Chapter 2: Biological Classification

Exercises — Exercises

Q1 Discuss how classification systems have undergone several changes over a period of time?

SOLUTION

Classification systems have evolved significantly from ancient times to the present.

1. Aristotle's system (earliest scientific attempt): Classified plants into trees, shrubs and herbs based on simple morphology. Divided animals into two groups — those with red blood and those without.

2. Two Kingdom system (Linnaeus era): All organisms were placed into either Kingdom Plantae or Kingdom Animalia. Limitation: did not distinguish prokaryotes from eukaryotes, unicellular from multicellular, or photosynthetic organisms (green algae) from non-photosynthetic ones (fungi).

3. Need for more kingdoms: Many organisms (e.g., bacteria, fungi, unicellular eukaryotes) did not fit neatly into plant or animal kingdoms. Additional criteria such as cell structure, mode of nutrition, habitat, reproduction, and evolutionary relationships were considered.

4. Five Kingdom classification — R.H. Whittaker (1969): Proposed five kingdoms: Monera, Protista, Fungi, Plantae and Animalia. Criteria used: cell structure (prokaryotic/eukaryotic), body organisation (unicellular/multicellular), mode of nutrition (autotrophic/heterotrophic), reproduction, and phylogenetic relationships.

5. Three-domain system (proposed later): Divides Kingdom Monera into two domains (Bacteria and Archaea), with all eukaryotic kingdoms forming a third domain, resulting in a six kingdom perspective.

Thus, classification systems have changed from simple morphology-based to complex, multi-criteria phylogenetic systems reflecting evolutionary relationships.

Answer: Classification evolved from Aristotle's simple morphology-based grouping, through Linnaeus' two-kingdom system, to Whittaker's five-kingdom classification (Monera, Protista, Fungi, Plantae, Animalia) based on cell structure, body organisation, nutrition mode, reproduction, and phylogeny. Later, a three-domain system further refined Kingdom Monera.

Q2 State two economically important uses of:
(a) heterotrophic bacteria
(b) archaebacteria

SOLUTION

(a) Heterotrophic bacteria — two economically important uses:

1. Food industry: Lactobacillus and related bacteria ferment milk to produce curd/yoghurt. They are also used in cheese making and other fermented food products.

2. Production of antibiotics: Bacteria such as Streptomyces produce antibiotics (e.g., streptomycin) that are widely used to treat bacterial infections in humans and animals.

(Other valid uses include nitrogen fixation in legume roots by Rhizobium, decomposition of dead organic matter aiding nutrient cycling, and industrial production of chemicals.)

(b) Archaebacteria — two economically important uses:

1. Biogas production: Methanogenic archaebacteria (methanogens) present in the gut of ruminants (cows, buffaloes) produce methane (biogas) from their dung. This biogas is used as a fuel source in rural areas.

2. Industrial applications: Thermoacidophiles (e.g., Sulfolobus) produce heat-stable enzymes (extremozymes) that are used in industrial processes such as PCR (Taq polymerase from thermophilic bacteria), food processing, and pharmaceutical manufacturing under extreme temperature and pH conditions.

Answer: (a) Heterotrophic bacteria: (1) ferment milk to curd; (2) produce antibiotics (e.g., streptomycin from Streptomyces). (b) Archaebacteria: (1) methanogens produce biogas (methane) from cattle dung; (2) thermoacidophiles yield heat-stable industrial enzymes.

Q3 What is the nature of cell-walls in diatoms?

SOLUTION

Diatoms belong to Chrysophytes in Kingdom Protista.

Nature of cell walls in diatoms:

1. The cell walls of diatoms form two thin overlapping shells (called frustules) that

fit together like the two halves of a soap box (one half fits inside the other).

2. The cell walls are embedded with silica, making them extremely hard and indestructible.

3. These silica-impregnated walls do not decay easily. Over billions of years, the accumulated deposits of diatom cell walls form diatomaceous earth (also called kieselguhr).

4. Diatomaceous earth is gritty in texture and is commercially used in polishing, and for filtration of oils and syrups.

Answer: Diatom cell walls are made of two overlapping silica-impregnated shells (frustules) that fit together like a soap box. The walls are indestructible and accumulate over time to form diatomaceous earth, used in polishing and filtration.

Q4 Find out what do the terms 'algal bloom' and 'red-tides' signify.

