Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

RQF LEVEL 5

FOOD AND BEVERAGE OPERATIONS

GENAB502

Applied Biology

TRAINEE MANUAL

April 2025

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APPLY BASIC KNOWLEDGE OF ECOLOGY

2025

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COORDINATION TEAM

Aimable Rwamasirabo

Felix Ntahontuye

Eugène Munyanziza

Production Team

Authoring and Review

Jean de Dieu Sindambiwe

Venuste Habimana

Rene David Nsabimana

Conception, Adaptation and Editorial works

Jean Marie Vianney Muhire

Vincent Havugimana

John Paul Kanyike

Formatting, Graphics, Illustrations, and infographics

Asoka Niyonsaba Jean Claude

Ngamije Hildebrand

Habimana Augustin

Coordination and Technical support

Ubukerarugendo Imbere Project and RTB

Project Implementation

MCT Global Ltd.

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LIST OF ABBREVIATIONS AND ACRONYMS

CBET: Competence Base Education and Training

PPE: Personal Protective Equipment

RQF: Rwanda Qualification Framework

RNA: Ribonucleic Acid

DNA: Deoxyribonucleic Acid

RTB: Rwanda TVET Board

TVET: Technical and Vocational Education and Training

REMA: Rwanda Environment Management Authority

MYA: Million Years ago

INTRODUCTION

This trainee's manual encompasses all necessary skills, knowledge and attitudes required to **Apply Basic Knowledge of Ecology**. Students undertaking this module shall be able to discuss theories of evolution and their evidence, describe ecosystems and illustrate mechanisms of environmental conservation. The writing process of this training manual embraced competency-based education and training (CBET) philosophy by providing practical opportunities reflecting real life situations.

The trainee's manual is subdivided into units, each unit has got various topics. You will start with a self-assessment exercise to help you rate yourself on the level of skills, knowledge and attitudes about the unit.

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

After these activities, you will learn more about the topics by doing different activities by reading the required knowledge, techniques, steps, procedures and other requirements under the key facts section, you may also get assistance from the trainer. 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 undertake progressive assessments known as formative and finally conclude with your self-reflection to identify your strengths, weaknesses and areas for improvement.

Do not forget to read the point to remember the section which provides the overall key points and takeaways of the unit.

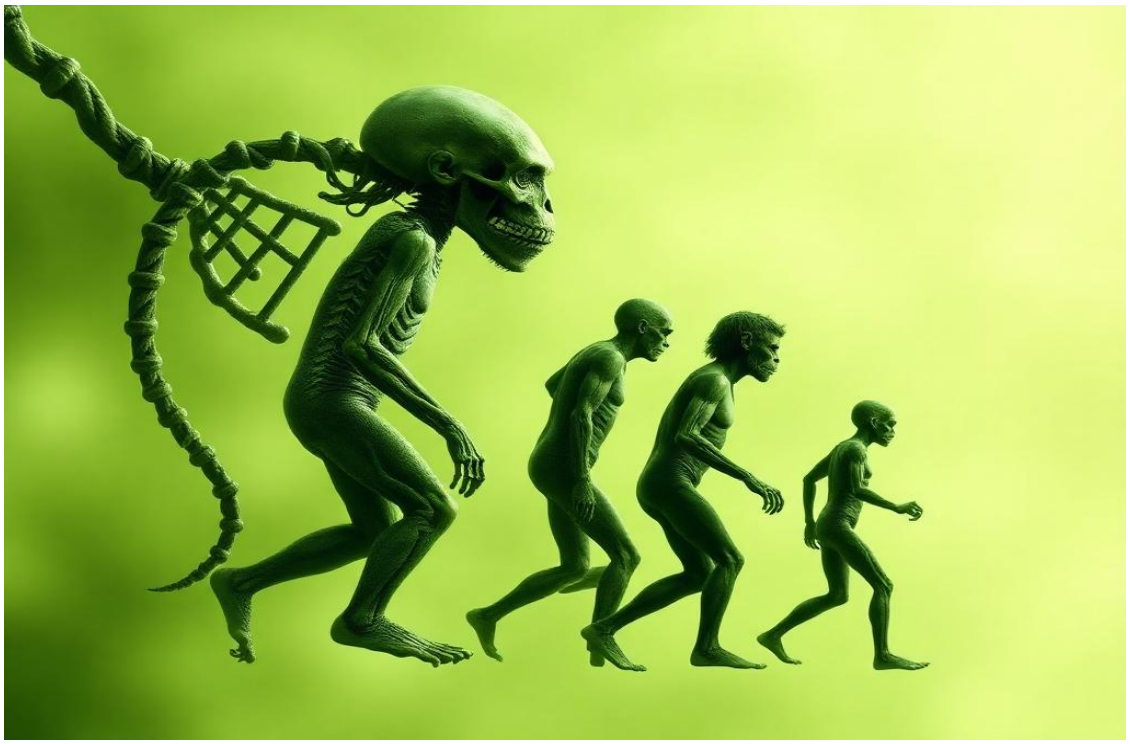
Module Units:

Unit 1: Discuss theories of evolution and their evidence.

Unit 2: Describe ecosystems

Unit 3: Illustrate mechanisms of environmental conservation

UNIT 1: THEORIES OF EVOLUTION AND THEIR EVIDENCE



Unit summary

This unit provides you with the knowledge, skills and attitudes required to understand theories of evolution for Living organism and provides knowledgeable explanation of origin of life**,** detailed evidence that confirm evolution then after you will clearly gain evolutional skills of Human including history, stages and characteristics. Then present-day evolution knowledge including concepts, factors, mechanisms and relevance for human and Plant in conservation.

Self-Assessment: Unit 1

1. Look at the unit illustration in the Manuals and answer the following questions:

   a). What does the illustration show?

   b). By comparing the images in illustration what they differ from?

   c). Basing on the illustration, what do you think this unit is about?

2. Fill in and complete self-assessment in the table below to assess your level of knowledge, skills and attitude under this unit.

   a). There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquired during the learning process

   b). Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?

   c). Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

   d). At the end of this unit, you will assess yourself again.

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe the origin of Life					
Define Abiogenesis					
Explain Primordial Soup Hypothesis					
Describe Lamarckism Theory					
Explain assumption and identify Merits and Demerits of Lamarckism					
Describe Neo-Darwinism Theory					

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain assumption and identify Merits and Demerits of Darwinism					
Explain Human Evolution					
Demonstrate Evidence of Evolution					
Explain how biochemistry and cell biology are the evidence of evolution					
Describe how Comparative embryology is the evidence of evolution					
Explain how Comparative anatomy should demonstrate if evolution take place					
Explain Stages in human evolution and their characteristics					
Illustrate Factors influencing present day evolution					
Describe Mechanisms of present-day evolution					

Key Competencies:

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

Discovery activity:

Task 1: Read and Answer the Questions

Scenario 1: In Earth's early days, volcanic eruptions and lightning energized a primordial soup of water and gases, enabling abiogenesis, where simple organic molecules formed. Over time, these molecules organized into self-replicating structures. Mutations in their genetic material led to diversity, while natural selection favored stable systems. The earliest life evolved, leaving clues in the fossil record and DNA evidence, marking the beginning of life's journey toward complexity and diversity.

After reading this scenario Answer the following Questions:

1. What do you think life really is?
2. How do you think life originated on Earth?
3. What are the basic components of life?
4. Why should it be water that is associated with life?
5. Is life possible anywhere outside the Earth? Why or why not?
6. How such energy things as the Sun account for the origin of life?
7. Where in the story about the origins of life does evolution come in?
8. What do you imagine the first organisms on Earth were like?
9. What are the scientific proofs about life's origin, how do scientists prove it?
10. What is Evolution?
11. What are evidences that describe evolution?
12. By using Drawing, how do you think first living organism looks like?

Topic 1.1: Explanation of the origin of life

Activity 1: Problem Solving

Task 2:

Scenario 2: The Story of Life's Evolution

Billions of years ago, Earth's conditions supported abiogenesis, where life originated from non-living chemical components. In a primordial soup of water, methane, and ammonia, organic molecules formed, eventually giving rise to simple cells. As these early organisms reproduced, mutations introduced diversity, and natural selection favored traits that enhanced survival. Over time, genetic changes accumulated, recorded in the fossil record, revealing the progression from simple to complex life forms. DNA evidence now links modern species to ancient ancestors, showing shared genetic codes. Homologous structures like vertebrate limbs highlight common origins, while vestigial organs, such as the human appendix, reflect evolutionary remnants. Processes like genetic drift further shaped populations, contributing to the vast biodiversity we observe today.

Based on the scenario answer the following questions:

1. What does abiogenesis propose about the origin of life?
2. Explain the significance of the primordial soup hypothesis.
3. Define natural selection and its role in evolution.
4. How do fossils provide evidence of evolution?
5. What does DNA similarity between species suggest?
6. Give an example of homologous structures.
7. Name a vestigial organ in humans.
8. How do mutations drive evolution?
9. What is genetic drift?
10. How does endosymbiosis explain the origin of mitochondria?

Key Facts 1.1 Explanation of the origin of life

- **Introduction on the origin of life**

The life origin on Earth is possibly one of the most interesting, if not the most complex topics which science deals with. How non-living chemical elements transformed into the first living organisms? Several answers have been given by scientists as to this phenomenon. The hypotheses concentrate mainly on how very simple molecules might have assembled themselves into the first building blocks of early Earth life conditions. Three most important hypotheses are:

✓ **Abiogenesis**

Abiogenesis is just what it means. It is the process by which life arises from non-living things naturally. The theory differs from the discredited concept of the spontaneous generation, according to which life appeared fully formed. It presupposes a number of chemical reactions which would have generated simple organic molecules, which then assembled themselves into proteins, nucleic acids. Largely based on physical and chemical processes under prebiotic (life-before) conditions. Provides for the natural

progression inorganic to organic.

✓ **Primordial Soup Hypothesis**

This hypothesis was proposed by Alexander Oparin and John Haldane states that the early atmosphere of the Earth is rich in gases such as methane (CH4), ammonia (NH3), hydrogen (H_2), and water vapor (H_2O). Further, these gases combined with energy sources such as lightning or ultraviolet radiation created a **'primordial soup'** in the oceans; organic molecules formed.

Miller-Urey Experiment (1953): Stanley Miller and Harold Urey tested this hypothesis by simulating early Earth conditions in the lab. They prepared a mixture of gases thought to be present in the early atmosphere of Earth, and passed electric sparks through the mixture (to simulate lightning). After one week, they found amino acids formed, which are the building blocks for proteins, thus demonstrating that simple organic molecules could result under prebiotic conditions. **Significance:** Shows how possibly the molecules necessary for the life might have been produced by Earth's environment.

✓ **Hydrothermal Vent Hypothesis**

The hypothesis states that life may have started at hydrothermal vents on the ocean floor. These vents release water with high temperature and minerals that originate from below the earth crust, thus providing a unique environment for chemical reactions.

- **Key Features:**
  - **Energy Source:** The heat and chemical gradients at the vents would have promoted organic molecules' formation.
  - **Mineral Catalysts:** Iron and sulfur minerals in vent systems probably acted as a catalyst in making more complex organic molecules.
  - **Protected Environment:** The deep-sea vents are protected from the sun's ultraviolet radiation, thus providing a safer environment for earlier life.
- **Evidence:** The present extremophiles derive their nourishment from near hydrothermal vents and probably early life evolve around such areas.

✓ **Religious and Philosophical Perspectives on the Origin of Life**

The birthright of every Living organism has been articulated rightly from religion to religion and belief to belief in answering this very fundamental question. Whereas all the creation stories have been seen to relate having touched some divine activity, so that the atheists slant their statements to more scientific explanations. The following is a detailed explanation of the ranges from a few different holy texts: the Christian Bible, the Quran, the Satanic Bible, and atheistic thought:

- **Bible:** The origin of life is from a divine action as written in the Book of Genesis.
  - **Creation Narrative:** In the beginning, God created the heavens and the earth, but all life he created within six days. People created in the image of God (Genesis 1:27) from dust, and Eve from one of Adam's ribs.
  - **Import or importance:** Emphasizes this uniqueness in that relationship, portraying humanity as stewards for creation.
  - **Interpretations:** Literalists take it as a historical record. Theistic Evolutionists said

that God uses evolution as a tool for his creating activity.

- **Quran:** It says that life originated from the will of Allah,
  - **Process of Creation:** All living things Allah has created from water (Quran 21:30). The human, as had been formed of clay or dust (Quran 15:26), resembles the Biblical account.
  - **Gradual Creation:** The scriptural impression of creation stages corresponds widely to a possible interpretation of gradual development.
- **Satanic Bible:** This Produced by Anton LaVey, said to be a holy book, it does not possess a creation myth, just like another religious book. It reflects in sense of philosophy on all points concerning human autonomy and a philosophy of naturalism.
  - **Life View:** Life is the product of natural processes and therefore not the result of any divine agency.
  - **Self-Orientation:** The book strongly affirms personal power: throws away religious dogmatism and insists on living just as things are.
  - **Interpretation:** It cares not where the origin of life comes in but it centers on living fully and living authentically.
- **Atheistic Ideas:** It would note the living world and quite possibly a dead world becoming living themselves as a source of meaning for atheists: unnatural cause. They would opt for rather scientific theories:
  - **Abiogenesis-** Life arose from non-living matter by the chemical process.
  - **Theory of Evolution:** Describes lawful changes and processes by which life derived from common ancestors.
  - **Purpose Perspective:** Life has no purpose in itself but derives meaning from personal experiences, relations, and achievements.

However, the origin of life in the religious book interpreted under different lenses, they reflect both the theological and philosophical approaches, but the science proved that the origin of life is result of conditions and processes that may lead to the first living organisms and Research continues to explore how simple molecules evolved into the

complex systems that characterize life today.

- **Evolution**

Evolution is a scientific theory that accounts for the change of organisms with respect to the properties of their genes from time to time through inheritance and adaptation; and to explain the variations among organisms in a variety of unending phenomena through time on this planet. Those things create the nature of the diversity of life on Earth and provide vast evidence by fields like biology, paleontology, and genetics.

✓ **Concepts in evolution**

Natural Selection

- **Definition:** Natural selection is the process by which organisms with traits providing an advantage in reproduction or survival in a given environment are more likely to pass those traits on in the next generation.
- **Survival of the fittest:** Those having favorable features survive and reproduce better.
- **Leads to adaptation:** In the long run, populations be correctly adapted to the environments.

Genetic Variation

- **Definition:** Genetic variation describes differences that characterize an individual DNA in the population.
- **Mutations:** Accidental changes in DNA that can well bring new traits into the living organism.
- **Gene Flow:** Movement of genes between two populations through migration.
- **Sexual reproduction:** Draw differences by combining genetic material of two parents.

Mutation

- **Definition:** Mutations are unintended or haphazard changes within the genetic code within organisms.
- **Role in Evolution:** New traits results which may have some beneficial, neutral, or detrimental effects. Important for creation of raw material on which natural selection operates.

Adaptation

- **Definition:** An adaptation is a feature of an organism which serves to increase its fitness i.e. its ability to survive and reproduce in a certain environment.
- **Examples:** Camouflage in animals to escape from predators.
- The long beaks of hummingbirds to reach nectar from various flowers.

Survival of the Fittest

- **Definition:** Fitness refers to an organism's ability to survive, reproduce, and pass its genes to the next generation.
- **Fallacy:** By "fittest" is not meant strongest but the best-suited to the environment.

Speciation

Definition: Speciation provides the process by which new species arise.

- **Types:**
  - ***Allopatric Speciation:*** *Occurs as populations are separated from each other by geographic isolation.*
  - ***Sympatric Speciation:*** *Occurs without geographical separation and results from ecological or behavioral isolation.*

Common Ancestry

- **Definition:** All living organisms are derived from a common ancestor and

diverged over time.

- **Evidence:** Common ancestry is supported by similarities in DNA, anatomy, and embryonic development.

Evolutionary Tree (Phylogenetics)

It refers to an evolutionary tree, which shows the relationship between species based on their common ancestors. Helps trace an organism's lineage and evolutionary history.

Genetic Drift

- **Definition:** Random changes in allele frequencies in a population, especially in small populations, are known as genetic drift.
- **Effect:** Could lead to loss of genetic diversity and coincidence fixation for specific traits.

Coevolution

- **Definition:** Coevolution occurs when two or more species simultaneously influence each other's evolution.
- **Example:** Flowers and their pollinators, such as bees, develop traits benefitting both.

These concepts in evolution not only explain how life changes on Earth, but it also explains the possible adaptations which ultimately lead to this overwhelming variety of species we see today. Evolution occurs because of survival, but it also includes the different interplay of genetic, environmental, and temporal factors.

- **Theories of evolution**

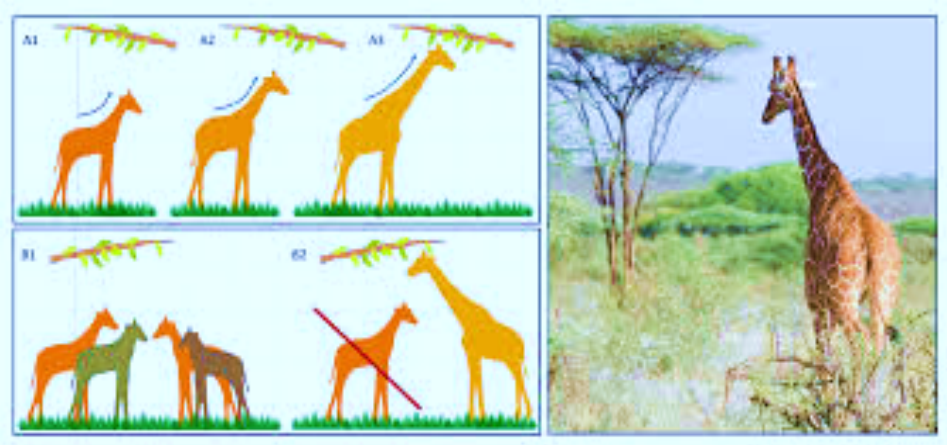
In the history of evolutionary narrative, certain theories have been put forth to discuss man's genesis and how life has developed and diversified over the ages. Each theory brings with account certain assumptions, merits, and limitations (demerits). Below is an overview of the primal theoretical constructs regarding evolution.

✓ **LAMARCKISM**

Lamarck's Theory of Inheritance of Acquired Characteristics this theory proposed by Jean-Baptiste de Monet Lamarck in the year 1744-1829. This theory was based on the principle that all the physical changes occurring in an individual during its lifetime are inherited by its offspring. This theory shows how there is a development of an organ when used many times,

- **Example:**

Evolution of giraffe: The ancestors of the giraffe looked like horses with small necks and forelimbs. They lived in areas where there was no surface vegetation. Therefore, they had to stretch their neck and forelimbs to eat leaves from tall plants. Consequently, these parts got elongated. This trait was transmitted in the successive generations.



Assumption:

- All organisms acquire the traits during their lifetime according to the needs or demands from the environment.
- The inherited acquired traits passed onto the offspring.

Use and disuse: Used most of their organs grow stronger while those not used fade away or shrivel.

Merits

The first person to consider the environmental influence on the evolution of a species.

The concept of how organisms adapt to their surroundings.

Demerits

Evidence not offered: Acquired characters are lent not inherited, such as muscles developed through exercise. Did not take into consideration genetic mechanisms of inheritance, which were later elucidated by Mendel in his work on heredity.

✓ **DARWINISM**

Darwinism Theory of Natural Selection proposed By Charles Darwin (1809-1882), an English naturalist, and several others postulated the theory of Darwinism which is a theory on biological evolution based on the fact that all species develop from or into the forms of organisms that have survived inherited variations that give a competitive and reproductive advantage-in organisms-for survival.

- Evolution is assumed according to Darwin as a process separated by time where species alter into new species and derive a common ancestor.
- Those best adapted survive.
- Fitness is fundamentally given by inheritance.
- The genetic must be the reason of selection and evolution.
- Better adapted individuals survive in a harsh environment.
- Adaptation is considered hereditary.
- It is genetically based.

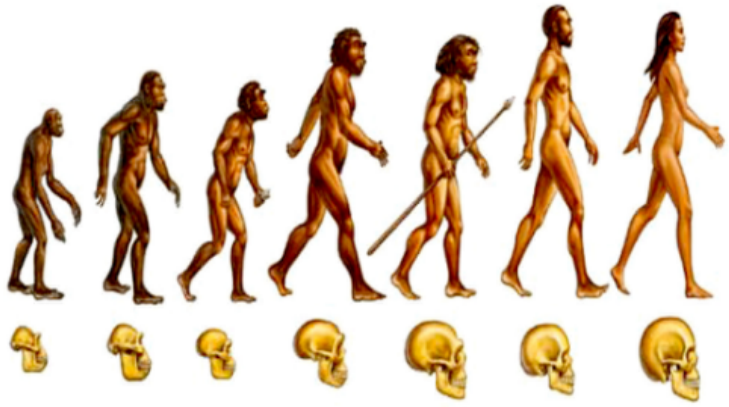
- Adaptation depends on natural selection and thus leads to fitness. Thus, we consider Natural selection and Branching descent as the two basic principles of Darwin's theory of evolution.

Assumption:

- There are more offspring than can survive.

- Individuals differ from other individuals in terms of specific traits; often, some of these traits are heritable.
- Traits that enhance survival and reproduction are passed to the next generation.
- Over time, advantageously represented characters are accumulated, leading to adaptation and speciation.

Merits



- The evidence of fossils, biogeography, and comparative anatomy speaks volumes in its support.
- How environmental pressures helped in the shaping of species is elucidated in this theory.
- Bases of modern evolutionary biology.

