Chapter 2

BIODIVERSITY

After studying this chapter, students will be able to:

- Define biodiversity and classification.
- Describe advantages of classification.
- List the taxonomic ranks of classification.
- Discuss the history of classification schemes.
- List the three distinct domains into which living organisms are broadly classified into.
- Describe the complications of classifying viruses.
- Outline the binomial nomenclature system.

Our planet is home to a vast variety of organisms, from tiny insects to towering trees. This variety is essential for the health and balance of our world. It provides us with food, medicine, and clean air. In this chapter, we will explore the variety of organisms and the method of classifying them into groups.

2.1- BIODIVERSITY

Biodiversity means the variety of organisms in a particular area. Biodiversity of an area is measured by considering the number of different kinds of organisms and the variation within each kind.

Biologists have discovered and classified almost two million kinds of organisms. However, they estimate that the total kinds of organisms on Earth is much greater. Biodiversity is not evenly spread out. The biodiversity in a place depends on factors like climate, altitude, and soil type. Tropical regions have more biodiversity than polar regions.

Importance of Biodiversity

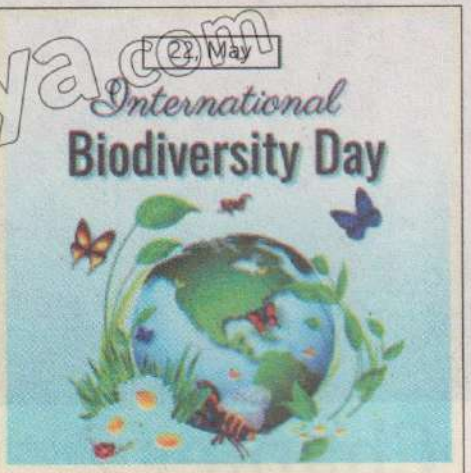
Biodiversity provides many essential services for humans and the planet. Here are some key benefits of biodiversity:

Ecosystem stability: Biodiversity helps to maintain the balance of ecosystems. It plays important role in biogeochemical cycles such as carbon cycle, and nitrogen cycle.

Climate regulation: Plants and algae absorb carbon dioxide. It helps to keep the climate balanced.

Natural resources: Biodiversity provides a vast array of resources, from food and medicine to building materials and fuel.

Economic benefits: Biodiversity supports different industries, including agriculture, tourism, and pharmaceuticals.



"The United Nations has designated May 22nd as International Biodiversity Day. It is celebrated to promote the protection of biodiversity.

2.2- Classification

Some people don't respect biodiversity on the grounds that it is useful for humans. Rather, they respect biodiversity on aesthetic and moral grounds.

Biologists have identified about 02 million kinds of organisms. Out of these, 0.5 million are the kinds of plants and 1.5 million are the kinds of animals. It is only a small percentage of the total kinds, which live on Earth. Every year, biologists discover thousands of new kinds of organisms. To better study such a large collection of organisms, biologists classify them. Classification is the process in which organisms are divided into groups and subgroups on the basis of similarities and differences found in them.

Aims and Principles of Classification

The main aims of classification are:

a. To determine similarities and differences among organisms so that they can be studied easily

b. To find the evolutionary relationships among organisms

Biologists classify organisms into groups and subgroups on the basis of similar physical characteristics. In recent times, they also take help from genetics. They find the genetic similarities and differences among organisms. Then they use this information to know similarities and differences in their structures and functions.

Advantages of Classification

- Classification allows biologists to group similar organisms together, making it easier to identify and understand their characteristics, relationships, and evolutionary history. It helps us understand the vast diversity of living organisms on Earth.
- Classification provides a framework for studying and comparing different species.
- It explains the inter-relationship amongst various organisms.
- It helps in the identification of new species and in understanding their evolutionary relationships.
- Classification provides a common language for biologists around the world, enabling effective communication in the study of organisms.

Overall, classification is crucial for our understanding of the natural world and for the conservation and management of biological diversity.

2.3- Taxonomic Ranks

The groups into which organisms are classified are known as taxonomic ranks or taxa (singular "taxon"). The Swedish botanist **Carl Linnaeus** devised the Linnaean system of taxonomic ranks in 1735. In this system, Linnaeus suggested seven taxonomic ranks i.e., kingdom, phylum (division), class, order, family, genus and species. In 1977, the rank of domain was added to this system. The taxonomic ranks are defined as below:

Domain: The highest taxonomic rank is domain. All organisms are divided into three domains: Archaea, Bacteria, and Eukarya.

