# CHAPTER 8.1 – CLASSIFICATION SYSTEM AND NAMING OF ORGANISMS

## The necessity of classification system and naming of organisms

- Biodiversity is the variety of living organisms (microorganisms, animals and plants) that interact with one another
- All organisms need to be scientifically classified based on defining features in a systematic manner, in order to facilitate studies and discussions among scientists at an international level

## Taxonomy

- Taxonomy is a field in biology which involves the classification, identification and naming of organisms in an organised manner
- Taxonomy strives to manage information and data which has been collected using a systematic and methodical approach to elucidate the scientific community
- Taxonomic classification system
    1. Classification
    2. Identification
    3. Naming

**CLASSIFICATION**

- Organisms are categorised based on physical features in a taxonomic hierarchy system

**IDENTIFICATION**

- Organisms are identified using dichotomous keys

**NAMING**

- Organisms are named using a binomial nomenclature system

## Classification of organisms

There are six kingdoms

- Archaebacteria
- Eubacteria
- Protista
- Fungi
- Plantae
- Animalia

**TERM ANALYSIS**

- Prokaryote → A type of cell which lacks a membrane-bound nucleus and membrane-enclosed organelles
- Eukaryote → Has a nucleus and membrane-enclosed organelles
- Unicellular → Single-celled
- Multicellular → More than one cell
- Heterotroph → an organism that cannot synthesise its own food but obtains food molecules by eating other organisms

- Autotroph → An organism that can synthesise its own food from organic materials by using light energy or chemical energy

# The main features of organisms in each kingdom

## ARCHAEBACTERIA

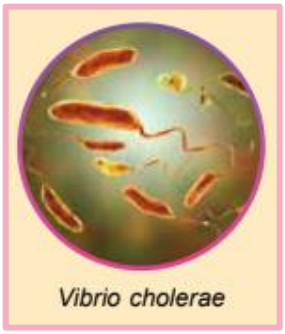
- ❑ Is a prokaryote organism
- ❑ Is a unicellular organism
- ❑ Can either be an autotroph or a heterotroph
- ❑ Are primitive bacteria
- ❑ Has cell walls with no peptidoglycan
- ❑ Lives in very hot, acidic, salty or anaerobic environments
- ❑ Can be divided into methanogen, halophile and thermophile
- ❑ Methanogen
    - i) Obligate anaerobic bacteria are found in swamps and the digestive tract of ruminants (animals' stomach) and humans
    - ii) Produces methane as a metabolic by-product
- ❑ Halophile
    - 1) Found in places with extremely high salt concentration (the Dead Sea)
    - 2)
- ❑ Thermophile
    - a) Bacteria that can withstand high temperatures and flourishes at an optimum temperature of 60°C to 80°C
    - b) Found in hot springs and highly acidic locations (the Yellowstone National Park, U.S.)
- ❑ For example
    - i. *Sulfolobus* sp. (sulphur-oxidising bacteria)
    - ii. *Halobacterium salinarum*

*Halobacterium salinarum*

## EUBACTERIA

- ⊕ Is a prokaryote organism
- ⊕ Is a unicellular organism
- ⊕ Usually, form colonies
- ⊕ Can either be an autotroph or a heterotroph
- ⊕ A.k.a. "true" bacteria
- ⊕ Has cell walls made up of peptidoglycan
- ⊕ Peptidoglycan is a.k.a. murein which is a polymer made up of sugars and amino acids
- ⊕ The cytoplasm of the eubacteria contains ribosome and plasmids
- ⊕ Has none of the membrane-enclosed organelles (mitochondria, endoplasmic reticulum)
- ⊕ Bacteria are classified according to their shape
- ⊕ For example,
    1. *Streptococcus pneumoniae*
    2. *Vibrio cholerae*
    3. *Salmonella* sp.


Streptococcus pneumoniae


Vibrio cholerae

## PROTISTA

- Is a eukaryote organism
- Can either be a unicellular or a multicellular organism
- Can either be a heterotroph or an autotroph or both
- Has a simple cell organisation without specialised tissue
- The cells contain a nucleus that is bound by a nuclear membrane as well as other membrane-bound organelles
- Protists are divided into three group
    a. Protozoa
    b. Algae
    c. Slime mould
- Examples of protozoa
    I. *Euglena* sp.
    II. *Amoeba* sp.
    III. *Paramecium* sp.
- Examples of algae
    A. *Chlamydomonas* sp.
    B. *Spirogyra* sp.
- Examples of slime mould
    1 *Physarum polycephalum*


Chlamydomonas sp. Spirogyra sp.

## FUNGI

- Is a eukaryote organism
- Can either be a unicellular or a multicellular organism
- They are also heterotrophs (saprophytes or parasites)
- Their cell wall is made up of chitin
- The body is made up of a thread-like network of hyphae called the mycelium
- Examples of fungi
    i) *Saccharomyces cerevisiae* (yeast)
    ii) *Agaricus* sp. (mushroom)
    iii) *Mycena haemaropus* (mushroom) mycena


Saccharomyces cerevisiae Agaricus sp.

## PLANTAE

- Is a eukaryote organism
- Includes all multicellular plants
- They are also autotrophs
- Can synthesise their own food via photosynthesis (photoautotroph) because they have chlorophyll
- Can undergo sexual or asexual reproduction
- Examples of plantae
    1) Seedless plants (ferns)
    2) Plants with seeds (all flowering plants)
    3) *Coleus blumei* (coleus)
    4) *Bougainvillea* sp.

*Bougainvillea* sp.

