions provided under task 20 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 3.1** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

**Possible answers:**

**1. What could be causing the issues in Green Valley?**

Possible issues and causes:

- **Water Scarcity:**

- ✓ Reduced rainfall due to climate change.
- ✓ Overuse of groundwater for agriculture or industry.
- ✓ Deforestation, leading to decreased water retention.
- ✓ Pollution of water sources.

- **Air Pollution:**

- ✓ Increased fossil fuel combustion from vehicles and industries.
- ✓ Deforestation, reducing carbon sequestration.
- ✓ Agricultural activities releasing methane.

- **Soil Degradation:**

- ✓ Deforestation, leading to erosion.
- ✓ Intensive agriculture, depleting soil nutrients.
- ✓ Pollution from industrial waste.

- **Loss of Biodiversity:**

- ✓ Habitat destruction from development.
- ✓ Pollution, affecting species survival.
- ✓ Climate change, altering species distribution.

**2. Draw a diagram of the water cycle and Carbon Cycle identify specific processes and describe their role in maintaining balance and explain how do human activities impact these cycles?**

- **Water Cycle Diagram:**

- ✓ (Imagine a diagram with these elements)
- ✓ **Evaporation/Transpiration:** Water changing from liquid to vapor.

- ✓ **Condensation:** Vapor forming clouds.
- ✓ **Precipitation:** Water falling as rain/snow.
- ✓ **Infiltration:** Water seeping into the ground.
- ✓ **Runoff:** Water flowing over land.
- ✓ **Groundwater Flow:** water flowing underground.
- ✓ **Human Impacts:**
  - ✚ Deforestation: Reduces transpiration and infiltration.
  - ✚ Pollution: Contaminates water sources.
  - ✚ Overuse: Depletes groundwater reserves.
  - ✚ Climate change: alters precipitation patterns.

- **Carbon Cycle Diagram:**

- ✓ (imagine a diagram with these elements)
- ✓ **Photosynthesis:** Plants absorb CO<sub>2</sub>.
- ✓ **Respiration:** Organisms release CO<sub>2</sub>.
- ✓ **Combustion:** Burning fossil fuels releases CO<sub>2</sub>.
- ✓ **Decomposition:** Organic matter releases CO<sub>2</sub>.
- ✓ **Ocean Absorption:** Oceans absorb CO<sub>2</sub>.
- ✓ **Human Impacts:**
  - ✚ Burning fossil fuels: Increases atmospheric CO<sub>2</sub>.
  - ✚ Deforestation: Reduces carbon sequestration.
  - ✚ Agriculture: Releases methane and CO<sub>2</sub>.

3. **Discuss how activities like deforestation or increased fossil fuel use might disrupt this cycle, affecting Green Valley's ecosystem.**

- **Deforestation:**

- ✓ Reduces transpiration, impacting local rainfall.
- ✓ Decreases carbon sequestration, increasing atmospheric CO<sub>2</sub>.
- ✓ Leads to soil erosion, impacting water quality.

- **Increased Fossil Fuel Use:**

- ✓ Increases atmospheric CO<sub>2</sub>, contributing to climate change.
- ✓ Alters precipitation patterns, impacting water availability.
- ✓ Contributes to air pollution, affecting plant and animal health.

4. **Why are the water and carbon cycles essential for life?**

- **Water Cycle:**

- ✓ Provides fresh water for drinking, agriculture, and industry.
- ✓ Regulates climate.
- ✓ Supports ecosystems.

- **Carbon Cycle:**

- ✓ Provides the building blocks for organic molecules.
- ✓ Regulates Earth's climate through the greenhouse effect.
- ✓ Supports photosynthesis, the basis of most food webs.

5. **Can you think of examples where disruptions to these cycles might affect the environment?**

- Droughts due to altered water cycles.
- Increased wildfires due to climate change (carbon cycle disruption).
- Ocean acidification from increased atmospheric CO<sub>2</sub>.
- Flooding from altered precipitation patterns.
- Loss of species due to habitat change.

6. **Discuss the flow of water through each stage and its significance.**

- **Evaporation/Transpiration:** Moves water from Earth's surface to the atmosphere.
- **Condensation:** Forms clouds, crucial for precipitation.
- **Precipitation:** Delivers fresh water to land and oceans.
- **Infiltration:** Replenishes groundwater, which supports ecosystems and human needs.
- **Runoff:** Transports water to rivers and oceans, shaping landscapes.
- **Groundwater Flow:** Sustains baseflow in rivers and provides water for wells.