Kingdom: Domain is further divided into kingdoms. For example, the domain Eukarya is divided into four kingdoms i.e., Animalia, Plantae, Fungi, Protista.

Phylum (Division: for plants and fungi): Each kingdom is subdivided into related phyla or divisions.

Class: Each phylum/division is divided into related classes.

Order: Each class is further divided into related orders.

Family: Each order is broken down into related families.

Genus: Each family is divided into related genera (singular genus).

Species: It is the lowest level of classification. A species is a group of similar organisms that can interbreed and produce fertile (capable of reproduction) offspring.

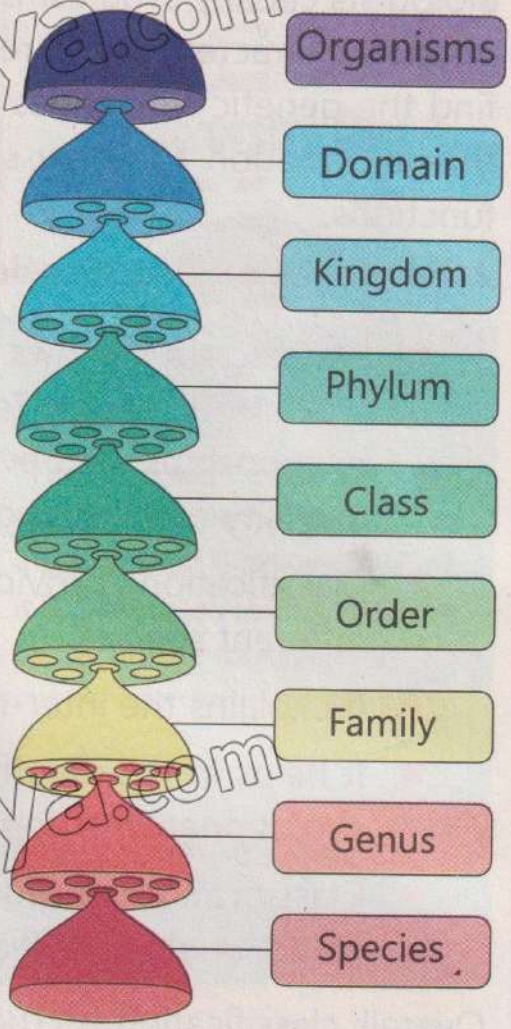


FIGURE 2.1: Taxonomic ranks

Table : Classification of fruit fly, human and pea

Taxonomic Rank	Fruit fly	Human	Pea
Domain	Eukarya	Eukarya	Eukarya
Kingdom	Animalia	Animalia	Plantae
Phylum or Division	Arthropoda	Chordata	Magnoliophyta
Class	Insecta	Mammalia	Magnoliopsida
Order	Diptera	Primates	Fabales
Family	Drosophilidae	Hominidae	Fabaceae
Genus	*Drosophila*	*Homo*	*Pisum*
Species	*Drosophila melanogaster*	*Homo sapiens*	*Pisum sativum*

2.4- HISTORY OF CLASSIFICATION

The history of the classification system can be traced back to ancient times.

- The Greek philosopher **Aristotle** (384-322 BC) was the first who classified organisms into two groups i.e., plants and animals.
- The Arab scholar **Abu Usman Umer Al-Jahiz** (781-869 AD) described the characteristics of 350 species of animals. He wrote a lot about the life of ants.
- The Italian botanist **Andrea Caesalpinia**(1519-1603 AD) divided plants into fifteen groups and called them genera.
- The French botanist **Tournefort** (1656-1708 AD) introduced the taxa of class and species.
- The Swedish biologist **Carl Linnaeus** (1707-1778 AD) created a taxonomic hierarchy of organisms with seven taxa i.e., kingdom, phylum, class, order, family, genus, and species.

In 1172 Ibn Rushd (Averroes) translated Aristotle's book "de Anima" into Arabic.

(a) Two-Kingdom Classification System

It was the earliest classification system in which all organisms were classified into two kingdoms i.e., Plantae and Animalia. The organisms that can prepare their own food (autotrophs) were classified in the kingdom plantae. On the other hand, the organisms that cannot make their own food (heterotrophs) were classified in kingdom animalia. According to this system, prokaryotes (bacteria, archaea) and fungi were members of kingdom plantae.

Taxonomists found this system unworkable because 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) characteristics. So, a separate kingdom was proposed for such organisms. This system also did not clear the difference between prokaryotes (bacteria and archaea) and eukaryotes.