**ANIMALIA**

- ↘ Is a eukaryote organism
- ↘ Involved all multicellular organism
- ↘ They are heterotrophs
- ↘ Most animals can move
- ↘ Most animals reproduce sexually
- ↘ Examples of animalia
    a) Invertebrate (starfish)
    b) Vertebrate (elephant)
    c) Alcedo atthis (common kingfisher)


## Taxonomy hierarchy

- ✓ The hierarchy system used in taxonomy is the Linnaeus hierarchy system
- ✓ The Linnaeus hierarchy system classifies organisms according to hierarchy starting from species to domain
- ✓ The orders of the hierarchy are
    A. Domain
    B. Kingdom
    C. Phylum
    D. Class
    E. Order
    F. Family
    G. Genus
    H. Species
- ✓ This classification order is known as the taxonomy hierarchy

**DOMAIN**

- ⊕ Domain is the highest taxonomic rank of organisms in the hierarchical biological classification system

**KINGDOM**

- ❑ Each kingdom is divided into smaller groups called phylum

**PHYLUM**

- Organisms in the same phylum have mutual characteristics
- Organisms in a particular phylum are different from organisms from different phylum
- Phylum is further divided into class

**CLASS**

- → Class is divided into order

**ORDER**

- ▪ Order is divided into family

**FAMILY**

- » Family is divided into genus

**GENUS**

- ◊ Genus is divided into species

**SPECIES**

- ↘ A species is the smallest group used to classify organisms
- ↘ Organisms of the same species are capable of interbreeding among themselves to produce viable fertile offsprings

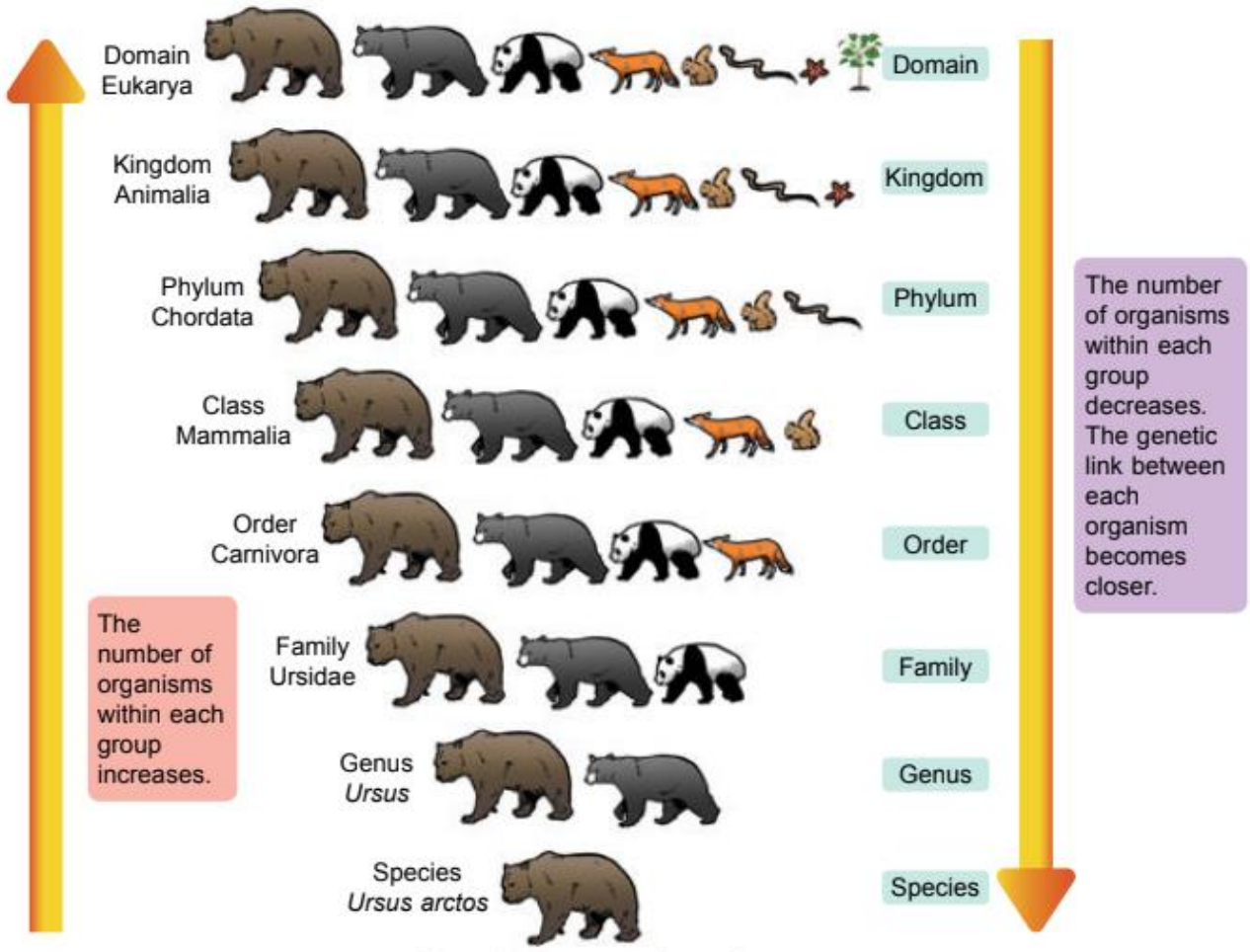



**Figure 8.3** Taxonomy hierarchy

# Binomial nomenclature system

- The formal system of naming organisms practised today is the called the Linnaeus binomial system
- The scientific name given to all organisms is accepted and used worldwide
- Each given name usually provides an idea of the organisms' traits, the state of their habitat, their country of origin or to honour the researchers that had studied them
- For example, in the scientific name for the pea plant (*Pisum sativum* L.), the L refers to Linnaeus, the first person who named the plant

