Chapter 1: The Living World

Exercises — Exercises

Q1 Why are living organisms classified?

SOLUTION

There are millions of living organisms on Earth, each varying enormously in size, shape, habitat, physiology, and behaviour. Studying every individual organism is practically impossible.

Classification is necessary for the following reasons:
1. It makes the study of a large variety of organisms manageable by grouping them into convenient categories.
2. It helps in identification — once an organism is placed in a group, its general characters become predictable.
3. It reveals evolutionary relationships and helps understand how organisms are related to one another.
4. It provides a universal system of communication so that a scientist in one country can understand the work of a scientist in another.
5. It is essential for applied fields like agriculture, medicine, forestry, and biotechnology, where knowledge of the organism is critical.

Answer: Classification makes the study of enormous biological diversity manageable, aids identification, reveals evolutionary relationships, and enables universal scientific communication.

Q2 Why are the classification systems changing every now and then?

SOLUTION

Classification systems change because our knowledge of organisms and the criteria we use to classify them keep improving over time.

Key reasons for change:
1. New organisms are continuously being discovered, including previously unknown species from unexplored habitats (deep ocean, rainforest canopy, soil microbiomes).
2. Advances in technology — such as electron microscopy, biochemistry, and molecular biology (DNA sequencing, genomics) — reveal new characters that were not available to earlier taxonomists.

3. Earlier classifications relied mainly on external morphology; modern taxonomy also considers cell structure, biochemical pathways, nucleotide sequences, and embryological development, all of which can overturn older groupings.
4. Better understanding of evolutionary relationships (phylogenetics) shows that some traditionally grouped organisms are not as closely related as thought, requiring reclassification.
5. New nomenclatural codes and international agreements refine the rules, leading to name changes and category revisions.

Answer: Classification systems change because new organisms are discovered, new technologies reveal previously unknown characters (molecular data, ultrastructure), and deeper understanding of evolutionary relationships requires regrouping of organisms.

Q3 What different criteria would you choose to classify people that you meet often?

SOLUTION

People encountered in daily life can be classified using a range of observable and known criteria:

1. Gender — male, female, others.
2. Age group — infant, child, teenager, adult, elderly.
3. Occupation/profession — student, teacher, doctor, farmer, businessperson, etc.
4. Place of origin or nationality — Indian, American, etc.; or by state/region.
5. Language spoken — Hindi, Tamil, English, etc.
6. Relationship — family, friend, colleague, acquaintance, neighbour.
7. Physical characteristics — height (tall/short), build (lean/stocky).

Note: Just as biological classification depends on the purpose and the characters chosen, the criteria for classifying people depend on the context (social, professional, demographic). Different purposes yield different groupings — similar to taxonomy.

Answer: People can be classified by gender, age group, occupation, nationality, language, relationship, or physical traits — the criteria chosen depend on the purpose of classification, just as in biology.

Q4 What do we learn from identification of individuals and populations?

SOLUTION

Identification is the process of correctly recognising an organism and assigning it to an already known taxon.

From the identification of individuals we learn:
1. The correct name (scientific and common) of the organism.
2. Its taxonomic position — which genus, family, order, class, and phylum/division it belongs to.
3. Its known characteristics — morphology, physiology, life cycle, ecological role.
4. Whether the organism is new to science (if it cannot be matched to any known taxon).

From the identification of populations we learn:
1. The range of variation within a species — how individuals in a population differ from one another.
2. Genetic diversity — important for conservation and understanding evolutionary potential.
3. Distribution and abundance of a species in different geographic areas.
4. Ecological relationships — how populations interact with each other and with their environment.

Answer: Identification of individuals reveals their correct taxon, known characters, and whether they represent new species; identification of populations reveals intraspecific variation, genetic diversity, distribution, and ecological roles.

Q5 Given below is the scientific name of Mango. Identify the correctly written name.
Mangifera Indica
Mangifera indica

SOLUTION

According to the rules of Binomial Nomenclature established by Carolus Linnaeus:
1. The genus name (first word) begins with a CAPITAL letter.
2. The specific epithet (second word) begins with a small (lowercase) letter.
3. Both words are printed in italics (or underlined when handwritten).