(b) Three-Kingdom Classification System

In 1866, the German zoologist **Ernst Hackel** proposed a third kingdom i.e., Protista for Euglena-like organisms. He also included prokaryotes (bacteria and archaea) in the kingdom Protista. In this system, fungi were still included in the kingdom Plantae. Some taxonomists disagreed about the position of fungi in kingdom Plantae. Fungi resemble plants in many ways but are heterotrophs which get their food by absorption. They do not have cellulose in their cell walls but possess chitin.

(c) Five-Kingdom Classification System

In 1937, French biologist **E-Chatton** suggested the terms, "Prokaryotic" to describe bacteria and "Eukaryotic" to describe protista, fungi, animals and plants. In 1969, American ecologist **Robert Whittaker** introduced the five-kingdom classification system. This system is based on;

- The levels of cellular organization i.e. prokaryotic (bacteria, archaea), unicellular eukaryotic (Protista) and multicellular eukaryotic (fungi, plants and animals)
- The modes of nutrition i.e. photosynthesis, absorption, and ingestion.

On this basis, organisms were classified into five kingdoms: Monera, Protista, Fungi, Plantae and Animalia. In 1988, American biologists Margulis and Schwartz modified the five-kingdom classification of Whittaker. They considered genetics along with cellular organization and mode of nutrition in classification. They classified the organisms into the same five kingdoms as proposed by Whittaker.

(d) Three-Domain Classification System

In 1977, American microbiologist **Carl Woese** (1928-2012) added a taxon i.e., **domain** above kingdom. He classified organisms into three domains i.e., Archaea, Bacteria, and Eukarya. It was actually a division of the prokaryotes in two domains i.e., Archaea and Bacteria. While all eukaryotes were placed in a single domain i.e., Eukarya. This classification is based on the differences between Archaea and Bacteria.