SOLUTION

Algal bloom:

Algal bloom refers to the rapid and excessive multiplication of algae (particularly cyanobacteria/blue-green algae) in a water body, resulting in a visible, often coloured scum on the water surface. It occurs when nutrient levels (especially nitrates and phosphates) are very high, a condition known as eutrophication. Cyanobacteria such as Microcystis and Anabaena are common bloom-forming organisms. Algal blooms deplete dissolved oxygen, block sunlight, and can release toxins that are harmful to aquatic life, livestock, and humans.

Red tides:

Red tides are caused by the explosive proliferation of certain red-pigmented dinoflagellates (e.g., Gonyaulax) in marine environments. When these organisms multiply rapidly, they impart a red or brownish-red colour to the sea — hence the name 'red tide'. The toxins released by these large numbers of dinoflagellates can kill fish and other marine animals. Red tides are a type of Harmful Algal Bloom (HAB) and are associated with contaminated seafood, which can cause paralytic shellfish poisoning in humans.

Answer: Algal bloom: rapid proliferation of cyanobacteria/algae in nutrient-rich (eutrophicated) water bodies, depleting oxygen and releasing toxins. Red tides: explosive multiplication of red dinoflagellates (e.g., Gonyaulax) turning the sea red; their toxins can kill marine animals and contaminate seafood.

Q5 How are viroids different from viruses?

SOLUTION

Viroids differ from viruses in the following ways:

1. Genetic material: Viroids consist of only a free, naked RNA molecule of very low molecular weight. Viruses contain either RNA or DNA enclosed within a protein coat (capsid).

2. Protein coat: Viroids lack a protein coat (capsid) entirely. Viruses possess a protein coat (capsid) made of capsomeres that protects the nucleic acid.

3. Size: Viroids are smaller than viruses.

4. Discovery: Viroids were discovered by T.O. Diener in 1971. Viruses were identified earlier (Ivanowsky, 1892; Beijerinck, 1898; Stanley, 1935).

5. Example of disease caused: Viroids cause potato spindle tuber disease. Viruses cause diseases like influenza, mumps, smallpox, AIDS (in animals/humans) and mosaic disease (in plants).

Answer: Viroids are smaller than viruses and consist of a free, naked RNA molecule with no protein coat. Viruses have either RNA or DNA enclosed in a protein capsid. Example: viroids cause potato spindle tuber disease; viruses cause influenza, AIDS, mosaic disease, etc.

Q6 Describe briefly the four major groups of Protozoa.

SOLUTION

Protozoans are heterotrophic protists that live as predators or parasites. There are four major groups:

1. Amoeboid protozoans:
   - Live in fresh water, sea water, or moist soil.
   - Move and capture prey using pseudopodia (false feet).
   - Marine forms have silica shells on their surface.
   - Some (e.g., Entamoeba) are parasites; Amoeba is the classic example.

2. Flagellated protozoans:
- Possess one or more flagella for movement.
- Can be free-living or parasitic.
- Parasitic forms cause diseases: e.g., Trypanosoma causes sleeping sickness; Leishmania causes kala-azar.

3. Ciliated protozoans:
- Aquatic, actively moving organisms with thousands of cilia.
- Have a cavity (gullet) opening to the outer cell surface; coordinated cilia movement steers food-laden water into the gullet.
- Example: Paramoecium.

4. Sporozoans:
- Have an infectious spore-like stage in their life cycle.
- Include diverse organisms; mostly endoparasites.
- Most notorious example: Plasmodium (malarial parasite), which causes malaria and has a massive impact on human health.

Answer: The four major groups of Protozoa are: (1) Amoeboid protozoans — move by pseudopodia (Amoeba, Entamoeba); (2) Flagellated protozoans — move by flagella, many parasitic (Trypanosoma); (3) Ciliated protozoans — move by cilia, have a gullet (Paramoecium); (4) Sporozoans — have spore-like infective stage (Plasmodium, the malarial parasite).

Q7 Plants are autotrophic. Can you think of some plants that are partially heterotrophic?

SOLUTION

Although most plants are autotrophic (they prepare their own food through photosynthesis), some plants are partially heterotrophic. These are of two types:

1. Insectivorous (carnivorous) plants: These plants grow in nitrogen-poor soils and supplement their nutrition by trapping and digesting insects and other small organisms.
- Examples: Bladderwort (Utricularia), Venus fly trap (Dionaea muscipula), Sundew (Drosera), Pitcher plant (Nepenthes).
- They are autotrophic for carbon (via photosynthesis) but obtain nitrogen and minerals heterotrophically from insects.

