Chapter 4: Animal Kingdom

Exercises — Exercises

Q1 What are the difficulties that you would face in classification of animals, if common fundamental features are not taken into account?

SOLUTION

Without common fundamental features as a basis, animal classification would become arbitrary and inconsistent. The key difficulties would be:

1. No systematic grouping — millions of animal species cannot be meaningfully arranged without shared criteria such as body symmetry, coelom, segmentation, or level of organisation.
2. Parallel/redundant groups — the same animal could be placed in multiple groups by different scientists using different individual traits, making classification non-universal.
3. Inability to determine evolutionary relationships — fundamental features reflect shared ancestry; without them, phylogenetic (evolutionary) relationships cannot be established.
4. Difficulty in identifying new species — a newly described organism could not be assigned a systematic position without a defined set of features to compare it against.
5. Confusion in communication — scientists worldwide would use different, incomparable classification systems, making scientific communication impossible.
6. Practical applications affected — medical, agricultural, and ecological work that relies on knowing an organism's phylum or class (e.g., identifying a parasite's biology) would be hampered.

Answer: Without common fundamental features (symmetry, coelom, segmentation, notochord, etc.), classification would be arbitrary, non-universal, and unable to reflect evolutionary relationships, making it impossible to assign systematic positions to new species or communicate findings globally.

Q2 If you are given a specimen, what are the steps that you would follow to classify it?

SOLUTION

To classify an unknown animal specimen, the following steps are taken in sequence:

Step 1 — Level of organisation: Determine whether the animal is at cellular, tissue, organ, or organ-system level. (e.g., sponges = cellular; cnidarians = tissue; flatworms and above = organ/organ-system).

Step 2 — Symmetry: Observe if the body is asymmetrical (Porifera), radially symmetrical (Cnidaria, Ctenophora, adult Echinodermata), or bilaterally symmetrical (most higher phyla).

Step 3 — Germ layers: Determine if the animal is diploblastic (two germ layers — ectoderm and endoderm, e.g., Cnidaria) or triploblastic (three layers including mesoderm, e.g., Platyhelminthes onward).

Step 4 — Coelom: Check for the presence and type of body cavity — acoelomate (no coelom, e.g., Platyhelminthes), pseudocoelomate (false coelom, e.g., Aschelminthes), or coelomate (true coelom lined by mesoderm, e.g., Annelida and above).

Step 5 — Segmentation: Determine if the body is segmented (metameric segmentation, e.g., Annelida) or unsegmented.

Step 6 — Notochord: Check for the presence of a notochord (at any life stage) to decide whether the animal belongs to Chordata or Non-chordata.

Step 7 — Further characters: Examine specific structural features such as type of skeleton (cartilaginous/bony), number of heart chambers, limbs, scales, feathers, hair, etc., to classify into the appropriate class within a phylum.

Using these steps in order, the specimen can be progressively narrowed down to its phylum, class, and beyond.

Answer: Classify sequentially: (1) level of organisation, (2) body symmetry, (3) germ layers (diplo-/triploblastic), (4) coelom type (acoelomate/pseudocoelomate/coelomate), (5) segmentation, (6) presence of notochord, then (7) specific features (skeleton, heart chambers, skin, appendages) to assign phylum and class.

Q3 How useful is the study of the nature of body cavity and coelom in the classification of animals?

SOLUTION

The body cavity (space between the body wall and gut wall) is one of the most important criteria for animal classification because it divides the entire animal kingdom into three major groups:

1. Acoelomates — Animals in which no body cavity is present between the body wall and the gut. Example: Platyhelminthes (flatworms). The mesoderm fills the space as solid mass.

2. Pseudocoelomates — Animals in which a body cavity is present but it is NOT lined by mesoderm. Mesoderm is present as scattered pouches between ectoderm and endoderm. This cavity is called pseudocoelom. Example: Aschelminthes (roundworms).

3. Coelomates — Animals in which a true body cavity (coelom) is present, completely lined by mesoderm on all sides. Example: Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata, Chordata.

The coelom is significant because:

- It allows organs to be suspended within the body cavity, protecting them from external shocks.
- It provides space for the development and growth of complex organ systems.
- It reflects evolutionary advancement — coelomates are more complex and evolutionarily derived than acoelomates.
- True coelom enables complex circulatory, reproductive, and excretory systems.

Thus, the presence, absence, or nature of the coelom is a fundamental character that divides the animal kingdom at a very broad level and reveals evolutionary relationships.

