SLO 3: Biodiversity

3.1 Introduction

3.1.1 Define the Terms 'Biodiversity' And 'Classification'

The term "biodiversity" has been derived from 'bio' and 'diversity'. "Diversity" means variety within a species and among species. Biodiversity is a measure of the variety of organisms present in different ecosystems.

To study such a large collection of organisms, biologists classify the organisms into groups and subgroups and for this task they require some system. Biological classification is a method by which biologists divide organisms into groups and subgroups.

3.1.2 Describe the Importance of Biodiversity

- ***Producing food:*** Biodiversity provides a wide variety of crops, livestock, and fish, which is crucial for food security and nutrition. Genetic diversity within these species allows more resistant to pests, diseases, and climate extremes, ensuring a stable and sustainable food supply.
- ***Obtaining drugs:*** Many modern medicines are derived, directly or indirectly, from biological sources. Over 50% of modern medicines originate from natural sources, including antibiotics from fungi and various pain relievers and cancer drugs from plant compounds.
- ***Industrial products:*** Biodiversity is a primary source of numerous raw materials for various industries.
- ***Building materials:*** Timber and wood are essential for construction and paper production.
- ***Fibers and textiles:*** Materials like cotton and silk are derived from biological sources.
- ***Natural chemicals:*** Plants provide products including resins, gums, adhesives, dyes, and rubber.
- ***Maintaining ecosystems:*** Each species, no matter how small, plays a specific role in capturing and storing energy and producing and decomposing organic matter. Diverse ecosystems are better able to withstand and recover from natural disasters and human-induced disturbances.
- ***Recycling nutrients:*** Biodiversity is directly involved in essential nutrient cycling processes that provide fertile soils. Microorganisms, fungi, and invertebrates (like earthworms) break down dead organic matter and waste products, returning essential nutrients such as nitrogen, phosphorus, and carbon back into the soil for use by plants.

3.2 Aims and Principles of Classification

3.2.1 Describe Aims and Principles of Classification

Aims of Classification

The branch of biology which deals with classification is called taxonomy and the branch which deals with classification and also traces the evolutionary history of organisms is known as systematics. The main aims are

1. To determine similarities and differences among organisms so that they can be studied easily.
2. To find the evolutionary relationships among organisms.

Principals of Classification

1. **Morphology**: it is the study of external features of an organism. These features are Homologous (similar in structure and have different functions) or Analogous (different in structure and have same functions).
2. **Cytology And Genetics**: organisms are classified on the basis of cellular study, genetic constitution and their development pattern.
3. **Biochemistry**: the chemical substances of the organisms are compared.

4. **Taxonomic Hierarchy**: The groups into which organisms are classified are known as taxonomic categories or taxa (singular taxon). The taxa are arranged in ascending order and form a ladder, called taxonomic hierarchy.
    a. Phylum: A phylum is a group of related classes.
    b. Class: A class is a group of related orders.
    c. Order: An order is a group of related families.
    d. Family: A family is a group of related genera.
    e. Genus: A genus is a group of related species.
    f. Species: A species consists of similar organisms.

3.3 Phylogeny

3.3.1 Define 'Phylogeny'

Phylogeny is the evolutionary history and line of descent of a species or a group of related organisms. It describes how different biological entities—such as species, genes, or broader taxonomic groups—are related to one another through shared ancestry.

3.3.2 Explain That Classification Systems Aim to Reflect Evolutionary Relationships

- ***Common Ancestry:*** Organisms are grouped together because they share a common ancestor. The more recently two species shared an ancestor, the more closely they are classified together.
- ***Hierarchical Divergence:*** Each level of the taxonomic hierarchy (from Domain to Species) represents a point in history where lineages diverged. A broader group, like a Phylum, represents a very ancient common ancestor, while a specific group, like a Genus, represents a much more recent one.