## THE STEPS TO WRITE THE SCIENTIFIC NAME

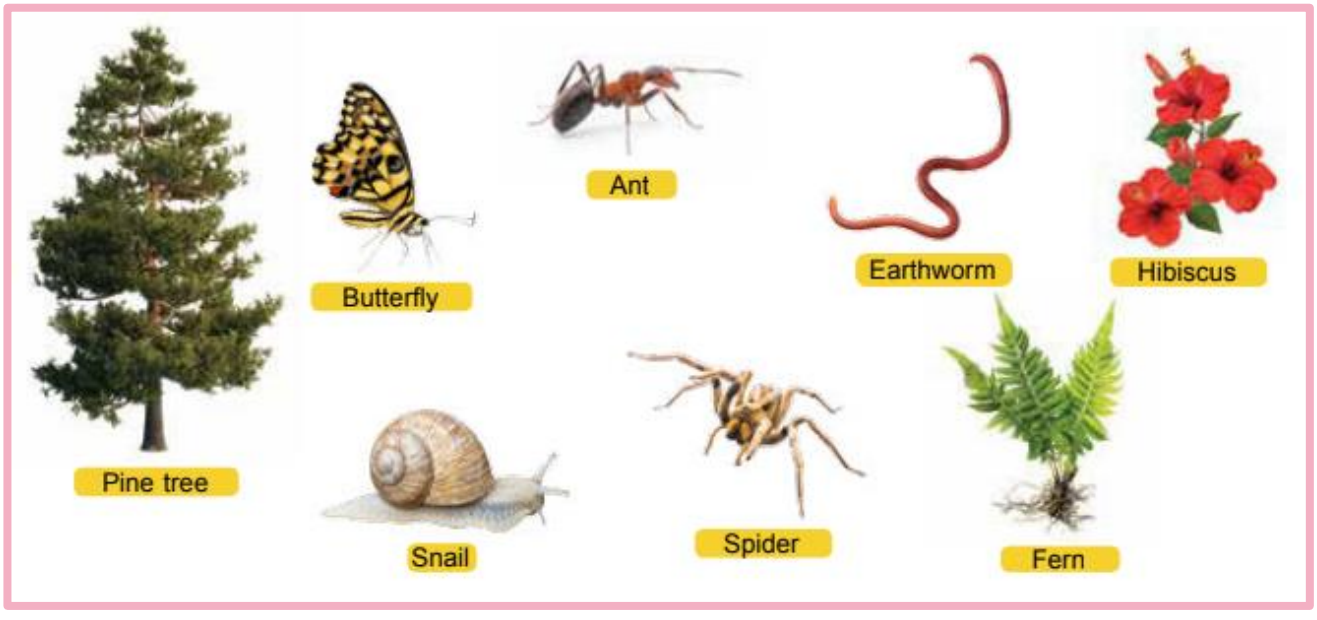
1. Each scientific name consists of two words
   - The first word is the name of the genus
   - The second word is the name of the species
2. The first letter of the genus is capitalised while the name of the species is not
3. All scientific names must be printed in italics
4. If handwritten, the two names must be underlined separately

## EXAMPLES OF SCIENTIFIC NAMES

| COMMON NAME | GENUS NAME | SPECIES NAME | SCIENTIFIC NAMES | |
|---|---|---|---|---|
| | | | HANDWRITTEN | PRINTED |
| Common kingfisher | Alcedo | atthis | Alcedo atthis | *Alcedo atthis* |
| Green paddy frog | Rana | erythraea | Rana erythraea | *Rana erythraea* |
| Paddy | Oryza | sativa | Oryza sativa | *Oryza sativa* |
| Sacred lotus | Nelumbo | nucifera | Nelumbo nucifera | *Nelumbo nucifera* |
| Common sunflower | Helianthus | annuus | Helianthus annuus | *Helianthus annuus* |
| Pea plant | Pisum | sativum L. | Pisum sativum L. | *Pisum sativum* L. |

## Dichotomous key

- A dichotomous key is a tool used by taxonomists to identify organisms based on similarities and differences
- One of the ways to build a dichotomous key is by using a series of couplets
- Each couplet is made up of two statements about the organism's traits or its grouping
- A dichotomous key is specific to an identification process
- When identifying other organisms, a different set of dichotomous keys is used
- The traits chosen must be based on obvious and observable features
- Overlapping traits must be avoided



| | | Dichotomous key |
|---|---|---|
| 1a | Animals | Go to 2 |
| 1b | Plants | Go to 6 |
| 2a | Has legs | Go to 3 |
| 2b | Does not have legs | Go to 5 |
| 3a | Three pairs of legs | Go to 4 |
| 3b | More than three pairs of legs | **Spider** |
| 4a | Has wings | **Butterfly** |
| 4b | Does not have wings | **Ant** |
| 5a | Has shell | **Snail** |
| 5b | Does not have shell | **Earthworm** |
| 6a | Has seeds | Go to 7 |
| 6b | Does not have seeds | **Fern** |
| 7a | Flowering plant | **Hibiscus** |
| 7b | Non-flowering plant | **Pine tree** |

**Figure 8.4** A sample of a dichotomous key

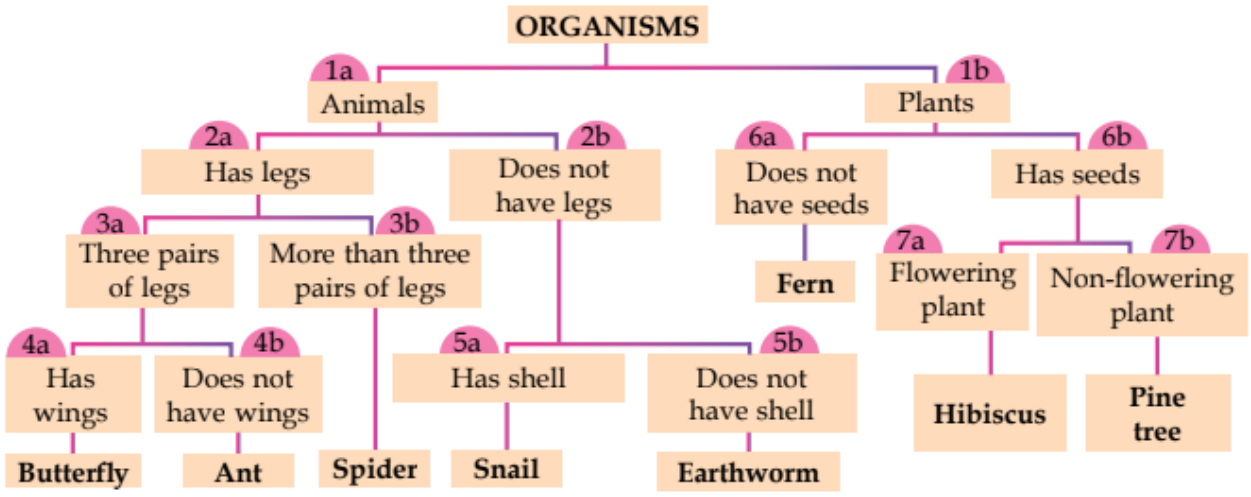



**Figure 8.5** Spider dichotomous key

# CHAPTER 8.2 – BIODIVERSITY

## Concept of biodiversity

### GENETIC DIVERSITY

- Genetic diversity refers to the genes variation of an individual within a population and the genes variation between different populations of the same species
- Differences in genes are due to individual isolation and adaptation to different environments
- No two individuals of the same species are identical
- For example, the huge variety in gene combination allows for genetic variation in plants such as paddy.
- There are many varieties of cultivated rice all over the world