Demerits

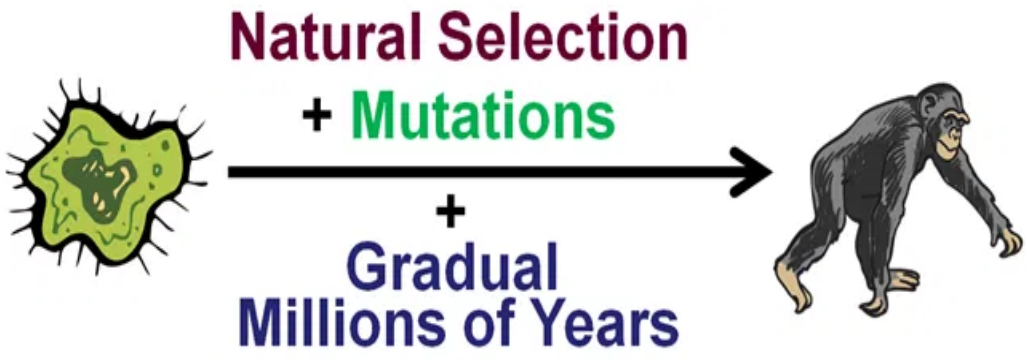
Did not account for genetics in his explanation on birth of variations.

Some detractors say it lays too much emphasis on survival, neglecting commensal or symbiotic relationships.

✓ **NEO-DARWINISM**

Neo-Darwinism (Modern Synthetic Theory) demonstrate the work of scientists R.A. Fischer, J.B.S. Haldane and Sewall Wright (1930s to 1940s), This theory is an updated version of Darwinism, incorporating Mendelian genetics and later discoveries in molecular biology.

It explains how:



- **Genetic mutations introduce variation.**
  - Natural selection acts on this variation.
  - Traits are passed through genes, not by acquiring characteristics during life (as Lamarckism suggests).
  - Modern understanding of DNA, mutations, and genetic drift has expanded this theory to provide a more complete understanding of evolutionary mechanisms.
- **Assumptions**
  - Combines Darwin's natural selection with Mendelian inheritance.
  - Genetic variation is induced by mutation, recombination, and gene flow. For gradual evolution, natural selection acts on these variations.
- **Merits**
  - All-embracing with multiple scientific disciplines which include genetics, paleontology, molecular biology. Explains gradual as well as adaptive evolution. Strengthened by modern molecular evidence such as DNA analysis.
- **Demerits**
  - Limited in explaining large-scale evolutionary changes, for instance, mass extinctions or sudden speciation events.

- The Special Creation Theories of Evolution
- According to Special Creation theory, life and the diversity of species are but conceived by a supernatural being or divine power in forms present today. This is founded primarily on religion and sacred texts than scientific evidence. It differs sharply from evolutionary theories that emphasize transformation through natural processes.

✓ **THE SPECIAL CREATION**

This theory says that all living organisms were created by God. God created the first man Adam. Father Suarez was a strong believer (supporter) of the theory of special creation. He believed that whole life on earth was formed in 6 days.

The assumptions of special creation:

- **Divine intervention-** A supernatural power directly created all living organisms, each with a purpose and design.
- **Immutability of Species:** Species are fixed and unchanged-were made and remain in their present forms; consequently, there is no evolution or common ancestry.

- **Recent Earth:** Most proponents will often believe the Earth is young, as many of them literally interpret the religious texts (for example, the Earth created in "six days").

Benefits of Special Creation (Merits)

- **Simplicity:** Gives direct answers to the origin of live forms without complicated scientific processes.
- **Cultural-religious Significance:** It is shared by most of the religious societies, thereby providing guides in the spiritual and moral sense.
- **Enhances Faith:** Adds to the there being design in creation, and thereby provides consolation and strength to those who see life as divinely planned.
- **An alternative viewpoint:** Functions in opposition to scientific theories to create a stimulus to philosophic and theological discourse.

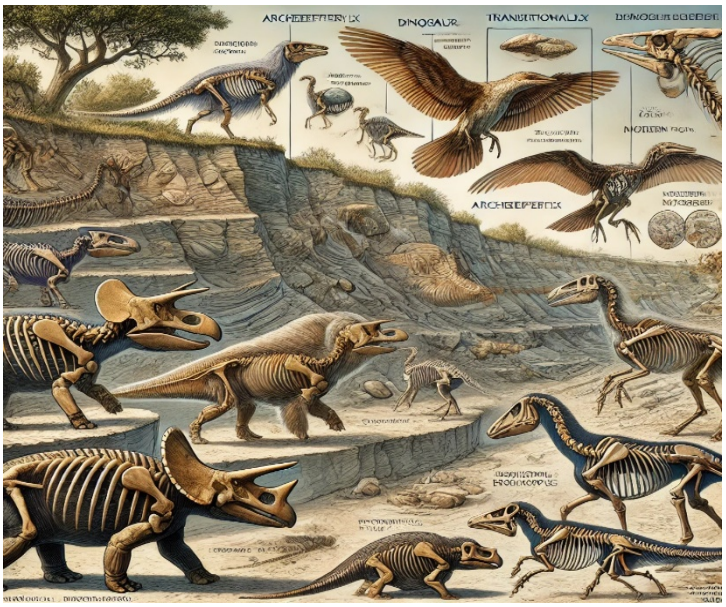
Disadvantages of Special creation (Demerits)

- **Absence of Empirical Evidence:** The theories of Special Creation are untestable, unobservable and unverifiable scientifically.
- **Incompatibility with Science:** It contradicts evidence already established scientifically such as the fossil records, homologous features in living organisms, and radiometric dating.
- **Mechanism of Biodiversity:** the inability to elucidate the mechanisms that are responsible for the diversity of life or the changes that are observed over time-an example being antibiotic resistance or speciation.
- **Static View of Life:** The assumption of immutability has something contrary to the observable evidence of evolution and adaptation.
- **Excluded from some Science Curriculum**: Since it is found to lack scientific rigor, and therefore is not included in the scientific curriculum.

✓ THE EVIDENCE FOR EVOLUTION

Paleontology

Paleontology proves that evolution is real. Paleontology acts like the history of life on earth because it can show the way species have transformed and their direct ancestry with regards to extinct organisms and their extant forms. This view is elaborated below and made with examples.



Fossil Records

The fossil record is a chronicle of all life that is preserved within the layers of sedimentary rock. It shows changes in species within millions of years. It provides evidence for:

- Extinction: The fossil of a species not existing anymore, for example: Dinosaurs.
- **Emergence of New Species:** Gradual appearance of new forms in progressively higher strata.
- **Stratification:** Fossils of deeper layers are older and simpler and fossils in upper layers are more recent and complex.

Transitional Fossils

They are the fossils which provide transitional evidence between itself and all other major groups of organisms and thus indicate the evolutionary transitions.

- **Archaeopteryx:** It has characteristics of reptiles (teeth, tail) as well as of birds (feathers, wishbone). It was considered a transitional between reptiles and birds.
- **Basilosaurus:** The ancestor of modern whales, which has vestigial hind limbs, connects terrestrial mammals and aquatic whales.

Evolution of the Horse

The horse lineage fossil example from an evolutionary point of view is exceedingly well-recorded evidence for gradual evolution.

- **Eohippus (Dawn Horse):** 55 million years ago, small, multi-toed and adapted for a forest environment.
- **Mesohippus:** Greater, with fewer toes, focusing on an adaptation for the open grasslands. One Toed hooves, extremely specialized for running on hard earth; the Modern horse is named Equus.

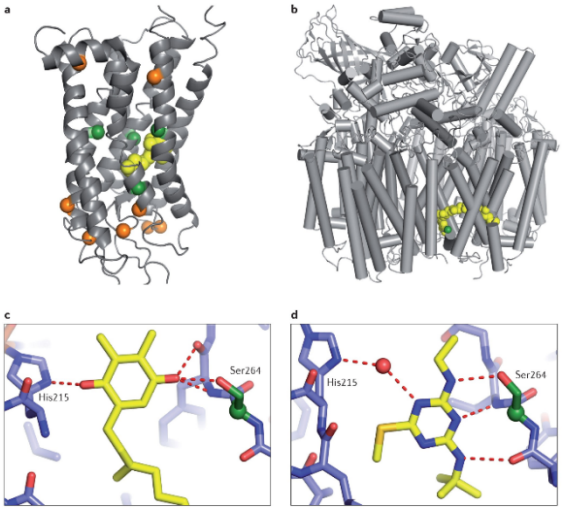
Homologous Structures in Fossils

Paleontology is the study of homologous structures: features that share anatomic similarity derived from a common ancestor:

- **Whales and Terrestrial Mammals:** Fossil evidence shows that the whale flipper evolved from limbs comparable to those of land mammals.
- **Forelimbs of** Vertebrates**:** Fossils of reptiles, birds, and mammals demonstrate a shared bone structure, despite quite different functions such as flying, swimming, and grasping.

✓ **Comparative biochemistry and cell biology**

Comparative biochemistries and cell biology will most probably give persuasive evidence for evolution in the similarities between molecular and cellular structures among different organisms, emphasizing their common ancestry.



✓ **Comparative Biochemistry**

DNA and Genetic Code

The most obvious perhaps is the fact that all living things have DNA as their genetic material and have as a result a universal genetic code (which includes the same codons coding for the same amino acids for all).

- **Example:** Humans share around 98 to 99% of their DNA sequences with chimpanzees, only further emphasizing how related our evolutionary history is.
- Such conserved genes such as those coding for essential enzymes like cytochrome c might be used as evidence for our common ancestry.

Protein Homology

Structural affinity is similarly manifested among different organisms, meaning that hemoglobin and myoglobin have quite similar structural derivations, only in small differences, which are the effect of evolutionary divergence.

- **Example:** Hemoglobin of both humans and gorillas differ at a few amino acids, which when compared with that of fish or amphibians, shows much greater divergence.

Biochemical Pathways

Conserved biochemical processes, like glycolysis and the Krebs cycle, repeat themselves in every form of life, suggesting that they originated from a common ancestor.

- **Example:** Almost identical processes in bacteria, plants, and animals are used for ATP synthesis.

✓ **Comparative Cell Biology**

Universal Cell Structures of Cells

All cells exhibit certain fundamental characteristics or structures such as plasma membranes, cytoplasm, and ribosomes. This would hint at one ancestry of the cells.

Such similarities indeed exist between prokaryotic and eukaryotic cells, but all these points add up to information contained in DNA for all organisms.

Organelles and Endosymbiosis

Mitochondria and chloroplasts belong with eukaryotic cells as they possess their inherent DNA and show resemblance with bacteria which support the endosymbiotic theory of evolution.

- **Example:** Mitochondria and chloroplasts are organs, which exhibit replication independently and display double membranes, inherited from ancestral prokaryotes.

Embryonic Cell Similarities

During the early stages of development, the structures of cells and processes in the embryos of different species are very similar with regard to each other, proving common ancestry.

- **Example:** Pharyngeal pouches which develop into gills in fish or parts of the ear in mammals are features shared by embryos of all vertebrates

✓ **Examples of Evolutionary Evidence**

Conserved Proteins: The structure of insulin is highly conserved in vertebrates, with little change over millions of years.

Molecular Clocks: Refers to the difference that can be accrued in DNA sequences of species used to estimate the time since their last common ancestor.

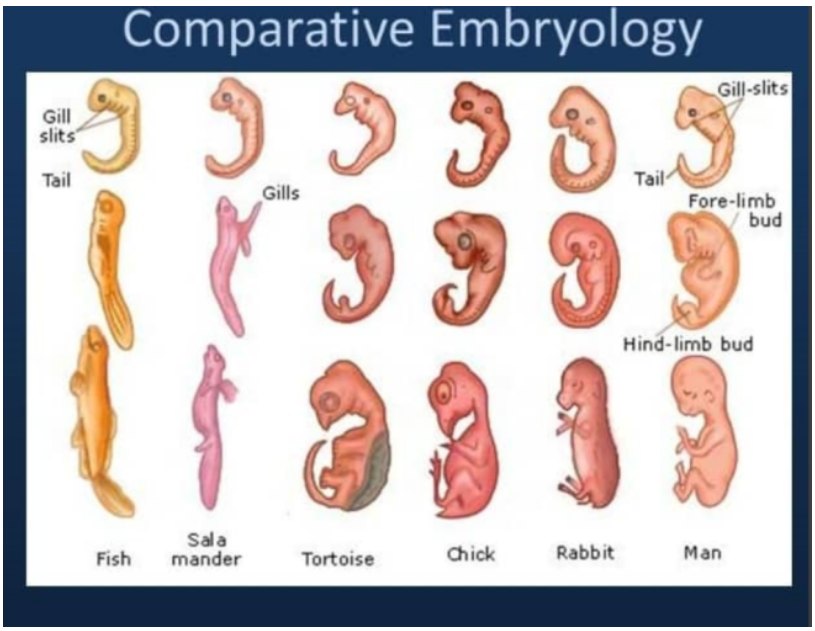
✓ **Importance of Comparative Biochemistry and Cell Biology**

It shows a molecular basis for evolution.

- Provides insights into evolutionary relationships and time of their occurrence.
- Points out universal processes that support single origin life.
- These arguments are also shown by images in some document including internal diagrams of conserved DNA sequences within protein structures and the similarities of cells across the organisms.

✓ **Comparative embryology:**

Comparative embryology basically studies the differences or similarities in the process of developing embryos across species. These highlights from inheritance and the fact that almost all other species evolve.



- **Fundamental Principles of Comparative Embryology**
  - **Similar Embryonic Characters**

    There have been remarkable resemblances in the early embryonic stages among vertebrates.

    - **Example: The pharyngeal pouches (gill slits):** These are present in embryos of fish, amphibians, reptiles, birds, and mammals. They develop into gills in an accruing fish, into ear and throat structures in mammals.
    - **Post-anal tail:** Present in embryos of all chordates, retained in some species (e.g., fish, reptiles) but vestigial in humans.

- **Notochord:** A cartilaginous rod found in all chordate embryos, which develops into the vertebral column in vertebrates.

Cases of Embryonic Similarities

- **The Fish and Humans**

  In the initial development stage, both embryos contain pharyngeal pouches which eventually form into gills in fish and into parts of the ear, tonsils, and throat in humans.

- **Birds and Mammals**

  While developing limb buds from both birds and mammal embryos, homologous structures are found though these structures get modified into wings or arms respectively.

- **Reptiles, birds, and mammals**

  The embryos of reptiles, birds, and mammals contain amniotic sacs, a feature that suggests development from the common ancestor of all amniotes.

Evolutionary Insights from Embryology

- **Ancestral commonality**

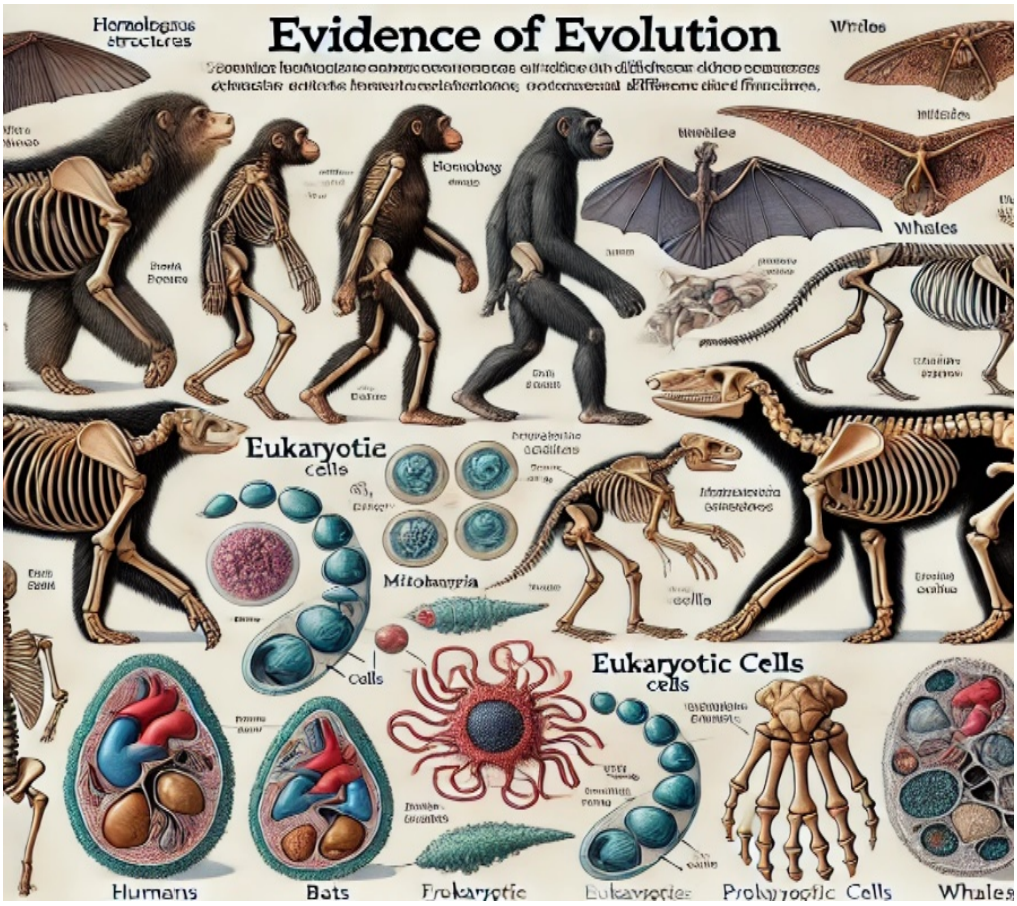
  The early embryonic stages are very much alike each other, hinting at the common ancestral lineage from which the particular organisms have emerged.

  - ***For example:*** *the occurrence of a notochord and dorsal nerve cord among chordates demonstrates that they descended from a single common ancestor.*

- **Divergence in Later Stages**

  Differences between animals can also be seen in their latter stages of development because of evolutionary divergence and show how such species were molded to their particular environment.

- **Vestigial Structures**



Certain embryological structures are superfluous in the adult organism, for example, the human tail and yolk sac. These are evolutionary vestiges.

Evidence of Modern Research

- **Molecular Studies**

Genetic or molecular studies show the occurrence of highly conserved developmental genes across all species such as gene for eye development.

- **Comparative genomic analysis**

The comparisons on DNA show that genes involved in the early development are common to many different species, thus supporting common ancestry.

Significance of Comparative Embryology

Demonstrates the existence of such common embryonic origins from which all different organisms follow a more or less similar developmental process.

Shows how modification of the developmental genes as an evolutionary process leads diversity in the adult form but retains similarities in embryos.

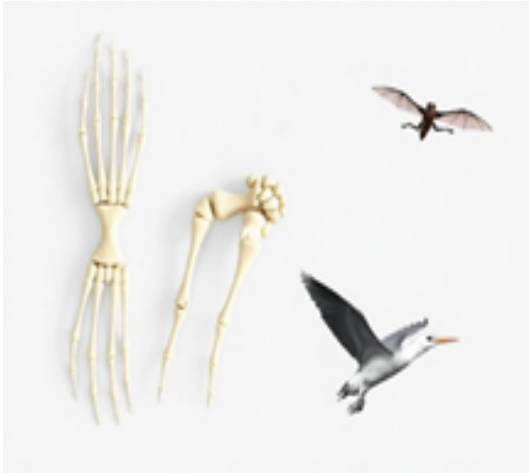
It gives us a glimpse of our evolutionary past, revealing features that connect today's species with their ancestors.

✓ **Comparative anatomy:**

Comparative anatomy provides a good amount of evidence for evolution by highlighting the structural and functional similarities among diverse organisms about their shared ancestry.

Comparative Anatomy.

Comparative anatomy examines the physical structures of organisms in order to reveal their evolutionary relationships.

Physical Structures	Description Features	Examples
Homologous Structures	Structures that have similar anatomy but different functions derived from a common ancestor.	 The forelimbs of vertebrates- humans (grasping), bats (flying), whales (swimming), and birds (flying)- show the same bone arrangements (humerus, radius, ulna, carpals, metacarpals, phalanges) despite their specialized uses.

Analogous Structures	Structures which have the same function but are different with reference to their anatomical origins, evidence to convergent evolution.	 Wings of insects, birds and bats are analogous, adapted for flight and developed independently from each other.
Vestigial Structures	Remains of organs that were reduced or non-functional in most modern species which in ancestral ones were functional.	the vestigial signs of evolution over time include the human appendix, whale pelvic bones
Embryology	Common ancestry is evident in similar embryonic stages in vertebrates.	  During embryonic development, fish, reptiles, birds, and mammals all have pharyngeal pouches which become gills in fish and parts of the ear in mammals.

✓ **DNA evidence:**

DNA evidence is one of the most significant examples for evolution. When scientists compare the genetic material of various species, they can find a pattern underlying the similarity or divergence of the species.

Key Concepts of DNA Evidence for Evolution

1. **Universal Genetic Code**
   - All living organisms share the same code of genetics: DNA is transcribed into RNA, which is translated into proteins.
   - The codons-three base sequences that specify an amino acid to be added to a growing polypeptide chain-are universal for all life.

   Significance: It may suggest that all forms of life have a common origin.

2. **Genetic Similarities (Homology)**
   - The closely related species have the more similar DNA sequence as compared to the less closely related species.

3. Conserved Genes

- Certain genes are preserved almost unchanged across very different species because their functions are so fundamental (e.g., genes for basic cellular processes).

Example: The gene for cytochrome c, an enzyme responsible for cellular respiration, is stringently conserved from humans to yeast. Individual minor variations in that gene correspond to evolutionary relationships.

Importance of DNA Evidence

- Offers a benchmarked and quantifiable way of following the lines of evolutionary relationship.
- Proves the hypothesis made in fossil records, comparative anatomy, and embryology.
- Discovers concealed changes in evolution, like gene duplications, mutations, and the like, which are not manifested in corporeal traits.
- DNA evidence closes the other dimensions of revolutionary proof into a coherent base for a common ancestry and an active process called evolution.