2. Parasitic plants: These plants depend on other living plants (hosts) for water,

minerals, and sometimes organic food.

- Example: Cuscuta (dodder) is a total stem parasite that lacks chlorophyll and entirely depends on the host.

- Partial parasites like Mistletoe (Viscum album) have chlorophyll and can photosynthesize but obtain water and minerals from the host.

Thus, insectivorous plants and parasitic plants represent plants that are partially or fully heterotrophic.

Answer: Insectivorous plants (Bladderwort, Venus fly trap, Pitcher plant, Sundew) are partially heterotrophic — they photosynthesize but trap insects for nitrogen. Parasitic plants like Cuscuta (dodder) lack chlorophyll and depend entirely on the host for nutrients.

Q8 What do the terms phycobiont and mycobiont signify?

SOLUTION

These terms are used in the context of lichens, which are symbiotic associations between algae and fungi.

Phycobiont: The algal component of a lichen is called the phycobiont. The alga is autotrophic — it contains chlorophyll and can perform photosynthesis to prepare food (organic matter) for both partners.

Mycobiont: The fungal component of a lichen is called the mycobiont. The fungus is heterotrophic — it provides shelter (physical structure), absorbs mineral nutrients, and retains water for the algal partner.

Together, both partners benefit mutually: the alga provides food through photosynthesis and the fungus provides shelter, moisture, and minerals — making lichens a classic example of mutualistic symbiosis.

Lichens are also excellent pollution indicators because they do not grow in areas with polluted air (they are sensitive to sulphur dioxide and other pollutants).

Answer: Phycobiont = the algal component of a lichen (autotrophic, provides food via photosynthesis). Mycobiont = the fungal component (heterotrophic, provides shelter, water, and minerals). Together they form a mutualistic symbiosis.

Q9 Give a comparative account of the classes of Kingdom Fungi under the following:
(i) mode of nutrition
(ii) mode of reproduction

SOLUTION

(i) Mode of nutrition:

Phycomycetes: Mostly saprophytic (decomposers on decaying wood/organic matter); some are obligate parasites on plants (e.g., Albugo on mustard).

Ascomycetes: Can be saprophytic, decomposers, parasitic, or coprophilous (growing on dung). Example: Penicillium (saprophyte/parasite), yeast (saprophyte).

Basidiomycetes: Mostly saprophytic (mushrooms on soil/dead logs); some are parasitic on living plants (rusts and smuts). Example: Agaricus (saprophyte), Puccinia (parasite).

Deuteromycetes: Some members are saprophytes or parasites; a large number are decomposers of litter that help in mineral cycling. Example: Alternaria, Trichoderma.

(ii) Mode of reproduction:

Phycomycetes:
- Vegetative: fragmentation.
- Asexual: zoospores (motile) or aplanospores (non-motile), produced endogenously in sporangium.
- Sexual: zygospore formed by fusion of isogamous, anisogamous, or oogamous gametes.

Ascomycetes:
- Vegetative: fragmentation, budding (in yeast).
- Asexual: conidia produced exogenously on conidiophores.
- Sexual: ascospores produced endogenously in sac-like asci; asci are arranged in fruiting bodies called ascocarps.

Basidiomycetes:
- Vegetative: fragmentation (common); asexual spores generally absent.
- Sexual: plasmogamy by fusion of two vegetative/somatic cells; dikaryotic stage forms basidium; karyogamy and meiosis produce four basidiospores exogenously on basidia arranged in basidiocarps. Sex organs are absent.

Deuteromycetes:

- Only asexual reproduction is known: conidia produced on septate, branched mycelium.
- Sexual stage unknown (hence called 'imperfect fungi').
- Vegetative reproduction also occurs.

Answer: (i) All four classes are primarily heterotrophic: Phycomycetes and Basidiomycetes are saprophytic/parasitic; Ascomycetes add coprophilous forms; Deuteromycetes are mainly decomposers/saprophytes. (ii) Phycomycetes: zoospores/aplanospores + zygospore (sexual); Ascomycetes: conidia + ascospores in asci; Basidiomycetes: basidiospores on basidia (no asexual spores); Deuteromycetes: only conidia (no sexual stage known).

Q10 What are the characteristic features of Euglenoids?

SOLUTION

Euglenoids are a group of unicellular protists. Their characteristic features are:

1. Habitat: Majority are freshwater organisms found in stagnant water.

2. Cell covering: They lack a cell wall. Instead, they have a protein-rich, flexible layer called pellicle surrounding the cell.

