Unit 1: Biodiversity & Classification

Long / Descriptive Questions | Complete Answers

Three-Domain System of Classification

Q1. Explain the Three-Domain System of Classification. How is it different from the Five-Kingdom system?

Five,Kingdom Classification

- Proposed by American ecologist Robert Whittaker in 1969.
- All living organisms were grouped into five kingdoms: Monera, Protista, Fungi, Plantae, and Animalia.
- Kingdom Monera contained all prokaryotes (organisms without a nucleus); the remaining four kingdoms held the eukaryotes (organisms with a nucleus).

Three,Domain Classification

American microbiologist Carl Woese proposed the three,domain system in 1990, based on molecular and genetic (rRNA) studies. It gives a more accurate picture of the evolutionary relationships between organisms.

Woese found that prokaryotes are not all alike, they exist in two very different forms, Bacteria and Archaea — and introduced three domains in place of kingdoms:

1. Domain Bacteria | true bacteria (prokaryotes)
2. Domain Archaea | ancient, bacteria,like organisms (prokaryotes)
3. Domain Eukarya | all eukaryotes (protists, fungi, plants, animals)

Key Differences

- The five,kingdom system grouped all prokaryotes into one kingdom (Monera); the three,domain system splits prokaryotes into two distinct domains, Bacteria and Archaea.
- Molecular evidence shows Archaea are more closely related to Eukarya than to Bacteria, meaning Eukarya likely evolved from an archaeal lineage after Archaea and Bacteria diverged.

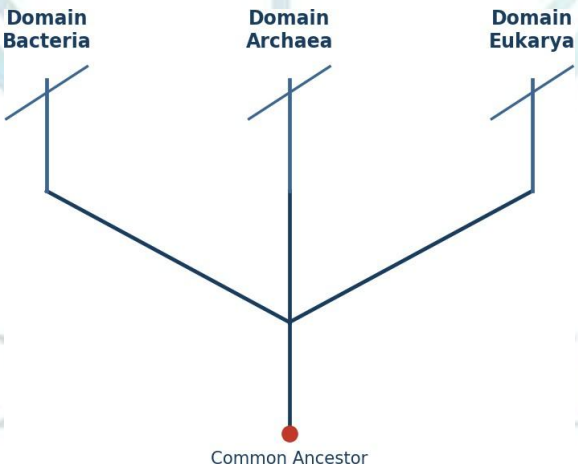

Fig: Evolutionary tree of the three domains, from a common ancestor

Q2. Describe the distinguishing unique characteristics of Domain Archaea. Write their major groups. / Explain how archaea are unique from bacteria and eukarya.

In the five,kingdom system, archaea were included in kingdom Monera. The name comes from the Greek *archaios* ("ancient"), archaea are prokaryotes that diverged from bacteria very early in evolutionary history. They were initially classed as a group of bacteria and called *archaebacteria*.

- **Size:** individual cells range from 0.1 μm to over 15 μm in diameter; some form aggregates or filaments up to 200 μm long.
- **Morphology:** spherical, rod,shaped, spiral, lobed, or rectangular.
- **Reproduction:** exclusively asexual, binary or multiple fission, fragmentation, or budding. Mitosis and meiosis do not occur.

What Makes Archaea Unique

- **Cell membrane:** lipids are joined to glycerol by ether linkages, with branched fatty acid chains, making archaeal membranes more resistant to extreme conditions. Bacteria and Eukarya instead use ester linkages with unbranched fatty acid chains.
- **Cell wall:** lacks cellulose and peptidoglycan; instead contains distinct polysaccharides and proteins (some archaea have pseudopeptidoglycan). Bacterial walls contain true peptidoglycan (sugars cross,linked by amino acids); eukaryotic walls, where present, are cellulose (plants) or chitin (fungi).
- **Genetics:** archaea share several gene sequences and regulatory features with eukaryotes, pointing to a closer evolutionary relationship with Eukarya.
- **Metabolism:** archaea alone perform methanogenesis (methane production), a pathway absent in Bacteria and Eukarya. Bacteria carry out photosynthesis, nitrogen fixation, and fermentation; Eukarya carry out cellular respiration, photosynthesis (plants/algae), and various fermentations.

Major Groups of Archaea

- **Methanogens:** produce methane as a metabolic byproduct.
- **Halobacteria:** live in extremely saline environments.
- **Thermococci:** found in hot environments.
- **Thaumarchaeota:** involved in the nitrogen cycle.

Q3. Describe the general characteristics of Domain Bacteria. / Describe the characteristics which distinguish bacteria from other domains.

In the five,kingdom system, bacteria were also placed in kingdom Monera, they are the "true bacteria," with several traits distinguishing them from Archaea and Eukarya.

- **Cell structure:** prokaryotic, no true nucleus or membrane,bound organelles.
- **Cell wall:** composed of peptidoglycan (murein), a polymer that gives structural support and shape.
- **Genetic material:** a single, circular chromosome of DNA located in the nucleoid region.
- **Plasmids:** most bacteria carry small circular DNA molecules that can transfer between cells, aiding genetic diversity and adaptation.
- **Reproduction:** primarily asexual, via binary fission.
- **Nutrition:** autotrophic (e.g., photosynthetic bacteria) or heterotrophic (e.g., decomposers).
- **Morphology:** cocci (spherical), bacilli (rod,shaped), spirilla (spiral), and vibrios (comma,shaped); cells may occur singly, in pairs (diplococci), chains (streptococci), or clusters (staphylococci).

- **Appendages:** flagella for movement; pili and fimbriae (hair,like structures) for surface attachment and gene exchange.
- **Respiration:** can be obligate aerobes, obligate/facultative anaerobes, microaerophiles, or aerotolerant anaerobes; some ferment in the absence of oxygen.
- **Extremophiles:** some bacteria thrive in extreme heat (thermophiles), high salinity (halophiles), or low pH (acidophiles).
- **Pathogenicity & symbiosis:** some bacteria cause disease via toxins; many live symbiotically with other organisms (mutualism or commensalism).

Major Groups of Bacteria

- Proteobacteria (Gram,negative), e.g., *Escherichia coli*, *Rhizobium*, *Helicobacter pylori*
- Firmicutes (Gram,positive), e.g., *Bacillus subtilis*, *Lactobacillus*, *Clostridium botulinum*
- Actinobacteria, e.g., *Streptomyces*, *Mycobacterium tuberculosis*
- Cyanobacteria, e.g., *Anabaena*, *Spirulina*
- Spirochaetes, e.g., *Treponema pallidum*
- Acidobacteria, e.g., *Acidobacterium*
- Aquificae, e.g., *Aquifex pyrophilus*

Q4. Explain the general characteristics of Domain Eukarya.

Domain Eukarya includes all organisms with eukaryotic cells, fundamentally different from the prokaryotic cells of Bacteria and Archaea.