3.3.3 Describe Basis of Classification of Living Organisms

Homology:

Homology refers to structures, genes, or traits in different species that are similar because they were inherited from a common ancestor. Homologous traits are the primary evidence used to classify life. They reveal "descent with modification". These structures may have different functions in modern species, but they share the same fundamental anatomical or genetic blueprint. For example, the forelimbs of humans (for grasping), bats (for flying), and whales (for swimming) all share the same bone arrangement (humerus, radius, ulna), indicating a shared mammalian ancestor.

Analogy:

Analogy refers to structures that perform similar functions but evolved independently in unrelated organisms. This is often the result of convergent evolution, where different species adapt to similar environments in similar ways. These structures have different internal anatomies and different embryonic origins despite their outward functional similarity. For example, the wings of a bird and the wings of an insect both allow for flight, but bird wings are modified bony limbs, while insect wings are outgrowths of their exoskeleton.

3.4 History of Classification Systems

3.4.2 Compare Two-Kingdom, Three-Kingdom, Four-Kingdom and Five-Kingdom Classification Systems

Feature	*Two-Kingdom System*	*Three-Kingdom System*	*Four-Kingdom System*	*Five-Kingdom System*
Proposed By	Carolus Linnaeus (1735)	Ernst Haeckel (1866)	Herbert Copeland (1938)	R.H. Whittaker (1969)
Kingdoms	Plantae, Animalia	Plantae, Animalia, Protista	Plantae, Animalia, Protista, Monera	Plantae, Animalia, Protista, Monera, Fungi
Primary Basis	Gross morphology and mobility	Unicellular vs. multicellular nature	Presence or absence of a nucleus (Prokaryote vs. Eukaryote)	Cell structure, nutrition mode, and body organization
Fungi Status	Grouped with Plants	Grouped with Plants	Grouped with Plants/Protists	Separate Kingdom (heterotrophic/chitin wall)
Prokaryotes	Not recognized; grouped with plants	Included in Protista	Separate Kingdom (Monera)	Remained in Monera

3.4.3 Describe That Robert Whittaker's Five-Kingdom Classification System Provides a More Comprehensive Understanding of The Diversity of Living Organisms Compared to Other Classification Systems

Some taxonomists found two-kingdom classification system unworkable because:

1. Many unicellular organisms like Euglena have both plant-like (presence of chlorophyll) and animal-like (heterotrophic mode of nutrition in darkness and lack of cell wall) characters. So, there should be a separate kingdom for such organisms.
2. This system also ignored the difference between organisms having prokaryotic and those having eukaryotic cells.

Some taxonomists found three-kingdom classification system unworkable because:

1. It did not clear the difference between prokaryotes and eukaryotes.
2. Position of fungi in kingdom plantae. Fungi resemble plants in many ways but are not autotrophs. They are special form of heterotrophs that get their food by absorption. They do not have cellulose in their cell walls rather possess chitin.

Robert Whittaker introduced the five-kingdom classification system. This system is based on:

1. The levels of cellular organization i.e. prokaryotic, unicellular eukaryotic and multicellular eukaryotic
2. The principal modes of nutrition i.e. photosynthesis, absorption, and ingestion.

On this basis, organisms are classified into five Kingdoms: Monera, Protista, fungi, plantae and animalia.

3.5 Units of Classification

3.5.1 Explain the Hierarchical Structure of Classification from Species to Kingdom

All organisms are classified into five kingdoms, so the kingdom is the highest taxon of classification. On the basis of similarities, each kingdom is further divided into smaller taxa in the following ways:

Kingdom > Phylum > Class > Order > Family > Genus > Species

The smallest and basic unit of classification is species. Taxonomic studies consider a group of individual organisms with the fundamental similarities as a species. Thus, all the members of the particular species share the similar characteristics and can naturally interbreed to produce a fertile offspring. Closely related species are grouped together into genera. Similar genera are grouped together into families, families into orders, orders into classes, classes into phyla or division and phyla or division into kingdoms.