Applying these rules:

- 'Mangifera Indica' — INCORRECT because the specific epithet 'Indica' wrongly starts with a capital letter.
- 'Mangifera indica' — CORRECT because the genus 'Mangifera' starts with a capital letter and the specific epithet 'indica' starts with a lowercase letter.

Answer: Mangifera indica — correctly written. The genus starts with a capital letter and the specific epithet starts with a lowercase letter, per rules of binomial nomenclature.

Q6 Define a taxon. Give some examples of taxa at different hierarchical levels.

SOLUTION

Definition: A taxon (plural: taxa) is a unit of any rank or level used in biological classification. It represents a category in the taxonomic hierarchy to which a group of organisms is assigned based on shared characteristics.

Taxa exist at every level of the taxonomic hierarchy. Examples at different levels:

1. Kingdom — e.g., Animalia (all animals), Plantae (all plants).
2. Phylum/Division — e.g., Chordata (vertebrates + allies), Angiospermae (flowering plants).
3. Class — e.g., Mammalia (mammals), Insecta (insects), Dicotyledonae.
4. Order — e.g., Carnivora (flesh-eating mammals), Primata (primates), Polymoniales.
5. Family — e.g., Felidae (cats), Canidae (dogs), Solanaceae (potato family).
6. Genus — e.g., Panthera (lions, tigers, leopards), Solanum (potato, brinjal, tomato).
7. Species — e.g., Panthera leo (lion), Homo sapiens (human being), Mangifera indica (mango).

Each taxon represents a distinct biological entity with shared characteristics, not merely a morphological aggregate.

Answer: A taxon is a unit (category) of any rank in biological classification. Examples: Kingdom Animalia, Phylum Chordata, Class Mammalia, Order Carnivora, Family Felidae, Genus Panthera, Species Panthera leo.

Q7 Can you identify the correct sequence of taxonomical categories?
(a) Species Order Phylum Kingdom
(b) Genus Species Order Kingdom
(c) Species Genus Order Phylum

SOLUTION

The standard ascending taxonomical hierarchy is:
Species < Genus < Family < Order < Class < Phylum < Kingdom

Evaluating each option:
(a) Species → Order → Phylum → Kingdom
- Species to Order: correct direction (Order is above Species).
- Order to Phylum: correct (Phylum is above Order).
- Phylum to Kingdom: correct (Kingdom is above Phylum).
- However, Genus and Family are skipped but the sequence is in the correct ascending order. This option shows a valid ascending sequence.

(b) Genus → Species → Order → Kingdom
- Genus to Species: INCORRECT — Species is BELOW Genus, so this goes downward.
- This sequence is wrong.

(c) Species → Genus → Order → Phylum
- Species to Genus: correct (Genus is above Species).
- Genus to Order: correct direction (Order is above Genus; Family is skipped).
- Order to Phylum: correct (Phylum is above Order; Class is skipped).
- All steps are in the correct ascending direction.

Both (a) and (c) are in correct ascending order. Option (c) is the more complete and standard answer as it includes four consecutive-level skips all in the right direction.
The correct answer is (c): Species < Genus < Order < Phylum.

Answer: Option (c) — Species, Genus, Order, Phylum — is the correct ascending sequence. Option (b) is incorrect because Genus is ranked above Species, not below.

Q8 Try to collect all the currently accepted meanings for the word 'species'. Discuss with your teacher the meaning of species in case of higher plants and animals on one hand, and bacteria on the other hand.

SOLUTION

The concept of 'species' has several currently accepted meanings depending on the approach used:

1. Morphological (Typological) Species Concept: A species is a group of organisms sharing a similar set of morphological (structural) characters that distinguish them from other groups.

2. Biological Species Concept (Ernst Mayr, 1942): A species is a group of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups. This is the most widely cited definition for sexually reproducing organisms.

3. Phylogenetic (Evolutionary) Species Concept: A species is the smallest group of organisms that share a common ancestor and can be distinguished from other groups by unique derived characters.

4. Ecological Species Concept: A species occupies a unique ecological niche — the totality of its adaptations, habitat use, and resource utilisation distinguishes it.

For higher plants and animals:
- The Biological Species Concept works well because they reproduce sexually and reproductive isolation is a clear boundary.
- Morphological differences are also used, especially for fossil species or organisms that are geographically separated.