- **Cell structure:** a true nucleus enclosed by a nuclear membrane; membrane,bound organelles such as mitochondria, chloroplasts (in plants and algae), endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes. A cytoskeleton of microtubules, microfilaments, and intermediate filaments provides support, movement, and intracellular transport.
- **Genetic material:** DNA organized into multiple linear chromosomes within the nucleus, associated with histone proteins that help organize and regulate it.
- **Reproduction:** most eukaryotes reproduce sexually via meiosis and fertilization (generating genetic diversity); some also reproduce asexually via mitosis (identical offspring).
- **Complex organization:** in multicellular eukaryotes, cells differentiate into specialized types forming tissues and organs.
- **Evolutionary origin:** eukaryotes are believed to have arisen through endosymbiosis — aerobic bacteria (becoming mitochondria) and cyanobacteria (becoming chloroplasts) were engulfed by an anaerobic prokaryotic host cell, forming a lasting symbiotic relationship.

Taxonomic Hierarchy

Q5. Elaborate the hierarchical system for the classification of living organisms.

Classification is organized into a hierarchy of nested ranks (taxa; singular taxon), from the broadest to the most specific.

1. Domain

The highest level of classification. There are currently three domains: Archaea, Bacteria, and Eukarya.

2. Kingdom

One of the highest ranks, just below domain, grouping organisms that share fundamental characteristics. Example: within domain Eukarya there are kingdoms Animalia, Plantae, Fungi, and Protista.

3. Phylum

The next rank below kingdom. Organisms within a phylum share a basic body plan and significant structural features. Example: within kingdom Animalia, phylum Chordata includes all animals with a notochord — mammals, birds, reptiles, amphibians, and fishes.

4. Class

Divides organisms within a phylum by more specific shared traits. Example: within phylum Chordata, class Mammalia includes all mammals, characterized by hair and mammary glands.

5. Order

Groups organisms within a class by additional shared characteristics and evolutionary history. Example: within class Mammalia, order Primates includes humans, monkeys, and apes — characterized by large brains and opposable thumbs.

6. Family

Groups organisms within an order that are even more closely related. Example: within order Primates, family Hominidae includes great apes and humans.

7. Genus

A more specific rank within a family, grouping species that are very closely related and often visually similar. Example: within family Hominidae, genus *Homo* includes humans and their closest extinct relatives.

8. Species

The most specific level of classification, representing a single type of organism whose members can interbreed and produce fertile offspring. Example: within genus *Homo*, the species *Homo sapiens* refers to modern humans.

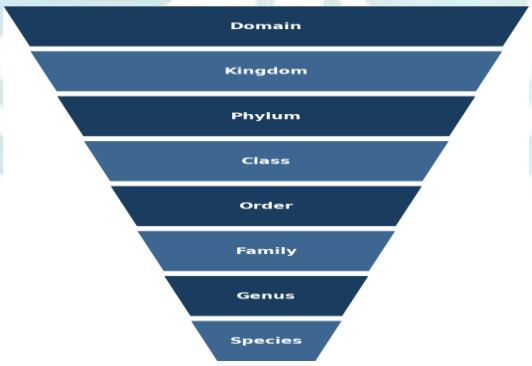

Fig: Taxonomic hierarchy — Domain → Kingdom → Phylum → Class → Order → Family → Genus → Species

Taxonomic Rank	Human (Homo sapiens)	Sparrow (Passer domesticus)	Onion (Allium cepa)
Domain	Eukarya	Eukarya	Eukarya
Kingdom	Animalia	Animalia	Plantae

Phylum	Chordata	Chordata	Angiosperms
Class	Mammalia	Aves	Monocots
Order	Primates	Passeriformes	Asparagales
Family	Hominidae	Passeridae	Amaryllidaceae
Genus	Homo	Passer	Allium
Species	Homo sapiens	Passer domesticus	Allium cepa

Salient Features of Kingdoms of Domain Eukarya

Q6. What are the salient features of kingdoms of domain Eukarya? / Describe the main characteristics of kingdom Protoctista, Fungi, Plantae, and Animalia. Provide examples for each kingdom.

Domain Eukarya consists of kingdoms Protista, Fungi, Plantae, and Animalia — all built from complex eukaryotic cells with a nucleus and membrane,bound organelles.

1. Kingdom Protista

Includes eukaryotes that are unicellular, colonial, filamentous, or simple multicellular (lacking multicellular sex organs). There are three main groups:

- **Protozoa** (animal,like protists): unicellular and heterotrophic — e.g., Paramecium, Amoeba, Plasmodium, Trypanosoma.
- **Algae** (plant,like protists): cellulose cell walls, chlorophyll, autotrophic — e.g., Euglena, diatoms, dinoflagellates, red/green/brown algae.
- **Fungus,like protists**: Myxomycota and Oomycota — hyphae,like, saprophytic (slime molds and water molds).
- **Parasitic protists:** some cause disease — malaria (Plasmodium), amoebic dysentery (Entamoeba histolytica), sleeping sickness (Trypanosoma).

2. Kingdom Fungi

Eukaryotic, heterotrophic organisms, unicellular or multicellular, with cell walls made of chitin. Fungi do not ingest food like animals — they absorb it from their surroundings. Examples: mushrooms, rusts, smuts, molds. Some fungi are used to make bread, cheese, and beer, or yield medicines such as penicillin.

- **Zygomycota:** aseptate (non,septate) hyphae — e.g., Rhizopus (bread mold).
- **Ascomycota:** largest fungal group, septate hyphae — e.g., molds, morels, truffles, cup fungi, Neurospora, yeasts. Most lichens and many mycorrhizae are Ascomycetes.
- **Basidiomycota:** septate hyphae — e.g., mushrooms, toadstools, puffballs, bracket/jelly fungi, rusts, smuts.

3. Kingdom Plantae

Eukaryotic, multicellular organisms with cellulose cell walls, autotrophic via photosynthesis, developing from an embryo. Examples: mosses, ferns, conifers, flowering plants.

- **Non,vascular plants (bryophytes):** lack conducting tissue — liverworts, hornworts, mosses.

• **Vascular plants (tracheophytes):** possess xylem and phloem. Seedless (ferns) or seed,bearing: gymnosperms (naked seeds, cone,bearing, no flowers/fruits — pine, spruce) and angiosperms (flowering plants, the most diverse group, seeds enclosed in fruit — monocots like grass and corn; dicots like rose and sunflower).

4. Kingdom Animalia

Eukaryotic, multicellular, heterotrophic organisms that develop from an embryo. They ingest food and digest it internally — e.g., mammals, birds, reptiles.

Q7. Draw a table showing distinguishing characteristics of the kingdoms of the three domains.