7. **Highlight how the processes connect and impact ecosystems.**

- The water and carbon cycles are interconnected.
- Photosynthesis (carbon cycle) relies on water (water cycle).
- Deforestation impacts both cycles, affecting local and global climates.
- Changes in precipitation patterns (water cycle) affect plant growth (carbon cycle).
- The cycles are essential for nutrient cycling, which is essential for healthy ecosystems.



### Activity 3: Application



#### Task 21:

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regarding their work. Support those who may carry out remedial activities.
6. Make a summary of **topic 3.1** by asking students to mention the main key points discussed.
7. You can follow the steps below to facilitate the task:
  - a. In small groups, analyze Biochemical cycles such as diagrams of Water cycle, Carbon Cycle, Nitrogen Cycle and Phosphorous cycle.
  - b. Each group will present how their evidence supports the description of biogeochemical cycles in Conservation of Nature then answer the following questions:
    1. On the Paper, create Four columns each for the water cycle, carbon cycle, Nitrogen Cycle and Phosphorous cycle. list effects of disruptions to each cycle. What solutions can reduce the negative effects on the water and carbon cycles?
    2. By using a short presentation comparing the water and carbon cycles, their key terms, processes, and effects that helps to connect theoretical concepts to practical applications.

## Topic 3.2: Explanation of ecosystem degradation

|                                                                                     |                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>Explain Ecosystem degradation clearly referring to natural equilibrium</li> </ol>                                                                                 |
|    | <p><b>Time Required:</b> 3 hours</p>                                                                                                                                                                                                                                                         |
|    | <p><b>Learning Methodology:</b> Group discussion, Trainer guided, Site visit, brainstorming and demonstration.</p>                                                                                                                                                                           |
|    | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/chalkboard</p> <p>Flipcharts, papers, wall charts, pictures</p> <p>Markers, chalks, tutorial videos</p>                                                                                             |
|  | <p><b>Preparation:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Brainstorming, demonstration and simulation, individual and group work, group discussion, documentary research</li> <li><input type="checkbox"/> Written assessment, oral presentation</li> </ul> |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Pollution (air, water, soil)</li> <li>✓ Invasive species and Climate change</li> <li>✓ Overexploitation of resources</li> </ul>                                                                                 |
|  | <p><b>Prerequisites:</b></p> <ul style="list-style-type: none"> <li>➤ Habitat destruction and fragmentation</li> <li>➤ Knowledge of Ecological Stressors</li> </ul>                                                                                                                          |



## Activity 1: Problem-Solving



### Task 22:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to read and answer the questions provided under task 22 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 3.2 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 23:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees read the scenario and answer the questions provided under task 23 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 3.2** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

**Possible answers:**

1. **What is natural equilibrium, and why is it essential for maintaining ecosystem stability?**

- **Natural Equilibrium:**

- ✓ Natural equilibrium, also known as ecological balance, refers to a state of dynamic stability within an ecosystem. In this state, populations of organisms, nutrient cycling, and energy flow remain relatively constant over time, with fluctuations occurring within a range of natural variability.
- ✓ It doesn't mean a static unchanging system. Rather it means a system where changes happen, but there is a system of feedback that returns the ecosystem to its "normal" operating range.

- **Importance for Ecosystem Stability:**

- ✓ It maintains biodiversity by preventing any single species from dominating.
- ✓ It ensures efficient resource utilization and nutrient cycling.
- ✓ It enhances ecosystem resilience to disturbances, allowing it to recover from natural fluctuations.
- ✓ It supports the provision of ecosystem services, such as clean water and air.

2. **How does nutrient cycling contribute to sustaining ecosystems, and what happens when it is disrupted?**

- **Contribution of Nutrient Cycling:**

- ✓ Nutrient cycling (e.g., carbon, nitrogen, phosphorus) ensures the continuous availability of essential elements for living organisms.
- ✓ Decomposers recycle organic matter, releasing nutrients back into the soil or water.
- ✓ Nutrient cycling supports plant growth, which forms the base of food webs.