### SPECIES DIVERSITY

- Species diversity refers to the variation and variability of organisms on Earth
- Species diversity includes the total number of species in a community (species richness) and the species distribution in a community (species evenness)
- For example, tropical rainforests have large species diversities
- There are 5-10 million of insect species while there can be more than two million species of flowering plants

### ECOSYSTEM DIVERSITY

- Ecosystem diversity refers to the biotic community and ecological process in ecosystem on the land, in the sea and other aquatic environments
- For example, there are ecosystems rich with biodiversity that can be found in the ocean, in the desert or even in the swamp

## Phylogenetic tree

- Phylogeny means the evolutionary history of a species or a group of organisms that are genetically linked
- A phylogenetic tree is a diagram that represents hypotheses on evolutionary relationships among a group of organisms
- Phylogenetic classification is the classification system that shows the evolutionary relationships and history of the studied organism
- Phylogenetic classification is now used in many modern classification systems
- In phylogenetic classification, classification is done using a homologous structure
- A homologous structure refers to a structure (body parts or body anatomy) that can be observed across multiple organisms which share the same ancestor even though the function of the structure may differ from one organism to another

- The evolutionary relationship and history between different types of species can be depicted via phylogenetic tree
- The branches in phylogenetic tree show how a species or a group of organisms diverge from the same ancestor
- For example, human, cat, whale and bat share the same bone structure but differ greatly in size and length
- Despite the differences in function, it is clear that the limbs of the four animals originate from one common ancestor

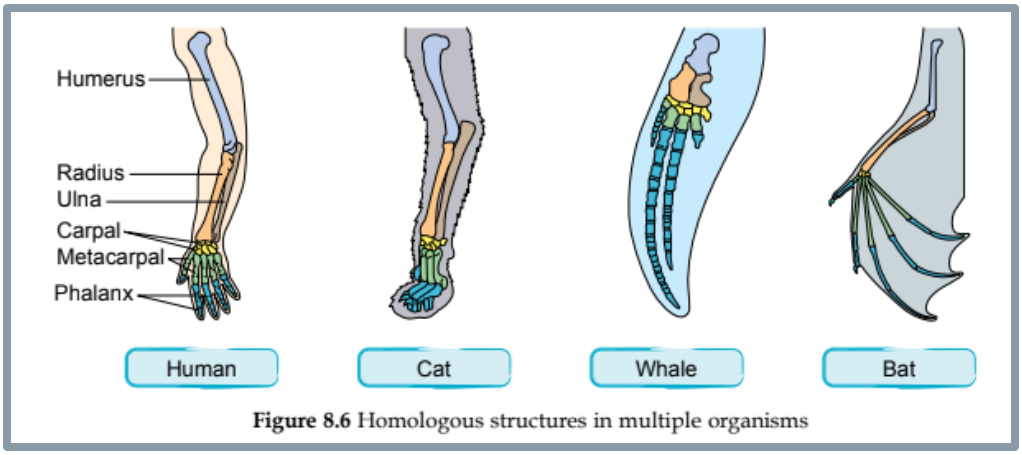



**Figure 8.6** Homologous structures in multiple organisms

- Evidence suggests that land plants evolved from green algae
- First land plants originated from non-vascular plants (mosses), followed by seedless vascular plants (ferns)
- Vascular plants then advance into gymnosperms and angiosperms, which are vascular plants with seed
- Examples of gymnosperms and angiosperms are conifers and flowering plants respectively
- Angiosperms are considered as the most successful plants since their seeds are enclosed inside the fruits to ensure species survival

