BIOLOGY

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1. Subdivisions of Biology

Anatomy

- Anatomy: Branch of biology dealing with the structure of organisms and their parts.
- Osteology: The scientific study of bones.
- Histology: The scientific study of tissues.
- Craniology: The scientific study of the human skull, including its shape, size, and other features.

Botany

- Janaki Ammal: First Indian woman to receive Ph.D./honorary D. Sc. in Botany (University of Michigan).
- Bryology: Study of mosses and liverworts.
- Valley of Flowers ('फूलों की घाटी'): Discovered by Frank S. Smythe.
- Birbal Sahni: Paleobotany.
- K.C. Mehta: Plant Pathology.
- P. Maheshwari: Embryology.
- M.S. Swaminathan: Green Revolution.

Cell Biology (Cytology)

- In a compound microscope, the correct sequence of light passage is: Condenser → Objective lens → Body tube → Eyepiece.
- When using centrifuges, tubes must be filled to the same level and placed at opposite locations to ensure proper balance.

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- Good laboratory ethics includes documenting mistakes, ensuring transparency, and reporting accurate information.

Ecology

- Ecology: Study of interactions among organisms and between organisms and their physical environment.
- Population: A group of organisms of one species, living in the same area at the same time.
- Community: A group of different species living and interacting in the same area.
- Food Chain: Shows the flow of energy, e.g., Grass (producer) → Goat (primary consumer) → Human (secondary consumer).
- Decomposers: Heterotrophic organisms (chiefly bacteria and fungi) that break down complex organic compounds of dead matter into simple usable substances.
- Aquatic Food Chain Example: Diatoms (producers) → Crustaceans (primary consumers) → Herrings (secondary consumers).
- Primary Producers in Oceans: Cyanobacteria and Diatoms.
- Necton: Swimming organisms in water.
- Plankton: Organisms floating in water.
- Upper Sea Aquatic Ecosystem: Contains both plankton and nekton.
- Man in Food Chain: Can be a primary consumer (herbivore) and a secondary consumer (carnivore/omnivore).
- Composting: Process of decomposing organic matter, primarily involves aerobic digestion.
- Symbiosis:
    - Commensalism: One member benefits, the other is neither benefited nor harmed.
    - Parasitism: One member benefits (parasite) at the expense of the other (host).
    - Mutualism: Both members benefit from the interaction.
- Population Growth with Unlimited Resources: Exhibits exponential growth (J-shaped curve).
- 10% Law: States that only about 10% of the energy is transferred from one trophic level to the next; proposed by Lindemann.
- Competitive Exclusion Principle: States that two species competing for the same limited resources cannot coexist stably; proposed by Gause.
- Biomagnification: Increase in concentration of non-metabolized, non-excreted toxicants (e.g., DDT, heavy metals) at successive trophic levels in a food chain.
- BOD (Biological Oxygen Demand): The amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at a certain temperature over a specific time.
- Biophilia: Means an urge to affiliate with other forms of life.
- Ozone Layer: Absorbs harmful Ultra-Violet (UV) rays from the sun.
- Biodegradable Materials: Substances that can be decomposed by natural processes (e.g., woollen mat, leather bag, jute basket).
- Non-biodegradable Materials: Substances that cannot be decomposed by natural processes (e.g., silver foil).

Evolutionary Biology

- Palaeontology: Study of plant and animal fossils.
- Gerontology: Study of ageing.
- Relative Biological Effectiveness (RBE): Damage is a result of radiation exposure.
- Effective Dose-50% (ED50): Dose resulting in a significant response in 50% of subjects.
- Wilhelm Wundt: Established the first Psychology Laboratory at Leipzig University, Germany.
- Crow & Crow: Defined Educational Psychology as the branch dealing with teaching and learning.
- Functionalism (Psychology): Associated with William James, John Dewey, James R. Angell.
- E.B. Titchener: Associated with Structuralism, not Functionalism.

- Narcissism: Characteristic often more powerful during Late Adolescence stage of development.