Answer: The coelom divides animals into three key groups — acoelomates (no cavity; e.g., Platyhelminthes), pseudocoelomates (false cavity not lined by mesoderm; e.g., Aschelminthes), and coelomates (true mesoderm-lined cavity; e.g., Annelida and above). This division reflects evolutionary complexity and is fundamental to animal classification.

Q4 Distinguish between intracellular and extracellular digestion?

SOLUTION

Intracellular digestion:
- Digestion occurs INSIDE the cell, within food vacuoles.
- Food particles are engulfed by the cell (phagocytosis) and digested by enzymes within the vacuole.
- Occurs in organisms at lower levels of organisation.
- Example: Sponges (Porifera) — digestion is entirely intracellular by choanocytes and amoebocytes.

Extracellular digestion:
- Digestion occurs OUTSIDE the cell, in a digestive cavity or gut lumen.
- Digestive enzymes are secreted into the cavity where food is broken down.
- Products are then absorbed by the surrounding cells.
- More efficient as it can handle larger food particles.
- Example: Most higher animals (Annelida, Arthropoda, Vertebrates, etc.).

Note: Some animals like Cnidarians and Ctenophores carry out BOTH intracellular and extracellular digestion.

Answer: Intracellular digestion: food is digested inside the cell within food vacuoles (e.g., Porifera). Extracellular digestion: food is digested outside the cell in a digestive cavity by secreted enzymes, then absorbed (e.g., most higher animals). Cnidarians and Ctenophores do both.

Q5 What is the difference between direct and indirect development?

SOLUTION

Direct development:
- The young one (offspring) hatching from the egg or born resembles the adult in body form.
- There is NO larval stage; the juvenile simply grows into an adult.
- Metamorphosis does not occur.
- Examples: Reptiles, Birds, Mammals, Osteichthyes (most bony fishes), some Aschelminthes.

Indirect development:
- The young one hatching from the egg is morphologically very different from the adult.

- A larval stage (or multiple larval stages) is present.
- The larva undergoes metamorphosis to transform into the adult form.
- The larva may occupy a different ecological niche and have different feeding habits from the adult.
- Examples: Insects (larva → pupa → adult), Frogs (tadpole → adult frog), Sponges (free-swimming larva), Echinoderms (free-swimming bilateral larva → radially symmetrical adult), Cyclostomata (ammocoetes larva).

Answer: Direct development: young one resembles the adult; no larval stage or metamorphosis (e.g., reptiles, birds, mammals). Indirect development: a morphologically distinct larval stage is present; larva undergoes metamorphosis to become the adult (e.g., frog tadpole, insect larva, echinoderm free-swimming larva).

Q6 What are the peculiar features that you find in parasitic platyhelminthes?

SOLUTION

Parasitic Platyhelminthes (flatworms such as Taenia — tapeworm, and Fasciola — liver fluke) have evolved several special adaptations for a parasitic lifestyle:

1. Hooks and suckers: Presence of hooks (hooks on scolex) and suckers (acetabula) for firm attachment to the host's tissues, preventing dislodgement by peristalsis or immune response.
2. Tegument: The body is covered by a specialized, thick, syncytial tegument (instead of a simple epithelium) which is resistant to the host's digestive enzymes and immune attack.
3. Loss of digestive system: Many endoparasitic forms like tapeworm (Taenia) lack a digestive system entirely; they absorb pre-digested nutrients directly through their body surface.
4. High reproductive capacity: They produce enormous numbers of eggs to ensure transmission to new hosts despite the low probability of completing the life cycle.
5. Complex life cycle: Multiple larval stages (e.g., oncosphere, cysticercus in Taenia; miracidium, sporocyst, redia, cercaria, metacercaria in Fasciola) involving one or more intermediate hosts, increasing transmission success.
6. Flame cells: Specialized excretory/osmoregulatory cells called flame cells (protonephridia) help in removing excess water and nitrogenous wastes in the host environment.
7. Reduced sense organs: Since they live inside the host's body, sensory organs

are greatly reduced or absent as they are not needed for finding food or detecting predators.

Answer: Parasitic platyhelminthes possess hooks and suckers for attachment, a protective tegument resistant to host enzymes, loss/reduction of digestive system (absorb nutrients through body surface), flame cells for osmoregulation/excretion, very high egg production, and complex life cycles with multiple larval stages and intermediate hosts.

Q7 What are the reasons that you can think of for the arthropods to constitute the largest group of the animal kingdom?