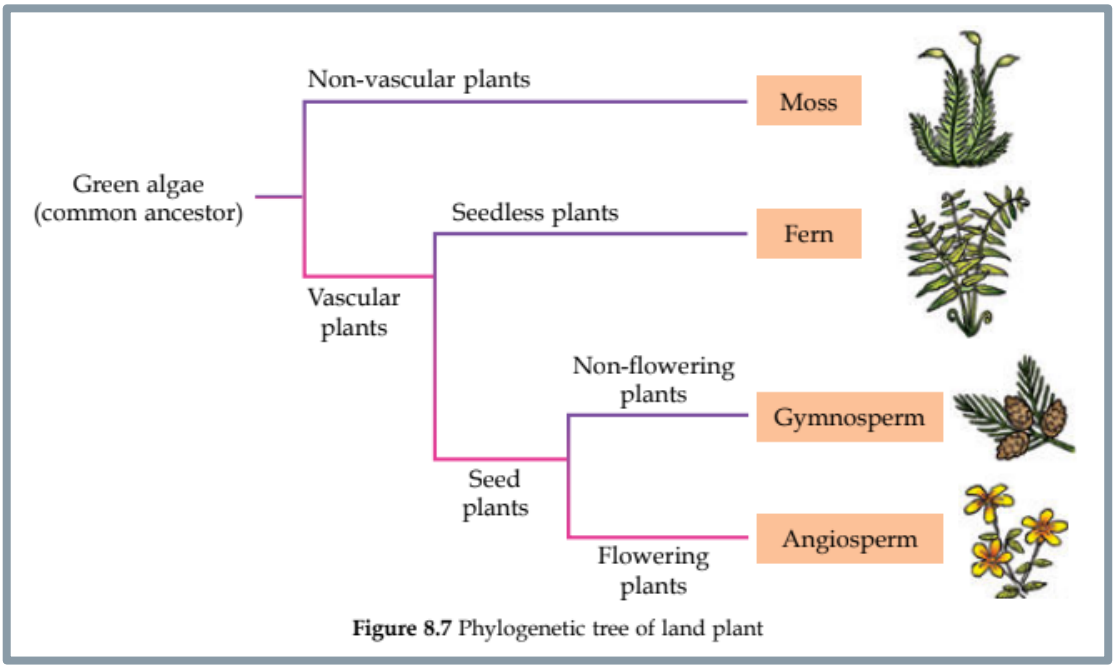



**Figure 8.7** Phylogenetic tree of land plant

# The importance of biodiversity on the environment and humans

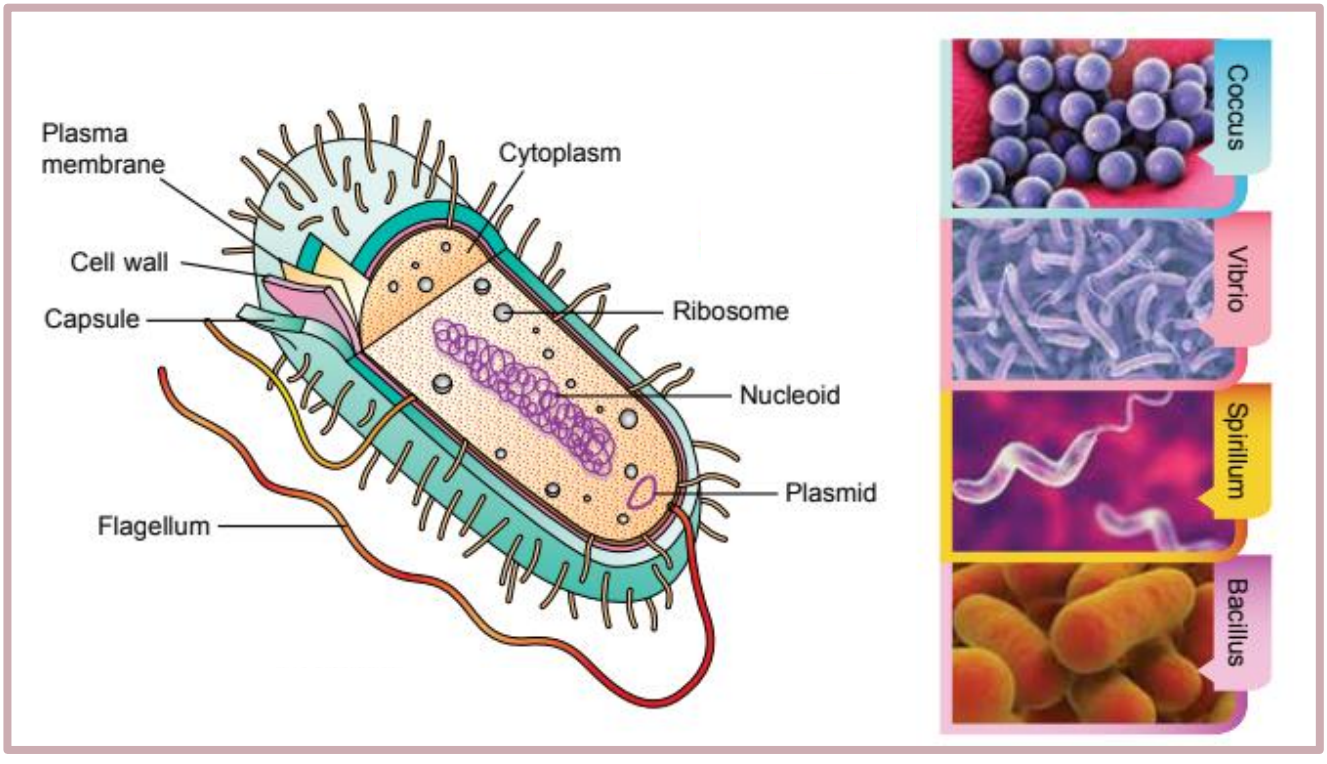
- Biodiversity also maintains a balance in nature, for both recreation and scientific research
- In situ conservation maintains species in their natural habitat (in the National Park and permanent forest reserves)
- Ex situ conservation in efforts to conserve species found outside of their natural habitats (in zoos and botanical gardens)

# CHAPTER 8.3 – MICROORGANISMS AND VIRUSES

## The main characteristics of microorganisms and viruses

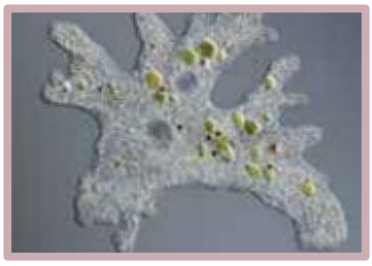
### BACTERIA

- Singular: bacterium
- Bacteria do not have nucleus due to the lack of nuclear membranes
- Their genetic materials exist in the form of chromosomal threads (DNA) that free-floating inside the cytoplasm which known as the nucleoid
- Some bacteria have plasmid, which is small DNA molecules that carry extra genes
- Bacteria range from 1 to 10 µm (micrometre) long
- Bacteria can exist as a single cell, a diploid (a pair), in filaments, chain or clusters
- Bacteria can exist in a few basic shapes
    a) Coccus (sphere)
    b) Vibrio (comma)
    c) Bacillus (rod or cylinder)
    d) Spirillum (spiral)
- The shape of the bacteria can be known from the name itself
- For example:
    i) *Lactobacillus* sp. (rod or cylinder)
    ii) *Streptococcus* sp. (sphere)
    iii) *Staphylococcus aureus* (sphere)



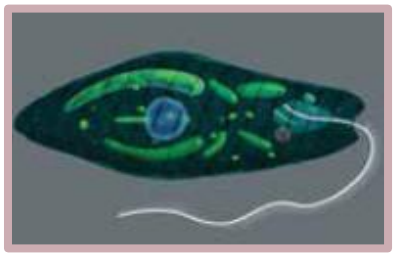
## PROTOZOA

- Singular: protozoan
- Protozoa are animal-like unicellular microorganisms
- Protozoa move around using pseudopodia (false feet), cilia or flagellum
- Protozoa are usually found in aquatic habitats
- Protozoa are heterotrophs or autotroph
- Euglena sp. is an autotroph that consists of chloroplasts and can undergo photosynthesis
- Protozoa can be free-living or parasitic
- For example:
    1) Amoeba sp. (move by pseudopodia)
    2) Paramecium sp. (move by cilia)
    3) Euglena sp. (move by flagellum)



*Amoeba* sp.

*Paramecium* sp.



*Euglena* sp.