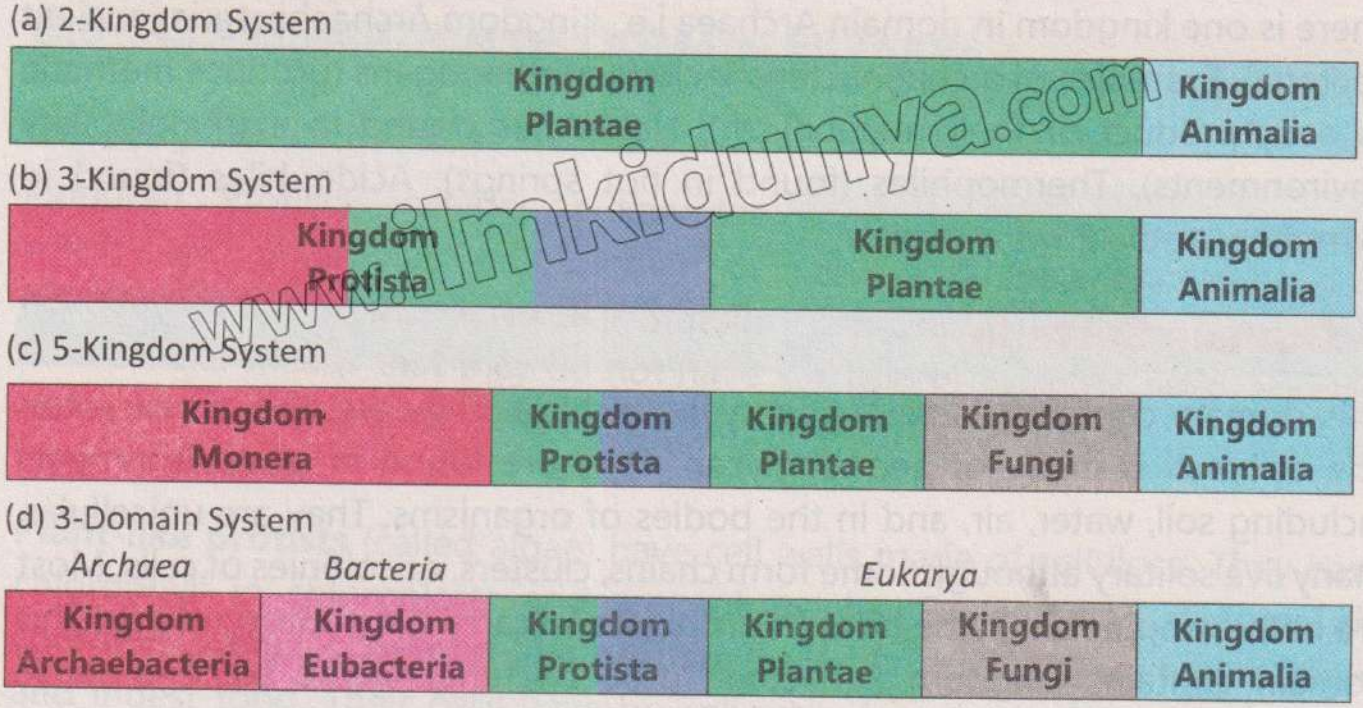


FIGURE 2.2: Different Classification Systems

2.5- DOMAINS OF LIVING ORGANISMS

The following are the main characteristics of the three domains of organisms.

1- Domain Archaea

These are the most primitive organisms on Earth. They are prokaryotes but their cell wall does not contain peptidoglycan but is made of various polypeptides and proteins. Their rRNA (ribosomal RNA) resembles more to eukaryotes than to bacteria. Their cell membrane contains unique lipids which enable them to live in extreme environments e.g., hot springs, salt lakes, and acidic or alkaline waters. However, they also exist in more common environments like soil and oceans. Some archaea obtain energy from inorganic compounds such as sulphur or ammonia. Their other groups perform photosynthesis but do not produce oxygen.

FIGURE 2.3: Diversity in domain Archaea

There is one kingdom in domain Archaea i.e., kingdom Archaebacteria (ancient bacteria). Examples of archaebacteria include Methanogens (produce methane as a by-product of their metabolism), Halophiles (found in extremely salty environments), Thermophiles (found in hot springs), Acidophiles (found in extremely acidic environments).

2- Domain Bacteria

This domain contains bacteria and cyanobacteria. They are also prokaryotes. 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 solitary although some form chains, clusters, or colonies of cells. Most are heterotrophic but some have chlorophyll and carry out photosynthesis. This domain contains kingdom Eubacteria (true bacteria). Some bacteria cause diseases. Many bacteria are beneficial e.g., decomposer bacteria play important role in nutrient recycling.

3. Domain Eukarya

The domain includes all unicellular and multicellular eukaryotes. They have complex eukaryotic cells with nucleus and other membrane-bound organelles. This domain contains kingdoms protista, fungi, plantae and animalia.

FIGURE 2.4: Three Domains

2.6- CLASSIFICATION OF DOMAIN EUKARYA

(a) Kingdom Protista

Kingdom Protista includes eukaryotes which are unicellular or colonial or filamentous or simple multicellular. Simple multicellular means that they do not have multicellular sex organs. There are three types of protists.

Certain protists are parasitic and cause diseases. For example, *Plasmodium* causes malaria and *Entamoeba* causes a type of dysentery called amoebic dysentery.

Plant-like protists (called algae) have cell walls made of cellulose. They have chlorophyll in chloroplasts and are autotrophs. *Euglena* and diatoms are common examples. **Animal-like protists** (called protozoans) are heterotrophs and ingest food. Their cells have no cell wall. *Amoeba* and *Paramecium* are common examples. **Fungus-like protists** (called molds) absorb nutrients from decaying organic matter. Their cell walls are made of cellulose instead of chitin. Slime molds and water molds are examples.

FIGURE 2.5: Common protists

(b) Kingdom Fungi

This kingdom consists of fungi. They are heterotrophic. Fungi get nutrients in a unique way. They do not ingest food like animals and some protists. They absorb food from decaying matter present in their surroundings. Fungi are eukaryotic and have cell wall around their cells. Their cell wall is made of chitin (a polysaccharide). Most of the fungi are multicellular e.g., mushrooms, rusts, smuts and molds while a few are unicellular e.g., yeast.

Some fungi are used in the production of bread, cheese and beer. An antibiotic, called penicillin, is derived from the fungus *Penicillium*.

Smut fungi on leaf Toadstool Bracket fungi Sweet Tooth Fungi

FIGURE 2.6: Common fungi

(c) Kingdom Plantae

It includes plants which are eukaryotic, multicellular organisms with cell walls made of cellulose. They are autotrophic and prepare food through photosynthesis. All plants have multicellular sex organs. During sexual reproduction, they form embryos. Asexual reproduction through vegetative parts is also common. Examples are mosses, ferns, conifers and flowering plants.

Moss Fern Conifer Flowering plant

FIGURE 2.7: Common plants

(d) Kingdom Animalia

This kingdom includes animals which are eukaryotic, multicellular and heterotrophic. They develop from embryos. They ingest food and digest it within their bodies. Vertebrates and invertebrates are included in kingdom Animalia.