Feature	Bacteria	Archaea	Protista	Fungi	Plantae	Animalia
Cell Type	Prokaryotic	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Nuclear Envelope	Absent	Absent	Present	Present	Present	Present
Cell Wall	In all	In all	In some	In all	In all	Absent
Wall Composition	Peptidoglycan	Various	Polysaccharides/prot	eCinhsitin	Cellulose	No cell wall
Nutrition	Auto/hetero	Auto/hetero	Photo/hetero/combo	Absorptive hete	roPhotosynthetic a	Itnogestive heter o
Multicellularity	Absent	Absent	Absent (mostly)	Present (mostly)	Present	Present

Basic Terminology Related to Kingdom Animalia

Multicellular animals (metazoa) are grouped as:

• **Parazoa** (phylum Porifera): lack tissues organized into organs; indeterminate, asymmetrical shape.

• **Eumetazoa:** all other phyla; tissues are organized into organs and organ systems, divided into:

  • **Grade Radiata** (phylum Cnidaria): the simplest Eumetazoa, radially symmetrical.

  • **Grade Bilateria:** bilaterally symmetrical, with a distinct anterior end; can be divided into two equal halves along only one plane.

Diploblastic animals: body built from two layers (ectoderm and endoderm); little specialization, no true organs, no central nervous system, and a sac,like digestive system.

Triploblastic animals: body built from three layers (ectoderm, mesoderm, endoderm); higher specialization, true organs and organ systems, usually a blood vascular system, a central nervous system, and a tube,like digestive system.

• **Ectoderm** → integumentary and nervous systems.

• **Mesoderm** → muscular, skeletal, and reproductive systems.

• **Endoderm** → lining of the digestive tract and associated glands (e.g., liver).

Triploblastic animals may be acoelomate, pseudocoelomate, or coelomate:

• **Acoelomates** (e.g., Platyhelminthes): no body cavity; mesoderm forms a packing tissue (parenchyma) between ectoderm and endoderm.

• **Pseudocoelomates** (e.g., Aschelminthes): a false body cavity (pseudocoelom) between the body wall and gut, not lined by mesoderm/coelomic epithelium and unconnected to the reproductive/excretory organs.

• **Coelomates:** a true coelom lined by mesoderm lies between the body wall and gut, filled with coelomic fluid (e.g., annelids through chordates). Coelomates are further split into:

• **Protostomes** — the blastopore becomes the mouth; coelom forms by splitting of mesoderm (schizocoelous). Includes Aschelminthes, Annelida, Mollusca, Arthropoda.

• **Deuterostomes** — the mouth forms away from the blastopore, which becomes the anus; coelom forms as an outpouching of the gut (enterocoelous). Includes Echinodermata, Hemichordata, Chordata.

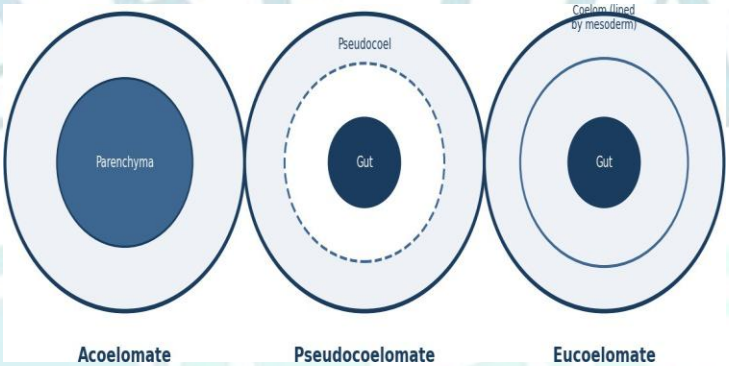

Fig: Body cavity types — acoelomate, pseudocoelomate, and eucoelomate cross,sections

Classification of Kingdom Animalia

Q8. Discuss the general characteristics of Phylum Porifera.

Phylum Porifera ("pore,bearing") contains the sponges.

• **Habitat:** mostly marine; some freshwater. *Leucosolenia* and *Euplectella* (Venus flower basket) are marine; *Spongilla* is a common freshwater sponge.

• **Organization:** no tissue,level organization; most are asymmetrical, some radially symmetrical; no nervous system.

• **Water flow system:** numerous pores (ostia) let water in; a larger opening (osculum) lets water out.

• **Body wall:** outer pinacoderm (flattened pinacocytes); middle jelly,like mesohyl (with amoeboid cells); inner choanoderm lining the spongocoel, made of choanocytes (collar cells). The skeleton consists of minute spicules of calcium carbonate or silica.

• **Reproduction:** mostly asexual, by budding or regeneration; some form resistant gemmules that release amoeboid cells to form a new sponge when conditions improve.

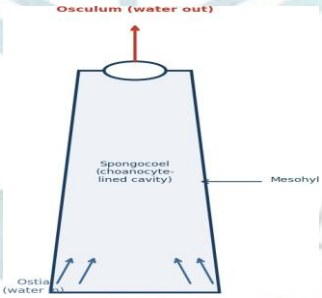

Fig: Water,flow system and body layers of a sponge (ostia → spongocoel → osculum)

Q9. Describe the general characteristics of Phylum Cnidaria.

• **Habitat:** almost all marine (a few freshwater, e.g., hydra, jellyfish); mostly colonial (obelia, corals, sea fans) and sessile (hydra, coral); jellyfish are motile.

• **Symmetry:** radially symmetrical, diploblastic.

• **Body structure:** two tissue layers — epidermis (from ectoderm) and gastrodermis (from endoderm) — separated by jelly,like mesoglea containing amoeboid cells.

• **Defense:** cnidocytes containing nematocysts, used to sting and capture prey.

• **Digestion:** a blind gastrovascular cavity (enteron) with a single opening (mouth, which also expels waste), surrounded by tentacles — a sac,like digestive system.

• **Nervous system:** a diffuse nerve net; no central nervous system, respiratory, excretory, or transport systems.

• **Body forms:** polyps (cylindrical, sessile, attached at the aboral end, reproduce asexually) and medusae (umbrella,shaped, free,swimming, reproduce sexually).

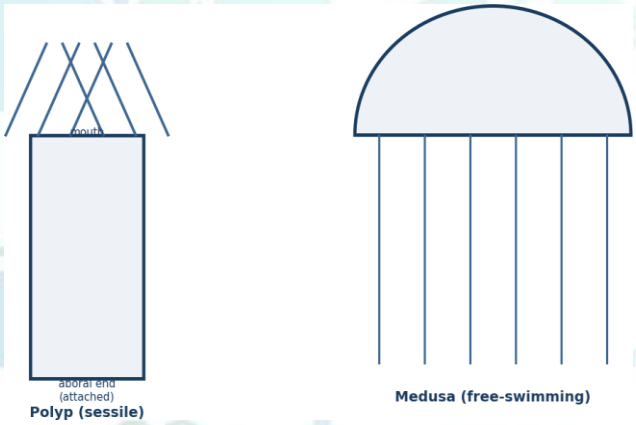

Fig: Polyp and medusa body forms in Cnidaria (e.g., Hydra and jellyfish)

Q10. Describe the general characteristics of Phylum Platyhelminthes.