## ALGAE

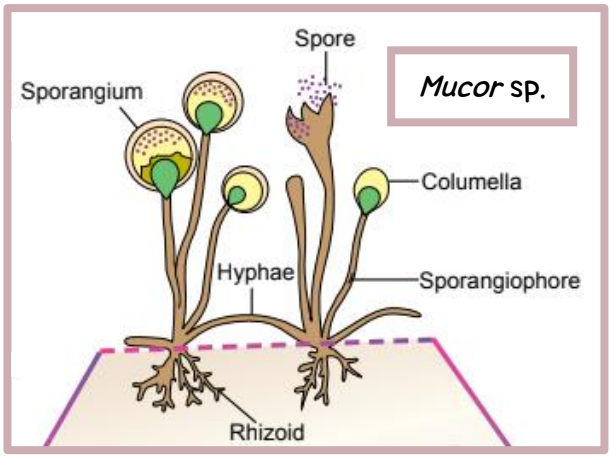
- Singular: alga
- Consists of unicellular microorganisms (*Chlamydomonas* sp.) and multicellular organisms (brown algae, *Fucus* sp.)
- Some algae have flagellum to move in water
- Algae are autotrophs that have chloroplasts and can undergo photosynthesis
- Algae do not have leaves, stems or roots like plants do
- Algae live in ponds, lakes and ocean

*Chlamydomonas* sp.

*Fucus* sp.

## FUNGI

- Singular: fungus
- Fungi are heterotrophs, either parasites or saprophytes
- Fungi do not contain roots, stem and leaves but have cell walls created by chitin
- Fungi exist in the form of mycelium, which is made up of a network of threads called the hyphae
- Fungi are unicellular microorganisms (yeast, *saccharomyces cerevisiae*) or multicellular microorganisms (*Mucor* sp.)
- Fungi are found in dark or moist places and on decomposing or dead organisms




*Mucor* sp.

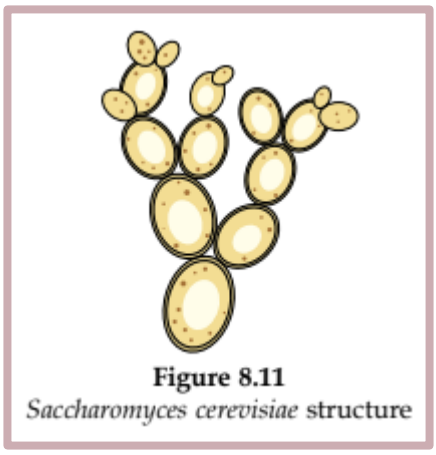
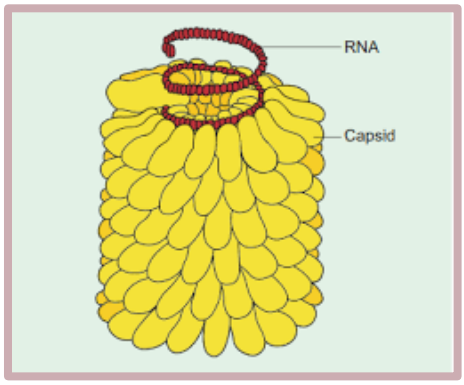


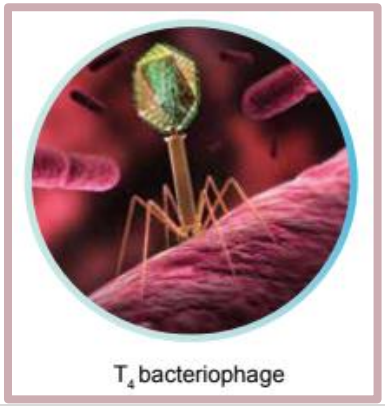
**Figure 8.11**
*Saccharomyces cerevisiae* structure

## VIRUSES

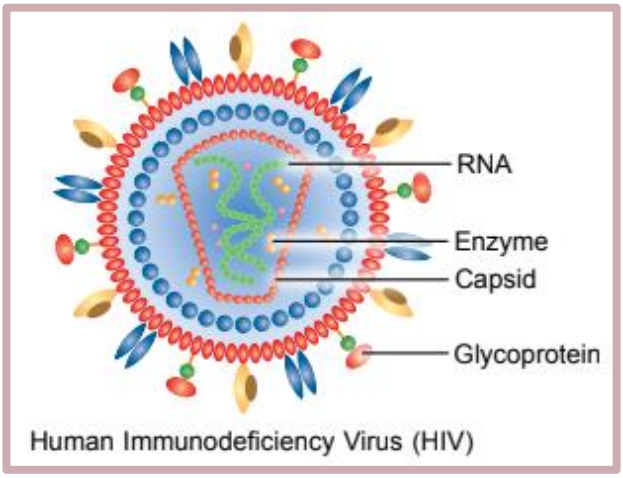
- Singular: virus
- Viruses are not included in any of the kingdoms because they are not cellular organisms
- The virus does not carry out any life processes outside of a cell
- Viruses reproduce using living cells by injecting their genetic materials into host cells
- Viruses are made up of nucleic acid (DNA or RNA) and capsids that made from protein
- The size of a virus is too small (20 nm to 400 nm)
- Virus cannot be seen using a light microscope but can only be seen using an electron microscope
- For examples:
    a. Tobacco mosaic virus
    b. $T_4$ bacteriophage
    c. HIV (Human Immunodeficiency Virus)




Tobacco mosaic virus



$T_4$ bacteriophage



Human Immunodeficiency Virus (HIV)

# The role of microorganisms in the nitrogen cycle

- ⊕ Plants require nitrogen to synthesise protein in plant tissues
- ⊕ Nitrogen is obtained from the soil in the form of ammonium ions ($NH_4^+$) and nitrate ions ($NO_3^-$)

## NITROGEN-FIXING

- Nitrogen-fixing bacteria live in the root nodules of legumes (*Rhizobium* sp.) and free-living nitrogen-fixing bacteria in the soil (*Azotobacter* Sp.)
- These bacteria fix the nitrogen from the atmosphere and changes it to ammonium ions ($NH_4^+$) via the nitrogen-fixing process

## OXIDATION OF NITROGEN

→ Lightning in a thunderstorm oxidises nitrogen to form nitrogen dioxide ($NO_2$)

→ Nitrogen dioxide ($NO_2$) dissolves in rainwater to form nitrous acid and nitric acid ($HNO_3$)

→ Both acid form nitrate salts in the soil

→ Industrial fertilisers provide ammonium fertilisers and nitrates in the soil

## DECOMPOSITION

❖ When plants and animals die, decomposition is carried out by decomposers (bacteria and saprophytic fungi)

## AMMONIFICATION

➢ Protein in body tissue of dead organisms will be broken down into ammonium ions ($NH_4^+$) via ammonification

## NITRIFICATION

♥ Ammonium ion are converted into nitrite ions ($NO_2^-$) via nitrification by nitrifying bacteria (*Nitrosomonas* sp.)