Activity 2: Guided practice

Task 3:

Scenario 1: Understanding the Origin of Life and Evolutionary Theories (Exploring the Mystery of Life's Beginnings)

Sandra work as a researcher team at MRC (Munini Research center) She is requested to prepare for the national science fair-an educational exhibition "Origin of Life and Evolution". The exhibition illustrates this very complex theme to the many audiences such as students, parents, and educators. Design an interactive evidence-based presentation relevantly staged and inscribed with major theories and evolutionary evidence.

Key objectives:

- **The origin of life under scientific theories:**
    - *Abiogenesis, (chemical origin of life).*
    - *The Primordial Soup Hypothesis, that is, the Miller-Urey experiment.*
    - *The RNA World Hypothesis.*
- **Theories of evolution include:**
    - *Darwin's Theory of Natural Selection.*
    - *Lamarck's Theory of Inheritance of Acquired Characteristics.*
    - *The Modern Synthetic Theory of Evolution- integration of genetics.*
- **Present evidence supporting evolution:**
    - *Fossil evidence.*
    - *Comparative anatomy, e.g., homologous and vestigial structures.*
    - *Molecular biology, e.g., protein and DNA similarities.*
    - *Evidence from Biogeography.*

Required:

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:

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

Activity 3: Application

Task 4: Building Evolutionary Timelines

Produce a timeline that marks important events in the birth of life, and in evolutionary history, such as abiogenesis, multicellularity and major evolutionary transitions illustrate these events with the available materials, and then answer the question below:

Questions:

1. What is the significance of homologous structures in understanding evolution?
2. How does the fossil record provide evidence for the theory of evolution?
3. Why the universal genetic code is considered strong evidence for a common origin of life?
4. Describe how natural selection drives evolutionary change in populations.
5. What role did endosymbiosis play in the development of complex cells?

Topic 1.2: Description of Human evolution and Present-day evolution

Activity 1: Problem Solving

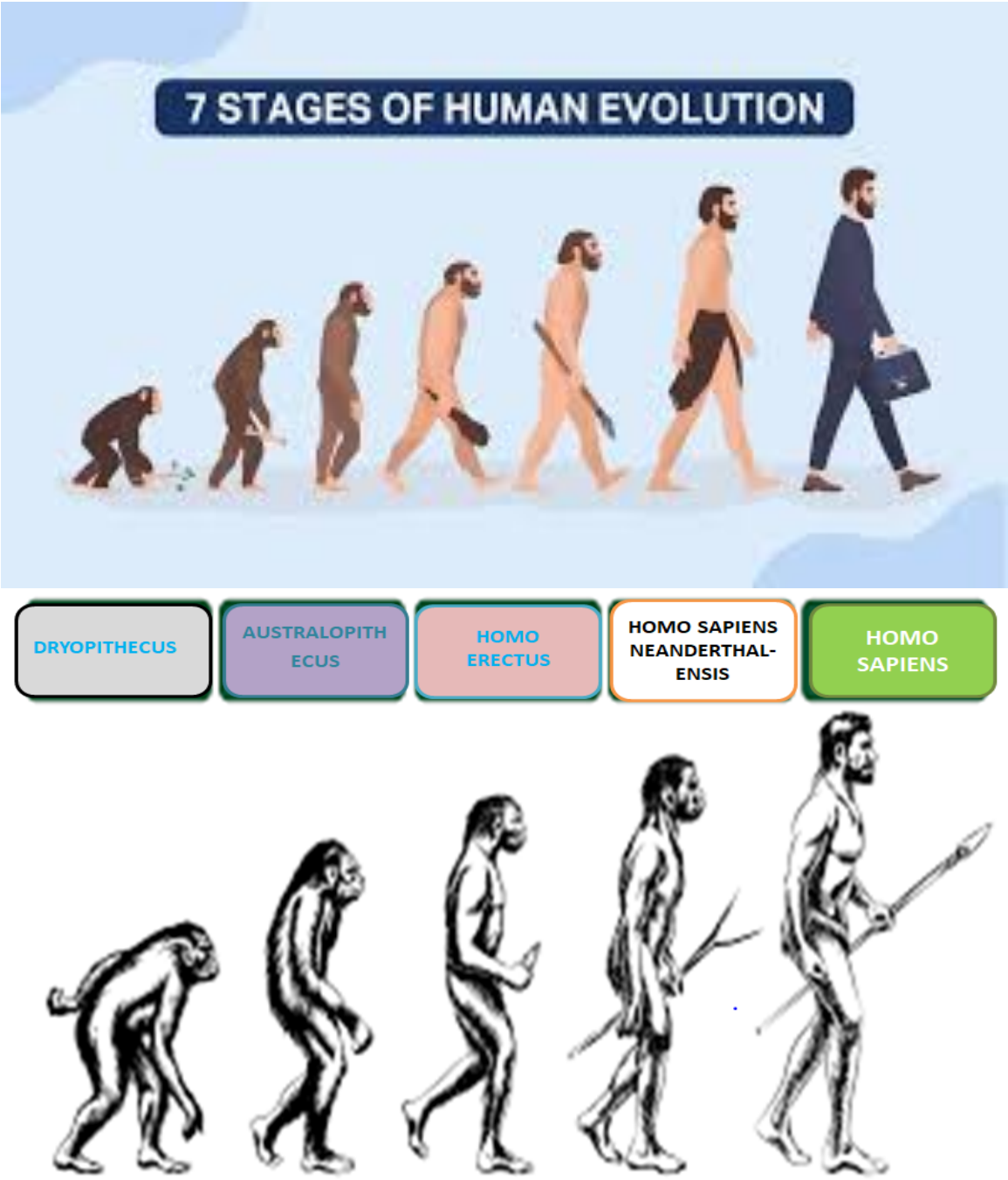
Task 5:

Apparently, humans cross the million years evolved from their ape ancestors, proven by fossils, DNA, and various other cultural artifacts that bring many generations of changes leading to the very modern form of Homo sapiens. Evidence and mechanisms of evolutionary change will be critically analyzed by students in order to answer questions regarding ancestry tracing, understanding the sense of natural selection, or interpreting fossil evidence to identify ancestral features. By using your past understanding on Human creation History answer the following questions:

1. How do scientists use fossils to trace the evolutionary history of humans?
2. What similarities and differences exist between modern humans and our closest primate relatives?
3. What evidence supports the theory that humans and chimpanzees share a common ancestor?
4. How did the development of bipedalism influence early human lifestyles and survival?

Key Facts 1.2 Description of Human evolution and Present-day evolution

- **HISTORY OF HUMAN EVOLUTION**



The human beings on this planet from extinct primates are popularly termed "human evolution.

Homo sapiens represent culture-bearing, upright-bipedal, terrestrial, and, most probably,

the first evolved instance about 315,000 years ago on the soil of Africa.

Today, we are the single living member of the genus Hominini, which commonly refer to as the human tribe. There is much fossil evidence that other hominins, like Australopithecus, as well as various species of Homo, have preceded us for millions of years, even that our species lived for a while together with at least one other member of its genus, H. neanderthalensis-the Neanderthals.

The history of human evolution traces the lineage of humans back to a common ancestor shared with great apes (chimpanzees, bonobos, gorillas).

✓ **Key events in Human history include:**

a). **Divergence from a common ancestor:** Human ancestors diverged from the chimpanzee lineage around 6-7 million years ago.

b). **Development of bipedalism:** One of the earliest traits distinguishing human ancestors was the ability to walk upright on two legs, which allowed for more efficient locomotion.

c). **Brain expansion:** Over time, early humans developed larger brains, which led to more advanced tools, social behaviors, and cultural practices.

d). **Migration out of Africa:** Homo sapiens originated in Africa and then migrated to other parts of the world, interbreeding with another hominin species such as Neanderthals.

• **STAGES IN HUMAN EVOLUTION AND THEIR CHARACTERISTICS**

The evolution of the human species from early bipedal hominids has been characterized by progressive increases in the average brain size and improvements in tool usage as well as the development and use of culture and behavioral norms with further steps toward the modern and complex societies of Homo sapiens.

✓ **DRYOPITHECUS**

An extinct genus that lived in the Miocene epoch approximately 12 to 9 million years ago. This genus is an essential part of the evolutionary tree, as it is thought to be the ancestor of modern apes (chimpanzee, gorilla, and orangutan) and man.

Characteristics of Dryopithecus

- **Physical Features:**
  - *Such as living in trees outside that are medium in size.*
  - *Possesses long arms and curved fingers that enable brachiation (swinging from tree to tree).*
  - *Most probably had grasping hand structure.*

Skulls and teeth:

- *Dentition indicates consumption of fruits and leaves.*
- *Canine teeth are typical for such early apes-were highly pronounced.*
- *Possesses quite small brains ad compared to modern apes.*

Lifestyle:

- *Arboreal but sometimes also walked terrestrially.*
- *Inhabited warm, densely forested regions of Europe, Africa, and Asia.*
- *Most probably lived in some sorts of social groups like other modern apes.*

Evolutionary Importance:

- *Part of the ancestral line that leads to today's great apes and humans.*
- *Fossils of Dryopithecus fill the evolutionary gap between early apes and later hominins.*

- **Fossil discoveries:** Dryopithecus fossils are mainly found in Europe such as France, Spain, and Hungary. They give credence to the environmental conditions of Miocene apes and their adaptations to the environment.

✓ **RAMAPITHECUS**

The extinct primate genus Ramapithecus existed from 12 to 8 million years ago during the Miocene epoch. Once thought to be directly linked to the ancestry of humans, its classification has been revised on the basis of the new evidence linking it with the evolutionary lineage of the modern great apes, mainly orangutans.

- **Characteristics of Ramapithecus**

  Physical features smaller body size compared with today's apes Dental and jaw structure suggested a diet composing fruits and tougher vegetation, thus indicative of being adaptable. Semi-bipedal posture was postulated but it hasn't yet been confirmed.

- **Skull and teeth:** Reduced canine size compared to earlier apes similar to modern human's thick tooth enamel correlating to hard or coarse food consumption. Shorter face than most other co-existing apes, indicative of evolutionary improvements.

- **Life Style:** Woodland or savanna dwelling species, changing from completely forest habitation. Probably arboreal (Inhabiting in trees), but sometimes moving on ground. Fossil Discoveries

The first discovery of Ramapithecus fossils happened in the 1930s from the Siwalik Hills of North India, with additional findings in Pakistan and Africa. Dissecting fragments included parts of jaws and teeth, which led the general supposition of some connection to being closer to humans at the beginning.

✓ **AUSTRALOPITHECUS**

It is a genus of early hominids. They were prevalent in Africa about four million to two million years ago. This is an important stage on the evolutionary path of mankind. Australopithecus is a very early member bridging early apes with the genus Homo. Australopithecus has had more fossil discoveries and is most probably for this reason one of the best-known ancestors of humans.

Characteristics of Australopithecus

- ***Bipedalism:*** *Fully adapted for walking in upright bipedal locomotion. Retained some climbing traits, such as having long arms and curved fingers.*
- ***Brain Size:*** *Mined-sized ranging from 400-550 cm³ with a larger size than that of previous apes, though smaller than modern humans.*
- ***Physical Traits:*** *Height: Around 1.2 to 1.5 meters (4-5 ft). Weight: About 25 to 50 kg (55-110 lbs). Bear ape-like facial features with a protruding*

jaw low cranial capacity but small.

- ***Diet:*** *Diet of fruits, seeds and maybe meat. Some species, for example some Australopithecus robustus, have chewing adaptations that are particularly well-developed.*

Social behavior:

Probably lived in small groups. There is no evidence to show that they were capable of advanced tool usage, although at least some of these species are likely to have used simple forms of objects for performing tasks.

Feature Representing the Genus Australopithecus

- ***Australopithecus afarensis (3.9–2.9 million years ago):*** *The famous fossil 'Lucy' discovered in the modern Ethiopian area. Most widely studied species presenting compelling evidence of being bipedal.*
- ***Australopithecus africanus (3–2 million years ago):*** *Found in South Africa, for example, Taung child, having made slight increases into brain capacity and relatively human-like teeth.*
- ***Australopithecus anamensis (4.2–3.9 million):*** *It was the oldest of the genus and transitioned to earlier apes, and then A. afarensis.*
- ***Australopithecus robustus (2-1.2 million****): Robust, with large jaws and teeth for heavy chewing. Presumably a side branch of human evolution.*
- ***Australopithecus sediba (1.98 million years ago):*** *Possibly a transitional species due to its characteristics being trait of both Australopithecus and Homo.*

Significance in Human Evolution

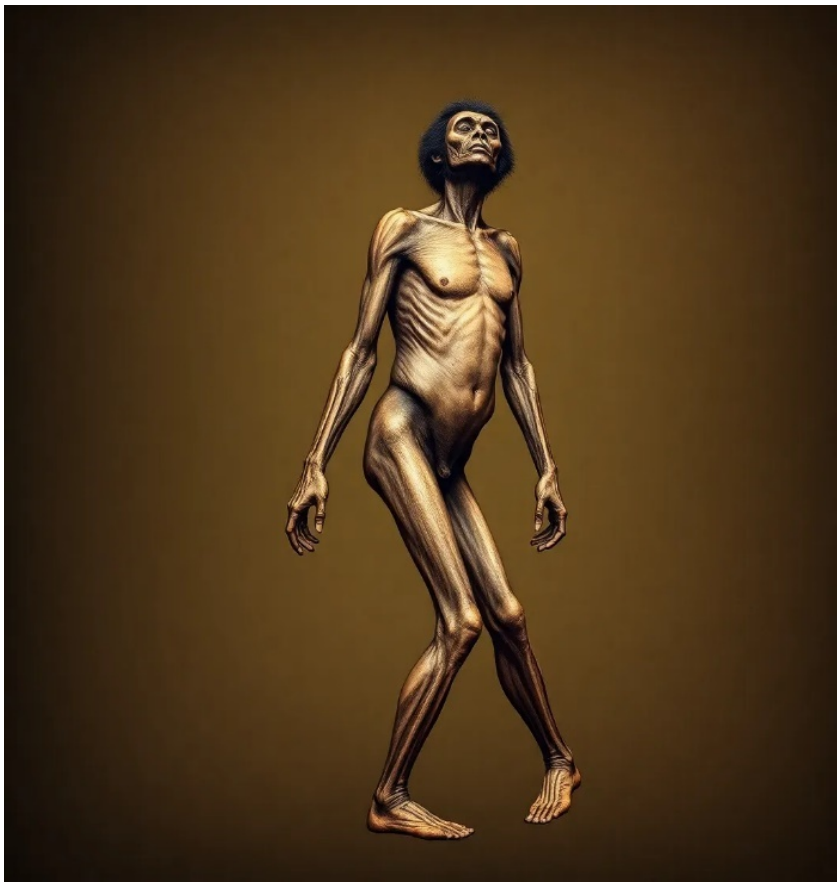
- Australopithecus shows the first stages of bipedalism, one of the characteristics of humans.
- Skeletal remains of these hominins are a crucial information for understanding how their ancestors adapted to arboreal (inhabiting trees) and terrestrial environments.

- It is not an ancestor of modern humans, but it is an important link in our evolutionary chain from Homo erectus onward to Homo sapiens.

Fossil Discoveries

- Hadar in Ethiopia, Laetoli in Tanzania, and Sterkfontein in South Africa are famous sites.
- Tracks at Laetoli have been identified as direct evidence for bipedal locomotion.
- The remains discovered in 1974, "Lucy," remains one of the most celebrated fossils, casting rays upon the morphological characteristics and lifestyle of Australopithecus.

✓ **HOMO ERECTUS**



The man turned upright **Homo erectus** ("upright man") is an extinct species of early

humans that lived from just over 1.9 million years ago until around 110,000 years ago. Homo erectus appears to have been one of the most successful and widely distributed hominin species by the evidence of fossils found across Africa, Asia, and even Europe. Homo erectus signifies an important link in the human evolutionary narrative, with dramatic changes in tool use, social behavior, and migration.

- **Characteristic Features of Homo erectus**

  - ***Bipedality:*** *Fully upright, the ability for long-distance walking. Adopted for a life in wide-open grasslands and savannas.*
  - ***Brain Size:*** *Between 600 and 1,100 cm^3, considerably larger than the earlier hominins Australopithecus and Homo habilis Thus, better problem-solving and social coordination were enabled.*

- **Physical Features:**

  - *Height: About 1.5–1.8 meters (5–6 feet).*
  - *Build: Lean, muscular body adapted to hot climates.*
  - *With prominent brow ridges and a low, elongated skull.*

- **Tool-using:** Manufactured more advanced stone tools (namely Acheulean tools) like hand axes. Tools were more sophisticated and standardized than those of earlier species.
- **Of Fire:** The First hominin species to grasp fire domestication which provided warmth, protection, and cooking food.
- **Diet:** This was an omnivorous species. Evidence shows that its diet most likely included increased meat intake. Hunted and scavenged single-handedly for food.
- **Social Behavior:** Live in groups, indicating behavior similar to cooperating ones.

  In-the-end of communication which was probably very rudimentary, but likely lacking any full language.

- **Fossil Records:**

  - Java Man (1891): Found in Indonesia, one of the earliest fossils described as Homo erectus.
  - Peking Man (1920s): Remains discovered in Zhoukoudian, China, gave

evidence of fire use.

- Evidence from Africa (like Turkana Boy discovered in Kenya) suggest that it is from Africa that Homo erectus later diverged into the rest of the world.

Its historical manhood as well as primitive significance in human evolution

- *Homo erectus was the first hominin to migrate outside Africa and reach as far as Asia and Europe.*
- *Some steps that are foregrounded include the size of the brain, tool production, and mastery over fire.*
- *Thought to be an ancestor of later species: Homo heidelbergensis and Homo sapiens.*

Benefits (Merits)

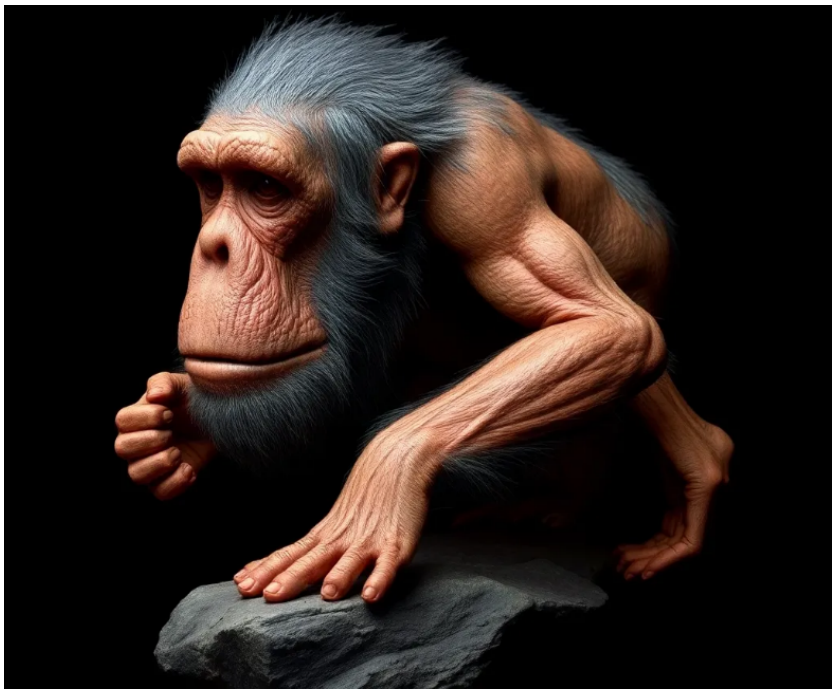
- ***Advanced Adaptations:*** *Had cultural and behavioral adaptations that improved survival.*
- ***Global migration:*** *The first of the hominin species to disperse widely, reflecting regional evolutionary pathways.*
- ***Inventiveness Technologically:*** *It is much that began developing tool-making for more than one million years.*

Cons (Demerits)

- *Cognition Restriction: Their brain was smaller than that of modern man and though it was advanced, it was limited in scope. This prohibits complex languages from being formed, and also curtails abstractions.*
- *Extinction: Finally, even as they thrived, Homo erectus also vanished, perhaps due to competition with better-adapted future hominin species, like Homo sapiens.*

One of the primary characters is definitely Homo erectus about the evolutionary history towards modern humans-a crucial turn in terms of physical and cultural evolution.

✓ **HOMO SAPIENS NEANDERTHALENSIS (NEANDERTHALS)**



Homo sapiens neanderthalensis, popularly known as Neanderthals, is an extinct sub-species of men that lived between about 400,000 to 40,000 years ago. Neanderthals are still closely related to modern humans (Homo sapiens sapiens), sharing a much-recent common ancestor with them diverging from one another around 600,000 years ago. Usually, these early men occupied Europe and western Asia during the Ice Age. Neanderthals were hardy and had undergone further adaptations in cold climates, with a cultural feature as well as physical traits that best defined their species.

Characteristics of Neanderthals

- **Physical Attributes:**
  - ***Build:*** *Robust, stocky, muscular body, suited for cold climate.*
  - ***Skull Features:*** *Low elongated skull; prominent brow ridges; large nasal cavity for warming air.*
  - ***Brain Volume:*** *Average brain capacity (~1,450 cm³), but larger than*

modern humans, different organization.

- **Cultural Traits and Behavior:**
  - *Their tool-making skills evidenced by the Mousterian tools, which were from stone flakes.*
  - *Evidence of fire use for cooking, warmth, and protection.*
  - *Had symbolic behavior, such as burials, and possible use of pigments for body decoration.*
- **Eating and Living:**
  - Omnivorous but it actually depended primarily on hunting the big Ice Age animals.
  - Caves were their home, and they had open-air shelters.