2.7- Status of Virus in Classification

Viruses are ultramicroscopic creatures that are at the borderline of living and non-living. They are acellular i.e., they are not made of cells and do not have organelles. A virus consists of nucleic acid (DNA or RNA) surrounded by a protein coat. They cannot run metabolism. For the synthesis of their proteins and to increase in number, viruses become parasites in organisms (plants,

animals, and bacteria). Viruses are not included in the classification system because they lack any of the characteristics of the three domains of life.

FIGURE 2.8: Two common viruses – Left; A bacteriophage (virus which attacks bacteria) and Right; Influenza virus

Prions and viroids are also acellular particles and are also not included in classification system. Prions are composed of protein only and Viroids are composed of circular RNA only. Both these particles cause infectious diseases in certain plants. They are also a cause of cancer.

Table : Characteristics of the Domains and Kingdoms of Life

Domain	Archaea	Bacteria	Eukarya			
Kingdom	Archaebacteria	Eubacteria	Protista	Fungi	Plantae	Animalia
Cell Type	Prokaryotic		Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Nuclear Envelope	Absent		Present	Present	Present	Present
Cell Wall	Archaebacteria: polypeptides and proteins Eubacteria: peptidoglycan		Present in some, various types	Chitin	Cellulose and other polysaccharides	Absent
Mode of Nutrition	Autotroph or heterotroph		Autotroph or heterotroph, or combination	Absorptive heterotroph	Autotroph	Ingestive heterotroph
Multi - cellularity	Absent in all		Absent in most	Present in most	Present in all	Present in all

Coronavirus is a virus, identified in late 2019 in Wuhan, China. It caused a pandemic of respiratory illness, called COVID-19. The virus primarily spreads through respiratory droplets when an infected person coughs, sneezes, talks, or breathes. It can also spread by touching surfaces contaminated with the virus. Wearing a mask over nose and mouth can help to prevent the spread of disease. Common symptoms of this disease include fever, cough, shortness of breath, fatigue, body aches, loss of taste or smell, sore throat, and headache. In some cases, it can lead to severe respiratory problems, especially in older adults and people with underlying health conditions. Washing hands frequently with soap for at least 20 seconds or use of hand sanitizer with at least 60% alcohol can also prevent the spread of disease. Vaccination plays a crucial role in protecting from COVID-19. Vaccines help immune system to recognize and fight the virus, reducing the severity of the disease.

2.8- BINOMIAL NOMENCLATURE

The great Swedish biologist Carl Linnaeus was the founder of the system of giving scientific names to organisms. The scientific name of an organism consists of two parts. The first part is the name of the genus to which the organism belongs. The second part is the name of the species. The system of scientific naming of organisms is termed as binomial nomenclature.

Common Name	Scientific Names
Onion	*Allium cepa*
Potato	*Solanum tuberosum*
Tomato	*Solanum esculentum*
Honeybee	*Apis cerana*
Tiger	*Panthera tigris*
Human being	*Homo sapiens*

Significance of Binomial nomenclature

- In binomial nomenclature, two organisms cannot have the same name. The words of scientific name are taken from Latin language (spoken by no country) so that no country is favoured. The scientific name of an organism is same anywhere in the world. This system provides a standard way of communication, whether the language of a particular biologist is Chinese, Arabic, Spanish, or English.

- Various regions have different names for the same organism e.g. the common name of onion in Urdu is 'Piyaz' but in different regions of Pakistan it is also known as 'ganda' or 'bassal' or 'vassal'. In other countries it has other sets of names.
- In some cases, several different organisms are called by the same common name, e.g. 'blue bell' is used for dozens of plants with bell shaped flowers. Similarly, 'black bird' is used for crow as well as for raven.
- Common names have no scientific basis. For example; a fish is a vertebrate animal with a backbone, fins and gills. But several common names of 'silver fish', 'cray fish', 'jellyfish', and 'star fish' do not fit to the true definition of fish.

Rules of Binomial nomenclature

The scientific naming of an organism is done in accordance with some international rules. Some important rules of binomial nomenclature are:

1. For scientific naming, words are taken from Latin language.
2. Every scientific name has two parts. The genus name always comes first followed by the species name.
3. Every scientific name should have to be unique because the same name cannot be used for naming two different organisms.
4. The first part of the name i.e. genus name should begin with a capital letter. The second part of the name i.e. species name should begin with small letter.
5. At the time of printing of a scientific name, it should be typed in Italics.
6. When a scientific name would be hand written, two parts of it should be separately underlined.