Phylum Platyhelminthes ("flatworms") are unsegmented, soft, dorsoventrally flattened worms.

• **Habitat:** mostly free,living (e.g., planaria); some endoparasitic (liver fluke, tapeworm, blood fluke).

• **Organization:** triploblastic; tapeworms are unusually segmented among flatworms.

• **Body cavity:** acoelomate — parenchyma fills the space between body wall and organs.

• **Symmetry:** bilateral, with distinct left/right and dorsal/ventral sides.

• **Excretion:** a network of tubular protonephridia, each branch ending in a flame cell whose cilia draw fluid into the tubules; waste exits through a nephridiopore.

• **Respiration & circulation:** absent.

• **Nervous system:** cerebral ganglia at the anterior end, connected to longitudinal nerve cords linked by transverse branches.

• **Eyespots:** most free,living flatworms have two simple eyespots anteriorly.

• **Reproduction:** asexual by fission; sexually,reproducing flatworms are hermaphrodites.

Q11. Outline the general characteristics of Phylum Nematoda.

Phylum Nematoda ("thread,like") — roundworms. Pseudocoelomates are grouped into seven phyla collectively called Aschelminthes, of which Nematoda is the representative phylum.

- **Habitat:** some free,living in water/soil (e.g., *Caenorhabditis elegans*); many parasitic (ascaris, hookworm, pinworm, whipworm).
- **Organization:** triploblastic, bilaterally symmetrical, unsegmented; pseudocoelomate (false body cavity filled with fluid).
- **Digestion:** tube,like, with a mouth anteriorly and anus posteriorly (simplified in parasitic forms).
- **Excretion:** protonephridia plus two excretory canals uniting anteriorly into a single canal that opens via a ventral nephridiopore.
- **Nervous system:** a nerve ring around the pharynx connected to four longitudinal nerve cords.
- **Sense organs:** raised, hair,like sensory papillae on the lips.
- **Respiration & circulation:** no defined systems.
- **Reproduction:** unisexual — males have testes, females have ovaries.

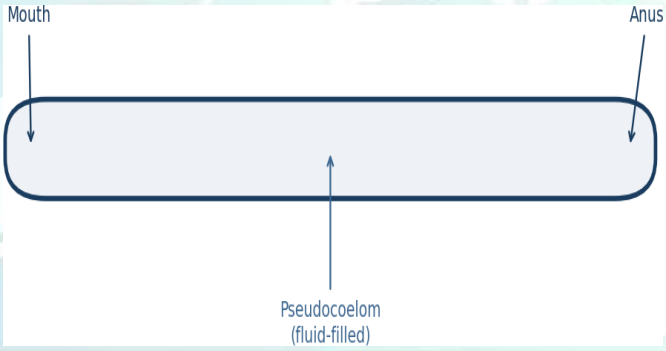

Fig: Basic roundworm (Nematoda) body structure with a fluid,filled pseudocoelom

Q12. Describe the general characteristics of Phylum Mollusca.

Phylum Mollusca ("soft,bodied") — soft, unsegmented bodies.

- **Habitat:** widely distributed; many aquatic (mussels, octopus, oyster), others in moist places (land snails).
- **Organization:** triploblastic, bilaterally symmetrical, true coelomates; grouped among the protostomes.
- **Body plan:** three regions — head, visceral mass (digestive, excretory, reproductive organs), and a muscular foot.
- **Mantle:** an epithelial fold around the visceral mass, enclosing the mantle cavity; usually secretes a calcareous shell.
- **Radula:** a rasping, tongue,like feeding organ, present in all classes except Bivalvia.
- **Circulation:** open,type (except in cephalopods); the heart has one ventricle and two auricles.
- **Digestion:** tube,like, with mouth and anus.
- **Excretion:** paired nephridia collect waste from sinuses and discharge it into the mantle cavity via the coelom around the heart.
- **Respiration:** gills.
- **Nervous system:** three pairs of interconnected ganglia (head, visceral mass, foot).

- **Locomotion:** the muscular foot (some are sessile); mostly unisexual.
- **Classes:** Gastropoda (slug, garden snail), Bivalvia (mussel, oyster), Cephalopoda (octopus, cuttlefish).

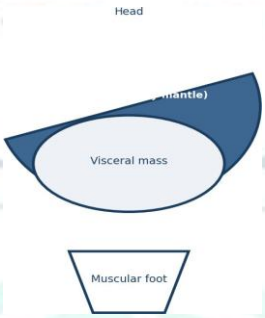

Fig: General mollusc body plan — head, visceral mass, mantle/shell, and foot

Q13. Describe the general characteristics of Phylum Annelida.

Phylum Annelida ("little rings") — segmented worms.

- **Habitat:** marine (nereis), freshwater (leech), and damp soil (earthworm); some ectoparasitic (leeches).
- **Organization:** bilaterally symmetrical, triploblastic, protostome coelomates.
- **Metameric segmentation:** the body is divided into repeated segments separated internally by septa, each with its own circulatory, excretory, and neural elements.
- **Setae:** chitinous bristles in the ventral wall of each segment, used for anchoring during movement (absent in leeches). The body is covered by a moist, acellular cuticle.
- **Digestion:** tube,like, divided into distinct functional regions (simplified in parasites).
- **Excretion:** ciliated, funnel,shaped metanephridia, one pair per segment.
- **Circulation:** closed,type, with specialized pulsating vessels (pseudohearts); blood usually contains haemoglobin.
- **Respiration:** through the skin.
- **Nervous system:** a cerebral ganglion (brain) with a double ventral nerve cord bearing ganglia in each segment.
- **Receptors:** tactile, chemo,, balance, and photoreceptors (some with well,developed eyes).
- **Reproduction:** mostly hermaphroditic (earthworm, leech); some unisexual (nereis).

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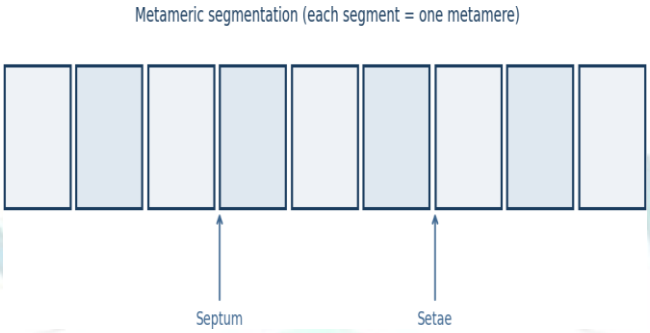

Fig: Metameric segmentation in annelids — repeated segments separated by septa

Q14. Elaborate the general characteristics of Phylum Arthropoda.