Society: Lived in small, cooperative groups.

- *These groups also presumably took care of their injured or elderly members, suggesting some level of social cohesion and possible empathy.*

Language and Communication:

- *Most likely had the ability to speak given the presence of a gene associated with human language (the FOXP2 gene) and the structure of their vocal tract.*

Fossil Discoveries

- *The Neander Valley, Germany (1856): The first fossil identified as Neanderthal.*
- *Shanidar Cave, Iraq: Evidence of burial possibly with flowers.*
- *La Chapelle-aux-Saints, France: Near-complete skeleton with robust features.*

Interaction with Modern Humans Interbreeding

- *DNA analysis gives evidence whose modern human beings non-African*

inherit 1-4% of their genome from Neanderthals proving that cross-breeding was involved in the process.

- *Competition and extinction: Neanderthals are not parts as competitive modern humans were for resources, possibly serviceable, but rather competitive-organism extinction.*
- *Importance to Human Evolution:*

Fittingness: Neanderthals perfectly adapted to cold climates show human versatility.

- ***Technology and Culture:*** *Their tools and cultural practices make them Harvard educated in archaic humans.*
- ***Inheritance:*** *The modern man has inherited from them genetic contributors to the immune system and dermal pigmentation.*

Merits (Advantages)

- ***Top-Notch Instruments:*** *Neanderthal culture had made fine instruments for their multidimensional uses.*
- ***Symbolism and Rituals:*** *Some burials and putative art reveal abstract thinking and complex social behavior.*
- ***Environmental Adaptation:*** *Physiology suited them to withstand Ice Age conditions.*

Disadvantages (Demerits)

- ***Few Innovations:*** *Just like modern humans, technologies and tools do not change with time.* ***Vulnerable People:*** *Small and isolated populations made them vulnerable to competition and environmental changes.*
- ***Extinction:*** *Neanderthals were adaptable, but they eventually went extinct about 40,000 years ago. Neanderthals constitute a very important chapter in the story of human evolution. They illustrate how humans diversified and adapted and then eventually molded their course towards*

modernity.

✓ **HOMO SAPIENS SAPIENS**

The term 'Homo sapiens' refers to the subspecies of humans in modern civilization. the evolutionary progress of intellectual specialization which made modern humans so distinct from earlier human species like Neanderthals and Homo erectus. The "sapiens" segment denotes either "wise" or "knowing." Thus, this classification would fit the reality of the fact regarding our much-advanced cognitive ability in comparison with other animals.

Characteristics of Homo Sapiens Sapiens

- **Anatomical Modality:**
  - *Small and rounded skull in comparison with the earliest hominins.*
  - *Flat face with smaller brow ridges along with chin prominence.*
  - *A body that became adapted for upright walking and tool usage.*
- **Behavioral Modality:**
  - Highly sophisticated cognition that involves complex language, abstract thinking and cultural expression.
  - Uses tools, art and symbolic thought.
  - Agriculture, urbanization and an advanced technology were developed.
- **Evolutionary Context:**
  - Is thought to have appeared in Africa about 200,000 to 300,000 years ago.
  - Overcame or else fused with other hominins such as Neanderthals (Homo sapiens neanderthalensis) and Denisovans.
- **Global Disperse:**
  - It migrated out of Africa in waves to populate all continents except Antarctica.
  - They adapted to the different environments through cultural and technological innovations.

- **PRESENT-DAY EVOLUTION CONCEPT DEFINITION**

Evolution in the modern context refers to the **gradual change in the genetic makeup of a population over time**. While natural selection remains an important mechanism, modern influences such as technology, medicine, and culture also play a significant role. This change leads to the emergence of new species and the extinction of others

✓ **Present-Day Evolution Concept Definition**

Natural Selection:

Natural selection is one of the basic mechanisms of evolution. Organisms with advantageous traits are more likely to survive and reproduce and thus pass on those traits to their offspring. In this process, it is a story of survival of the fittest.

Natural Selection Action:

- **Variation:** Individuals in a population differ from one another in their traits, that is, there is genetic variation. This variation can occur due to mutation or genetic recombination.
- **Selection:** Such traits turn out to be more advantageous than the other ones as the environment puts pressure on such individuals: changes in environment, predation, or competition over resources benefit them. Over time, if individuals reproduce those whose characteristics are advantageous, the offspring tend to inherit those favorable characteristics.

- **Adaptation:** Over time, the proportion of advantageous traits is likely to increase in a population's genome, which will eventually adapt to the environment.

✓ **Modern Examples of Natural Selection include:**

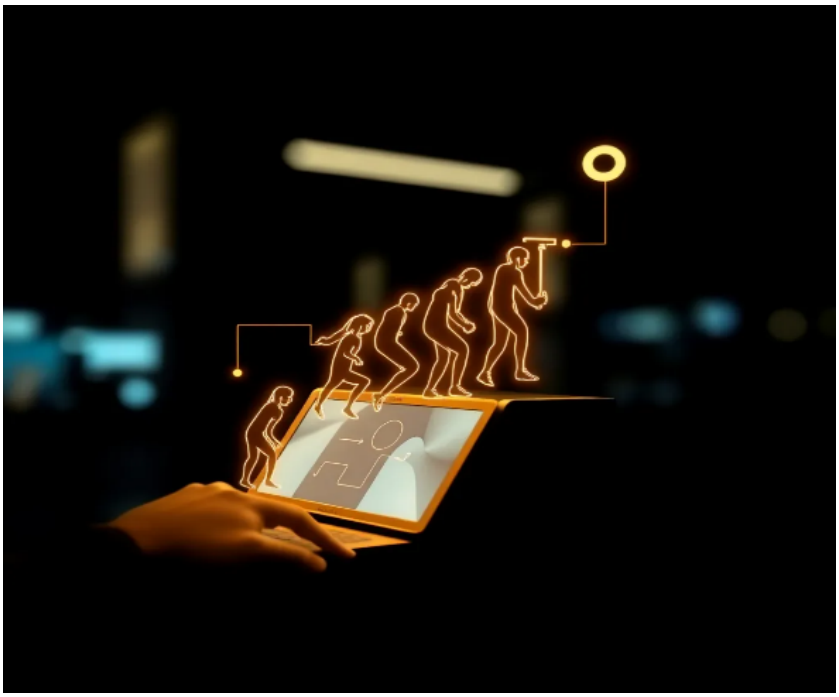
- **Antibiotic Resistance:** Bacteria tend to develop resistance to antibiotics by means of natural selection. Random mutation confers some resistance to one bacterium among many others. When that bacterium comes into contact with antibiotics, it will survive and reproduce, increasing the number of antibiotic-resistant strains.
- **Insect Pesticide Resistance:** Similarly, one type of pest with the desired pesticide resistance will survive the exposure, and from there, it will reproduce and pass this gene on to the next generation.

✓ **Mutation**

Mutation stands for a change or alteration in the organism's DNA sequence. Mutation is one of the most important mechanisms through which evolution occurs. It is thought that changes may be spontaneous during DNA replication or may be due to an environmental condition like radiation or chemicals. Today continues to be a critical venue, in which mutation operates, being one of the major agents of genetic diversity and adaptation in humans or other organisms.

- **Types of Mutation**
  - **Beneficial Mutations:** Provide benefit like resistance to a disease or improve adjustment to the environment.
    - ***Example:*** *Certain individuals with a mutation in one copy gene show resistance to HIV.*
  - **Neutral Mutations:** Do not have an immediate effect on fitness of an organism but may gather over generations and might become very important with change in environment.
  - **Harmful Mutations:** They give disadvantages; for example, genetic disorders and decrease survival.
    - ***Example:*** *Mutations yielding hereditary conditions such as cystic fibrosis.*

✓ **Technology**



Technology has profoundly influenced the trajectory of evolution and accelerates the pace of change and introduces new selective pressures. While these technological advancements offer immense potential for improving human life, they also raise ethical concerns and pose challenges to our understanding of evolution. As technology continues to evolve, it is essential to consider the long-term consequences of these developments on the human species.

Different ways technology is shaping our evolution:

- **Gene Editing:** Some Technologies allow precise manipulation of the human genome, potentially eradicating genetic diseases and enhancing desirable traits.
- **Biomedical Advancements:** Medical advancements enable individuals with previously fatal conditions to survive and reproduce, altering the genetic pool.
- **Reproductive Technologies:** Assisted reproductive technologies (ART) like IVF and preimplantation genetic diagnosis (PGD) allow for selective breeding and genetic engineering of offspring.
- **Information Age:** The constant influx of information and rapid technological

advancements challenge our cognitive abilities, potentially leading to the evolution of new mental skills.

- **Social media and Virtual Reality:** These technologies shape our social interactions, influencing our behavior, values, and relationships, which may have evolutionary implications.
- **Climate Change:** Climate change forces populations to adapt to new environmental conditions, potentially leading to evolutionary changes.
- **Pollution and Toxins:** Exposure to pollutants can induce genetic mutations, some of which may be beneficial or harmful.
- **Processed Foods:** The widespread consumption of processed foods can influence our metabolism and digestive systems, potentially leading to evolutionary adaptations.
- **Nutritional Supplements:** The use of supplements can alter our nutritional needs and influence our genetic makeup.
- **Reduced Physical Activity:** Increased reliance on technology can lead to decreased physical activity, potentially impacting our musculoskeletal system and overall health.

✓ **Factors influencing present-day evolution**

While the traditional mechanisms of evolution, such as natural selection, genetic drift, gene flow, and mutation, continue to shape life on Earth, several factors are accelerating and altering the course of evolution in the modern era.

1. **Traditional Evolutionary Forces**

i. ***Natural Selection:*** *This remains a fundamental driver of evolution, favoring individuals with advantageous traits that increase their survival and reproductive success.*

ii. ***Genetic Drift:*** *Random fluctuations in allele frequencies, especially in small populations, can lead to significant evolutionary changes.*

iii. ***Gene Flow:*** *The movement of genes between populations can introduce new genetic variation and alter allele frequencies.*

iv. ***Mutation:*** *Spontaneous changes in DNA sequence provide the raw material for evolution, creating new genetic diversity.*

2. **Modern Influences on Evolution**

i. Technological Advancements:

- ***Genetic Engineering:*** *Techniques like CRISPR-Cas9 allow for precise manipulation of the genome, potentially accelerating evolutionary change.*
- ***Medical Interventions:*** *Advanced medical treatments can extend lifespans and alter reproductive patterns, influencing the genetic makeup of future generations.*

ii. Environmental Factors:

- ***Climate Change:*** *Rapid climate change can exert significant selective pressures, favoring individuals with adaptations to new environmental conditions.*
- ***Pollution:*** *Exposure to pollutants can induce genetic mutations, some of which may be beneficial or harmful.*

iii. Cultural and Social Factors:

- ***Cultural Evolution:*** *Cultural practices, such as diet, lifestyle, and social norms, can influence human evolution.*
- ***Migration and Interbreeding:*** *Increased human mobility can lead to gene flow between populations, promoting genetic diversity and accelerating evolutionary change.*

3. **Unique Human Factors**

i. ***Conscious Decision-Making:*** *Humans can consciously choose mates and make decisions that impact the genetic makeup of future generations.*

ii. ***Cultural Transmission:*** *Cultural knowledge and practices can be transmitted across generations, influencing behavior and shaping evolutionary trajectories.*

Note that while technology and human intervention can accelerate evolutionary change, the underlying principles of natural selection and genetic variation remain fundamental. The interplay between these traditional forces and modern influences is shaping the course of human evolution in unprecedented ways.

✓ **Mechanisms of present-day evolution**

Present-day evolution refers to the ongoing changes in genetic and phenotypic traits of organisms due to various evolutionary forces. These mechanisms shape how species, including humans, adapt to changing environments, lifestyles, and challenges. Present-day evolution operates through multiple mechanisms, from natural forces like mutation and natural selection to human-driven processes such as artificial selection and gene editing. These mechanisms interact with modern environments, technologies, and cultural practices, ensuring that evolution remains a dynamic and ongoing process in the modern world.

1. **Mutation**

   - **Definition**: A random change in an organism's DNA that introduces genetic variation.
   - **Role in Evolution**: Mutations are the raw material for evolution, creating new alleles that may influence an organism's fitness.

   Examples in the Present Day:

   - **Disease resistance**: Mutations in the CCR5 gene offer some humans resistance to HIV.
   - **Pathogen evolution**: Bacteria develop mutations that make them resistant to antibiotics, a pressing global health concern.

2. **Natural Selection**

   - **Definition**: The process where individuals with traits better suited to their environment are more likely to survive and reproduce.
   - **Role in Evolution**: Natural selection determines which genetic variations are advantageous and become more common in a population.

Examples in the Present Day:

- **Antibiotic resistance**: Bacteria resistant to antibiotics thrive and multiply while non-resistant strains die out.
- **Adaptation to modern environments**: Traits like lactose tolerance in adults are selected in populations with a history of dairy consumption.

3. **Gene Flow (Migration)**

- **Definition**: The movement of genes between populations due to migration and interbreeding.
- **Role in Evolution**: Increases genetic diversity and spreads advantageous traits between populations.

Examples in the Present Day:

- **Human migration**: Global travel and migration mix diverse gene pools, contributing to genetic diversity.
- **Animal populations**: Wildlife corridors allow gene flow between previously isolated populations, increasing genetic resilience.

4. **Sexual Selection**

- **Definition**: A type of natural selection where traits that increase an individual's chances of mating become more common.
- **Role in Evolution**: Drives the development of traits that may not necessarily improve survival but enhance reproductive success.

Examples in the Present Day:

- **Human mate preferences**: Traits like physical appearance, intelligence, or social status can influence reproductive choices.
- **Animal displays**: Peacocks with more vibrant plumage may attract more mates, perpetuating their genes.

5. **Epigenetics**

- **Definition**: Heritable changes in gene expression caused by environmental factors rather than changes in the DNA sequence.
- **Role in Evolution**: Epigenetic changes can influence traits and be passed down to

offspring, contributing to evolutionary processes.

Examples in the Present Day:

- **Diet and health**: Environmental factors like nutrition and stress can affect gene expression, influencing health outcomes in future generations.

6. **Climate Change and Environmental Pressure**

   - **Definition**: Changing climates and environments act as new selective pressures.
   - **Role in Evolution**: Forces species to adapt, migrate, or face extinction.

Examples in the Present Day:

- **Animal adaptation**: Polar bears are adapting to changing ice patterns by hunting more on land.
- **Human evolution**: Communities in high-altitude regions have adapted to low oxygen levels.

✓ **The Relevance of Present-Day Evolution**

For Human Beings

1. **Understanding Human Origins:** Studying evolution helps us understand our origins, our place in the natural world, and our relationship with other species.
2. **Health and Medicine:**
   - ***Genetic Diseases:*** *Understanding genetic mutations can help identify and treat genetic disorders.*
   - ***Drug Development:*** *Evolutionary principles can be applied to develop new drugs and treatments.*
   - ***Disease Resistance:*** *Studying how pathogens evolve can help us develop strategies to combat them.*
3. **Human Behavior:** Evolutionary psychology helps us understand the evolutionary origins of human behavior, such as altruism, aggression, and mate selection.
4. **Anthropology and Archaeology:** Evolutionary theory is essential for understanding human history, culture, and migration patterns.

In Conservation

1. **Species Conservation:** Understanding the evolutionary history of species helps identify endangered species and develop effective conservation strategies.
2. **Ecosystem Management:** Evolutionary principles can be used to predict how ecosystems will respond to environmental changes and to develop strategies for ecosystem restoration.
3. **Sustainable Practices:** Evolutionary knowledge can inform sustainable practices, such as agriculture and fisheries, by understanding how populations adapt to changing conditions.
4. **Climate Change Mitigation:** Evolutionary studies can help us predict the impacts of climate change on biodiversity and develop strategies to mitigate these impacts.

Activity 2: Guided practice

Task 6: Description of stages involved in human evolution

Procedure:

Step1: Review Key Concepts

Briefly explain the impact of below concepts in the origin of life:

a). Natural selection

b). Mutation

c). Technological Effects

Step2: Case Study Analysis

By identifying the key evolutionary mechanisms, give one example of a case study related to present-day evolution for each of the following cases:

a). The evolution of antibiotic resistance in bacteria

b). The impact of climate change on species distribution and behavior

Step3: Relevance of Present-Day Evolution

Referrer to your experience on human evolution Explain:

a). How the concepts of natural selection, Technology and mutation apply to the genetic engineering in agriculture

b). How does the understanding of evolution impact human health and medicine?

c). What are the implications of genetic engineering for human evolution?

d). How can evolutionary principles be applied to conservation efforts?

e). What are the ethical considerations of human-induced evolutionary change?

Activity 3: Application

Task 7:

Activity 1: Nature Walk and Observation

Procedure:

1. Take a nature walk in a local park or natural area.
2. Observe different species and their adaptations to the environment.
3. Discuss how natural selection has shaped the diversity of life.
4. Create a poster or presentation for each of TWO hominid species of your choice.

Activity 2: Evolutionary Timeline

Procedure:

Refer to the poster/presentation created in previous activity extract the following key information:

- ✓ Name of the species
- ✓ Time period
- ✓ Physical characteristics
- ✓ Important tools or behaviors

1. Arrange the posters in chronological order on the timeline.
2. 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 analyze 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.

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. Fill in and complete the self-assessment table below to reassess your level of knowledge, skills, and attitudes under this unit.

   a). There is no right or wrong way to answer this reassessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

   b). Think about yourself; do you think you have the knowledge, skills, or attitudes to do the task? How well?

   c). Read the statements across the top, tut a check-in a curriculum that best represents your level of knowledge, skills, and attitudes.

My experience **Knowledge, skills and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Describe the origin of Life					
Define Abiogenesis					
Explain Primordial Soup Hypothesis					

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe Big-bang theory by explaining assumption and identify Merits and Demerits					
Describe Darwinism Theory by explaining assumption and identify Merits and Demerits					
Describe Neo-Darwinism Theory by explaining assumption and identify Merits and Demerits					
Define Abiogenesis					
Explain Primordial Soup Hypothesis					
Explain assumption and identify Merits and Demerits of Lamarckism					
Demonstrate Evidence of Evolution					
Define Paleontology					
Explain how biochemistry and cell biology are the evidence of evolution					
Describe how Comparative embryology is the evidence of evolution					

2. Fill in the table below and share results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve
1. **2.** **3.**	**1.** **2.** **3.**	**1.** **2.** **3.**

UNIT 2: DESCRIBE ECOSYSTEMS

Unit summary

This unit provides you with the knowledge, skills and attitudes required to describe ecosystem usually viewed as a dynamic community of living organisms interacting with each other and their non-living environment. Ecosystems would involve knowledge of ecological factors such as climate, water, and also sunlight as life-influencing factors. Then identify the Skills on biotic and abiotic components, analyze the energy flow, and interpret the food chain and webs. And indeed, among the most important attitudes are the nurturing of curiosity toward nature, the valuing of biodiversity, and the embracing of conservation, studying relationships between organisms in the light of symbiosis, predation, or competition really shows their interdependence. A balanced ecosystem can sustain life, as well as create the environmental platform on which the health of the environment depends; hence, it may become necessary to nurture responsible stewardship in ensuring ecological integrity and sustainability.

Self-Assessment: Unit 2

1. Look at the unit illustration in the Manuals and discuss:

   a). What does the illustration show?

   b). What do you think will be topics to be covered under this unit based on the illustration?

2. Fill out the below self-assessment. Think about yourself: do you think you can do this? How well? Read the statements across the top. Assess your level of knowledge, skills and attitudes under this unit.

   a). There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquired during the learning process

   b). Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?

   c). Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

   d). At the end of this unit, you will assess yourself again.

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain what ecosystem is all about and its importance.					
Explain ecological factors (biotic and abiotic)					
Compare and contrast food chains and food webs					
Describe the importance of biodiversity and ecological balance					

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify human activities that contribute to ecosystem degradation?					
Analyze the impacts of pollution, deforestation, and climate change on ecosystems?					
Evaluate the effectiveness of conservation strategies?					
Proposed solutions to mitigate and protect ecosystem degradation					
Illustrate environmental issues and sustainability					

Key Competencies:

Knowledge	Skills	Attitudes
Describe of the energy flows, nutrient cycles, and habitat types.	Apply environmental science to identify environmental factors	Environmental awareness and responsibility.
Explain interdependencies, and scientific inquiry.	Interpret interactions (symbiosis, competition)	Respect for ecological balance,
Define the effects of human activities on ecosystems	Generate solutions to real-world problems.	Having sense of responsibility to use scientific knowledge for the environment.
Compare biodiversity and ecosystem	Observe, and analyze complex environmental	Curiosity and appreciation to the ecosystems' conservation.

Knowledge	Skills	Attitudes
Differentiate biotic and abiotic factors and nutrient cycling.	Analyze interactions between living and non-living components.	Adaptation to the new concept

Discovery activity:

Task 8: Read this short scenario on Explanation of ecological factors and answer the following questions:

In a forest ecosystem, sunlight is the pure energy source that powers photosynthesis and nourishes plants. Soil quality is also a major contributor to plant growth. Water availability is the lifeblood itself that supports life. Temperature is a governing factor concerning the distribution of species, while air composition determines respirology. This abiotic factor works together with biotic factors which include herbivores, eating plant parts, and predators controlling population balance. water, as it irritates plants* and animals, are a few examples that do indicate how ecological factors influence ecosystems.

1. Define the terms abiotic factor and biotic factors and give three examples on each.
2. How does temperature affect the distribution of organisms?
3. Explain the role of water in an ecosystem.
4. What is the significance of sunlight as an ecological factor?
5. How does soil quality influence plant growth and the entire ecosystem?
6. How do organisms adapt to changes in their environment due to ecological factors?