KEY POINTS

- Biodiversity is a measure of the variety of living organisms present in different ecosystems including terrestrial, marine and desert ecosystems.
- Classification is the process in which organisms are divided into groups and subgroups on the basis of similarities and differences found in them.
- The groups into which organisms are classified are known as taxonomic ranks or taxa (singular "taxon").
- The highest level of classification is the domain.
- Living organisms are broadly classified into three domains: Archaea, Bacteria, and Eukarya.
- The members of kingdom protista are unicellular or simple multicellular organisms and have eukaryotic cells.
- Fungi are eukaryotic heterotrophic organisms which absorb food.
- Plants are eukaryotic multicellular autotrophs and have multicellular sex organs.
- Animals are eukaryotic multicellular heterotrophs which ingest food and digest it in specialized cavities.
- Viruses lack any of the characteristics of the three domains or six kingdoms of life; therefore, they are not included in the classification system.
- The scientific name of every organism consists of two parts; first is the name of the genus and second is the name of its species.

EXERCISE

A. Select the correct answers for the following questions.

1. Which of the following taxonomic ranks represents the broadest rank?
   a) Species
   b) Genus
   c) Kingdom
   d) Domain
2. Which characteristics is unique to organisms in the domain Archaea?
   a) Cell walls made of peptidoglycan
   b) Presence of a nucleus
   c) Ability to live in extreme environments

d) Lack of ribosomes

3. Which of these statements is NOT related to bacteria?
   a) Do not have a nucleus.
   b) Cell wall made of peptidoglycan
   c) Most are heterotrophic
   d) Have chlorophyll in their chloroplast.
4. Which of these organisms belongs to the domain Eukarya?
   a) *Escherichia coli*
   b) Yeast
   c) Coronavirus
   d) None of these
5. Which of the following is a key characteristic that distinguishes eukaryotic cells from prokaryotic cells?
   a) Lack of a cell wall
   b) Presence of a nucleus
   c) Absence of ribosomes
   d) Smaller size
6. Which kingdom includes organisms that are primarily unicellular, eukaryotic, and often heterotrophic?
   a) Archaea
   b) Protista
   c) Fungi
   d) Plantae
7. Why are fungi included in heterotrophic organisms?
   a) Have chitin in cell wall
   b) Absorb nutrients
   c) Reproduce by spores
   d) Cannot prepare food
8. Why it is impossible to classify viruses within traditional biological kingdoms?
   a) They lack cellular structure and organelles.
   b) They cannot perform photosynthesis.
   c) They are smaller in size than bacteria.
   d) They are parasites.
9. Which of the following is the correct way for writing the scientific name of humans?
   a) *Homo sapiens*
   b) Homo sapiens
   c) Homo Sapiens
   d) homo sapiens
10. Which information you can get if you know the scientific name of an organism?
    a) Kingdom and phylum
    b) Phylum and genus
    c) Genus and species
    d) Class and species

B. Write short answers.

1. What is the term used to describe the variety of organisms in ecosystems?
2. How is the biodiversity crucial for humans and for the planet Earth?
3. What are the seven taxonomic ranks used in the Linnaean system?
4. Write the taxonomic ranks of lion and corn?
5. What are the basic differences between archaea and bacteria?
6. What are the shortcomings of the three-kingdom classification system?
7. Which kingdom includes organisms that are multicellular and heterotrophic, and lack cell walls?
8. Enlist the distinguishing characteristics of fungi.
9. List the three domains that encompass all living organisms.
10. Why cannot we classify viruses in any kingdom?
11. How does binomial nomenclature facilitate clear communication about organisms across different languages?

C. Write answers in detail.

1. Discuss biodiversity and its significance in maintaining the health of ecosystems.
2. Explain the importance of classification in biology and how it helps us understand the relationships between different organisms.
3. Describe the Linnaean system of classification in detail, stating the seven taxonomic ranks and their relationships.
4. Compare and contrast the domains Archaea and Bacteria, focusing on their key characteristics.
5. Describe the diagnostic characteristics of the four kingdoms within the domain Eukarya.
6. Discuss the challenges of classifying viruses within the traditional three domains of life.
7. Explain the rules and guidelines for suggesting scientific names to organisms.

D. Inquisitive questions.

1. How might placing an organism in the incorrect taxonomic group affect conservation or scientific studies?
2. Imagine you discover a new organism. What steps would you take to classify and name it according to the principles of binomial nomenclature?