Phylum Arthropoda ("jointed legs") includes insects, crustaceans, spiders, scorpions, and centipedes, found in nearly every habitat.

- **Organization:** triploblastic, bilaterally symmetrical, protostome coelomates; the coelom is reduced, present mainly around the reproductive and excretory systems.
- **Jointed appendages:** modified for running, swimming, capturing prey, respiration, or reproduction; mouth appendages form varied mouthparts.
- **Body plan:** segmented, with segments fused into tagmata — head, thorax, and abdomen.
- **Exoskeleton & ecdysis:** a chitinous cuticle secreted by the epidermis is periodically shed (ecdysis/molting, driven by the hormone ecdysone) to allow growth.
- **Circulation:** open,type; colorless blood (haemolymph, no haemoglobin) flows through the hemocoel.
- **Respiration:** tracheal tubes opening via spiracles (terrestrial forms); gills in aquatic forms.
- **Digestion:** tube,like, with distinct regions (mouth, esophagus, crop, gizzard, mesenteron, ileum, colon, rectum, anus).
- **Excretion:** Malpighian tubules at the midgut–hindgut junction, excreting solid uric acid crystals.
- **Nervous system:** a brain of three fused ganglia pairs, a double ventral nerve cord, well,developed compound eyes and antennae.
- **Reproduction:** unisexual, egg,laying.
- **Classes:** Crustacea (crayfish, crab), Insecta (fly, mosquito, butterfly), Arachnida (spider, mite, scorpion), Myriapoda (centipede, millipede).

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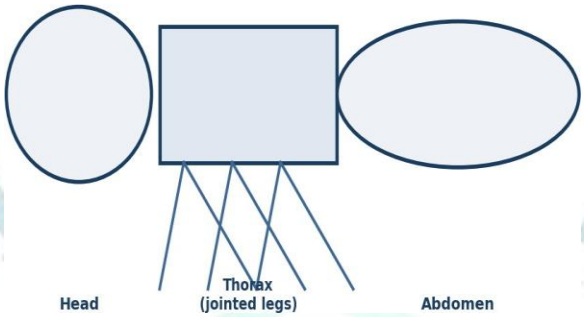

Fig: Arthropod tagmata — head, thorax, and abdomen, with jointed appendages

Q15. Explain the general characteristics of Phylum Echinodermata.

Phylum Echinodermata ("spiny,skinned") — exclusively marine animals of varied shapes: flattened/biscuit,shaped (cake urchin), star,shaped with short arms (starfish), globular (sea urchin), star,shaped with long arms (brittle star), and elongated (sea cucumber).

- **Organization:** triploblastic, deuterostome coelomates; larvae are bilaterally symmetrical but adults show radial symmetry (body parts arranged in five, or a multiple of five, around an oral–aboral axis).
- **Skeleton:** a calcareous endoskeleton of plates (ossicles), derived from mesoderm, some projecting through the skin as spines.
- **Water,vascular system:** a ring canal around the mouth opens externally through a sieve,like madreporite; radial canals (five, or a multiple of five) give off lateral canals ending in tube feet, which extend and attach to the substrate for locomotion.
- **Digestion:** tube,like — mouth, oesophagus, stomach, intestine, rectum, anus.
- **Respiration & excretion:** no specialized organs.
- **Nervous system:** a nerve net, nerve ring, and radial nerves; sensory receptors are spread over the body surface and tube feet.
- **Reproduction:** unisexual; asexual reproduction can occur by division of the body followed by regeneration of each half.

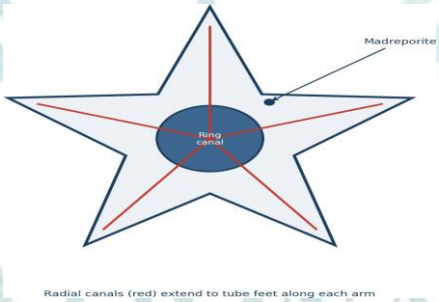

Fig: The echinoderm water,vascular system — madreporite, ring canal, and radial canals

Chordata & Classification of Vertebrates

Q16. Outline the major four characteristics of Chordata, and describe their major groups.

Chordates are bilaterally symmetrical, triploblastic, deuterostome coelomates. Four features are unique to chordates, present at some stage of development:

1. **Notochord:** a rod,like, semi,rigid body of vacuolated cells running between the gut and the dorsal nerve cord. Lower chordates keep it for life; in vertebrates it is largely replaced by the vertebral column during development.

2. **Pharyngeal slits:** paired openings in the pharynx wall, present in all chordate embryos. In some (Amphioxus, fishes) they become gills; in some (most amphibians) they are functional for part of the life cycle; in others (reptiles, birds, mammals) they are modified for other purposes.

3. **Tubular (dorsal, hollow) nerve cord:** runs the length of the body just dorsal to the notochord, expanding anteriorly into a brain.

4. **Post,anal tail:** extends posteriorly beyond the anal opening; retained for life in some chordates, lost during development in others.

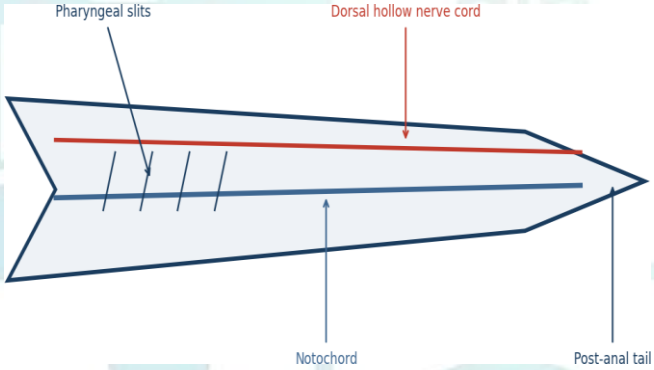

Fig: Diagnostic chordate features — notochord, dorsal nerve cord, pharyngeal slits, post,anal tail

Classification

Phylum Chordata includes two major groups — invertebrate chordates and vertebrates.

- **Subphylum Urochordata:** notochord and nerve cord present only in the free,swimming larvae (e.g., sea squirts).
- **Subphylum Cephalochordata:** notochord persists throughout life (e.g., Amphioxus).

Vertebrates (higher chordates): possess a vertebral column and cranium, divided into seven classes placed within two groups.

Classification of Vertebrates

Q17. Describe the basic characteristics of group Pisces.

- **Habitat:** exclusively aquatic (freshwater or marine).
- **Body:** streamlined/fusiform, reducing water resistance.