Topic 2.1: Explanation of ecological factors

Activity 1: Problem Solving

Task 9:

A local community is considering building a new shopping mall on a piece of land that is currently a small forest. As an environmental scientist, you are tasked with conducting an ecological impact assessment of the proposed development. Completing this task, you will gain a deeper understanding of ecological concepts and the importance of considering environmental impacts in decision-making.

1. What type of ecosystem is present on the land?
2. What are the dominant plant and animal species in this ecosystem?
3. Identify the key abiotic factors that influence the ecosystem.
4. Describe the food web and energy flow within the ecosystem.
5. What are the potential negative impacts of the development on the ecosystem?
6. How might the development affect the local community and its residents?
7. How can we balance economic development with environmental conservation?
8. What are the long-term consequences of destroying natural habitats?
9. How can we promote sustainable development that minimizes harm to the environment?

Key Facts 2.1 Explanation of ecological factors

- **INTRODUCTION TO ECOLOGY**

Ecology is the scientific study of interactions between living organisms and their physical environment. It examines how organisms, including plants, animals, and microorganisms, relate to each other and to factors such as climate, soil, and water. Ecology also explores energy flow, nutrient cycling, and population dynamics within ecosystems. By understanding these relationships, ecology provides insights into biodiversity, ecosystem health, and the impact of human activities on the environment. This knowledge is essential for addressing environmental challenges, conserving natural resources, and promoting sustainable practices that ensure the well-being of all life on Earth.

✓ **Key terms Definition**

These are just a few of the many key terms in ecology. Understanding these terms is essential for understanding the complex interactions between organisms and their environment.

- **Ecology:** The scientific study of the interactions between organisms and their environment.

- **Population:** A group of individuals of the same species living in the same area at the same time.
- **Community:** A group of populations of different species living in the same area at the same time.
- **Habitat:** The place where an organism lives.
- **Niche:** The role and position of an organism in its environment.
- **Food Chain**: A linear sequence of organisms through which energy and matter flow.
- **Food Web:** A complex network of interconnected food chains.
- **Trophic Level:** The position of an organism in a food chain or food web.
- **Producer:** An organism that produces its own food through photosynthesis or chemosynthesis.
- **Consumer:** An organism that obtains energy by consuming other organisms.
- **Decomposer:** An organism that breaks down dead organic matter.
- **Biodiversity:** The variety of life on Earth at all levels, from genes to ecosystems.
- **Ecosystem Services:** The benefits people obtain from ecosystems, such as clean air, water, and food.
- **Ecosystem:** A biological community of interacting organisms and their physical environment.
- **Biotic Factors:** Living components of an ecosystem, such as plants, animals, fungi, and bacteria.
- **Abiotic Factors:** Non-living components of an ecosystem, such as climate, soil, water, and sunlight.
- **Energy Flow:** The movement of energy through an ecosystem, from producers to consumers and ultimately to decomposers.
- **Nutrient Cycling:** The process by which nutrients, such as nitrogen, phosphorus, and carbon, are recycled through the ecosystem.

✓ **Types of ecology**

Ecology is a broad field that can be divided into several subdisciplines, each focusing on different levels of biological organization. Through exploring these various levels of ecological organization, ecologists gain insights into the more complex interplays that would produce, in the future, conservation and management strategies for sustainable

resources. Here are some of the main types of ecology

- **Organismal Ecology:** Studies how individual organisms adapt to their environment. Investigates the relationship between organisms and their physical and biological environments. Studies individual organisms considering their behavior, physiology, and morphology.
- **Population Ecology:** Studies the dynamics of populations of a single species.
  - Examines factors affecting population size, density, growth rate, and distribution.
  - Investigates how populations interact with their environment and other populations.
- **Community Ecology:** Focuses on the interactions between different species within a community. Studies competition, predation, mutualism, and other ecological relationships. Examines the structure and diversity of communities.
- **Ecosystem Ecology:** Examines the flow of energy and nutrients through ecosystems.
  - Studies the interactions between biotic and abiotic factors in an ecosystem. Investigates how human activities impact ecosystems.
- **Landscape Ecology:** Studies the patterns and processes across landscapes. Examines how spatial patterns influence ecological processes. Investigates the effects of human activities on landscapes.
- **Global Ecology:** Examines ecological processes at a global scale. Studies the impact of human activities on the biosphere. Investigates climate change, biodiversity loss, and other global environmental issues.

• **Ecological factors**

Ecological factors are the environmental conditions that influence the survival, growth, and reproduction of organisms. They can be broadly categorized into **biotic factors** and **abiotic factors**; these factors interact in complex ways to shape the distribution and abundance of organisms in an ecosystem. Understanding ecological factors is crucial for studying the dynamics of ecosystems and addressing environmental challenges.

✓ **Biotic Factors**

Biotic factors are the living components of an ecosystem that bear on them in their survival, growth, and reproduction. It includes all plants, animals, microorganisms, fungi, and other living beings. Biotic factors form producers (plants), consumers (animals), and decomposers (bacteria and fungi) in energy transfer and nutrient cycling and in maintaining ecological balance. Interactions of the associated biotic factors include predation, competition, symbiosis, and mutualism-they are responsible for shaping the structure and dynamics of the different ecosystems.

✓ **Living organisms Relationship**

Organisms within an ecosystem interact with each other in various ways. These interactions can be beneficial, harmful, or neutral. These relationships are essential for maintaining the balance and diversity of ecosystems. They influence the distribution and abundance of species, as well as the flow of energy and nutrients through the ecosystem. Here are some of the most common types of relationships:

Symbiotic Relationships

- **Mutualism:** A relationship where both species benefit.
  - ***Example:*** *Bees pollinating flowers while collecting nectar.*
- **Commensalism:** A relationship where one species benefit, and the other is neither harmed nor benefited.
  - *Example**: Barnacles attaching to whales for transportation.***
- **Parasitism:** A relationship where one species benefit, and the other is harmed.
  - ***Example:*** *Ticks feeding on the blood of a host animal.*

Non-Symbiotic Relationships

- **Predation:** One organism (predator) kills and consumes another (prey).
  - ***Example:*** *A lion hunting a zebra.*
- **Competition:** Organisms compete for limited resources such as food, water, or territory.
  - ***Example:*** *Two species of birds competing for the same insect prey.*

✓ **Abiotic Factors**

Abiotic factors are the non-living components of an ecosystem that influence the living organisms within it. These factors shape the environment and affect the distribution, abundance, and behavior of species. They alter habitats and affect what organisms can survive and thrive in them. They have an important role in photosynthesis, nutrient cycling, and changes in environmental conditions. These abiotic factors interact with each other to create a complex environment that shapes the diversity of life on Earth.

- ***For example:*** *temperature and precipitation influence the type of vegetation that can grow in a particular region, which in turn affects the types of animals that can live there.*

Some of the key abiotic factors include **Physical Factors and Chemical Factors**:

✓ **Physical Factors**

- **Temperature:** Affects metabolic rates, distribution of organisms, and seasonal patterns.
- **Light:** Essential for photosynthesis in plants and influences the behavior of many animals.
- **Water:** Essential for life, influencing plant growth and animal survival.
- **Soil:** Provides nutrients and water for plants, and influences the distribution of organisms.
- **Air:** Supplies oxygen for respiration and carbon dioxide for photosynthesis.

✓ **Chemical Factors**

- **Salinity:** The salt concentration in water, affecting the distribution of aquatic organisms.
- **pH:** The acidity or alkalinity of soil or water, influencing the survival of organisms.
- **Nutrients:** Essential for plant growth and development.
- **Oxygen:** Essential for aerobic respiration in many organisms.

Activity 2: Guided Practice

Description of changes and characteristics of a forcing shaped freshwater pond would include that the aquatic organisms as aquatic plants rely on sunlight for photosynthesis, temperature; and pH levels that remain undecided would all affect fish and microorganisms. Oxygen depletion occurred during a heatwave where the water temperature increased and the bacteria put stress on fish. Further aluminum runoff from nearby farms initiates an algal bloom, thus decreasing oxygen levels. This entire situation describes how abiotic factors like sunlight, temperature, and water quality, plus interactions with biotic factors like algae, directly or indirectly affect the whole pond ecosystem.

Task 10: After reading the above scenario regarding the concept of ecological factors and their impact on living organisms do the following assignments:

Identify biotic and abiotic factors in your school environment then presenting them to your classmates, your presentation must include the following:

- How each factor influences living organisms?
- How do abiotic and biotic factors interact to create a balanced your school ecosystem.
- What happens when an ecosystem is disrupted by human activities or natural disasters?
- How you can we protect and conserve your school ecosystems.

Activity 3: Application

Task 11: Ecological Impact Assessment of a Proposed Development

Scenario 4: A local government is considering a proposal to build a new Classroom Block in a Gardened area. As an Ecological scientist, your task is to conduct an ecological impact assessment of the proposed project through completing this task,

Step 1: In the garden ecosystem identify the following:

a). The type of ecosystem is present in the Gardened area

b). The dominant plant and animal species in this ecosystem?

Step 2: Assess Abiotic Factors:

a). Identify factors which influence the ecosystem.

b). Explain how 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). Advise the local government on how might the development disrupt the interactions between different species. (Three sentences are enough)

Step 4: Predict Potential Impacts

a). List the potential negative impacts of the classroom blocks on the ecosystem.

b). Explain clearly to the local government how the development might affect the local community and its residents.

Step 5: Propose Mitigation Strategies to:

a). Minimize the negative impacts of the development by consider strategies such as wildlife corridors, noise barriers, and pollution control measures.

Topic 2.2: Description of ecosystems

Activity 1: Problem Solving

Nyungwe Forest is a stunning example of a mountain rainforest ecosystem in Rwanda. This forest is home to a rich array of plant and animal species, including endangered primates like the chimpanzee and the golden monkey. The forest floor is covered with a thick layer of decaying plant matter, which provides nutrients for soil organisms and supports a diverse community of fungi and bacteria. The Nyungwe Forest is also home to numerous rivers and streams, which flow through the forest, providing water for the plants and animals. These waterways support a variety of aquatic life, including fish, amphibians, and invertebrates. However, the Nyungwe Forest faces threats such as deforestation, poaching, and climate change. Understanding the complex interactions between the biotic and abiotic factors in this ecosystem is crucial for its conservation and sustainable management.

Task 12: After Reading the previous short description on Nyungwe ecosystem and answer for the following Questions:

1. What is the difference between a biotic and an abiotic factor?
2. Name two major types of ecosystems.
3. What is the role of decomposers in an ecosystem?
4. Explain the concept of limiting factors in relation to productivity.
5. What is the role of sunlight in primary productivity?
6. Discuss the impact of human activities on ecosystem productivity.

Key Facts 2.2 Explanation of ecological factors

- **Definitions of ecosystem**

An ecosystem is a complex system of living organisms (biotic factors) interacting with their non-living environment (abiotic factors). These components are interconnected through energy flows and nutrient cycles.

Here are some key definitions related to ecosystems:

Key Terms	**Definitions in Ecosystem Ecology:**
Producer	An organism that produces its own food through photosynthesis or chemosynthesis.
Consumer	An organism that obtains energy by consuming other organisms
Decomposer	An organism that breaks down dead organic matter
Food Chain	A linear sequence of organisms through which energy and matter flow.
Food Web	A complex network of interconnected food chains.
Trophic Level	The position of an organism in a food chain or food web.

Ecological Niche	The role and position of an organism in its environment.
Biodiversity	The variety of life on Earth at all levels, from genes to ecosystems.
Ecosystem Services	The benefits people obtain from ecosystems, such as clean air, water, and food.
Primary Productivity	The rate at which energy is captured and stored by primary producers.
Secondary Productivity	The rate at which energy is incorporated into the bodies of consumers.
Limiting Factor	A factor that limits the growth or distribution of a population.

- **Types of ecosystems**

Ecosystems are classified based on their physical environment and the organisms they support, each type of ecosystem has unique characteristics, including its climate, soil type, and the species that inhabit it. These Characteristics comprises factors influence the energy flow and nutrient cycling within the ecosystem. shaping biodiversity and interactions within it.

✓ **Common types of ecosystems include:**

1. **Terrestrial Ecosystems:** The types of ecosystems which are predominantly found on land are called the terrestrial ecosystems. Terrestrial ecosystems cover approximately 140 to 150 million km^2, which is about 25 to 30 percent of the total earth surface area includes forests, grasslands, deserts, and tundra. Some common types are:

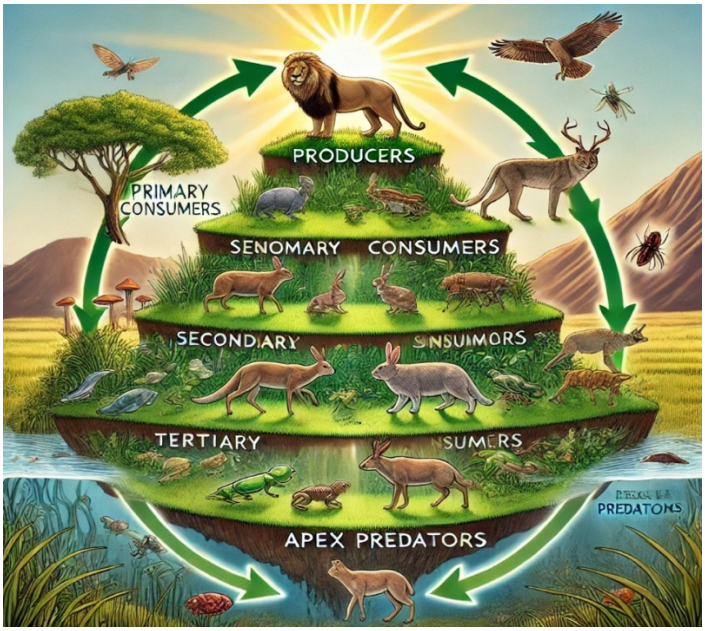
   - ***Forests:*** *Densely populated areas with trees.*
   - ***Grasslands:*** *Areas dominated by grasses.*
   - ***Deserts:*** *Dry, arid regions with sparse vegetation.*
   - ***Tundra:*** *Cold, treeless regions with low-growing vegetation.*

2. **Aquatic Ecosystems:** An aquatic ecosystem includes a group of interacting organisms which are dependent on one another and their water environment for nutrients and shelter. These ecosystems are found in water. They can be further categorized into:

   - **Freshwater Ecosystems**
     - ***Lentic Ecosystems:*** *Still water bodies like lakes and ponds.*
     - ***Lotic Ecosystems:*** *Flowing water bodies like rivers and streams.*
   - **Marine Ecosystems**
     - ***Coastal Ecosystems:*** *Near the coast, including estuaries, mangroves, and coral reefs.*
     - ***Open Ocean Ecosystems:*** *Deep-sea ecosystems and the open ocean.*

3. **Artificial Ecosystems:** An artificial ecosystem is a human-made environment that changes some aspects of natural ecosystems, but is created to serve a specific purpose or meet human needs, it is characterized by organized physical, chemical, and biological environments where biotic and abiotic components interact with each other to survive, Artificial ecosystems are not self-sustaining and can perish without human help. They also often lack the natural balance found in native ecosystems. **Examples:** Aquariums, agriculture fields, zoos, tree plantations, urban landscapes, rice paddies, cropland, and gardens

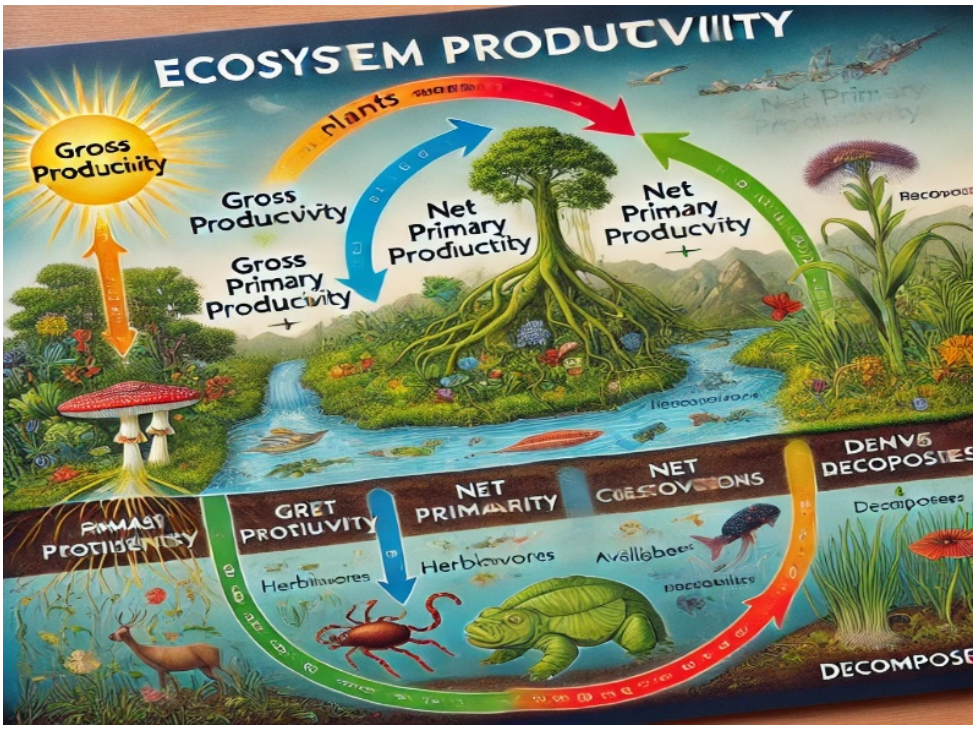
- **Trophic levels of organisms within ecosystem**



Organisms in an ecosystem are classified into **trophic levels** represent the different feeding positions in a food chain or food web. Energy flows through an ecosystem from one trophic level to the next is based on their role in the flow of energy and nutrients, these levels form the basis of food chains and webs, demonstrating energy transfer and ecological balance.

- ✓ **Producers (Autotrophs)**: Plants, algae, and some bacteria that produce energy through photosynthesis.
- ✓ **Primary Consumers (Herbivores)**: Organisms that eat producers (Plants), like rabbits or insects.
- ✓ **Secondary Consumers (Carnivores)**: Predators that eat primary consumers, such as snakes or small fish.
- ✓ **Tertiary Consumers**: Top predators that feed on secondary consumers, like eagles or sharks.
- ✓ **Decomposers (Detritivores)**: Organisms like fungi and bacteria that break down dead matter, recycling nutrients back into the ecosystem.

- **Productivity in ecosystem**



✓ **Concepts of productivity**

Refers to the rate at which energy is captured and converted into biomass by organisms. It is a critical measure of the efficiency of energy conversion by organisms. Understanding ecosystem productivity is crucial for managing and conserving ecosystems, as it provides insights into the health and sustainability of these systems. Higher productivity supports greater biodiversity and more robust ecosystems, influenced by factors like sunlight, temperature, nutrient availability, and water.

✓ **Types of Productivity**

Primary Productivity:

- **Gross Primary Productivity (GPP):** The total amount of energy captured by primary producers **(plants, algae)** through photosynthesis.
- **Net Primary Productivity (NPP):** The amount of energy stored by primary producers after accounting for energy used in respiration. This is the energy available to the next trophic level. **NPP = GPP - Respiration.**
- **Secondary Productivity:** The energy stored (incorporated into the bodies of consumers.) in consumers' biomass, derived from consuming producers or other consumers.

✓ **Factors Affecting Productivity**

1. **Climate:** Temperature, precipitation, and sunlight intensity affect the rate of photosynthesis and other biological processes.
2. **Nutrient Availability:** The availability of nutrients like nitrogen, phosphorus, and potassium limits plant growth and productivity.
3. **Water Availability:** Water is essential for photosynthesis and other metabolic processes.
4. **Soil Quality:** Soil fertility and structure influence plant growth and productivity.
5. **Herbivory and Predation:** The consumption of plants by herbivores and animals by predators can affect the flow of energy through the ecosystem.
6. **Human Activities:** Human activities such as deforestation, pollution, and climate change can significantly impact ecosystem productivity.

Activity 2: Guided Practice

Understanding ecosystem productivity and trophic levels is crucial for recognizing their role in maintaining ecological balance. Ecosystem productivity begins with producers, like plants and algae, converting solar energy into chemical energy through photosynthesis. This energy forms the foundation for trophic levels, starting with primary consumers (herbivores), followed by secondary and tertiary consumers (carnivores and omnivores), and apex predators at the top. Energy transfer between these levels decreases progressively due to energy loss in metabolic processes. Net primary productivity determines the energy available to support higher trophic levels. The interrelation highlights the importance of producers in sustaining ecosystems and the delicate balance required to maintain biodiversity and ecosystem health.

Task 13: Conclude the interconnectedness of productivity and trophic by doing the following activities:

1. Write down two reasons why does energy decrease as it moves up trophic levels?
2. Give tangible examples showing why are there fewer apex predators than primary consumers?
3. Draw a diagram of ecosystem productivity (showing primary productivity, gross productivity, and net productivity) and explain how net productivity affects the energy available for higher levels.
4. From above diagram identify the role does primary productivity play in an ecosystem?

Activity 3: Application

Task 14: Exploring Ecosystems and Ecological Principles

This task aims to develop your comprehensive understanding of ecology, ecosystem dynamics, and human impacts on the environment. So you are requested to accomplish the following assignments:

Assignment 1: Observe your school environment; identify and analyze biotic factors, abiotic factors and their interactions, after name the type of observed ecosystem, and then list its components.

Assignment 2: Create a food chain or web, labeling producers, consumers, and apex predators while illustrating energy flow and discussing energy loss at each trophic level.

Assignment 3: Explore gross and net productivity, identifying factors like sunlight or soil quality affecting ecosystem productivity. And also examine biological relationships, including predation, competition, symbiosis, and cooperation, using examples from your environment.