Taxa	Human	Pea
Kingdom	Animalia	Plantae
Phylum	Chordate	Magnoliophyta
Class	Mammalia	Magnoliopside
Order	Primates	Fabales
Family	Moninidae	Fabaceae
Genus	Homo	Pisum
Species	Sapiens	Sativum
Scienti c name	Homo sapiens	Pisum sativum

3.5.2 Differentiate Among the Domains of Biological Classification System

Feature	Bacteria	Archaea	Eukarya
Cell Nucleus	Absent	Absent	Present
Cell Wall	Peptidoglycan	No peptidoglycan	No peptidoglycan
Membrane Linkage	Ester-linked	Ether-linked	Ester-linked
RNA Polymerases	One type	Several types	Several types
Antibiotic Response	Growth inhibited	Growth NOT inhibited	Growth NOT inhibited
DNA Form	Circular	Circular	Linear

3.6 Binomial Nomenclature

3.6.1 List the Universal Rules Adopted for Writing the Scientific Name of a Species

1. Scientific names are usually printed in italics, such as *Homo sapiens*. When handwritten they are underlined (Homo sapiens).
2. The first term (generic name) always begins with capital letter, while species name is never capitalized (even when derived from a proper name).
3. The scientific name is generally written in full when it is first used. But when several species from the same genus are being listed, it may then be abbreviated by just using an initial for genus; for example, *Escherichia coli* becomes *E. Coli*
4. Sometimes the author's name appears after species name which means the species was described by Him. For example; (mango plant) *Mangifera indica L*. It means Mangifera indica was first described by Linnaeus.

3.6.2 Explain the Significance of Using Binomial Nomenclature in Ensuring Clarity and Consistency in Scientific Communication

In biological research, common names cause many problems. Different regions have different names for the same organism. For example; common name of onion in Urdu is 'Piyaz' but in different regions of Pakistan it is also known as 'Ganda' or 'basal' or 'vassal'. In science, it is known with a single name as *Allium cepa*. In some cases, different organisms are called by the same common name. For example; 'black bird' is used for crow as well as for raven.

Through a system of nomenclature, each species of animal, plant or others receives a name of two terms of which first identifies the genus to which it belongs and the second the species itself or its specific names. The advantages of scientific over common names are that they are accepted by speakers of all languages, that each name applies only to one species, and that each species has only one name.

3.6.3 Apply the Rules of Binomial Nomenclature for Writing the Scientific Names

Onion plant	*Allium cepa*
Mango plant	*Mangifera indica L.*
Neem plant	*Azadirachta indica*
Red Rose	*Rosa indica*
Cat	*Felis catus*
Frog	*Rana tigrina*
Housefly	*Musca domestica*
Common sea star (starfish)	*Asterias rubens*
House crow	*Corvus splendens*

3.6.4 Assess Likely Evolutionary Relationships Between Organisms Based on Their Binomial Names

- Recent Common Ancestry: If two organisms share a genus, it indicates they diverged from a common ancestor relatively recently in geological time. For example, Lion (*Panthera leo*) and the Tiger (*Panthera tigris*) both belong to the genus *Panthera*. This instantly signals to a biologist that they are more closely related than either is to a Wolf (*Canis lupus*).
- Unique Identity: Even if they share a genus, different species names confirm they are distinct lineages that no longer interbreed in the wild. (e.g., Panthera leo vs. Panthera onca for a jaguar)

3.7 The Five Kingdoms

3.7.1 Describe Salient Features of Prokaryotes Taking Bacteria as An Example

The cell wall is made of peptidoglycan. They are found in all environments including soil, water, air, and in the bodies of organisms. They are unicellular. Many live in solitary although some form chains, clusters, or colonies of cells. Most are heterotrophic but some have chlorophyll and carry out photosynthesis. Some bacteria cause diseases. Many bacteria are beneficial e.g.; decomposer bacteria play important role in nutrient recycling.

3.7.2 Describe Salient Features of The Given Protists

Chlamydomonas (The Green Alga)

It is a unicellular, motile green alga commonly found in freshwater.

- Shape: Usually oval or pear-shaped.
- Cell Wall: Possesses a definite cell wall made of cellulose (a plant-like feature).