SOLUTION

Arthropoda is the largest phylum of the animal kingdom, comprising over two-thirds of all named species (primarily insects). Several features account for this remarkable diversity and success:

1. Chitinous exoskeleton: The hard, waterproof chitinous exoskeleton protects against desiccation, predation, and physical injury, allowing colonisation of diverse and harsh environments including deserts.
2. Jointed appendages: Jointed legs allow versatile locomotion — walking, running, swimming, burrowing, and flying — enabling exploitation of multiple ecological niches.
3. Flight (in insects): Wings evolved in insects allow rapid dispersal over large areas, escape from predators, and colonisation of new habitats faster than any non-flying invertebrate.
4. Complete metamorphosis: Many arthropods (especially insects) undergo complete metamorphosis (holometabolism), so larval and adult stages occupy different niches, reducing intraspecific competition for food.
5. Varied respiratory systems: Gills (aquatic), book gills (horseshoe crab), book lungs (spiders/scorpions), and tracheal systems (insects) enable exploitation of aquatic and terrestrial habitats.
6. Small body size: Small size requires less food and space, enabling large populations in limited resources and rapid reproduction.
7. Short generation time and high reproductive rate: Many arthropods reproduce rapidly and in large numbers, allowing fast evolution and adaptation to changing environments.
8. Versatile sensory organs: Compound eyes, antennae, statocysts enable

efficient foraging, mate-finding, and predator-avoidance.

9. Adaptation to almost all habitats: Found in marine, freshwater, terrestrial, and aerial environments — no other invertebrate phylum has such breadth.

Answer: Arthropods are the largest animal group due to their protective chitinous exoskeleton (resists desiccation), jointed appendages (versatile locomotion), evolution of wings (flight in insects enabling dispersal), complete metamorphosis (reduces competition between larval and adult stages), diverse respiratory organs, small body size, high reproductive rates, and ability to colonise virtually all habitats.

Q8 Water vascular system is the characteristic of which group of the following: (a) Porifera (b) Ctenophora (c) Echinodermata (d) Chordata

SOLUTION

The water vascular system is the most distinctive feature of phylum Echinodermata.

It is a hydraulic system of fluid-filled canals derived from coelom, and it functions in:

- Locomotion (via tube feet — podia)
- Capture and transport of food
- Respiration

Examples of echinoderms with a water vascular system: Asterias (starfish), Echinus (sea urchin), Antedon (sea lily), Cucumaria (sea cucumber), Ophiura (brittle star).

Answer: (c) Echinodermata. The water vascular system is the most distinctive feature of echinoderms; it functions in locomotion (tube feet), food capture and transport, and respiration.

Q9 "All vertebrates are chordates but all chordates are not vertebrates". Justify the statement.

SOLUTION

Phylum Chordata is characterised by three fundamental features present at some stage of life: (i) notochord, (ii) dorsal hollow nerve cord, and (iii) paired pharyngeal gill slits.

Chordata is divided into three subphyla:

1. Urochordata (Tunicata): Notochord present only in the larval tail; absent in

adult. Example: Ascidia, Salpa.

2. Cephalochordata: Notochord extends from head to tail and persists throughout life. Example: Branchiostoma (Amphioxus).

3. Vertebrata: Notochord present only during embryonic development; replaced by a cartilaginous or bony vertebral column (backbone) in the adult.

Subphyla 1 and 2 (Urochordata and Cephalochordata) are collectively called Protochordates. They possess chordate characters (notochord, dorsal nerve cord, gill slits) but they do NOT have a vertebral column.

Therefore, all members of subphylum Vertebrata are chordates (they belong to phylum Chordata), but not all chordates are vertebrates — the protochordates are chordates without a vertebral column.

This justifies the statement: 'All vertebrates are chordates but all chordates are not vertebrates.'

Answer: Phylum Chordata includes three subphyla: Urochordata, Cephalochordata (collectively Protochordates — no vertebral column), and Vertebrata (vertebral column present). Protochordates have chordate features (notochord, dorsal nerve cord, gill slits) but no backbone, so they are chordates but not vertebrates. Every vertebrate belongs to Chordata, but Chordata also contains protochordates that are not vertebrates.

Q10 How important is the presence of air bladder in Pisces?

SOLUTION

The air bladder (swim bladder) is a gas-filled sac present in most bony fishes (Class Osteichthyes) but absent in cartilaginous fishes (Class Chondrichthyes).

Importance of the air bladder:

1. Buoyancy regulation: The primary function. By adjusting the amount of gas in the air bladder, the fish can control its density and remain at a particular depth in the water column without continuous swimming effort.

2. Energy conservation: Since neutral buoyancy is maintained by the air bladder, the fish does not need to constantly swim to avoid sinking, saving considerable muscular energy.