Genetics

- **Genetics:** Branch of biology studying heredity and variation in living organisms.
- **Heredity:** Transmission of characteristics from parents to offspring.
- **Variation:** Differences among individuals of the same species.
- **Coefficient of Variation (CV):** A statistical measure of the relative dispersion of data points around the mean.
- **CV Calculation:** (Standard Deviation / Mean) × 100%.
- **CV Purpose:** Used to compare the relative variability or dispersion between two or more data sets, especially when they have different units of measurement (e.g., plant height in cm, seed weight in g) or vastly different means. It provides a unitless comparison.

Microbiology

- Curd formation from milk is due to bacteria (e.g., Lactic Acid Bacteria).
- Bacteria that feed on decaying organic matter are heterotrophic (specifically saprophytic).
- E. coli is a common indicator organism for polluted water, particularly fecal contamination.
- Denitrification (conversion of nitrates to nitrogen gas) is primarily carried out by bacteria.
- The limiting water activity ($A*w$) for the growth of any microorganism is approximately 0.60 (e.g., for xerophilic molds). Most bacteria require $Aw > 0.91$.
- *Louis Pasteur discovered the process of fermentation.*

Physiology

- *Physiology: Branch of biology that studies the normal functions of living organisms and their parts.*
- *Living vs. Non-living Beings:*
  - *Living beings demonstrate growth, repair, and metabolic processes.*
  - *Non-living beings do not exhibit these characteristics.*
- *Bionics: The study of functions, characteristics, and phenomena observed in the living world and the application of this knowledge to machines.*
- *Adolescence:*
  - *Described as the "stage of stress and storm" by Stanley Hall.*
  - *At its terminal stage, muscle weight constitutes approximately 45% of the total body weight.*
- *Svante Pääbo: Awarded the Nobel Prize in Physiology or Medicine in 2022.*
- *Sound Waves:*
  - *In air, sound waves are longitudinal.*
  - *Speed of sound is maximum in solids (e.g., metals), followed by liquids, then gases; it cannot travel in a vacuum.*
- *Liquid Volume Units: Common units include Litre (L) and millilitre (ml).*
- *Candle Burning: Involves both physical changes (e.g., wax melting) and chemical reactions (e.g., combustion).*
- *Formalin: An aqueous solution of formaldehyde.*
- *Wastewater Treatment - Trickling Filters: Always provided between the primary sedimentation tank and the final settling tank to remove organic solids.*
- *Wastewater Treatment - Grit Chambers:*
  - *Grit particles typically range from 0.1 to 1 mm in size.*
  - *Stokes' Law is applicable for settling particles with a diameter less than 1 mm.*
  - *The loss of head in a grit chamber varies from 0.06 to 0.6 m.*
- *Sludge Index: The ratio of the volume of activated sludge typically varies from 150 to 300.*
- *Imhoff Tank: Gas vent area is generally provided as 20 to 25% of the plan area.*
- *High-Rate Trickling Filter: The depth of the tank may vary from 1.8 to 2.7 m.*

Zoology

- *Acarology: Study of Mites and Ticks.*
- *Cetology: Study of Whales and Dolphins.*
- *Geoponics: Study of Agriculture.*
- *Ichthyology: Study of Fish.*
- *Dr. Salim Ali: Renowned Ornithologist, known as 'Bird Man of India'.*
- *Ornithology: Scientific study of Birds.*
- *Entomology: Study of Insects.*
- *Mycology: Study of Fungi.*
- *Phycology: Study of Algae.*
- *Desmology: Study of Ligaments.*
- *Aristotle: Father of Biology.*
- *Theophrastus: Father of Botany.*
- *Hippocrates: Father of Medicine.*
- *Gregor Johann Mendel: Father of Genetics.*
- *Sericulture: Rearing of Silk worms for silk production.*
- *Silk: An animal product.*
- *Apiculture (Bee-keeping): Culture of Honey bees for honey production.*
- *Horticulture: Cultivation and maintenance of gardens.*
- *Aquaculture: Farming of aquatic organisms.*
- *Pisciculture: Rearing of Fish.*
- *Products obtained from insects: Silk, Honey, Lac.*
- *Pearl: Obtained from molluscs, not insects.*
- *Common Myna: A bird known to stalk alongside cattle for insects disturbed by their movement.*
- *Zoology: Study of animals, encompassing both living and dead organisms.*
- *National Research Centre on Pig: Located at Guwahati.*
- *Naphthalene balls: Used as an Insect repellent.*
- *Ethology: Science of animal behaviour.*
- *NEET: Entrance examination for MBBS (Bachelor of Medicine, Bachelor of Surgery) and BDS (Bachelor of Dental Surgery) courses.*