♥ Nitrite ions will be converted to nitrate ions ($NO_3^-$) by the nitrifying bacteria (*Nitrobacter* sp.)

## DENITRIFICATION

Δ The nitrates will then be absorbed by plant roots and used to synthesise proteins

Δ When the plants are eaten by animals, nitrogen gets transferred to the animal's tissue

Δ Denitrifying bacteria convert nitrates in the soil into nitrogen gas through the denitrification process

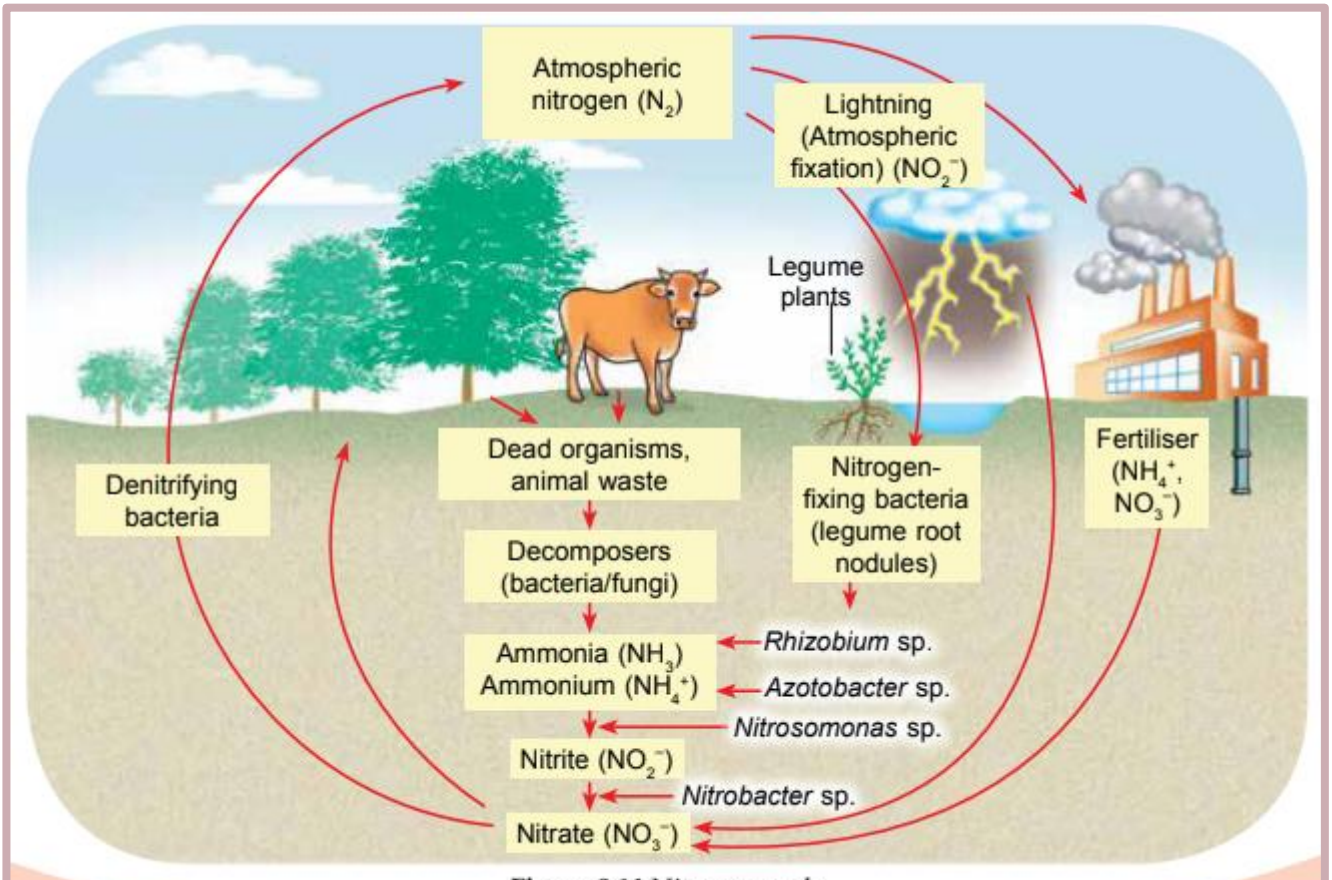
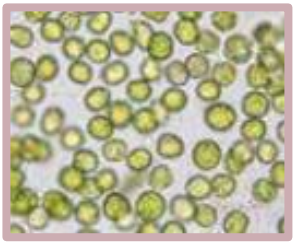



**Figure 8.14** Nitrogen cycle

# The role of microorganisms

## MICROORGANISMS AS PRODUCERS

- Microorganisms like phytoplankton are usually found floating on the surface of the oceans, ponds or lakes
- As they have chlorophyll, phytoplankton can undergo photosynthesis
- Phytoplankton is important to aquatic ecosystem as producers in food chain



Phytoplankton

## MICROORGANISMS AS DECOMPOSERS

- Saprophytic fungi and saprophytic bacteria are known as decomposers that decompose organic materials from dead organisms
- Decomposers break down complex organic materials (animal wastes, carcases and rotting trees) into simple compounds (ammonium ions)
- Decomposers secrete digestive enzymes into the decaying organic materials, then absorb the products of the digestive process
- The products of this process contain important elements required by plant (carbon, nitrogen and sulphur) which are returned to the soil
- These materials are then absorbed by plants

Fungi on a rooting trunk

## MICROORGANISMS AS PARASITES

- ✓ In a parasitic relationship, the parasite benefits from the relationship while the host is harmed or sometimes die from the negative effects caused by the parasite
- ✓ Parasites will continue to benefit for as long as this interaction continues
- ✓ Hence, most parasites try not to kill their host
- ✓ For example, *Plasmodium* sp., a protozoan that lives inside the female *Anopheles* mosquito
- ✓ Malaria is transmitted to anyone who is bitten by the mosquito when the parasite gets transferred into the blood circulation system of the person

*Plasmodium* sp.