- ✓ It maintains soil fertility and water quality.
  - **Disruption of Nutrient Cycling:**
    - ✓ **Eutrophication:** Excessive nutrient inputs (e.g., from fertilizers) lead to algal blooms and oxygen depletion in aquatic ecosystems.
    - ✓ **Soil Degradation:** Deforestation and unsustainable agriculture can deplete soil nutrients and increase erosion.
    - ✓ **Atmospheric Pollution:** Nitrogen and sulfur oxides contribute to acid rain, which alters soil and water pH.
    - ✓ Disrupted nutrient cycling decreases the productivity and resilience of the ecosystem.
3. **Explain the stages and types of energy flow in an ecosystem and their significance.**
- **Stages and Types of Energy Flow:**
    - ✓ **Solar Energy Capture:** Producers (plants, algae) capture sunlight through photosynthesis, converting it into chemical energy (gross primary productivity).
    - ✓ **Respiration:** Producers use some of the captured energy for their own metabolic processes (net primary productivity).
    - ✓ **Energy Transfer:** Energy is transferred to consumers (herbivores, carnivores) through food consumption.
    - ✓ **Energy Loss:** Energy is lost as heat at each trophic level (second law of thermodynamics).
  - **Significance:**
    - ✓ Energy flow is unidirectional, starting with the sun and dissipating as heat.
    - ✓ It supports the trophic structure of ecosystems, determining the abundance and diversity of organisms.
    - ✓ It influences ecosystem productivity and efficiency.
4. **How does population regulation depend on balanced nutrient cycling and energy flow?**
- **Population Regulation:**
    - ✓ Nutrient availability influences plant growth, which in turn affects herbivore populations.
    - ✓ Energy availability at each trophic level limits the population sizes of consumers.

- ✓ Balanced nutrient cycling and energy flow maintain stable predator-prey relationships.
  - ✓ Disruptions can lead to population imbalances, such as overgrazing or predator decline, causing cascading effects throughout the ecosystem.
  - ✓ Populations are regulated through carrying capacity, which is directly linked to the amount of available energy and nutrients.
5. **What are the forms of ecosystem degradation observed, and what solutions can address these issues?**
- **Forms of Ecosystem Degradation:**
    - ✓ **Habitat Destruction and Fragmentation:** Deforestation, urbanization, and agricultural expansion.
    - ✓ **Pollution:** Air, water, and soil contamination from industrial, agricultural, and urban activities.
    - ✓ **Climate Change:** Altered temperature and precipitation patterns, sea-level rise, and ocean acidification.
    - ✓ **Invasive Species:** Introduction of non-native species that disrupt native ecosystems.
    - ✓ **Overexploitation:** Overfishing, overhunting, and unsustainable resource extraction.
    - ✓ **Desertification:** Degradation of dryland ecosystems.
  - **Solutions:**
    - ✓ **Protected Areas:** Establish and manage national parks and reserves.
    - ✓ **Sustainable Practices:** Promote sustainable agriculture, forestry, and fishing.
    - ✓ **Pollution Control:** Implement stricter regulations on industrial emissions and waste disposal.
    - ✓ **Climate Change Mitigation:** Reduce greenhouse gas emissions through renewable energy and energy efficiency.
    - ✓ **Habitat Restoration:** Reforestation, wetland restoration, and removal of invasive species.
    - ✓ **Community Engagement:** Empower local communities to participate in conservation efforts.
    - ✓ **Policy and Regulations:** Enact and enforce environmental laws and regulations.



### Activity 3: Application



#### Task 24

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regarding their work. Support those who may carry out remedial activities.
6. Make a summary of **topic 3.2** by asking students to mention the main key points discussed.
7. You can refer to the possible answers below to facilitate the task:

#### Possible answers:

1. **What is biodiversity loss, and why is it important to address in ecosystems?**
  - **Biodiversity Loss:**
    - ✓ Biodiversity loss refers to the decline in the variety of life forms within a given ecosystem, region, or the entire planet. This includes the loss of species, genetic diversity within species, and the degradation of ecosystems.
  - **Importance:**
    - ✓ Ecosystem Stability: Diverse ecosystems are more resilient to disturbances and better able to recover from them.

- ✓ **Ecosystem Services:** Biodiversity provides essential services like pollination, water purification, and climate regulation.
- ✓ **Food Security:** Many food sources rely on diverse ecosystems.
- ✓ **Human Health:** Biodiversity is a source of medicines and contributes to overall well-being.
- ✓ **Ethical Considerations:** Many believe that all species have an intrinsic right to exist.

## 2. What are the major causes of biodiversity loss, and how can they be mitigated?

- **Major Causes:**

- ✓ **Habitat Destruction and Fragmentation:** Deforestation, urbanization, agriculture.
- ✓ **Pollution:** Air, water, and soil contamination.
- ✓ **Climate Change:** Altered temperature and precipitation patterns.
- ✓ **Invasive Species:** Introduction of non-native species.
- ✓ **Overexploitation:** Overfishing, overhunting, unsustainable logging.