- **Scales:** dermal — placoid, cycloid, or ctenoid, depending on the fish.
- **Skeleton:** cartilaginous (sharks, rays) or bony (most modern fish).
- **Respiration:** through gills, usually covered by an operculum in bony fish.
- **Circulation:** closed, two,chambered heart (one auricle, one ventricle); single and incomplete circulation.
- **Fins:** paired and unpaired fins provide locomotion, balance, and direction.
- **Reproduction:** mostly oviparous, some viviparous; fertilization external (bony fish) or internal (cartilaginous fish).
- **Thermoregulation:** ectothermic (cold,blooded).

Class	Key Characteristics	Examples
Class Myxini (jawless)	Mouth with four pairs of tentacles; 5–15 pairs of pharyng	aHasglitfsish
Class Cephalaspidomorphi (ja	wSleuscsk)ing mouth, seven pairs of pharyngeal slits	Lamprey
Class Chondrichthyes (jawed)	Cartilaginous skeleton, large upper tail lobe, no swim bla	dSehraluksng, skates, rafish
Class Osteichthyes (jawed)	Bony skeleton, pneumatic sac as lungs or swim bladder	Lungfish, coelacanths

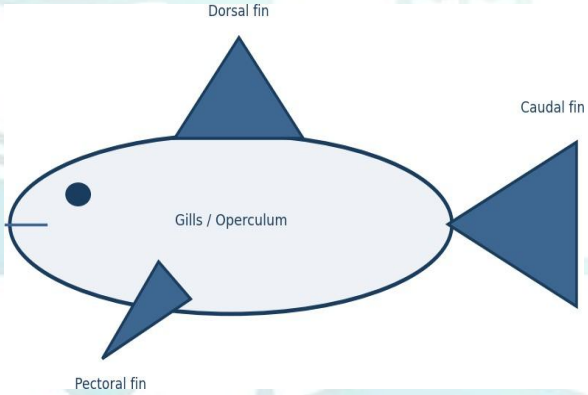

Fig: General fish body plan — fins, gills/operculum, and streamlined body

Q18. Describe the common traits of Class Amphibia.

The first class of tetrapods.

- **Skeleton:** bony; unlike fish, amphibians have a neck — the first (cervical) vertebra moves against the skull, allowing it to nod.
- **Skin:** smooth, scaleless, moist — aids gas exchange, temperature regulation, and water absorption/storage.
- **Heart:** double,circuit, three,chambered (two atria, one ventricle).
- **Respiration:** gills in the larval stage; lungs and skin in the adult stage.
- **Thermoregulation:** ectothermic and poikilothermic; hibernate in winter.
- **Examples:** tailed amphibians (salamander, newt, mudpuppy), tail,less amphibians (frog, toad), legless amphibians (caecilian).
- **Reproduction:** unisexual; fertilization usually external.

Fig: Salamander, newt, frog, toad, and caecilian — representative amphibians

Q19. Discuss the common characteristics of reptiles.

• **Amniotic eggs:** reptiles are the first group with amniotic eggs, protected by extra,embryonic membranes — amnion, allantois, and chorion — which keep the embryo from drying out, nourish it, and allow development on land.

• **Food:** amniotic eggs contain abundant yolk (primary food source) and albumin (extra nutrients and water).

• **Shell:** a leathery, calcareous shell, partly permeable to gases but not to water.

• **Skin:** dry and scaly.

• **Endoskeleton:** bony, harder than in amphibians; a longer skull; the first two cervical vertebrae (atlas and axis) allow greater head movement.

• **Heart:** ventricle incompletely partitioned into left and right sides.

• **Thermoregulation:** ectothermic and poikilothermic, like amphibians.

• **Reproduction:** internal fertilization; oviparous.

• **Examples:** lizards, snakes, tuatara, crocodiles.

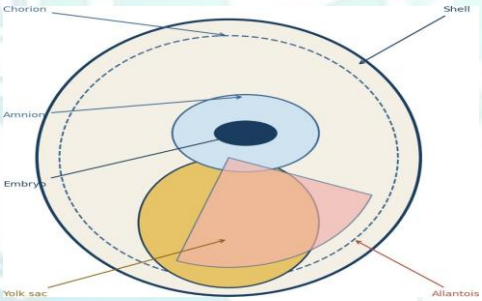

Fig: The amniotic egg — shell, chorion, amnion, embryo, yolk sac, and allantois

Q20. Explain in detail the specific traits which belong to all Aves (birds).

• **Feathers:** cover the body, forming flight surfaces that provide lift and steering, and prevent heat and water loss.

• **Thermoregulation:** endothermic — internal heat production maintains a nearly constant core temperature (homeothermic).

• **Body plan:** streamlined and spindle,shaped; forelimbs modified into wings; bones are light due to large air spaces; the sternum bears a large keel for flight,muscle attachment.

• **Digestion:** the crop (an outpouching of the esophagus) stores food for rapid ingestion; the gizzard has muscular walls that crush food.

• **Heart:** four,chambered, with complete separation of atria and ventricles, and a right aortic arch.

• **Nervous system:** well developed, with vision and hearing as the dominant senses.

• **Respiration:** nares open into the pharynx, then trachea and bronchi; the syrinx (voice organ) sits at the base of the trachea; bronchi lead to air sacs and lungs made of parabronchi.

• **Bills:** a lightweight bill replaces teeth; bills and tongues are adapted to different diets and feeding habits.

• **Fertilization:** internal; development is external — birds are oviparous, with amniotic eggs (large yolk and albumin, leathery shell).

• **Running (flightless) birds:** ostrich, kiwi, rhea, cassowary, emu.

• **Flying birds:** pigeon, parrot, crow, eagle, robin, and most others.

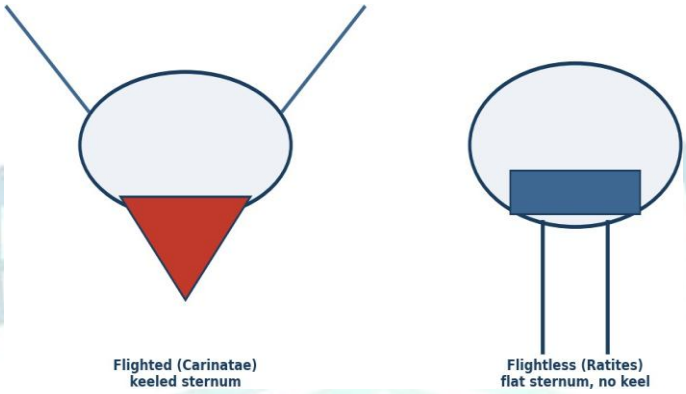

Fig: Keeled sternum in flighted birds vs. flat sternum in flightless ratites

Q21. How are mammals the most advanced class of Chordata?