3. In the absence of air bladder (Chondrichthyes): Cartilaginous fishes like sharks lack an air bladder. Therefore they must swim continuously to avoid sinking, relying on their large oily liver and pectoral fins for some lift.

4. Secondary functions: In some species, the air bladder is connected to the inner

ear and aids in sound detection (hearing). In some primitive bony fishes (e.g., lungfishes), the air bladder is modified into a lung-like structure for breathing air.

Answer: The air bladder in bony fishes (Osteichthyes) regulates buoyancy by adjusting gas volume, allowing the fish to remain at a chosen depth without continuous swimming — conserving energy. Cartilaginous fishes (Chondrichthyes) lack it and must swim constantly to avoid sinking. In some species it also aids hearing and in primitive forms serves as a respiratory organ.

Q11 What are the modifications that are observed in birds that help them fly?

SOLUTION

Birds (Class Aves) show numerous structural adaptations (modifications) for flight:

1. Forelimbs modified into wings: The forelimbs are transformed into wings bearing flight feathers (remiges) that provide lift and thrust.
2. Streamlined body: Spindle-shaped, aerodynamic body reduces air resistance (drag) during flight.
3. Feathers: Lightweight, yet strong contour and flight feathers provide insulation, aerodynamic surfaces, and controlled airflow.
4. Hollow (pneumatic) bones: The long bones are hollow with internal air cavities (pneumatized), greatly reducing body weight without sacrificing structural strength.
5. Fully ossified, rigid endoskeleton: The bony skeleton with fused bones (e.g., synsacrum, pygostyle) provides a rigid, stable framework for powerful flight muscles.
6. Keel (sternal keel): An enlarged sternum (keel) in most birds provides attachment for powerful flight muscles (pectoralis major).
7. Four-chambered heart: Complete separation of oxygenated and deoxygenated blood ensures high oxygen supply to flight muscles during sustained flight.
8. Warm-bloodedness (homoiothermous): Constant, high body temperature supports the high metabolic rate required for sustained flight.
9. Air sacs: Air sacs connected to lungs create a unidirectional airflow system supplementing lung respiration, ensuring a continuous supply of oxygen even during exhalation.
10. Absence of urinary bladder and reduced reproductive organs (outside breeding): Reduces body weight.

11. Beak instead of heavy jaw: Lightweight beak replaces heavy teeth and jaw bones.

Answer: Birds are adapted for flight by: forelimbs modified into wings, streamlined body, flight feathers, hollow pneumatic bones (reduced weight), four-chambered heart (efficient oxygen delivery), homoiothermy (high metabolic rate), air sacs for continuous oxygenation, a keeled sternum for flight muscle attachment, and a lightweight beak instead of heavy jaws/teeth.

Q12 Could the number of eggs or young ones produced by an oviparous and viviparous mother be equal? Why?

SOLUTION

Generally, the number of eggs produced by an oviparous mother is MUCH GREATER than the number of young ones produced by a viviparous mother. They are unlikely to be equal, and here is why:

Oviparous animals:

- Eggs are laid outside the body and are exposed to environmental hazards: predation, desiccation, temperature extremes, disease.
- The probability of each egg surviving to become an adult is very low.
- To compensate, oviparous animals produce very large numbers of eggs (e.g., a frog may lay thousands of eggs; a fish may produce millions).

Viviparous animals:

- The embryo develops inside the mother's body and is protected from environmental hazards.
- The mother provides nutrition and a stable internal environment.
- Survival rate of each offspring is very high.
- Therefore, far fewer young ones are born per reproductive event (e.g., most mammals give birth to one to a few young ones at a time).

Conclusion: Because oviparous young are much more vulnerable, their mothers must produce far more offspring to ensure species survival. A viviparous mother, by investing more per offspring, can produce fewer but with higher survival probability. So while theoretically a viviparous mother could produce the same number of young ones as an oviparous mother lays eggs, in practice this does not occur due to the inverse relationship between parental investment per offspring and offspring number.

Answer: No, generally the number is not equal. Oviparous mothers produce far more eggs (sometimes millions) because eggs are exposed to environmental risks (predation, desiccation) with low individual survival. Viviparous mothers produce far fewer young ones because the embryo is protected within the body, receives nourishment, and has a high survival rate — requiring less reproductive output.