- Locomotion: Moves using two flagella located at the anterior (front) end.
- Nutrition (Autotrophic): Contains a single, large, cup-shaped chloroplast for photosynthesis.
- Light Sensitivity: Has a small, red-pigmented stigma (eyespot) that helps it detect light for photosynthesis.
- Storage: Contains a pyrenoid within the chloroplast, which is involved in starch synthesis.

2. Paramecium (The Ciliate)

It is a unicellular, complex protozoan often described as "slipper-shaped."

- Shape: Elongated and asymmetrical, resembling the sole of a slipper.
- Outer Covering: Instead of a rigid cell wall, it has a thin, flexible membrane called a pellicle, which maintains its shape while allowing slight deformation.
- Locomotion: Covered in thousands of tiny, hair-like projections called cilia. These beat in a coordinated rhythm to swim.
- Nutrition (Heterotrophic): It has an oral groove (a mouth-like indentation) that leads to a cytostome (cell mouth). Food is swept into the oral groove by cilia and digested in food vacuoles.
- Osmoregulation: Contains two star-shaped contractile vacuoles that pump out excess water to prevent the cell from bursting.
- Nuclear Dualism: Uniquely possesses two types of nuclei:
  - Macronucleus: Controls daily metabolic functions.
  - Micronucleus: Involved in reproduction

Feature	Chlamydomonas	Paramecium
Category	Plant-like Protist (Algae)	Animal-like Protist (Protozoa)
Locomotory Organ	Two Flagella	Numerous Cilia
Nutrition	Autotrophic (Photosynthesis)	Heterotrophic (Ingestion)
Cell Boundary	Cell Wall (Cellulose)	Pellicle (Flexible)
Special Organelles	Cup-shaped Chloroplast, Stigma	Oral Groove, Contractile Vacuole
Nucleus	Single Nucleus	Two Nuclei (Macro & Micro)

3.7.3 Describe Salient Features of Fungi Taking Rhizopus as An Example

Fungi are eukaryotic organisms. They are characterized by their absorptive mode of nutrition, filamentous structure, and unique cell wall composition. Rhizopus is a key example of the general fungal features and has specific structural characteristics.

- Eukaryotic: Fungi are eukaryotes with membrane-bound nuclei and organelles, but they lack chlorophyll and cannot perform photosynthesis.
- Heterotrophic: They are heterotrophs that obtain nutrients by absorbing dissolved organic molecules from their environment, typically by secreting digestive enzymes externally.
- Cell Walls: Fungal cell walls are rigid and primarily composed of chitin and glucans, which provide structural strength, unlike plant cell walls made of cellulose.
- Reproduction via Spores: Fungi primarily reproduce by producing vast quantities of non-motile spores that are dispersed by wind or water. They exhibit both asexual and sexual reproduction.
- Ecological Role: Fungi are essential decomposers in ecosystems, breaking down dead organic matter like dead plants, fruits, and bread, and recycling nutrients back into the environment.

3.7.4 Classify Kingdom Plantae Based On Their Major Characteristics

Kingdom Plantae is broadly classified based on characteristics such as whether they produce seeds or not, the presence of flowers, and, for flowering plants, the number of cotyledons.

Seed Production

Group	Description	Key Feature	Examples
Cryptogams	Non-seed-producing plants	Reproduce via spores; do not produce flowers or fruits	Algae, Mosses, Ferns
Phanerogams	Seed-producing plants	Possess well-developed reproductive organs that produce seeds	Gymnosperms, Angiosperms

Flowering and Seed Type

Group	Flowers	Seed Type	Examples
Gymnosperms	Non-flowering; produce cones	Naked seeds (not enclosed in a fruit or ovary)	Pines, Firs, Cedars, Cycads
Angiosperms	Flowering plants; produce flowers	Enclosed seeds (within a fruit, which develops from the ovary)	Roses, Mangoes, Wheat, Lilies

Number of Cotyledons

Group	Cotyledons	Leaf Venation	Root System	Flower Parts	Examples
Monocotyledons	One cotyledon	Parallel	Fibrous roots	Three	Grasses, Rice, Wheat, Lilies
Dicotyledons	Two cotyledons	Net-like	Taproot system	Four or five	Roses, Mangoes, Beans, Sunflowers