- **Mitigation:**

- ✓ **Habitat Protection:** Establish and manage protected areas.
- ✓ **Sustainable Resource Use:** Promote sustainable forestry, fishing, and agriculture.
- ✓ **Pollution Control:** Implement stricter regulations and promote clean technologies.
- ✓ **Climate Change Mitigation:** Reduce greenhouse gas emissions.
- ✓ **Invasive Species Management:** Implement control and eradication programs.
- ✓ **Restoration Ecology:** Restore degraded habitats.
- ✓ **Education and Awareness:** Raise public awareness about the importance of biodiversity.

## 3. How do overgrazing, deforestation, and improper agricultural practices contribute to soil degradation?

- **Overgrazing:**

- ✓ Removes vegetation cover, exposing soil to erosion.
- ✓ Compacts soil, reducing water infiltration and aeration.

- ✓ Reduces soil fertility by depleting organic matter.
  - **Deforestation:**
    - ✓ Removes tree cover, increasing soil erosion.
    - ✓ Reduces water retention and increases runoff.
    - ✓ Depletes soil nutrients and organic matter.
  - **Improper Agricultural Practices:**
    - ✓ Monoculture depletes soil nutrients.
    - ✓ Excessive tillage increases soil erosion.
    - ✓ Overuse of fertilizers and pesticides contaminates soil and water.
    - ✓ Lack of cover crops, and crop rotation, reduces soil health.
4. **What are the impacts of different types of environmental pollution on ecosystems and human well-being?**
- **Air Pollution:**
    - ✓ Acid rain, damaging forests and aquatic ecosystems.
    - ✓ Respiratory problems and other health issues in humans.
    - ✓ Climate change due to greenhouse gas emissions.
  - **Water Pollution:**
    - ✓ Eutrophication, leading to oxygen depletion and fish kills.
    - ✓ Contamination of drinking water, causing health problems.
    - ✓ Harm to aquatic organisms and ecosystems.
  - **Soil Pollution:**
    - ✓ Reduced soil fertility and plant growth.
    - ✓ Contamination of food crops.
    - ✓ Groundwater contamination.
    - ✓ Heavy metal accumulation in organisms.
  - **Plastic Pollution:**
    - ✓ Entanglement of marine life.
    - ✓ Microplastic consumption by animals and humans.
    - ✓ Habitat destruction.
5. **What solutions can you propose to balance resource use and reduce biodiversity loss and pollution in this region?**
- **Integrated Land Management:**
    - ✓ Promote sustainable agriculture and forestry practices.

- ✓ Implement land-use planning to minimize habitat destruction.
- ✓ Restore degraded ecosystems.
- **Pollution Control:**
  - ✓ Invest in wastewater treatment and waste management systems.
  - ✓ Promote the use of renewable energy sources.
  - ✓ Implement regulations to control industrial emissions and agricultural runoff.
- **Biodiversity Conservation:**
  - ✓ Establish and manage protected areas.
  - ✓ Promote eco-tourism and community-based conservation.
  - ✓ Control invasive species.
- **Resource Efficiency:**
  - ✓ Promote recycling and waste reduction.
  - ✓ Encourage water conservation and efficient irrigation.
  - ✓ Support sustainable consumption patterns.
- **Education and Awareness:**
  - ✓ Raise public awareness about the importance of biodiversity and environmental protection.
  - ✓ Educate farmers and land managers about sustainable practices.
  - ✓ Incentive programs for sustainable practices.
- **Policy and Enforcement:**
  - ✓ Enact and enforce environmental laws and regulations.
  - ✓ Provide incentives for sustainable development.

### Topic 3.3: Application of environmental protection Strategies.

|                                                                                     |                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><b>Objectives:</b></p> <p>By the end of the topic, trainees will be able to:</p> <ol style="list-style-type: none"> <li>Discuss Environmental protection strategies effectively in accordance with its conservation principles.</li> </ol>                                                |
|    | <p><b>Time Required: 2 hours.</b></p>                                                                                                                                                                                                                                                        |
|    | <p><b>Learning Methodology:</b> Group discussion, trainer guided, site visit, brainstorming and demonstration.</p>                                                                                                                                                                           |
|    | <p><b>Materials, Tools and Equipment Needed:</b></p> <p>Computer, projector, white board/chalkboard</p> <p>Flipcharts, papers, wall charts, pictures</p> <p>Markers, chinks, tutorial videos</p>                                                                                             |
|  | <p><b>Preparation:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Brainstorming, demonstration and simulation, individual and group work, group discussion, documentary research</li> <li><input type="checkbox"/> Written assessment, oral presentation</li> </ul> |
|  | <p><b>Cross Cutting Issues:</b></p> <ul style="list-style-type: none"> <li>✓ Emphasis on Preventative Measures</li> <li>✓ Community Engagement and Participation</li> <li>✓ Interdisciplinary Approaches:</li> </ul>                                                                         |
|  | <p><b>Prerequisites:</b></p> <ul style="list-style-type: none"> <li>➤ Knowledge of Relevant Environmental Policies and Regulations</li> <li>➤ Understanding of Environmental Impacts</li> </ul>                                                                                              |