## MICROORGANISMS AS SYMBIONTS

» A symbiont is an organism which has a close relationship with another organism (known as the host)

» There are two types of symbionts

1. Ectosymbiont
   → Lives outside the host cells
   → Example: Ectomycorrhiza, a fungus which lives around plant roots

Ectomycorrhiza

2. Endosymbiont
   - Lives inside the host cells
   - Example: Protozoa *Trichonympha* sp. which lives in the alimentary canals of termites

*Trichonympha* sp. in termites

# Definition of pathogens and vectors

## PATHOGENS

♥ A pathogen is an organism which causes diseases

♥ Example:
   a. Viruses
   b. Bacteria
   c. Protozoa
   d. Fungi

♥ An infection is caused when a pathogen enters the body, divides and multiplies

- ♥ The disease caused by pathogens will occur when the cells inside the body are damage
- ♥ This is caused by the infection and the infected person shows the symptoms

## VECTORS

- Δ Vectors are organisms which transmit pathogens and cause certain diseases
- Δ Example:
  - i. Mosquitoes
    - ◊ The dengue virus is transmitted to humans through *Aedes aegypti* mosquito bites
  - ii. Flies
    - ▪ The bacteria *Vibrio cholerae* is spread amongst humans through files
    - ▪ When a person consumes food that has been contaminated by *Vibrio cholerae*, they might get cholera
  - iii. Cockroaches
    - ❖ *Salmonella typhi* bacteria are transmitted to humans through food and water that has been contaminated by cockroaches

# The effects of pathogens on human health

## VIRUS

- Δ Example of disease: Hepatitis B
- Δ Symptoms of disease:
  - a) Inflammation (hepatic cirrhosis)
  - b) Swollen chest
  - c) Skin and eyes sclera become yellowish
  - d) May cause fatalities

## BACTERIA

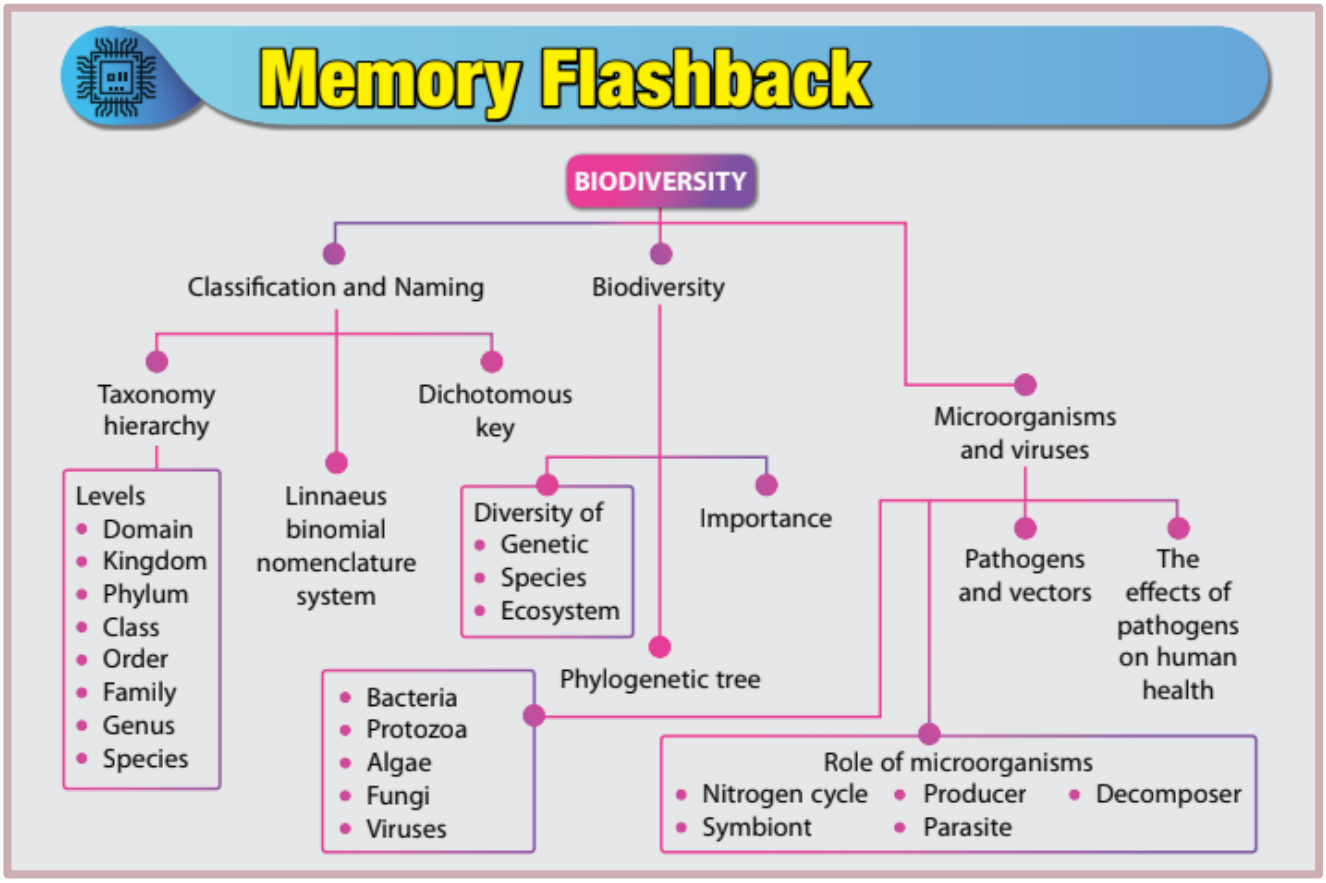
- ⊕ Example of disease: Tuberculosis
- ⊕ Symptoms of disease
  - 1) Loss of weight
  - 2) Coughing blood
  - 3) Shortness of breath

## PROTOZOA

- ❑ Example of disease: Dysentery
- ❑ Symptoms of disease:
  - 1 Stomach ache
  - 2 Diarrhoea
  - 3 Vomit

## FUNGI

- Example of disease: Tinea versicolour
- Symptoms of disease:
  - I. Whitish of pinkish patches on the skin


Memory Flashback
BIODIVERSITY
Classification and Naming
Biodiversity
Microorganisms and viruses
Taxonomy hierarchy
Dichotomous key
Levels
Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species
Linnaeus binomial nomenclature system
Diversity of
Genetic
Species
Ecosystem
Importance
Phylogenetic tree
Bacteria
Protozoa
Algae
Fungi
Viruses
Pathogens and vectors
The effects of pathogens on human health
Role of microorganisms
Nitrogen cycle
Producer
Decomposer
Symbiont
Parasite