- **Mammary glands:** functional in females, nourishing young with milk; hair covers the body.
- **Skin glands:** sebaceous (oily secretion) and sudoriferous (sweat, for evaporative cooling).
- **Teeth:** two sets across a lifetime — milk teeth and permanent teeth.
- **Ear:** external pinna present; the middle ear has three bones — malleus, incus, and stapes.
- **Thermoregulation:** endothermic and homeothermic.
- **Heart:** four,chambered, with a left aortic arch.
- **Diaphragm:** a muscular sheet separating the coelom into thoracic and abdominal cavities.
- **Larynx:** a well,developed voice apparatus with vocal cords and epiglottis.
- **Fertilization:** internal.

Classification

- **Monotremes:** egg,laying mammals in which the embryo develops fully inside the egg — oviparous — e.g., duckbill platypus, echidna (spiny anteater).
- **Marsupials:** females have an abdominal pouch (marsupium); young are born immature and complete development in the pouch — e.g., opossum, kangaroo, Tasmanian wolf, quoll.
- **Placental mammals:** the most advanced group — a placenta forms between the uterine wall and fetus, nourishing it and removing wastes; they are viviparous — e.g., dolphin, rat, monkey, bat, elephant, human.

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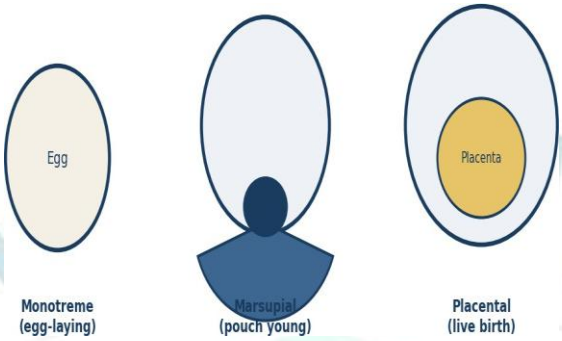

Fig: The three mammalian reproductive groups — monotremes, marsupials, and placentals

Classification of Viruses

Q22. Why are viruses not a part of any domain/kingdom?

Acellularity: viruses are not considered organisms because they are acellular — not made of cells. They lack the defining characteristics of the three domains of life, so they are not classified in any domain or kingdom.

Structure: a virus consists of nucleic acid (DNA or RNA) surrounded by a protein coat.

Reproduction: viruses cannot carry out metabolism on their own; they depend entirely on a host cell (plant, animal, or bacterium) to replicate and synthesize their proteins.

Classification: viruses are classified by their genetic material, replication strategy, morphology, and host range, following guidelines set by the International Committee on Taxonomy of Viruses (ICTV).

Q23. Write a note on the classification of viruses on the basis of host range, morphology, and genetic material.

1. On the Basis of Host Range

- **Animal viruses:** infect animals, including humans — e.g., influenza virus, rabies virus.
- **Plant viruses:** e.g., Tobacco Mosaic Virus, Potato Virus X.
- **Bacteriophages:** infect bacteria — e.g., T4 phage, Lambda phage.
- **Archaeal viruses:** infect archaea — e.g., Sulfolobus spindle,shaped virus.

2. On the Basis of Morphology

- **Helical viruses:** a helical capsid surrounds the nucleic acid — e.g., Tobacco Mosaic Virus, rabies virus.
- **Icosahedral viruses:** a symmetrical, 20,faced capsid — e.g., adenoviruses, herpesviruses.
- **Complex viruses:** combine icosahedral and helical features, sometimes with tails — e.g., bacteriophages.
- **Enveloped viruses:** an outer lipid envelope from the host membrane surrounds the capsid — e.g., influenza virus, HIV.
- **Non,enveloped (naked) viruses:** no lipid envelope, only a capsid enclosing the nucleic acid — e.g., poliovirus, adenovirus.

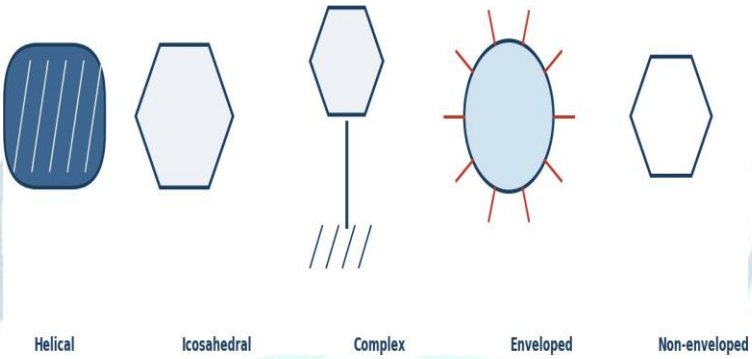

Fig: Basic virus shapes — helical, icosahedral, complex, enveloped, and non,enveloped

3. On the Basis of Genetic Material

• **DNA viruses** — dsDNA: adenoviruses (respiratory infections), herpesviruses (herpes, chickenpox); ssDNA: parvoviruses (gastroenteritis).

• **RNA viruses** — ssRNA: coronaviruses (COVID,19), influenza viruses (flu); dsRNA: rotaviruses (gastroenteritis).

4. On the Basis of Replication Strategy

• **Positive,sense RNA viruses:** genome is directly translated by host ribosomes — e.g., poliovirus, Hepatitis C virus.

• **Negative,sense RNA viruses:** genome must be transcribed into mRNA by a viral RNA polymerase before translation — e.g., rabies virus, Ebola virus.

• **Reverse,transcribing viruses:** replicate through a DNA intermediate using reverse transcriptase, and may carry an RNA or DNA genome — e.g., retroviruses such as HIV (RNA genome); hepadnaviruses such as Hepatitis B virus (DNA genome).

Ecosystem, Niche & Biodiversity

Q24. Describe the concept of an ecosystem and niche.

Ecosystem

An ecosystem is a dynamic, interactive system made up of living organisms and their physical environment, including both biotic and abiotic factors.

• **Biotic components:** all living organisms (plants and animals) supported within the biosphere, which extends roughly 8–10 km above and below Earth's surface.

• **Abiotic components:** non,living components — air (atmosphere), water (hydrosphere), and soil (lithosphere).

Niche

A niche is the role or function of an organism or species within its ecosystem — its habitat, its interactions with other organisms (predation, competition, symbiosis), and its role in energy flow.

- A niche specifies how an organism obtains energy and materials — its predators, prey, and competitors, along with its behavior and interactions.
- It also includes the physical factors needed for survival, such as temperature range, humidity, and soil/water pH.

Q25. Define biodiversity. Explain the different levels at which biodiversity can be assessed. How do these levels contribute to our understanding of biological diversity and conservation efforts?