Assignment 4: Finally assess human impacts, reflecting on activities that affect the ecosystem positively or negatively, and propose sustainable solutions.

Note that a report featuring diagrams, examples, and observations will be submitted as the evidence.

Topic 2.3: Explanation of relationship between living organisms

Activity 1: Problem Solving

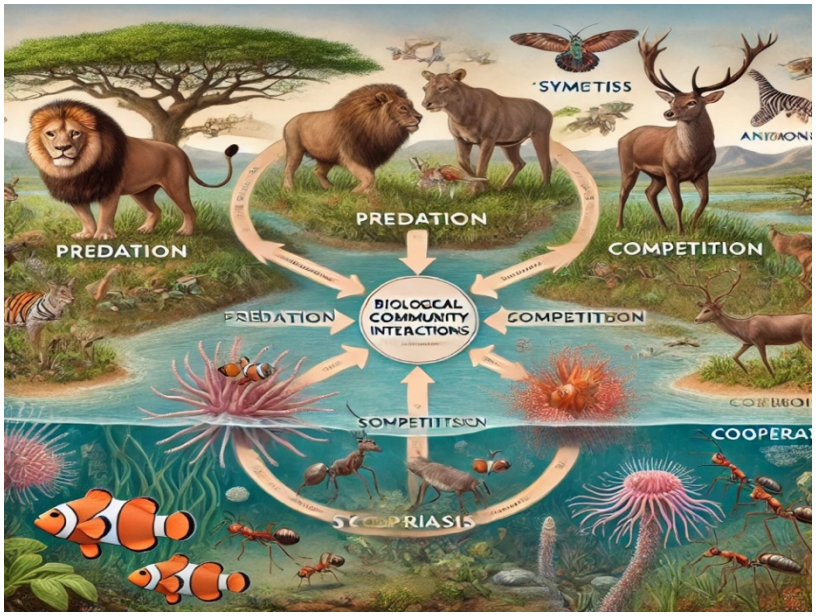
Living organisms in a biological community interact through relationships like predation, competition, symbiosis, and cooperation, which significantly affect their survival, reproduction, and population dynamics. These interactions create a balance within ecosystems, shaping biodiversity and ecological stability, demonstrating the interconnectedness of life forms and their environment.

Task 15: Discovering Questions

1. How many types of interactions among organisms you know in a biological community, what are them?
2. How does predation influence population dynamics?
3. What role does competition play in resource allocation among species?
4. Can symbiotic relationships benefit both organisms? Provide examples.
5. How does cooperation between species contribute to ecosystem stability?
6. What factors determine the nature of interactions between organisms?
7. How do environmental changes affect these interactions?
8. What is the impact of human activities on these relationships?
9. How do these interactions influence biodiversity?
10. Why are balanced interactions essential for ecosystem health?

Key Facts 2.3: Explanation of relationship between living organisms

- **Relationships Among Living Organisms in Biological Communities**



Living organisms within a biological community interact in various ways, influencing their survival, reproduction, and population dynamics. Here are some key types of relationships:

✓ **Predation:** is a biological interaction where one organism (the predator) hunts, kills and consumes another organism (the prey). This relationship is essential for maintaining ecological balance, as it regulates prey populations, prevents overgrazing or overpopulation, and promotes natural selection by favoring traits that enhance survival in both predators and prey.

- ***Examples:*** *Lion preying on a zebra, a hawk catching a mouse.*

✓ **Competition:** is a fundamental ecological interaction that shapes the structure and dynamics of ecosystems. It occurs when individuals or populations of different species or within the same species strive for the same limited resources. These resources can include food, water, space, light, mates, or any other factor essential for survival and reproduction.

- **Intraspecific Competition:** Competition between individuals of the same species. It can lead to the evolution of adaptations that reduce competition, such as territoriality, dominance hierarchies, and resource partitioning.
- **Interspecific Competition:** Competition between individuals of different species. It can have significant impacts on the distribution and abundance of species in an ecosystem. In some cases, it can lead to competitive exclusion, where one species outcompetes another, driving it to extinction or forcing it to adapt to a different niche.

✓ **Symbiosis:** a close and often long-term interaction between two or more different biological species. These relationships [1] can take various forms, with varying degrees of benefit or harm to the involved organisms.

- **Types of Symbiosis:**

1. **Mutualism:** In this type of symbiosis, both species benefit from the interaction.
    - ***Example:*** *Bees and flowers. Bees collect nectar from flowers, which they use for food, while simultaneously pollinating the flowers, aiding in their reproduction.*
2. **Commensalism:** In commensalism, one species benefits from the interaction, while the other species is neither harmed nor benefited.
    - ***Example:*** *Remoras and sharks. Remoras attach themselves to sharks and feed on scraps of food left behind by the shark, without affecting the shark.*
3. **Parasitism:** In parasitism, one species benefit (the parasite) at the expense of the other species (the host).
    - ***Example:*** *Ticks and dogs. Ticks feed on the blood of dogs, causing them harm and potentially transmitting diseases.*

Symbiotic relationships play a crucial role in shaping the structure and dynamics of ecosystems. They can promote biodiversity, facilitate nutrient cycling, and influence the evolution of species. Understanding these intricate interactions is

essential for comprehending the complex web of life.

✓ **Amensalism** is a type of biological interaction where one organism is harmed or inhibited, while the other organism remains unaffected. It's a unidirectional relationship where one species suffers, and the other experiences neither benefit nor harm.

- ***Examples of Amensalism**: **Penicillium mold and bacteria:** Penicillium mold produces penicillin, an antibiotic that kills certain bacteria, but the mold itself is not harmed.*

✓ **Cooperation:** Organisms of the same species work together for mutual benefit. is a widespread phenomenon that plays a crucial role in shaping the structure and dynamics of ecosystems. It involves interactions where individuals of the same or different species work together for mutual benefit or the benefit of the group.

- ***Examples:** Social insects like ants and bees, cooperative hunting in wolves.*

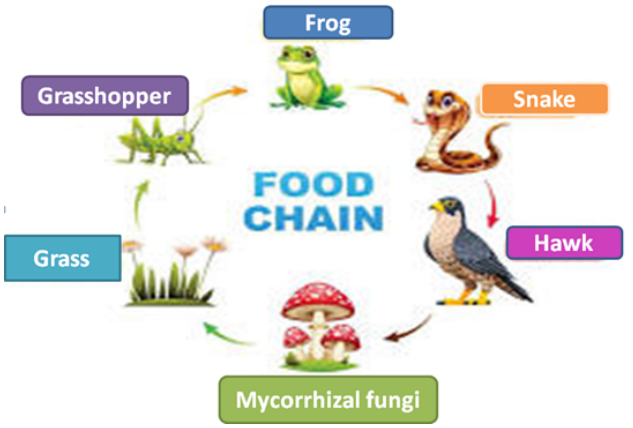
- **Energy flow in ecosystem**

Energy flow in an ecosystem is a fundamental concept, describing how energy moves through a series of organisms. This flow is unidirectional, meaning it travels in one direction and cannot be recycled within the ecosystem. The sun is the ultimate source of energy for most ecosystems. Plants, known as primary producers, capture sunlight through photosynthesis and convert it into chemical energy stored in organic molecules like glucose.

✓ **Food Chains and Food Webs**

Energy flows through ecosystems via food chains and food webs. A food chain is a linear sequence of organisms, each feeding on the preceding one. A food web is a more complex network of interconnected food chains, showing the multiple feeding relationships within an ecosystem. They depict how energy and nutrients flow from one organism to another, shaping the structure and dynamics of the ecosystem.

Food Chains: Linear Pathways of Energy

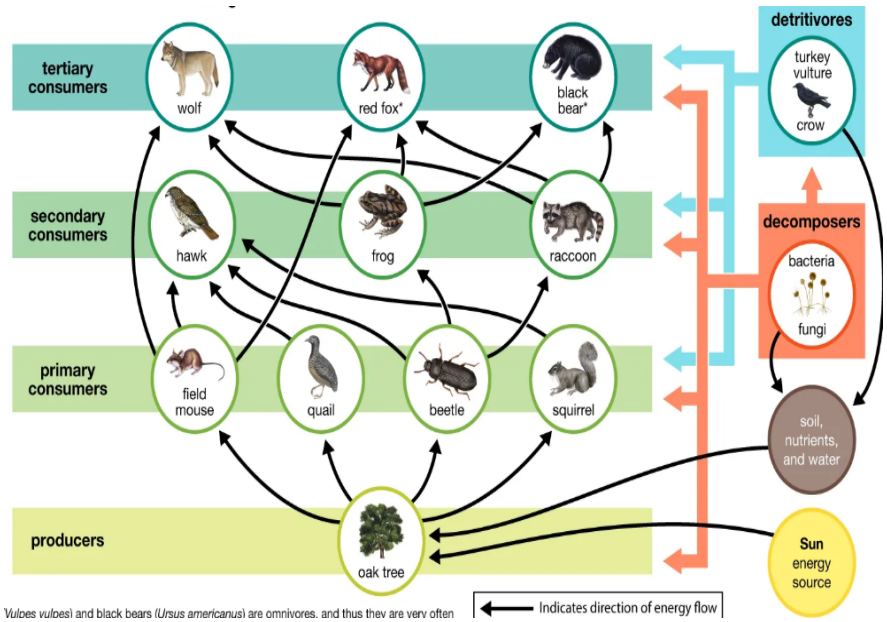


A food chain is a linear sequence of organisms, each feeding on the preceding one. It represents a simplified model of energy transfer within an ecosystem.

Food Chain: Grass > Grasshopper > Frog > Snake > Hawk

- **Producers:** At the base of the food chain are producers, primarily green plants, which convert sunlight into chemical energy through photosynthesis.
- **Primary Consumers:** Herbivores, such as rabbits or grasshoppers, consume producers and obtain energy from them.

Secondary Consumers: Carnivores that eat herbivores are secondary consumers. Examples include frogs, snakes, or small birds.



- **Tertiary Consumers:** Top predators, such as hawks or wolves, occupy the highest level in the food chain, feeding on secondary consumers.

  - **Food Webs:** Complex Networks of Interactions

    Food webs provide a more realistic representation of feeding relationships within an ecosystem. They show the interconnectedness of multiple food chains, illustrating the complex network of interactions among various organisms.

  - **Food Web:** Complex network of interconnected food chains

    In a food web, an organism may occupy multiple trophic levels, consuming or being consumed by various species. This complexity reflects the diverse feeding habits of organisms in nature.

- **Human impact on the ecosystem**

By understanding the significant impact of human activities on ecosystems and taking proactive steps to mitigate these impacts, we can work towards a more sustainable future for both humans and the environment. These impacts can be broadly categorized into several key areas:

- **Habitat Destruction and Fragmentation:**

  - **Deforestation:** Clearing forests for agriculture, logging, and development destroys habitats and disrupts ecosystems.
  - **Urbanization:** Expanding cities and infrastructure fragment habitats, isolating populations and reducing biodiversity.

- **Pollution:**

  - **Air Pollution:** Emissions from industries, vehicles, and power plants contribute to air pollution, harming plant and animal life.
  - **Water Pollution:** Industrial waste, agricultural runoff, and sewage contamination pollute water bodies, affecting aquatic ecosystems.

- **Climate Change:**

  - **Greenhouse Gas Emissions:** Burning fossil fuels and deforestation release

greenhouse gases, trapping heat and causing global warming.

- **Climate Change Impacts:** Rising temperatures, altered precipitation patterns, and ocean acidification disrupt ecosystems and threaten biodiversity.

Overexploitation of Resources:

- **Overfishing:** Unsustainable fishing practices deplete fish populations and disrupt marine ecosystems.
- **Overhunting:** Excessive hunting and poaching can drive species to extinction.

Invasive Species:

- **Introduction of Non-Native Species:** The introduction of non-native species can outcompete native species, disrupt food webs, and damage ecosystems.

✓ **Consequences of Human Impact:**

Biodiversity Loss: Habitat destruction, pollution, and climate change are major drivers of biodiversity loss, threatening the extinction of countless species.

Ecosystem Degradation: Human activities can degrade ecosystems, reducing their ability to provide essential services such as clean air, water, and food.

Human Health Impacts: Pollution and climate change can have negative impacts on human health, including respiratory problems, waterborne diseases, and heat-related illnesses.

✓ **Approach Required on Human Impact:**

Addressing the human impact on ecosystems requires a multi-faceted approach, including:

1. **Sustainable Practices:** Adopting sustainable practices in agriculture, forestry, and fisheries.
2. **Conservation Efforts:** Protecting and restoring habitats, conserving threatened species, and establishing protected areas.

3. **Reducing Pollution:** Implementing pollution control measures and promoting clean energy technologies.
4. **Climate Change Mitigation:** Reducing greenhouse gas emissions and adapting to the impacts of climate change.

Activity 2: Guided Practice

In any ecosystem, living organisms interact with each other in various ways. These interactions can be beneficial, harmful, or neutral. Understanding these relationships is crucial for comprehending the balance and dynamics of ecosystems.

Task 16: Understanding Relationships between Living Organisms by Exploring Relationships in a Local Ecosystem

Take a field trip around your school or natural area, Observe the interactions between different organisms and record observations in the notebooks, then using drawing/diagrams/illustrations describe the relationships you witness by focus on the following:

1. The different types of observed relationships between living organisms.
2. Specific ecosystem and relationships within the whole ecosystem.

Activity 3: Application

In any ecosystem, living organisms interact with each other in various ways. These interactions can be beneficial, harmful, or neutral. Understanding these relationships is crucial for comprehending the balance and dynamics of ecosystems. Imagine a savanna ecosystem in Africa. You observe the following interactions:

1. Lions hunt and kill zebras for food.
2. Giraffes and zebras graze on the same acacia trees.
3. Oxpeckers feed on ticks on the backs of zebras.
4. Tsetse flies bite and feed on the blood of zebras, transmitting diseases.

Task 17: Case Study Analysis

1. Identify the type of relationship in each of the four scenarios.
2. Explain how each relationship affects the populations of the organisms involved and the overall ecosystem.
3. Predict what might happen if one of these relationships were disrupted (e.g., if lions were removed from the ecosystem).
4. Evaluate the ability to identify and explain relationships between organisms based on the case study.

Formative Assessment

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.
26. Explain how human activities can disrupt the balance of energy flow in an ecosystem.
27. Design a simple experiment to investigate the impact of a specific abiotic factor on plant growth.
28. Design A poster illustrating the different trophic levels in a marine ecosystem.
29. Develop A short story or poem that depicts the interconnectedness of living organisms in an ecosystem.
30. Propose A solution to a local environmental problem based on your understanding of ecological principles.
31. Develop A presentation on the importance of protecting endangered species and their habitats.

Points to Remember

- **There are 4 Types of Ecology (Population Ecology, Community Ecology, Ecosystem Ecology, and Landscape Ecology)**
- **There are TWO Ecological Factors (living components "biotic factors" and non-living components "Abiotic Factors").**
- **Here are relationships among Living Organisms:(Predation, Competition, Symbiosis, Mutualism, Commensalism, Parasitism, and Amensalism)**
- **Exist 7 Types of Ecosystems(Forest Ecosystems, Tundra, Ecosystems, Desert Ecosystems, Freshwater Ecosystems, Ocean Ecosystems, Grassland Ecosystems, Alpine Ecosystems**

Self-Reflection

1. Fill in and complete the self-assessment table below to reassess your level of knowledge, skills, and attitudes under this unit.

   a). There is no right or wrong way to answer this reassessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

   b). Think about yourself; do you think you have the knowledge, skills, or attitudes to do the task? How well?

   c). Read the statements across the top, tut a check-in a curriculum that best represents your level of knowledge, skills, and attitudes.

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain what ecosystem is all about and its importance.					
Explain ecological factors (biotic and abiotic)					
Compare and contrast food chains and food webs					
Describe the importance of biodiversity and ecological balance					
Identify human activities that contribute to ecosystem degradation?					

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Analyze the impacts of pollution, deforestation, and climate change on ecosystems?					
Evaluate the effectiveness of conservation strategies?					
Proposed solutions to mitigate and protect ecosystem degradation					
Illustrate environmental issues and sustainability					

2. Fill in the table below and share results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**
3.	**3.**	**3.**
4.	**4.**	**4.**
5.	**5.**	**5.**
6.	**6.**	**6.**

UNIT 3: MECHANISMS OF ENVIRONMENTAL CONSERVATION

Unit summary

This unit provides you with the knowledge, skills and attitudes required to Describe biogeochemical cycles (through which elements such as water, carbon, nitrogen, and phosphorus) travel and transform within all Earth's systems, Explain ecosystem degradation and how to apply of environmental protection strategies within a kind of balance in ecosystems.

Self-Assessment: Unit 3

1. Look at the unit illustration in the Manuals and discuss:

   a). What does the illustration show?

   b). What do you think will be topics to be covered under this unit based on the illustration?

2. Fill out the below self-assessment. Think about yourself: do you think you can do this? How well? Read the statements across the top. Assess your level of knowledge, skills and attitudes under this unit.

   a). There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquired during the learning process

   b). Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?

   c). Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

   d). At the end of this unit, you will assess yourself again.

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe the Biogeochemical cycles?					
Explain Process of Water, carbon, Nitrogen phosphorous cycles and their Effects.					
Describe Natural /ecological equilibrium concept					
Identify forms of ecosystems degradation					

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe causes of biodiversity Loss					
Demonstrate Causes of biodiversity loss					
Describe Environmental pollutions and environment sustainability compliance					
Apply Environmental conservation strategies					

Key Competencies:

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

Discovery activity:

Task 18:

Basing on your experience and by relating to the information in the above scenario below, answer the questions that follow

Consider a River in tour Home District experienced a severe drought in 2023. A team of young scientists from the Environmental Research Institute is tasked with studying its impacts. They will conduct field observations, analyze weather data, and interview local experts (farmers, fishermen, forest rangers) to assess the drought's effects on the environment. This includes monitoring water levels, plant growth, animal behavior, and the potential impacts on the water, carbon, and nutrient cycles. The goal is to understand the drought's effects on the ecosystem, empower peoples with knowledge for future droughts, and improve water resource management and environmental protection in the face of climate change.

1. Describe what a biogeochemical cycle is all about?
2. List the key stages of the water cycle
3. Explain how does the water cycle contribute to the distribution of water on Earth?
4. Explain how does carbon dioxide enter the atmosphere?
5. Explain how is carbon removed from the atmosphere?
6. Explain why is nitrogen fixation an important process in the nitrogen cycle?
7. Explain how do humans impact the nitrogen cycle?
8. Explain how does the phosphorus cycle differ from the other biogeochemical cycles?
9. Explain how might a drought affect the water cycle and the productivity in the local ecosystem?

Topic 3.1: Description of biogeochemical cycles

Activity 1: Problem Solving

Task 19:

Read and answer the following questions.

These tasks are adapted based on the specific learning objectives and the age group of the students and the accompanying tasks aim to encourage you to think critically about biogeochemical cycles, their interconnectedness, and their importance for life on Earth. And consider if you are a team of young scientists tasked with creating an educational topic for a local science museum about biogeochemical cycles. The exhibit should be engaging and informative for visitors of all ages.

1. Define biogeochemical cycles.
2. Explain the difference between the water cycle and the carbon cycle.
3. Design a simple diagram illustrating the nitrogen cycle.
4. Analyze the impact of deforestation on the carbon cycle.
5. Evaluate the effectiveness of different strategies for reducing human impact on the water cycle.
6. Develop a creative story or poem that explains the interconnectedness of the biogeochemical cycles.
7. List the key stages of the water cycle.
8. Explain the role of decomposers in the nitrogen cycle.
9. Compare and contrast the water cycle and the phosphorus cycle.
10. Assess the potential impact of climate change on the biogeochemical cycles.

Key Facts 3.1 Description of biogeochemical cycles

- **Biogeochemical cycles definition**

Biogeochemical cycle can be termed as pathways within which chemical elements and compounds move through the environment of Earth which would include living beings (bio), geological formations (geo) and also through chemical reactions.

These cycles describe how key elements such as carbon, nitrogen, oxygen, phosphorus, and water continue to be recycled and reused on the planet.

✓ **Water cycle**

The water cycle also known as the hydrological cycle is a continuous process through which water circulates within the Earth and its atmosphere.

Key term Definition:

1. **Evaporation:** The process where liquid water changes into water vapor, rising into the atmosphere.
2. **Transpiration:** The process where plants release water vapor into the atmosphere using leaves.
3. **Condensation:** The process where water vapor cools and changes back into liquid water, forming clouds.
4. **Precipitation:** The release of water from the atmosphere in the form of rain, snow, sleet, or hail.
5. **Infiltration:** The process where water soaks into the ground.
6. **Runoff:** The flow of water over the land surface, such as into rivers, lakes, and oceans.
7. **Groundwater:** Water that is stored beneath the Earth's surface in soil and rock layers.
8. **Water Vapor:** The gaseous state of water.
9. **Clouds:** Visible masses of condensed water vapor floating in the atmosphere.
10. **Precipitation:** Water released from the atmosphere in liquid or solid form (rain, snow, sleet, hail).

✓ **Process of Water Cycle**

It involves various stages**: Evaporation, Transpiration, Condensation, Precipitation, Infiltration, Percolation and Runoff.**

- **Evaporation:** Solar energy heats water from oceans, rivers, lakes, and other bodies, causing it to transform from liquid to vapor. This vapor rises into the atmosphere. The rate of evaporation depends on factors such as **temperature, wind, and surface area of the water body**.
- **Transpiration:** Plants absorb water from the soil through their roots and release it into the atmosphere as water vapor through tiny pores on their leaves called stomata. This process is driven by photosynthesis and contributes significantly to the water vapor in the atmosphere.
- **Condensation**

  As the water vapor rises, it encounters cooler temperatures in the atmosphere. The cooling causes the water vapor to condense into tiny water droplets or ice crystals, forming clouds. Dust particles in the atmosphere often serve as nuclei for condensation, facilitating the formation of clouds.