For bacteria:
- The Biological Species Concept does NOT apply well because bacteria reproduce asexually (binary fission) — there is no sexual reproduction or reproductive isolation.
- Bacteria frequently exchange genes horizontally (horizontal gene transfer) across very different lineages, blurring species boundaries.
- For bacteria, species are defined primarily by morphological, biochemical (metabolic), physiological, and molecular criteria (e.g., >97% similarity in 16S rRNA gene sequences or >70% DNA-DNA hybridization is used as a species boundary in bacteriology).
- Thus, bacterial 'species' is a more arbitrary, practical concept rather than a

biological one.

Answer: Species concepts include: (1) Morphological — shared structural characters; (2) Biological — interbreeding, reproductively isolated populations (Mayr); (3) Phylogenetic — shared common ancestor with unique derived characters; (4) Ecological — unique niche. For higher organisms, the biological concept applies; for bacteria (asexual, horizontal gene transfer), species are defined by biochemical/molecular criteria (16S rRNA similarity).

Q9 Define and understand the following terms:
(i) Phylum (ii) Class (iii) Family (iv) Order (v) Genus

SOLUTION

(i) Phylum:
A phylum is a taxonomic category above Class. In animals, it groups classes that share fundamental body-plan features. Example: Phylum Chordata includes all animals with a notochord and a dorsal hollow nerve cord at some stage of their life — fishes, amphibians, reptiles, birds, and mammals all belong here.

(ii) Class:
A class is a taxonomic category above Order and below Phylum. It includes related orders that share certain common features. Example: Class Mammalia includes warm-blooded vertebrates with hair/fur, mammary glands, and a four-chambered heart — orders Primata (primates) and Carnivora (carnivores) are both in this class.

(iii) Family:
A family is a taxonomic category above Genus and below Order. It groups related genera that share more characters than genera of other families but fewer characters than species within a genus. Example: Family Felidae includes genera Panthera (lion, tiger, leopard) and Felis (domestic cat); Family Solanaceae includes genera Solanum, Petunia, and Datura.

(iv) Order:
An order is a taxonomic category above Family and below Class. It is an assemblage of related families sharing a few common characters (fewer than within a family). Example: Order Carnivora includes families Felidae (cats) and Canidae (dogs); Order Polymoniales includes plant families Solanaceae and Convolvulaceae.

(v) Genus:

A genus is a taxonomic category above Species and below Family. It comprises a group of closely related species with more characters in common than species of other genera. Example: Genus Panthera includes species leo (lion), tigris (tiger), and pardus (leopard); Genus Solanum includes tuberosum (potato), melongena (brinjal), and nigrum (black nightshade).

Answer: (i) Phylum: animal category above Class sharing fundamental body-plan (e.g., Chordata). (ii) Class: groups related orders (e.g., Mammalia). (iii) Family: groups related genera (e.g., Felidae, Solanaceae). (iv) Order: groups related families (e.g., Carnivora). (v) Genus: groups closely related species (e.g., Panthera, Solanum).

Q10 Illustrate the taxonomical hierarchy with suitable examples of a plant and an animal.

SOLUTION

The taxonomical hierarchy has seven main obligate categories arranged in ascending order of inclusiveness:

Species < Genus < Family < Order < Class < Phylum/Division < Kingdom

EXAMPLE 1 — Animal: Housefly (Musca domestica)

Species : domestica
Genus : Musca
Family : Muscidae
Order : Diptera
Class : Insecta
Phylum : Arthropoda
Kingdom : Animalia

EXAMPLE 2 — Plant: Mango (Mangifera indica)

Species : indica
Genus : Mangifera
Family : Anacardiaceae
Order : Sapindales
Class : Dicotyledonae
Division : Angiospermae
Kingdom : Plantae

Key observation: As we move from Species upward to Kingdom, the number of common characteristics shared by organisms within that taxon DECREASES, while the number of organisms included INCREASES. Species has the most shared characters (lowest and most specific taxon); Kingdom has the fewest shared characters but the most organisms.

Answer: Animal example — Housefly: Species domestica, Genus Musca, Family Muscidae, Order Diptera, Class Insecta, Phylum Arthropoda, Kingdom Animalia. Plant example — Mango: Species indica, Genus Mangifera, Family Anacardiaceae, Order Sapindales, Class Dicotyledonae, Division Angiospermae, Kingdom Plantae.