## Activity 1: Problem-Solving



### Task 25:

1. Using an appropriate methodology such as brainstorming, group discussion, and trainer guided, Individual work, pair-share and guided discussions to analyze the paragraph and answer the questions provided under task 25 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
3. After the sharing session, refer students to **Key facts 3.3 and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.**



## Activity 2: Guided Practice



### Task 26:

1. Using an appropriate methodology, such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees read the scenario and answer the questions provided under task 26 in their trainee's manuals. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
2. During the task, students should be given a degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them to come to informed responses.
3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, genocide education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
5. After the sharing session, refer students have to refer to **Key Facts 3.3** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

**Possible answers:**

1. **What are the main environmental challenges facing Rwanda today?**
  - Deforestation and habitat loss.
  - Soil erosion and land degradation.
  - Water pollution and scarcity.
  - Air pollution, particularly in urban areas.
  - Waste management issues.
  - Climate change impacts (e.g., increased drought, rainfall variability).
  - Loss of biodiversity.
2. **Name two key environmental protection laws or policies implemented in Rwanda.**
  - The Organic Law Determining the Modalities of Protection, Conservation and Promotion of the Environment.
  - The National Environment and Climate Change Policy.
3. **How does Rwanda utilize protected areas for environmental conservation?**
  - Rwanda establishes national parks (e.g., Volcanoes National Park, Akagera National Park, Nyungwe Forest National Park) to protect biodiversity and critical habitats.
  - These areas serve as sanctuaries for endangered species, promote eco-tourism, and maintain ecosystem services.
  - They are also important for research and education.
4. **What role do community-based conservation initiatives play in Rwanda?**
  - Community-based conservation initiatives empower local communities to participate in environmental management.

- They promote sustainable resource use, reduce poaching and illegal logging, and enhance local livelihoods.
- They foster a sense of ownership and responsibility for conservation.
- They are important for the long-term sustainability of conservation efforts.

**5. How does Rwanda promote sustainable agriculture?**

- Promotion of terracing and agroforestry to prevent soil erosion.
- Use of organic farming and integrated pest management to reduce chemical use.
- Promotion of crop diversification and livestock management.
- Education and training for farmers on sustainable practices.
- Promotion of efficient irrigation techniques.

**6. Analyze the effectiveness of Rwanda's reforestation efforts in mitigating soil erosion and climate change.**

- Rwanda has had very successful reforestation campaigns.
- Effectiveness:
  - ✓ Reforestation has significantly reduced soil erosion by stabilizing slopes and improving water retention.
  - ✓ It has increased carbon sequestration, contributing to climate change mitigation.
  - ✓ It has enhanced biodiversity and restored degraded habitats.
  - ✓ Challenges include ensuring long-term maintenance of planted forests and addressing the root causes of deforestation.

**7. Discuss the challenges and opportunities of integrating environmental protection with economic development in Rwanda.**

- Challenges:
  - ✓ Balancing economic growth with environmental sustainability.
  - ✓ Ensuring that development projects are environmentally sound.
  - ✓ Addressing the costs of environmental protection.
  - ✓ Enforcing environmental regulations.
- Opportunities:
  - ✓ Promoting green growth and eco-tourism.
  - ✓ Investing in renewable energy and sustainable technologies.
  - ✓ Creating green jobs and enhancing livelihoods.

- ✓ Enhancing Rwanda's reputation as an environmentally responsible nation.

**8. How does Rwanda address the issues of illegal logging and wildlife trafficking?**

- Strengthening law enforcement and increasing patrols in protected areas.
- Implementing strict penalties for illegal activities.
- Collaborating with international organizations to combat wildlife trafficking.
- Engaging local communities in monitoring and reporting illegal activities.
- Promoting sustainable forest management.

**9. Evaluate the role of international cooperation and funding in supporting environmental protection initiatives in Rwanda.**

- International cooperation and funding are crucial for supporting Rwanda's environmental initiatives.
- They provide financial and technical assistance for conservation projects, capacity building, and research.
- They facilitate knowledge sharing and technology transfer.
- They support Rwanda's efforts to meet international environmental obligations.
- They help to fund projects that Rwanda may not have the budget for.