- **Precipitation**

  When the condensed water droplets in clouds grow large and heavy enough, gravity pulls them down to Earth in the form of precipitation. Precipitation can occur as rain, snow, sleet, or hail, depending on atmospheric conditions like temperature and wind patterns.

Infiltration, Percolation and Runoff

- **Infiltration:** Once precipitation reaches the ground, some water seeps into the soil. The rate of infiltration depends on the soil's permeability and saturation level.
- **Percolation:** The infiltrated water continues to move downward through soil and porous rock layers, replenishing groundwater reserves. This process plays a vital role in maintaining aquifers.
- **Runoff:** Water that does not infiltrate the ground flows over the surface as runoff. Runoff collects in streams, rivers, and eventually drains into larger water bodies like lakes and oceans. Runoff is influenced by factors such as topography, vegetation cover, and soil type.

✓ **There are other key stage necessary for water cycle**

Groundwater Flow: Some infiltrated water becomes part of underground aquifers, moving slowly through soil and rock layers. Groundwater eventually re-emerges at springs, wetlands, or directly into rivers and oceans, completing the cycle.

Sublimation: In certain climates, water can change directly from ice or snow to vapor without becoming liquid, a process called sublimation. This often occurs in high-altitude or cold regions.

The water cycle is not linear but a dynamic system. Water stages depends on environmental conditions, ensuring the continuous redistribution of Earth's water. By these interconnected processes, the water cycle sustains life, maintains ecosystems, and regulates global weather patterns.

✓ **Effects of water cycle**

The water cycle has profound effects on our planet, it is a vital process that sustains life on Earth and plays a critical role in shaping our environment and Its effects are far-reaching, influencing everything from the climate and ecosystems to human livelihoods and global water distribution.

- **Provides fresh water:** The cycle continuously replenishes freshwater sources like rivers, lakes, and groundwater, essential for human consumption, agriculture, and ecosystems.

- **Regulates climate:** Evaporation cools the Earth's surface. Condensation and precipitation release heat, influencing weather patterns. Clouds play a crucial role in regulating Earth's temperature.

- **Shapes the landscape:** Erosion and deposition of sediments by water sculpt the Earth's surface, creating valleys, canyons, and deltas. Precipitation can cause flooding, which can reshape landscapes.

- **Supports life:** Water is essential for all living organisms. The water cycle distributes water across the globe, making it available to diverse ecosystems and supporting a wide range of life.

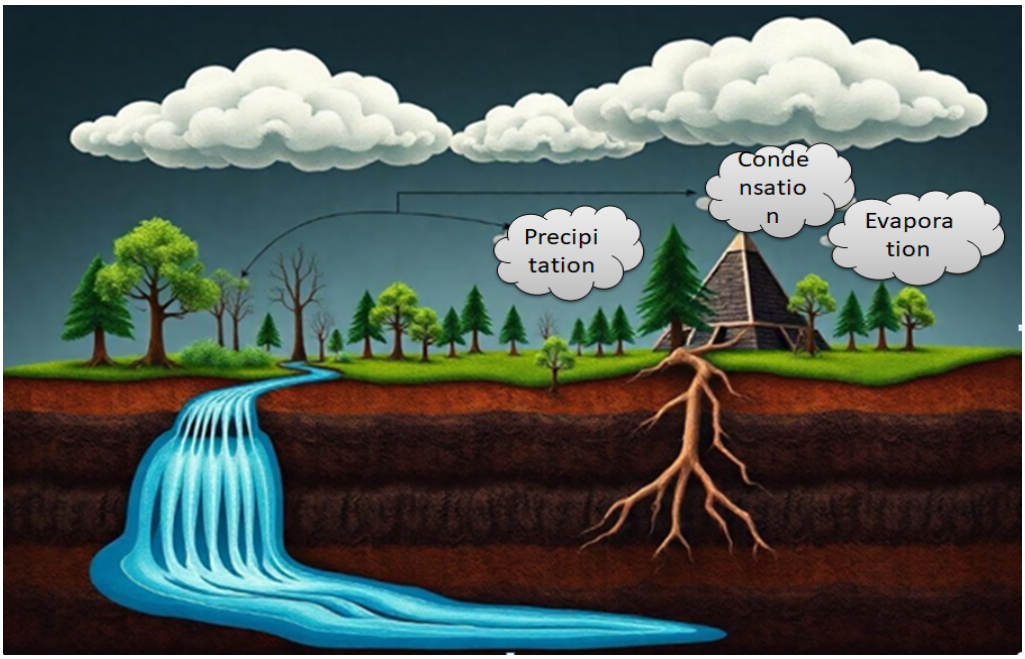
- **Human and Agricultural Impact:** Changes in the water cycle, such as reduced rainfall or prolonged droughts, directly affect agriculture by limiting water for crops and livestock.

  Industrial and urban activities depend on the predictable flow of the cycle for water supply and waste management.

- **Natural Disasters:** While beneficial, disruptions in the water cycle can lead to extreme weather events like floods, droughts, and hurricanes, causing significant environmental and socioeconomic impacts.

- **Natural Disasters:** While beneficial, disruptions in the water cycle can lead to extreme weather events like floods, droughts, and hurricanes, causing significant environmental and socioeconomic impacts.

✓ **The Carbon Cycle**



The carbon cycle is the process through which carbon is exchanged among Earth's atmosphere, oceans, land, and living organisms. It is fundamental to maintaining a balance of carbon on the planet and plays a critical role in regulating Earth's climate and supporting life. Below is an overview of the carbon cycle, its key processes, and its impacts.

✓ **Key term Definitions**

1. **Photosynthesis:** The process by which plants convert carbon dioxide from the atmosphere into organic compounds (glucose) using sunlight.
2. **Respiration:** The process by which organisms (plants, animals, and decomposers) release carbon dioxide into the atmosphere.
3. **Combustion:** The burning of organic matter (fossil fuels) that releases carbon dioxide into the atmosphere.
4. **Decomposition:** The breakdown of dead organisms by decomposers (bacteria and fungi), releasing (CO_2) into the atmosphere.
5. **Ocean-Atmosphere Exchange:** The exchange of carbon dioxide between the ocean and the atmosphere.

6. **Carbon Sink:** A natural or artificial reservoir that absorbs and stores more carbon from the atmosphere than it releases. Examples: forests, oceans, and soil.
7. **Fossil Fuels:** Coal, oil, and natural gas formed from the remains of ancient plants and animals, which contain stored carbon.
8. **Greenhouse Effect:** The trapping of heat in the Earth's atmosphere by greenhouse gases, including carbon dioxide.
9. **Carbon Sequestration:** The process of capturing and storing carbon dioxide from the atmosphere to mitigate climate change.

✓ **Processes of Carbon Cycle**

Photosynthesis

Plants, algae, and some bacteria absorb carbon dioxide (CO_2) from the atmosphere during photosynthesis. They use sunlight to convert CO_2 and water into glucose and oxygen, storing carbon in organic molecules. This process is the primary way carbon enters the biosphere.

Respiration

Living organisms, including plants, animals, and microbes, release CO_2 back into the atmosphere through respiration. By breaking down glucose for energy, they emit carbon as a byproduct.

Decomposition

When plants and animals die, decomposers like fungi and bacteria break down organic matter. This process releases carbon stored in the organisms back into the soil, where it can either remain or be converted into CO_2 and methane.

Ocean Uptake and Release

Oceans act as major carbon sinks, absorbing CO_2 from the atmosphere. Some of this carbon is used by marine organisms to form shells and skeletons, which eventually become sedimentary rock. Oceans also release CO_2 back into the atmosphere through diffusion.

Fossil Fuel Formation

Over millions of years, dead plants and animals can become fossil fuels (coal, oil, and natural gas) under high pressure and heat. These fuels store carbon in a geological reservoir.

Combustion

Burning fossil fuels for energy releases stored carbon as CO_2, a significant contributor to atmospheric carbon levels. Natural combustion, such as wildfires, also releases CO_2.

Volcanic Activity

Volcanoes release carbon from Earth's mantle into the atmosphere as CO_2 during eruptions, contributing to the geological carbon cycle.

Carbon Sequestration

Carbon can be stored in long-term reservoirs such as forests (biological sequestration), soil, and sedimentary rocks (geological sequestration), reducing its presence in the atmosphere.

✓ **Effect of the Carbon Cycle**

1. **Climate Regulation**

   The carbon cycle influences Earth's temperature by regulating CO_2 levels in the atmosphere. CO_2 is a greenhouse gas, trapping heat and contributing to the greenhouse effect. An imbalance can lead to global warming or cooling.

2. **Ecosystem Function**

   Carbon is a fundamental building block of life. The carbon cycle ensures a steady supply of carbon for the growth and energy needs of plants, animals, and microorganisms.

3. **Ocean Acidification**

   Increased CO_2 absorption by oceans leads to acidification, which can harm marine life, particularly organisms with calcium carbonate shells and skeletons.

4. **Carbon Storage in Soil**

Healthy soils store significant amounts of carbon, supporting agriculture and reducing atmospheric CO_2. Land-use changes, such as deforestation, disrupt this balance.

✓ **Human Influence on the Carbon Cycle**

Human activities, particularly the burning of fossil fuels, deforestation, and industrial processes, have significantly altered the carbon cycle. These activities release large amounts of CO_2 and methane into the atmosphere, exceeding the Earth's capacity to reabsorb them, leading to climate change and other environmental issues. Efforts like reforestation, renewable energy adoption, and carbon capture technologies aim to restore balance in the carbon cycle and mitigate its negative effects on the planet.

✓ **Nitrogen cycle**

Nitrogen is naturally converted between its different chemical forms and cycles through the atmosphere, soil, water, and living organisms-the nitrogen cycle. Nitrogen is one of the essential elements for life since it exists in amino acids, proteins, and DNA. The nitrogen cycle includes several important processes like **nitrogen fixation, nitrification, assimilation, ammonification, and denitrification,** during which nitrogen is transformed into forms that plants, animals, and microorganisms can utilize.

✓ **Key term definition**

1. **Nitrogen Fixation:** The process of converting atmospheric nitrogen into a usable form for plants, this is primarily carried out by bacteria.
2. **Nitrification:** The conversion of ammonia into nitrites and then into nitrates.
3. **Assimilation:** The process where plants absorb nitrates from the soil and use them to build plant proteins.
4. **Ammonification:** The process where decomposers (bacteria and fungi) break down dead organisms and waste products.
5. **Denitrification:** The process where denitrifying bacteria convert nitrates back into atmospheric nitrogen gas.
6. **Atmospheric Nitrogen:** The primary form of nitrogen in the atmosphere, making up about 78% of the air.
7. **Ammonia (NH_3):** A compound of nitrogen and hydrogen, form of nitrogen used by plant
8. **Nitrites (NO_2^-):** An intermediate form of nitrogen in the nitrification process.
9. **Nitrates (NO_3^-):** A form of nitrogen readily absorbed by plants.
10. **Decomposers:** Organisms, such as bacteria and fungi, that break down dead organic matter.

✓ **Process of nitrogen cycle**

The nitrogen cycle is a complex process that involves the conversion of nitrogen gas in the atmosphere into forms usable by plants and animals, and then back into atmospheric nitrogen, this continuous cycling of nitrogen is essential for life on Earth, as it ensures a constant supply of this vital element for plant growth and the functioning of ecosystems.

Here are the key stages:

1. **Nitrogen Fixation:** This is the crucial first step where atmospheric nitrogen gas (N_2) is converted into a usable form, primarily ammonia (NH_3). This process is carried out by:

2. **Nitrogen-fixing bacteria:** These bacteria live in the soil and on the roots of certain plants (legumes like beans and peas).
3. **Lightning:** The intense energy of lightning can break apart nitrogen gas molecules, allowing them to react with oxygen to form nitrogen oxides.
4. **Industrial processes:** Human activities like the production of fertilizers also fix nitrogen.
5. **Nitrification:** Ammonia (NH_3) produced during nitrogen fixation is converted into nitrites (NO_2^-) and then into nitrates (NO_3^-) by soil bacteria.
6. **Assimilation:** Plants absorb nitrates (NO_3^-) from the soil through their roots and use them to build proteins and other essential compounds. Animals then obtain nitrogen by consuming plants or other animals.
7. **Ammonification:** When plants and animals die, or when animals excrete waste, decomposers (bacteria and fungi) break down the organic nitrogen compounds into ammonia (NH_3).
8. **Denitrification:** In the final stage, denitrifying bacteria convert nitrates (NO_3^-) back into atmospheric nitrogen gas (N_2), completing the cycle.

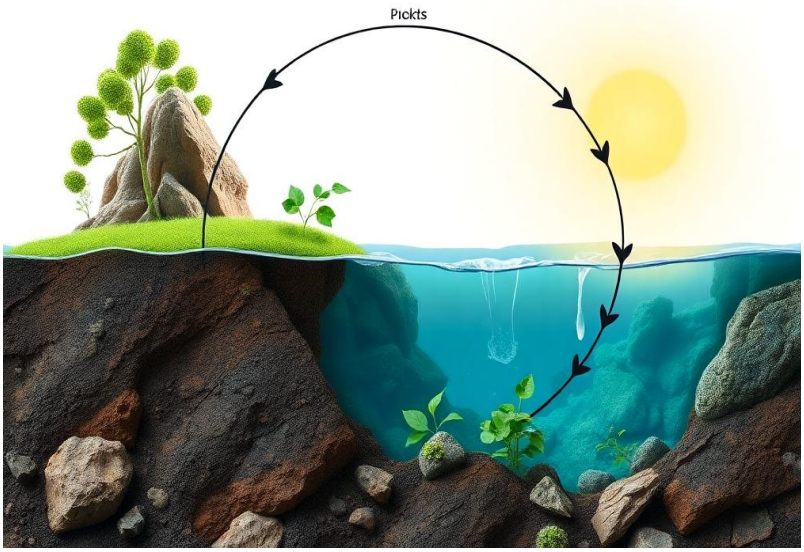
✓ **Effects of nitrogen cycle**

The nitrogen cycle has effects on the environment and life on Earth, the nitrogen cycle is a critical process for life in ensuring a continuous supply of nitrogen in usable form nitrogen for plants and animals, but human activities have significantly altered its natural balance, leading to a range of environmental and human health impacts.

- It maintains soil fertility, supports plants rely on the nitrogen cycle to obtain the nitrogen they need for growth and development and contributes to ecosystem productivity.
- **Essential for Life:** Nitrogen is a crucial component of amino acids, the building blocks of proteins, and nucleic acids (DNA and RNA), essential for all living organisms. The nitrogen cycle ensures a continuous supply of this vital element for life.
- **Food Webs:** The availability of nitrogen influences the productivity of ecosystems, impacting the entire food web.

- **Eutrophication:** Excess nitrogen from fertilizers and other human activities like fossil fuel combustion, can disrupt this cycle, leading to environmental issues causing excessive plant and algae growth (algal blooms). This can lead to oxygen depletion, fish kills, and the degradation of water quality.
- **Greenhouse Gas Emissions:** Nitrous oxide (N_2O), a greenhouse gas, is produced during certain stages of the nitrogen cycle. Increased human activities have led to higher levels of nitrous oxide in the atmosphere, contributing to climate change and can contribute to air pollution, including smog and acid rain.
- **Human Health:** High levels of nitrogen pollution can impact human health through air and water contamination.

✓ **Phosphorous cycle**



The phosphorus cycle is the movement of phosphorus through the lithosphere, hydrosphere, and biosphere. The phosphorus cycle is a slow and relatively localized cycle compared to other biogeochemical cycles like the carbon and nitrogen cycles. The atmosphere plays a minimal role in the phosphorus cycle, as phosphorus compounds do not readily enter the gaseous phase. The phosphorus cycle is crucial for maintaining healthy ecosystems and agricultural productivity.

Unlike other cycles, it lacks a gaseous phase. Phosphorus is released from rocks through weathering, absorbed by plants, transferred to animals through food chains, and returned to soil via decomposition.

✓ **Key term definition**

These terms are crucial to understanding the phosphorus cycle's role in ecosystems and its environmental impacts.

1. **Phosphorus:** A chemical element essential for life, primarily found in rocks, soil, water, and living organisms. It is a key component of DNA, RNA, ATP molecules, and cell membranes.
2. **Weathering:** The process by which rocks containing phosphorus minerals are broken down by wind, water, or chemical reactions, releasing phosphate ions (PO_4^{3-}) into the soil or water.
3. **Phosphate Ions (PO_4^{3-}):** The form of phosphorus available for uptake by plants from soil and water. These ions are soluble and essential for biological processes.
4. **Assimilation:** The process where plants absorb phosphate ions from the soil or water and incorporate them into organic molecules like nucleic acids and ATP.
5. **Decomposition:** The breakdown of organic matter by decomposers, such as bacteria and fungi, returning phosphorus to the soil or water as inorganic phosphate.
6. **Sedimentation:** The process where phosphorus in water settles as sediment, forming phosphate-rich rocks over time. This step makes phosphorus unavailable until uplift and weathering occur.
7. **Uplift:** A geological process where buried phosphate rocks are exposed to the surface over millions of years due to tectonic activity, reintroducing phosphorus into the cycle.
8. **Runoff:** The movement of phosphorus from soil to water bodies through surface water flow, often caused by rainfall or irrigation. Excessive runoff can lead to eutrophication.
9. **Eutrophication:** A process where excess phosphorus in water leads to algal blooms, depleting oxygen and harming aquatic ecosystems.
10. **Reservoirs:** The main storage locations for phosphorus, including rocks, soil, sediments, and living organisms.

✓ Process of Phosphorous cycle

- **Weathering of Rocks:** Phosphorus is primarily found in rocks as phosphate minerals. Weathering processes, such as wind, water, and ice, break down these rocks, releasing phosphate into the soil and water.
- Plant **Uptake:** Plants absorb dissolved phosphate from the soil through their roots and incorporate it into their tissues.
- **Consumption and Transfer:** Animals consume plants and obtain phosphorus. When animals die or excrete waste, the phosphorus returns to the soil.
- **Decomposition:** Decomposers, such as bacteria and fungi, break down dead organisms and waste products, releasing phosphorus back into the soil.
- **Leaching and Runoff:** Phosphorus can be leached from the soil into water bodies or transported by runoff.
- **Sedimentation:** In aquatic environments, phosphorus can accumulate in sediments over time.
- **Geological Uplift:** Geological processes can lift these sediments, forming new rocks containing phosphorus, restarting the cycle.

✓ **Effects of the Phosphorus Cycle**

- **Essential for Life:** Phosphorus is a crucial element for all living organisms and microbial growth, influencing ecosystem productivity. It forms part of DNA, RNA, and ATP, which are vital for energy transfer and cell development. Limited phosphorus availability in soil can constrain crop yields and ecosystem health.
- **Limiting Nutrient:** In many ecosystems, phosphorus availability limits and favor plant growth and productivity in soil through natural processes like weathering and decomposition. Fertile soil supports agriculture and sustains plant-based ecosystems.
- **Eutrophication:** Excess phosphorus in water bodies can lead to eutrophication, causing algal blooms and oxygen depletion. This harms aquatic life, disrupts ecosystems, and affects water quality
- **Human Impact:** Human activities, such as fertilizer use, mining phosphate rocks and improper waste management, can significantly disrupt the phosphorus cycle, leading to environmental problems, while over-extraction depletes reserves.
- Although phosphorus is not directly linked to atmospheric cycles, its availability can influence carbon fixation by plants and algae, indirectly affecting climate regulation through primary productivity.
- Balancing the phosphorus cycle is critical for sustaining agriculture, preventing water pollution, and maintaining ecosystem health.

Activity 2: Guided Practice

Task 20:

Read the scenario below and perform the tasks required

Scenario: "The Case of Green Valley's Disrupted Cycles"

Green Valley, a thriving agricultural community surrounded by forests and rivers, has recently experienced unusual environmental changes. Prolonged droughts, increased flooding, and declining crop yields have raised concerns. The community suspects these issues are related to disruptions in the water and carbon cycles. As environmental scientists, your class has been tasked with investigating these disruptions. You will identify key terms, explain processes, and analyze the effects of the water and carbon cycles to propose solutions for Green Valley.

a). Explain what could be causing the issues in above said Green Valley?"

b). Draw a diagram of how the water and carbon cycles processes can be according to your understanding?

c). Think of two examples where descriptions from the above cycles are essential for life and explain how can affect the environment?

d). Explain how activities like deforestation or increased fossil fuel use might disrupt this cycle, affecting Green Valley's ecosystem.

e). Highlight how the processes connect and impact ecosystems.

Activity 3: Application

Task 21:

Read the paragraph below and perform the tasks required

Nyungwe National Park in Rwanda is one of the biodiversity hotspots that comprise vital factors in controlling biogeochemical cycles. The thick forests drive the carbon cycle by photosynthesis while deep wetlands and streams maintain a water cycle. Weather and soil erosion are the causes of Phosphorous and Nitrogen cycles. Although human encroachment is a threat to these processes, resulting in reduced carbon deposits, altered water flow, and nutrient imbalances, preserving the ecosystems in Nyungwe National Park will go a long way in keeping those cycles, ensuring biodiversity, and stabilizing regional climate.

Required:

1. Design the diagrams of Nitrogen cycle and Phosphorous cycle. Note that your designed diagrams need to show the following considerations:
    a). How your evidence supports the description of biogeochemical cycles in conservation of Nature.
    b). Indicate what solutions can reduce the negative effects on the Nitrogen and Phosphorous cycles
2. Make a comparison between the water, Carbon, Nitrogen and Phosphorous cycles, by considering their key terms, processes, and effects that helps to connect theoretical concepts to practical applications.