3. Flagella: They possess two flagella — a short one and a long one — used for locomotion.

4. Nutrition (mixotrophic): They are photosynthetic autotrophs in the presence of sunlight. When deprived of sunlight, they behave as heterotrophs by predating on other smaller organisms. This dual mode of nutrition makes them mixotrophic.

5. Pigments: The photosynthetic pigments of euglenoids are identical to those found in higher plants (chlorophyll a and b, carotenoids).

6. Eyespot (stigma): They possess a light-sensitive eyespot (stigma) that helps them detect light.

7. Reservoir and contractile vacuole: Used for osmoregulation.

8. Example: Euglena is the most well-known euglenoid.

9. Classification note: Euglenoids show features of both plants (photosynthesis, plant-like pigments) and animals (no cell wall, heterotrophic when dark, motility), making their classification controversial.

Answer: Euglenoids (e.g., Euglena) are freshwater protists with a flexible protein pellicle (no cell wall), two flagella (one short, one long), plant-like photosynthetic pigments, and mixotrophic nutrition — photosynthetic in light, heterotrophic in dark.

Q11 Give a brief account of viruses with respect to their structure and nature of genetic material. Also name four common viral diseases.

SOLUTION

Structure of viruses:

1. Viruses are non-cellular, acellular organisms — they have no cytoplasm, nucleus, or organelles.
2. They are nucleoproteins: they consist of a nucleic acid core (genetic material) surrounded by a protein coat.
3. Protein coat (capsid): Made of small protein subunits called capsomeres, arranged in helical or polyhedral (icosahedral) geometric forms. The capsid protects the nucleic acid.
4. Some viruses (animal viruses) also have a lipid-containing outer envelope derived from the host cell membrane.
5. They are inert crystalline structures outside a living cell; they can be crystallised (W.M. Stanley, 1935).
6. Viruses are obligate intracellular parasites — they replicate only inside a living host cell by taking over the host's cellular machinery.

Nature of genetic material:

1. Viruses contain either RNA or DNA — never both.
2. Plant viruses: generally have single-stranded RNA as genetic material.
3. Animal viruses: have either single-stranded RNA, double-stranded RNA, or double-stranded DNA.
4. Bacteriophages (viruses infecting bacteria): usually double-stranded DNA.
5. The nucleic acid (genetic material) is the infectious component.

Four common viral diseases:

1. Influenza (flu) — caused by Influenza virus (ssRNA).
2. AIDS (Acquired Immunodeficiency Syndrome) — caused by HIV (Human Immunodeficiency Virus, ssRNA retrovirus).
3. Mumps — caused by Paramyxovirus.
4. Smallpox — caused by Variola virus (dsDNA).

(Plant viral diseases: tobacco mosaic disease, leaf roll, mosaic formation, yellowing — caused by plant viruses.)

Answer: Viruses are non-cellular nucleoproteins with a nucleic acid core (RNA or DNA, never both) enclosed in a protein capsid of capsomeres. Plant viruses have ssRNA; animal viruses have ssRNA, dsRNA or dsDNA; bacteriophages have dsDNA. Four viral diseases: influenza, AIDS, mumps, smallpox.

Q12 Organise a discussion in your class on the topic – Are viruses living or non-living?

SOLUTION

This is a discussion-based activity. Below are the key arguments for both sides:

Arguments that viruses are NON-LIVING:

1. They are acellular — no cytoplasm, no organelles, no metabolic activity outside a host.
2. They can be crystallised (W.M. Stanley, 1935) — a property of non-living chemicals.
3. They cannot grow, respire, or respond to stimuli independently.
4. They have no independent energy metabolism.

Arguments that viruses are LIVING:

1. They contain genetic material (RNA or DNA) capable of mutation and evolution.
2. They can replicate (reproduce) inside a host cell.
3. They show host-specificity, suggesting a complex biological interaction.
4. They cause heritable changes (mutations) in the host — a property associated with living systems.

Conclusion:

Viruses are considered to occupy the boundary between living and non-living. They are non-living outside a host cell (inert crystalline structures) but exhibit characteristics of life (replication, genetic inheritance, evolution) once inside a host. They are best described as 'obligate intracellular parasites' or 'entities at the edge of life'.

Answer: Viruses show non-living properties (acellular, crystallisable, no independent metabolism) and living properties (genetic material, replication, mutation, host-specificity). They are best described as obligate intracellular parasites existing at the boundary of living and non-living.