Q13 Segmentation in the body is first observed in which of the following: (a) Platyhelminthes (b) Aschelminthes (c) Annelida (d) Arthropoda

SOLUTION

Metameric segmentation (the division of the body into a serial repetition of similar segments, called metameres) is first observed in phylum Annelida.
- Platyhelminthes: Acoelomate, no segmentation.
- Aschelminthes: Pseudocoelomate, no true segmentation.
- Annelida: TRUE metameric segmentation — the body is externally and internally divided into segments with a serial repetition of at least some organs. The earthworm (Pheretima) is a classic example. The phenomenon is called metamerism.
- Arthropoda: Also segmented, but they evolved from annelid-like ancestors; Annelida is where segmentation first appeared in the evolutionary sequence of animal phyla.

Answer: (c) Annelida. Metameric segmentation (metamerism) — the body divided into repeating segments (metameres) externally and internally — is first observed in phylum Annelida (e.g., earthworm).

Q14 Match the following:
(a) Operculum (i) Ctenophora
(b) Parapodia (ii) Mollusca
(c) Scales (iii) Porifera
(d) Comb plates (iv) Reptilia
(e) Radula (v) Annelida
(f) Hairs (vi) Cyclostomata and Chondrichthyes
(g) Choanocytes (vii) Mammalia
(h) Gill slits (viii) Osteichthyes

SOLUTION

(a) Operculum — (viii) Osteichthyes: The operculum is the gill cover present in bony fishes (Osteichthyes) that covers the four pairs of gills. It is absent in Chondrichthyes.
(b) Parapodia — (v) Annelida: Parapodia are lateral paddle-like appendages present in aquatic annelids like Nereis; they help in swimming.
(c) Scales — (iv) Reptilia: Reptiles have dry, cornified (keratinized) epidermal scales or scutes covering their body.
(d) Comb plates — (i) Ctenophora: Ctenophores have eight external rows of ciliated comb plates (ctenes) used for locomotion.
(e) Radula — (ii) Mollusca: The radula is a file-like rasping organ in the mouth of molluscs used for feeding by scraping food.
(f) Hairs — (vii) Mammalia: Hair is the unique and defining characteristic of the skin of mammals.
(g) Choanocytes — (iii) Porifera: Choanocytes (collar cells) are flagellated cells lining the spongocoel and canals of sponges; they create water currents and capture food particles.
(h) Gill slits — (vi) Cyclostomata and Chondrichthyes: Both cyclostomes (6-15 pairs of gill slits without operculum) and cartilaginous fishes (separate gill slits without operculum) have exposed gill slits.

Answer: (a)-(viii) Osteichthyes; (b)-(v) Annelida; (c)-(iv) Reptilia; (d)-(i) Ctenophora; (e)-(ii) Mollusca; (f)-(vii) Mammalia; (g)-(iii) Porifera; (h)-(vi) Cyclostomata and Chondrichthyes.

Q15 Prepare a list of some animals that are found parasitic on human beings.

SOLUTION

The following are animals (from various phyla) that parasitise human beings:

Phylum Platyhelminthes (Flatworms):
- Taenia solium and Taenia saginata — Tapeworms (intestinal parasites; larvae form cysticerci in muscles/brain).
- Fasciola hepatica — Liver fluke (parasitises the bile duct of the liver).
- Schistosoma — Blood fluke (causes schistosomiasis/bilharzia).

Phylum Aschelminthes (Roundworms):
- Ascaris lumbricoides — Common roundworm (intestinal parasite).
- Wuchereria bancrofti — Filarial worm (causes filariasis/elephantiasis;

transmitted by Culex mosquito).
- Ancylostoma duodenale — Hookworm (attaches to intestinal wall, causes anaemia).
- Enterobius vermicularis — Pinworm (caecum and appendix).
- Trichinella spiralis — Causes trichinosis (from undercooked pork).

Phylum Arthropoda:
- Pediculus humanus — Head louse (ectoparasite on scalp).
- Phthirus pubis — Pubic louse (ectoparasite).
- Sarcoptes scabiei — Itch mite (causes scabies; burrows into skin).
- Cimex lectularius — Bedbug (ectoparasite, feeds on blood).
- Various mosquitoes (Anopheles, Culex, Aedes) act as vectors for malarial parasites, filarial worms, and dengue virus.

Phylum Chordata (rare):
- Vandellia cirrhosa (Candiru fish) — A small catfish that is an occasional parasite of humans.

Answer: Parasites of humans include — Platyhelminthes: Taenia (tapeworm), Fasciola (liver fluke), Schistosoma (blood fluke); Aschelminthes: Ascaris (roundworm), Wuchereria (filarial worm), Ancylostoma (hookworm), Enterobius (pinworm); Arthropoda: Pediculus (head louse), Sarcoptes (itch mite), Cimex (bedbug).