Biodiversity ("biological diversity") refers to the variety of life forms across ecosystems — the richness and variability of organisms, their genes, and their interactions with each other and their environment.

i. Species Level

Assessed by identifying and counting the different species in a given area — including both species richness and their relative abundance and distribution. Helps biologists identify threatened or endangered species and act to conserve them.

ii. Genetic Level

Refers to the variety of genetic information within all individuals of a species — crucial for adaptability and survival against environmental change. Helps target conservation toward species with lower genetic variety, since fewer genetic variations raise extinction risk.

iii. Ecosystem Level

Assessment covers the range of habitats — forests, wetlands, grasslands, deserts — and how they function and contribute to ecological health. Helps guide restoration of degraded habitats and protection of at,risk ecosystems.

Q26. What is random sampling? Discuss the importance of random sampling methods in ecological studies.

Sampling investigates the abundance and distribution of species and populations within a given time and area; it can be random or systematic. In random sampling, the sampling location is chosen randomly, by chance.

Importance of Random Sampling

1. **Minimizes bias** — every part of the study area has an equal chance of being sampled, giving a more accurate picture of overall biodiversity.
2. **Provides reliable estimates** — data can be statistically analyzed for species richness, abundance, and distribution.
3. **Facilitates comparisons** — standardized data collection allows comparison between areas or habitats.
4. **Enhances representativeness** — covering different parts of the study area ensures the sample reflects the area's true diversity.
5. **Supports conservation efforts** — accurate assessments help identify high,conservation,value areas and track biodiversity changes over time.

Q27. Describe the various methods to assess biodiversity and discuss their importance.

Methods to Assess Distribution

- **1. Quadrat sampling:** divides the study area into a grid and samples within randomly selected squares (quadrats). Especially useful for plant populations or sessile organisms — e.g., recording plant species presence/absence within fixed quadrats in a forest.
- **2. Transect sampling:** lays a line or strip across the study area and records species at regular intervals along it. Effective for studying species distribution across environmental gradients — e.g., a transect from the high,tide to low,tide line recording intertidal organisms.
- **3. Aerial surveys:** use aircraft or drones to observe and record the distribution of organisms over large areas — e.g., tracking bird distribution across a wetland or monitoring large mammal populations in savannas.

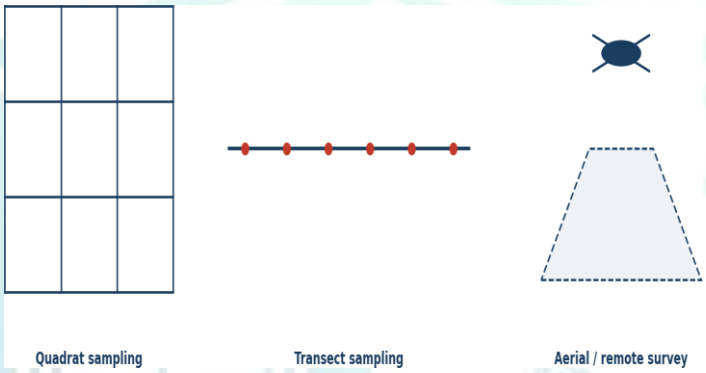

Fig: Quadrat sampling, transect sampling, and aerial/remote surveys

Methods to Assess Abundance

- **1. Point counts:** observing and recording the number of individuals of a species from a fixed point over a set period — commonly used for birds and other mobile animals.
- **2. Mark–recapture:** capturing, marking (tags, paint, bands), and releasing individuals, then recapturing them later to estimate population size and density — useful for animals difficult to count directly.
- **3. Quadrat counts:** counting individuals within each quadrat and using the counts to estimate overall abundance.
- **4. Capture,recapture models:** account for variables such as varying capture probabilities and movement between areas, helping estimate populations that move between locations.
- **5. Remote sensing:** uses satellite or drone imagery to assess abundance and distribution, particularly for large,scale or inaccessible areas.

Species and Speciation

Q28. Define species and speciation. Explain the concept of species according to the biological species concept. How does this definition help in understanding species boundaries and the process of speciation? Provide examples to illustrate your points.

Species

A species is generally defined as a group of individuals that can interbreed and produce fertile offspring under natural conditions.

• Members of the same species share common characteristics and genetic makeup, distinguishing them from other species — though identification by physical traits alone can be tricky, since cryptic species look similar but are genetically distinct.

• German,American biologist Ernst Mayr emphasized reproductive isolation as the key criterion: species are groups of interbreeding natural populations, and members of different species do not typically mate or produce viable, fertile offspring.

Speciation

Speciation is the evolutionary process by which new species arise from a common ancestor, through the accumulation of genetic changes that lead to reproductive isolation between populations.

Mechanisms of Speciation

• **1. Allopatric speciation:** a population is geographically separated into two or more isolated groups, which experience different environments and evolve independently. Over time, accumulated differences prevent interbreeding, even if the barrier is later removed. Example: Darwin's finches diversifying across the Galápagos Islands.

• **2. Peripatric speciation:** a small, isolated population at the edge of a larger population undergoes rapid evolutionary change and diverges from the parent population. Example: island species evolving from a small founding population.

• **3. Parapatric speciation:** adjacent populations occupy different environments along a gradient, with limited gene flow between them; over time, this can lead to reproductive isolation. Example: the grass *Anthoxanthum odoratum*, which shows different adaptations to varying soil conditions across a gradient.

• **4. Sympatric speciation:** new species arise within the same geographical area without physical barriers, often via polyploidy (multiple chromosome sets) or niche differentiation (subpopulations exploiting different resources). Example: certain plants undergoing polyploidy, leading to immediate reproductive isolation and new species formation.

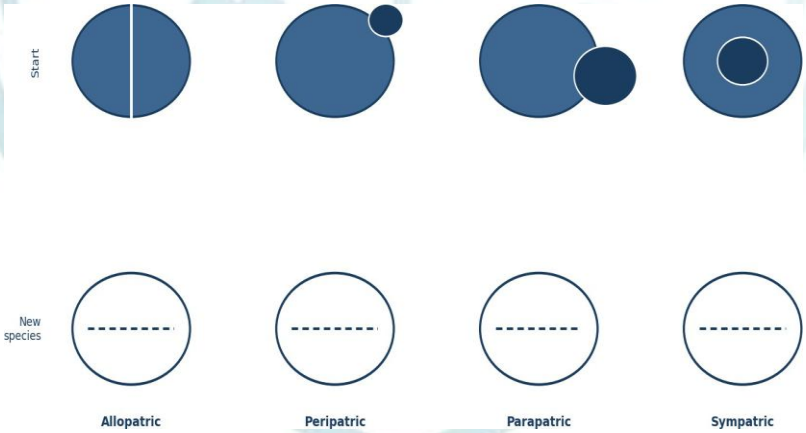

Fig: Allopatric, peripatric, parapatric, and sympatric speciation compared

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