3.7.5 Differentiate Between Monocot And Dicot Plants

MONOCOTS	DICOTS
TYPES OF ROOTS	
Fibrous root system. Primary root dies off early and is replaced by a cluster of thin, hair-like roots that grow from the base of the stem. Example: grass, onion.	Taproot system. A single, thick primary root grows deep into the soil, with smaller roots branching off from it. Examples: carrots, oak tree.
ARRANGEMENT OF VASCULAR BUNDLES IN STEM	
Scattered randomly, often described as looking like little "monkey faces."	Neat ring near the edge of the stem allows getting thicker/woody over time.
TYPES OF VENATIONS	
Veins in the leaves run parallel to each other from the base to the tip. Example: corn, lilies, grass.	Veins form a branching, net-like pattern (reticulate venation. Example: maple leaf, rose leaf.
NUMBER OF FLORAL LEAVES	
Trimerous. Number of petals, sepals, or stamens is usually 3 or a multiple of 3 (3, 6, 9).	Tetramerous or pentamerous. floral parts usually occur in groups of 4 or 5 or multiples like 8, 10, 15.

3.7.6 Differentiate Among Invertebrates Based On Their Salient Features

Organism	Phylum	Symmetry	Key Distinguishing Feature
Sycon	Porifera	Asymmetrical	Pore-bearing body with a canal system; sessile
Jellyfish	Cnidaria	Radial	Tentacles with stinging cells; jelly-like mesoglea.
Tapeworm	Platyhelminthes	Bilateral	Flat, ribbon-like body; lacks a digestive tract (absorbs food).
Roundworm	Nematoda	Bilateral	Cylindrical, unsegmented body; pointed ends
Earthworm	Annelida	Bilateral	Segmented body (metamerism); presence of a true coelom.
Snail	Mollusca	Bilateral	Soft body usually protected by a calcareous shell

Butterfly	Arthropoda	Bilateral	Jointed appendages; exoskeleton made of chitin; three-part body.
Sea Star	Echinodermata	Five-fold Radial	Spiny skin; water vascular system for movement via tube feet.

3.7.7 Differentiate Among Vertebrates (Fish, Frog, Lizard, Bird and Cat) Based on Their Salient Features

Vertebrate	Fish	Frog	Lizard	Bird	Cat
Body covering	scales	moist skin	dry skin with scales	feathers, with scales on legs	fur
Movement	fins (also used for balance)	four limbs, back feet are often webbed	four legs (apart from snakes)	two wings and two legs	four limbs
Reproduction	produce jelly covered eggs in water	produce jelly covered eggs in water	produce eggs with a rubbery, water-proof shell on land	produce eggs with a hard shell on land	produce live young
Blood	Cold blooded	Cold blooded	Cold blooded	Warm blooded	Warm blooded
Heart Chambers	2 chambers	3 chambers	3 chambers	4 chambers	4 chambers
Respiration	Gills	Gills (young), Lungs (adult)	Lungs	Lungs with Air Sacs	Lungs

3.8 Acellular Structure

3.8.1 Describe the General Structure of Virus

- Virus is non cellular obligate endoparasite (lives inside host cell).
- It does not have cellular organization but do have nuclear material either DNA or RNA.
- It has protein coat called capsid that encloses the nucleic acid.
- It reproduces only inside the host cell.
- Due to its non-cellular nature, it cannot be placed in any of the five kingdoms.
- It causes number of diseases like, cold, flue, dengue, polio, hepatitis, AIDS etc.

3.8.2 Justify the Exclusion of Viruses from The Five-Kingdom Classification System

There are many different types of viruses and they vary in their shape and structure. All viruses, however, have a central core of RNA or DNA surrounded by a protein coat. Viruses have no nucleus, cytoplasm, cell organelles or cell membrane, though some forms have a membrane outside their protein coats. So, virus particles are not cells. They do not feed, respire, excrete or grow, and it is arguable whether they can be classed as living organisms. Viruses do reproduce, but only inside the cells of living organisms, using materials provided by the host cell.