**10. How can Rwanda effectively communicate the importance of environmental conservation to its citizens and promote greater public awareness and participation?**

- Integrating environmental education into school curricula.
- Conducting public awareness campaigns through media and community outreach.
- Organizing environmental events and activities.
- Engaging local leaders and community groups in conservation efforts.
- Using social media and digital platforms to reach a wider audience.
- Providing incentives for environmentally friendly behaviors.



### Activity 3: Application



#### Task 27:

1. Explain to students that the following task links them to the world of work and will require them to apply the knowledge, skills and attitudes acquired; and working independently to perform the task required.
2. Using an appropriate methodology that require the trainee active participation like individual work, avail needed tools to assess trainees' understanding of the topic.
3. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
4. This activity requires students to work independently in their respective groups with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the answer sheets.
5. After the assessment of students' work, discuss with them the total marks (performance/competence) and use the individual forms to share and give feedback to the students regarding their work. Support those who may carry out remedial activities.
6. Make a summary of **topic 3.3** by asking students to mention the main key points discussed.
7. You can refer to the possible answers below to facilitate the task:

#### Possible answers:

1. **How does your chosen strategy address the root causes of the environmental challenge?**
  - **Root Causes of Deforestation/Soil Erosion:**
    - ✓ Unsustainable agricultural practices.
    - ✓ Demand for fuelwood and charcoal.
    - ✓ Lack of alternative livelihood options.
    - ✓ Inadequate land management planning.

- **Agroforestry/Sustainable Land Management Strategy:**

- ✓ **Addresses Unsustainable Agriculture:** Agroforestry integrates trees with crops and livestock, improving soil fertility, reducing erosion, and diversifying income.
- ✓ **Reduces Fuelwood Demand:** Agroforestry provides a sustainable source of fuelwood, reducing pressure on natural forests.
- ✓ **Creates Alternative Livelihoods:** It offers diverse income opportunities through timber, fruit, and other tree products.
- ✓ **Promotes Better Land Planning:** Encourages land-use planning that incorporates agroforestry and sustainable practices.

2. **What are the potential economic and social benefits of implementing your strategy?**

- **Economic Benefits:**

- ✓ Increased agricultural productivity.
- ✓ Diversified income for farmers.
- ✓ Reduced costs associated with soil erosion (e.g., reduced fertilizer use).
- ✓ Creation of jobs in agroforestry and related industries.
- ✓ Increased value of land.

- **Social Benefits:**

- ✓ Improved food security.
- ✓ Enhanced community resilience to climate change.
- ✓ Improved livelihoods and reduced poverty.
- ✓ Strengthened social cohesion through community-based projects.
- ✓ Improved health due to better nutrition.

3. **What are the potential challenges and risks associated with implementing your strategy?**

- **Challenges:**

- ✓ Resistance to change from traditional farming practices.
- ✓ Initial investment costs and time required for trees to mature.
- ✓ Lack of access to training and technical assistance.
- ✓ Land tenure issues.
- ✓ Potential for pest and disease problems.

- **Risks:**
  - ✓ Climate variability, which can affect tree growth.
  - ✓ Market fluctuations for agroforestry products.
  - ✓ Potential for conflicts over land use.

4. **How can you ensure the long-term sustainability of your chosen strategy?**

- **Community Involvement:** Engage local communities in planning and implementation.
- **Capacity Building:** Provide training and technical assistance to farmers.
- **Policy Support:** Implement policies that promote agroforestry and sustainable land management.
- **Market Development:** Create markets for agroforestry products.
- **Monitoring and Evaluation:** Regularly assess the effectiveness of the strategy and make adjustments as needed.
- **Financial Incentives:** Offer subsidies or tax breaks to encourage adoption.
- **Diversification:** Promote a variety of agroforestry systems to reduce risks.

5. **How can you effectively communicate the importance of your strategy to the Rwandan public?**

- **Public Awareness Campaigns:** Use radio, television, and social media to disseminate information.
- **Demonstration Farms:** Establish demonstration farms to showcase the benefits of agroforestry.
- **Community Meetings:** Organize community meetings to discuss the strategy and address concerns.
- **Educational Programs:** Integrate agroforestry and sustainable land management into school curricula.
- **Farmer Field Schools:** Provide hands-on training to farmers.
- **Success Stories:** Share success stories of farmers who have adopted agroforestry.
- **Collaboration:** Partner with local leaders, NGOs, and government agencies to communicate the message.
- **Use of local languages:** Communicate in Kinyarwanda.