Topic 3.2: Explanation of ecosystem degradation

Activity 1: Problem Solving

Task 22:

The country of Rwanda is known as the Land of a Thousand Hills and is one of the most and best Regulated countries in terms of fighting ecological degradation brought by deforestation, overgrazing, and encroachment of wetlands. The effects from these are results of soil erosion, water pollution, and biodiversity loss, and thus they affect agricultural productivity and affect people's livelihoods. Moreover, the clearing up of forests can interrupt the carbon and water cycles, making it less haphazard and prolonged in drought induced by climate change. Most of these should undermine Rwanda's vision for sustainable development, hence the urgent need for conservation to restore ecosystems and safeguard the communities that rely on them.

1. What is ecosystem degradation? Provide a comprehensive definition and discuss the key factors that contribute to it.
2. What are the consequences of ecosystem degradation? Explore the negative impacts on biodiversity, human health, and economic well-being.
3. List the three main human activities that contribute to ecosystem degradation in Rwanda.
4. Explain how deforestation disrupts the water cycle.
5. Design a simple experiment to measure the impact of soil erosion on water quality.
6. Examine the relationship between biodiversity loss and the decline in agricultural productivity.
7. Assess the effectiveness of Rwanda's current conservation efforts in mitigating ecosystem degradation.

Key Facts 3.2 Explanation of ecosystem degradation

- **Natural Equilibrium: A Delicate Balance**

Natural balance is said to be when the biological populations of the ecosystem are static and environmental conditions remain undisturbed by external influence. Such status occurs due to the interaction among organisms (which may include predation, competition, and symbiosis) and the availability of various natural factors such as water, nutrients, and light remains balanced with one another, thereby allowing the efficient functioning of the whole ecosystem. Such stability of natural balance maintains stable populations of species, continuous flow of energy through food webs, and sustained biogeochemical cycles. In short, natural equilibrium means recovery from minor emergencies and support for life forms of diverse nature.

✓ **Nutrient Cycling**

Nutrient cycling is the continuous movement of essential elements, such as nitrogen, phosphorus, and carbon, through the ecosystem. These elements are cycled between living organisms (biotic components) and non-living components (abiotic components) like soil, water, and air. This recycling ensures that essential nutrients are available for use by future generations of organisms.

✓ **Energy Flow**

Energy flow is the transfer of energy through an ecosystem, typically starting with sunlight and moving through a series of organisms. This energy is essential for life processes, such as growth, reproduction, and movement.

Types of Energy Flow

1. **Primary Production:** This is the process by which autotrophs, such as plants, convert solar energy into chemical energy through photosynthesis.
2. **Secondary Production:** This involves the transfer of energy from autotrophs to heterotrophs (organisms that cannot produce their own food), such as herbivores and carnivores.

Stages of Energy Flow

1. **Energy Input:** Solar energy is the primary source of energy for most ecosystems.
2. **Primary Production:** Autotrophs capture solar energy and convert it into chemical energy through photosynthesis.
3. **Consumption:** Heterotrophs consume autotrophs or other heterotrophs, transferring energy through the food chain.
4. **Respiration:** Organisms use energy from food for metabolic processes, releasing some energy as heat.
5. **Decomposition:** Decomposers break down dead organisms and waste products, returning nutrients to the ecosystem and releasing energy as heat.

✓ **The Importance of Natural Balance**

Natural equilibrium is crucial for maintaining healthy ecosystems. It ensures that resources are available for all organisms, prevents the overgrowth of any single species, and promotes biodiversity. Disruptions to natural equilibrium, such as habitat destruction, pollution, and climate change, can have significant negative impacts on ecosystems and the services they provide.

Understanding the concepts of nutrient cycling and energy flow is essential for

appreciating the complexity and interconnectedness of ecosystems. By recognizing the delicate balance of nature, we can better understand the importance of conservation efforts and sustainable practices in protecting our planet's biodiversity.

✓ **Population regulation**

Population regulation is a complex process that involves a variety of factors and the ecological processes that limit the growth of populations. Both density-dependent and density-independent factors play important roles in limiting population growth. Understanding population regulation is crucial for managing wildlife populations, conserving biodiversity, and addressing environmental challenges. These processes can be broadly categorized into two types

- *Density-Dependent factors*
- *Density-Independent Factors.*

Density-Dependent Factors:

- **Competition:** As population density increases, competition for resources like food, water, and space intensifies. This can lead to reduced birth rates, increased mortality rates, or both.
- **Predation:** Predators often focus on the most abundant prey species. As a prey population grows, it becomes more vulnerable to predation, which can help regulate population size.
- **Disease:** In dense populations, infectious diseases can spread more easily, leading to increased mortality rates.
- **Parasitism:** Parasites can weaken or kill their hosts, impacting population growth.
- **Waste Accumulation:** In high-density populations, the accumulation of waste products can pollute the environment and harm individuals.

Density-Independent Factors:

- **Natural Disasters:** Events like floods, fires, and extreme weather can impact populations regardless of their density.
- **Climate Change:** Changes in temperature, precipitation patterns, and other climate factors can affect population growth and survival.
- **Human Activities:** Human activities such as habitat destruction, pollution, and climate change can have significant impacts on population size.

• **Forms of Ecosystem Degradation**

Ecosystem degradation refers to the deterioration of the health and integrity of ecosystems, often due to human activities. Here are some key forms:

✓ **Habitat Destruction**

Deforestation: The clearing of forests for timber, agriculture, or development. This leads to habitat loss for countless species and disrupts vital ecosystem services like carbon sequestration and water regulation.

Urbanization: The expansion of cities and towns, often at the expense of natural habitats. This leads to habitat fragmentation, pollution, and the loss of biodiversity.

Agricultural Expansion: The conversion of natural areas into farmland, often through practices like slash-and-burn agriculture, which can degrade soil and destroy habitats.

✓ **Biodiversity Loss**

- **Definition:** The decline in the variety of life on Earth, including species, genetic diversity, and ecosystem diversity.
- Causes of biodiversity loss:
  - **Habitat Destruction:** As mentioned above, the loss of habitats is a major driver of biodiversity loss.
  - **Pollution:** Pollution can contaminate habitats, harm organisms, and disrupt ecosystems, leading to biodiversity loss.
  - **Climate Change:** Changes in temperature, precipitation patterns, and other climate factors can alter ecosystems, leading to shifts in species distributions and potential extinctions.
  - **Invasive Species:** The introduction of non-native species can disrupt ecosystems, outcompete native species, and lead to biodiversity loss.
- **Overexploitation**

  This also known as overharvesting, is the unsustainable use of natural resources at a rate that exceeds their ability to replenish themselves. such as overfishing and excessive logging, can lead to the decline and extinction of species, this can lead to resource depletion, ecological imbalance, and even the extinction of species. By understanding the consequences of overexploitation and promoting sustainable practices, we can help protect our planet's valuable natural resources for future generations.

✓ **Common Examples of Overexploitation:**

- **Overfishing:** Depleting fish stocks beyond their capacity to reproduce.
- **Unsustainable Hunting:** Hunting or poaching animals at rates that threaten their populations.
- **Unsustainable Mining:** Extracting minerals and other resources at a rate that depletes reserves and damages the environment.

✓ **Consequences of Overexploitation:**

- **Resource Depletion:** Overexploitation can lead to the exhaustion of natural resources, making them unavailable for future generations.

- **Economic Impacts:** Overexploitation can harm industries that rely on natural resources, such as fishing and forestry. It can affect the livelihoods of communities that depend on natural resources for their survival.

✓ **Mitigating Overexploitation:**

- **Sustainable Resource Management:** Implementing practices that ensure the long-term sustainability of natural resources.
- **Conservation Efforts:** Protecting endangered species and their habitats.
- **International Cooperation:** Establishing international agreements to regulate the exploitation of shared resources.
- **Public Awareness:** Educating the public about the importance of sustainable resource use.

✓ **Soil Degradation**

- **Overgrazing:** Excessive grazing by livestock can lead to soil compaction, erosion, and loss of fertility.
- **Deforestation:** The removal of trees can expose soil to erosion, leading to nutrient loss and degradation.
- **Improper Agricultural Practices:** Practices like excessive tillage and the use of harmful chemicals can degrade soil structure, reduce fertility, and contaminate water sources.

• **Environmental Pollution**

✓ **Air Pollution:** The release of harmful substances into the atmosphere, such as pollutants from vehicles, industries, and burning fossil fuels. This can lead to respiratory problems, climate change, and acid rain.

✓ **Water Pollution:** The contamination of water bodies with pollutants like chemicals, sewage, and agricultural runoff. This can harm aquatic life, threaten human health, and disrupt ecosystems.

✓ **Soil Pollution:** The contamination of soil with harmful substances, such as heavy metals, pesticides, and industrial waste. This can degrade soil fertility, harm plant and animal life, and contaminate water sources.

✓ **Noise Pollution:** Excessive or disturbing noise, such as from traffic, construction, and

industrial activities, which can harm human health and wildlife. These forms of ecosystem degradation are interconnected and often exacerbate one another. Addressing these challenges requires a multi-faceted approach that considers the complex interactions between human activities and the environment.

Activity 2: Guided Practice

Task 23:

Read the scenario below and answer the questions that follow

In a small farming community, environmental scientists observe the ecosystem's natural equilibrium being disrupted. Excessive fertilizer use has altered nutrient cycling, and improper waste disposal has impeded energy flow through the food web. The energy flow imbalance impacts plants and animals, affecting population regulation. Additionally, deforestation and soil erosion are evident forms of ecosystem degradation, threatening the community's livelihood. Your class is tasked with identifying the issues and proposing sustainable solutions to restore balance in this ecosystem.

Questions

1. What is natural equilibrium, and why is it essential for maintaining ecosystem stability?
2. How does nutrient cycling contribute to sustaining ecosystems, and what happens when it is disrupted?
3. Explain the stages and types of energy flow in an ecosystem and their significance.
4. How does population regulation depend on balanced nutrient cycling and energy flow?
5. What are the forms of ecosystem degradation observed, and what solutions can address these issues?

Activity 3: Application

Task 24: In-Class and Outdoor Activity

In a rural region experiencing rapid population growth, biodiversity loss has become a critical concern. Overexploitation of resources, such as overfishing and illegal hunting, has driven several species to near extinction. Soil degradation caused by overgrazing, deforestation, and improper agricultural practices has reduced crop yields. Additionally, environmental pollution from industrial activities has worsened, with air, water, soil, and noise pollution affecting both ecosystems and human health.

You are tasked with analyzing these issues and proposing solutions.

Topic 3.3: Application of environmental protection Strategies.

Activity 1: Problem Solving

Task 25:

Read the paragraph below and answer the questions that follow

Rwanda's Environmental Protection Framework

Kigali City is one of the cleanest and environmentally protected city in Rwanda, has established a comprehensive framework of environmental protection laws to safeguard natural resources and promote sustainable development. These laws address key issues such as air quality by regulating vehicle and industrial emissions, water resources by preventing pollution and encouraging conservation, and waste management through strict disposal and recycling regulations. Biodiversity conservation laws protect wildlife and natural habitats, while urban planning regulations ensure environmentally sustainable development. Additionally, an environmental impact assessment is mandatory for major projects to evaluate potential ecological effects. Enforced by the Rwanda Environment Management Authority (REMA) and other agencies, these evolving laws aim to tackle emerging challenges and secure Kigali's long-term environmental sustainability.

1. Which agency is responsible for enforcing environmental protection laws in Rwanda?
2. How do city's laws regulate air quality in the city?
3. What measures are in place to protect water resources in Rwanda?
4. Describe the waste management strategies included in environmental framework.
5. How do biodiversity conservation laws contribute to protecting wildlife and natural habitats?
6. What role do urban planning regulations play in ensuring sustainable development?

7. Why is an environmental impact assessment mandatory for major development projects in city?
8. What are the potential penalties for violating environmental protection laws?
9. How do city's environmental protection laws evolve to address new challenges in sustainability?

Key Facts 3.3: Application of environmental protection Strategies.

✓ **Environmental conservation**

The practice of protecting and preserving natural resources and ecosystems to ensure their sustainability for present and future generations. It encompasses a wide range of activities, from protecting endangered species to mitigating climate change.

Environmental conservation is crucial for maintaining a healthy planet and ensuring the well-being of both humans and other living beings.

It involves a wide range of activities, including:

- Protecting endangered species
- Conserving natural habitats
- Reducing pollution

- Promoting sustainable resource use
- Addressing climate change

✓ **Key term definition:**

- **Protection:** This involves safeguarding natural resources and ecosystems from harm, such as pollution, habitat destruction, and climate change.
- **Preservation:** This focuses on maintaining the integrity and functioning of natural ecosystems, including biodiversity and ecological processes.
- **Sustainability:** This emphasizes the need to use natural resources in a way that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.
- **Responsibility:** It highlights the responsibility of humans to act as stewards of the environment and ensure its long-term health.

✓ **Principles of Environmental Conservation**

Environmental conservation principles focus on sustainable resource use, ecosystem protection, and biodiversity preservation. They emphasize reducing pollution, promoting renewable energy, and preventing habitat destruction. These principles advocate for responsible consumption, climate change mitigation, and community engagement, ensuring that natural resources are preserved for current and future generations while maintaining ecological balance.

- **Precautionary Principle:** When there is uncertainty about the potential negative impacts of a human activity, precautionary measures should be taken to prevent environmental harm.
- **Polluter Pays Principle:** The principle that those who cause pollution should bear the costs of its prevention and remediation.
- **Principle of Participation:** The active involvement of stakeholders, including local communities, in environmental decision-making processes.
- **Public Participation:** Ensuring that the public has access to information and opportunities to participate in environmental decision-making.
- **Sustainability:** Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.
- **The Integration Principle:** Recognizing the interconnectedness of environmental,

social, and economic systems, and integrating these considerations into decision-making processes.

- **Resource Efficiency:** Using resources wisely and minimizing waste to reduce environmental impact.

✓ **Environmental Protection Approaches**

- **Conservation of Natural Resources:** Sustainable management and use of natural resources, such as water, forests, and minerals.
- **Protected Areas:** Designating and managing areas for conservation, such as national parks, wildlife sanctuaries, and marine protected areas.
- **Reforestation and Afforestation:** Planting trees to restore degraded forests and create new forests.
- **Sustainable Agriculture:** Practices that promote environmental health, economic profitability, and social equity.
- **Renewable Energy Use:** Utilizing renewable energy sources, such as solar, wind, and hydropower, to reduce reliance on fossil fuels.

✓ **Importance of Environmental Protection**

- **Maintaining Biodiversity:** Protecting the diversity of life on Earth, which is essential for ecosystem health and human well-being.
- **Ensuring Clean Air and Water:** Safeguarding the quality of air and water resources, which are essential for human health and the environment.
- **Mitigating Climate Change:** Reducing greenhouse gas emissions and adapting to the impacts of climate change.
- **Promoting Human Health:** Protecting the environment can improve human health by reducing exposure to pollution and promoting access to clean air and water.
- **Supporting Economic Development:** A healthy environment can support sustainable economic development and create jobs in sectors such as ecotourism and renewable energy.

• **Environmental Pollution Control**

Environmental pollution control refers to the various methods and strategies employed to limit or eradicate the release of harmful substances and energies into the environment.

✓ **Goal:** To minimize the negative impacts of pollution on human health, ecosystems, and the environment as a whole.

- ✓ **Methods:** This can involve a wide range of techniques, including:
  - **Prevention:** Minimizing the production of pollutants at the source.
  - **Treatment:** Cleaning up pollutants after they have been released.
  - **Control Technologies:** Using devices and systems to reduce emissions (e.g., scrubbers, filters).
  - **Regulations:** Implementing laws and policies to limit pollution.
  - **Public Awareness:** Educating the public about the importance of pollution control and encouraging responsible behavior.

- **Types of Environmental Pollution Control**
  - ✓ **Air Pollution Control:** Reducing emissions from vehicles, industries, and other sources to improve air quality.
  - ✓ **Water Pollution Control:** Preventing the discharge of pollutants into water bodies and cleaning up contaminated water sources.
  - ✓ **Soil Pollution Control:** Preventing the contamination of soil with harmful substances and rehabilitating contaminated sites.
  - ✓ **Noise Pollution Control:** Reducing excessive noise levels to protect human health and wildlife.
  - ✓ **Waste Management Control:** Implementing effective waste management systems, including recycling, composting, and waste reduction.

Activity 2: Guided Practice

Task 26:

Read the scenario below and answer the questions that follow:

Rwanda has implemented a comprehensive action plan to ensure environmental sustainability, focusing on conservation, resource management, and climate resilience. This includes enforcing robust environmental laws, such as the Environmental Management and Protection Law, and implementing a ban on single-use plastics to reduce waste. Biodiversity conservation efforts include expanding protected areas like Volcanoes and Nyungwe National Parks and promoting reforestation programs like the Green Rwanda Initiative. Waste management is prioritized through recycling programs and monthly community clean-up campaigns like "Umuganda," fostering collective responsibility for a cleaner environment. Additionally, Rwanda focuses on water resource management by protecting wetlands and encouraging rainwater harvesting to address water scarcity. Climate change mitigation is supported through the adoption of renewable energy and climate-smart agricultural practices. Public awareness campaigns and environmental education in schools ensure community involvement, while international collaborations and adherence to global agreements like the Paris Climate Accord strengthen Rwanda's environmental initiatives. These efforts solidify Rwanda's position as a global leader in sustainable development and environmental protection.

1. What are the main environmental challenges facing Rwanda today? (This assesses basic understanding of Rwanda's environmental issues.)
2. Name two key environmental protection laws or policies implemented in Rwanda. (Tests knowledge of specific policies.)
3. How does Rwanda utilize protected areas for environmental conservation? (Focuses on a specific conservation strategy.)
4. What role do community-based conservation initiatives play in Rwanda? (Examines the involvement of local communities.)

5. How does Rwanda promote sustainable agriculture? (Assesses knowledge of specific practices.)
6. Analyze the effectiveness of Rwanda's reforestation efforts in mitigating soil erosion and climate change. (Requires analysis of a specific strategy and its impacts.)
7. Discuss the challenges and opportunities of integrating environmental protection with economic development in Rwanda. (Examines the complex relationship between conservation and economic growth.)
8. How does Rwanda address the issue of illegal logging and wildlife trafficking? (Explores the enforcement and challenges related to combating illegal activities.)
9. Evaluate the role of international cooperation and funding in supporting environmental protection initiatives in Rwanda. (Assesses the importance of external assistance.)
10. How can Rwanda effectively communicate the importance of environmental conservation to its citizens and promote greater public awareness and participation? (Focuses on public engagement and education.)

Activity 3: Application

Task 27:

Read the scenario below and perform the tasks required

The United States employs a multifaceted environmental protection strategy focusing on legislation, innovation, and community action. Key laws like the Clean Air Act and Clean Water Act regulate pollution, while agencies like the Environmental Protection Agency (EPA) enforce standards. Renewable energy initiatives, conservation programs, and climate policies aim to reduce greenhouse gas emissions and protect ecosystems. Public awareness campaigns and partnerships with private sectors foster sustainable practices, ensuring environmental resilience and resource preservation for future generations.

Required:

1. Create your own proposal of environmental protection strategy
2. How does your chosen strategy address the root causes of the environmental challenge?
3. What are the potential economic and social benefits of implementing your strategy?
4. What are the potential challenges and risks associated with implementing your strategy?
5. How can you ensure the long-term sustainability of your chosen strategy?

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

Formative Assessment

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

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

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. Fill in and complete the self-assessment table below to reassess your level of knowledge, skills, and attitudes under this unit.

   a). There is no right or wrong way to answer this reassessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

   b). Think about yourself; do you think you have the knowledge, skills, or attitudes to do the task? How well?

   c). Read the statements across the top, tut a check-in a curriculum that best represents your level of knowledge, skills, and attitudes.

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe the Biogeochemical cycles?					
Explain Process of Water, carbon, Nitrogen					

My experience Knowledge, skills and attitudes	I do not have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
phosphorous cycles and their Effects.					
Describe Natural /ecological equilibrium concept					
Identify forms of ecosystems degradation					
Describe causes of biodiversity Loss					
Demonstrate Causes of biodiversity loss					
Describe Environmental pollutions and environment sustainability compliance					
Apply Environmental conservation strategies					

2. Fill in the table below and share results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**
3.	**3.**	**3.**
4.	**4.**	**4.**

REFERENCES:

1. Charles Darwin,1859, "On the Origin of Species" ((at: https://en.wikipedia.org/wiki/On_the_Origin_of_Species)
2. Jerry A. Coyne, January 1, 2008 "Why Evolution Is True" (at: https://www.goodreads.com/book/show/4005310-why-evolution-is-true)
3. Richard Dawkins,1987, Reissue Edition "The Blind Watchmaker"
4. "Ecology and Ecosystem Conservation" by Oswald J. Schmitz https://www.academia.edu/33324897/Ecology_and_Ecosystem_Conservation_Ecology_and_Ecosystem_Conservation
5. James,A., K. J. Gaston, and A. Balmford. 2001. Can we afford to conserve biodiversity? Bio- Science 51:43–52.
6. Lubchenco, J., S. R. Palumbi, S. D. Gaines, and S. Andelman. 2003. Plugging a hole in the ocean:
7. The emerging science of marine reserves. Ecological Applications 13 (supplement): S3–S7.
8. Sinclair, A. R. E., D. Ludwig, and C.W. Clark. 2000. Conservation in the real world. Science
9. "Conservation Biology" by Bradley J. Cardinale, Richard B. Primack, and James D. Murdoch.
10. William Berryman Scott, 2010 "The Theory of Evolution: With Special Reference to the Evidence Upon Which It Is Founded" (at: https://www.amazon.com/Theory-Evolution-Special-Reference-Evidence/dp/1163769029)

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