1. The followings are approaches of Environmental protection. Answer by True or False.
  - a. Protected areas
  - b. Sustainability
  - c. Renewable Energy Use
  - d. Conservation of Natural Resources
  - e. Polluter pays

### **Section A: Answer all Questions**

1. Define the term "evaporation."
2. Describe the role of transpiration in the water cycle.
3. Explain how human activities can disrupt the water cycle.
4. Explain the process of photosynthesis in the context of the carbon cycle.
5. How does the burning of fossil fuels impact the carbon cycle?
6. What are the potential consequences of an imbalance in the carbon cycle?
7. Describe the role of nitrogen-fixing bacteria in the nitrogen cycle.
8. Explain how the use of fertilizers can affect the nitrogen cycle.
9. What is the importance of nitrogen for living organisms?
10. Why is the phosphorus cycle considered as relatively slow cycle?
11. Explain how human activities, such as mining, can disrupt the phosphorus cycle.
12. What are the potential consequences of excess phosphorus in aquatic ecosystems?
13. Explain how predation can act as a density-dependent factor in population regulation.
14. Describe how deforestation contributes to soil erosion.
15. Discuss the potential consequences of soil pollution for human health.

## **Section B: Answer Only Three (3) Questions of your Choice**

16. Explain the "polluter pays" principle and provide an example of its application.
17. Describe the importance of protected areas for biodiversity conservation.
18. Explain how air pollution can contribute to acid rain.
19. Describe the potential impacts of water pollution on aquatic ecosystems.
20. Discuss the importance of waste reduction and recycling in environmental pollution control.

### **Answers:**

#### **Section A:**

**1. Define the term "evaporation."**

- Evaporation is the process by which a liquid, typically water, changes into a gas or vapor. It occurs when molecules in the liquid gain enough kinetic energy to escape from the liquid's surface and enter the atmosphere.

**2. Describe the role of transpiration in the water cycle.**

- Transpiration is the process by which water is absorbed by plant roots, transported through the plant, and then evaporated from its leaves and other aerial parts into the atmosphere. It plays a significant role in moving water from the soil to the atmosphere, contributing to atmospheric moisture and rainfall.

**3. Explain how human activities can disrupt the water cycle.**

- Human activities such as:
  - ✓ Deforestation: Reduces transpiration and increases runoff.
  - ✓ Urbanization: Increases impermeable surfaces, leading to increased runoff and decreased groundwater recharge.
  - ✓ Over-extraction of groundwater: Depletes aquifers and lowers water tables.
  - ✓ Pollution: Contaminates water sources, making them unusable.
  - ✓ Climate change: alters precipitation patterns, and increases evaporation rates.

**4. Explain the process of photosynthesis in the context of the carbon cycle.**

- Photosynthesis is the process by which plants, algae, and some bacteria use sunlight, water, and carbon dioxide (CO<sub>2</sub>) to produce glucose (sugar) and oxygen.

In the carbon cycle, photosynthesis removes CO<sub>2</sub> from the atmosphere, storing carbon in organic molecules, thus acting as a carbon sink.

**5. How does the burning of fossil fuels impact the carbon cycle?**

- Burning fossil fuels (coal, oil, and natural gas) releases large amounts of stored carbon into the atmosphere as CO<sub>2</sub>. This increases the concentration of atmospheric CO<sub>2</sub>, contributing to the greenhouse effect and climate change.

**6. What are the potential consequences of an imbalance in the carbon cycle?**

- Potential consequences include:
  - ✓ Global warming and climate change.
  - ✓ Ocean acidification.
  - ✓ Changes in precipitation patterns.
  - ✓ Increased frequency and intensity of extreme weather events.
  - ✓ Disruption of ecosystems.

**7. Describe the role of nitrogen-fixing bacteria in the nitrogen cycle.**

- Nitrogen-fixing bacteria convert atmospheric nitrogen gas (N<sub>2</sub>), which is unusable by most organisms, into ammonia (NH<sub>3</sub>), a form of nitrogen that plants can absorb. This process is essential for making nitrogen available to living organisms.

**8. Explain how the use of fertilizers can affect the nitrogen cycle.**

- Excessive use of nitrogen-based fertilizers can lead to:
  - ✓ Leaching of nitrates into groundwater, contaminating drinking water.
  - ✓ Runoff into aquatic ecosystems, causing eutrophication.
  - ✓ Release of nitrous oxide (N<sub>2</sub>O), a potent greenhouse gas, into the atmosphere.

**9. What is the importance of nitrogen for living organisms?**

- Nitrogen is a crucial component of:
  - ✓ Proteins: Essential for building and repairing tissues.
  - ✓ Nucleic acids (DNA and RNA): Carry genetic information.
  - ✓ Chlorophyll: Used by plants for photosynthesis.

**10. Why is the phosphorus cycle considered as relatively slow cycle?**

- The phosphorus cycle is slow because phosphorus is primarily found in rocks and sediments. It is released through slow processes like weathering and erosion, and there is no atmospheric component to the cycle.

**11. Explain how human activities, such as mining, can disrupt the phosphorus cycle.**

- Mining for phosphate rock increases the rate at which phosphorus is released from the Earth's crust.
- Excess phosphorus ends up in fertilizers, and then runs off into waterways.
- Deforestation reduces the amount of phosphorus held in biomass.
- These actions move large amounts of phosphorus much faster than natural processes.

**12. What are the potential consequences of excess phosphorus in aquatic ecosystems?**

- Excess phosphorus can lead to eutrophication, which causes:
  - ✓ Algal blooms: Rapid growth of algae, which block sunlight and deplete oxygen.
  - ✓ Dead zones: Areas of low oxygen where aquatic life cannot survive.
  - ✓ Loss of biodiversity.

**13. Explain how predation can act as a density-dependent factor in population regulation.**

- Predation is density-dependent because predators often focus their hunting efforts on areas with higher prey densities. As prey populations increase, predators have more food available, leading to increased predator populations or hunting success, which in turn reduces the prey population.

**14. Describe how deforestation contributes to soil erosion.**

- Deforestation removes the protective cover of vegetation, which:
  - ✓ Reduces water infiltration.
  - ✓ Increases runoff.
  - ✓ Exposes soil to wind and rain, which can easily erode it.
  - ✓ The root systems that hold the soil in place are removed.

**15. Discuss the potential consequences of soil pollution for human health.**

- Soil pollution can lead to:
  - ✓ Contamination of food crops, leading to ingestion of toxins.
  - ✓ Contamination of groundwater, affecting drinking water supplies.
  - ✓ Direct exposure to pollutants through skin contact or inhalation, causing various health problems such as respiratory issues, neurological damage, and cancer.

## **Section B:**

### **16. Explain the "polluter pays" principle and provide an example of its application.**

- The "polluter pays" principle states that those who produce pollution should bear the costs of managing it to prevent damage to the environment.
- Example: A factory that discharges untreated wastewater into a river would be required to pay for the cleanup of the river and any damage caused to aquatic ecosystems. Carbon taxes are another example.

### **17. Describe the importance of protected areas for biodiversity conservation.**

- Protected areas:
  - ✓ Provide habitats for diverse species.
  - ✓ Maintain ecosystem integrity.
  - ✓ Protect endangered species.
  - ✓ Serve as genetic reservoirs.
  - ✓ Allow for scientific research and monitoring.

### **18. Explain how air pollution can contribute to acid rain.**

- Air pollutants, such as sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>), released from burning fossil fuels, react with water, oxygen, and other chemicals in the atmosphere to form sulfuric acid and nitric acid. These acids then fall to the Earth as acid rain.

### **19. Describe the potential impacts of water pollution on aquatic ecosystems.**

- Water pollution can:
  - ✓ Reduce dissolved oxygen levels, harming aquatic life.
  - ✓ Introduce toxic chemicals, causing death or disease in organisms.
  - ✓ Cause eutrophication, leading to algal blooms and dead zones.
  - ✓ Alter the pH of water, affecting sensitive species.
  - ✓ Reduce biodiversity.

### **20. Discuss the importance of waste reduction and recycling in environmental pollution control.**

- Waste reduction and recycling:
  - ✓ Reduce the amount of waste sent to landfills, minimizing soil and groundwater contamination.

- ✓ Conserve natural resources by reusing materials.
- ✓ Reduce energy consumption and greenhouse gas emissions associated with manufacturing new products.
- ✓ Reduce the amount of pollution created by the extraction of raw materials.



### Points to Remember

- Biogeochemical Cycles encompasses the movement and transformation of elements (carbon, nitrogen, phosphorous and water) through the Earth's systems.
- Biodiversity Loss refers to the decline in the variety of life on Earth at all levels, including species, genetic, and ecosystem diversity.
- Natural Equilibrium describes the stable state of an ecosystem where populations, resources, and environmental conditions remain relatively constant.
- Environmental Conservation involves the protection and preservation of natural resources and ecosystems to ensure their sustainability for future generations.
- Ecosystem Degradation refers to the deterioration of ecosystem health and function, often caused by human activities.



### Self-Reflection

1. Ask learners to re-take the self-assessment at the beginning of the unit. They should then fill in the table in their Trainee's Manual to Identify their areas of strength, areas for improvement and actions to take to improve.
2. Discuss trainees' results with them. Identify any areas that are giving many trainees difficulties and plan to give additional support as needed (ex. use class time before you begin the next learning outcome to go through commonly identified difficult concepts).

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