2. Evolution of Life

Evidences for Evolution: Paleontological, comparative anatomy, embryological, molecular, biogeographical.

- *Paleontological Evidence (Fossils): Study of preserved remains/traces of past life. Demonstrates gradual changes in life forms over geological time.*
- *Connecting Links (Transitional Fossils): Organisms showing features of two different groups, indicating evolutionary transitions.*
- *Archaeopteryx: A connecting link fossil between Reptiles (skeletal features, teeth, bony tail) and Aves (feathers, wishbone).*
- *Living Fossils: Organisms that have changed little over millions of years and resemble their fossil ancestors.*
- *Peripatus (velvet worm): A living fossil connecting Annelida and Arthropoda. Other examples include Limulus (King Crab) and Latimeria (Coelacanth).*
- *Comparative Anatomy & Morphology: Comparison of structural features among different organisms.*
- *Homologous Organs: Similar in structure and origin, but different in function. Indicate common ancestry (divergent evolution). E.g., forelimbs of mammals (human arm, whale flipper, bat wing).*
- *Analogous Organs: Different in structure and origin, but similar in function. Indicate convergent evolution. E.g., wings of insects and birds.*
- *Vestigial Organs: Reduced or non-functional organs in an organism, functional in ancestors. E.g., human appendix, wisdom teeth, pelvic girdle in whales.*
- *Embryological Evidence: Similarities in early embryonic development among different species suggest common ancestry. E.g., transient presence of gill slits and a tail in vertebrate embryos (fish, birds, mammals).*
- *Molecular Evidence: Similarities in DNA, RNA, and protein sequences (e.g., cytochrome c, hemoglobin) indicate evolutionary relatedness; more similar sequences imply closer common ancestry. The universal genetic code supports a common origin of life.*

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- *Biogeographical Evidence: Geographical distribution of species. Distribution patterns are influenced by evolution, speciation, and continental drift.*
- *Adaptive Radiation: Diversification of species from a common ancestor to fill different ecological niches, often observed in isolated geographical areas (e.g., Darwin's finches on the Galapagos Islands, Australian marsupials).*

Human Evolution: Primate ancestry, hominid lineage, key evolutionary changes (bipedalism, brain size, tool use).

- *Primate Ancestry:*
- *Primates evolved ~55-85 million years ago (MYA).*
- *Shared traits: Grasping hands/feet, stereoscopic vision, relatively large brains, slow life history.*
- *Hominid Lineage:*
- *Hominoids (apes) diverged from Old World monkeys ~25-30 MYA.*
- *Hominins (human lineage) diverged from chimpanzees ~6-7 MYA.*
- *Early Hominins (~7-4.4 MYA): Sahelanthropus, Orrorin, Ardipithecus – earliest evidence of bipedalism.*
- *Australopithecus (~4.2-2 MYA): Fully bipedal, small brain (400-500 cc), e.g., A. afarensis (Lucy).*
- *Paranthropus (~2.7-1.2 MYA): Robust australopiths, specialized chewing adaptations.*
- *Homo habilis (~2.8-1.5 MYA): "Handy man," first to use stone tools (Oldowan), brain size 600-750 cc.*
- *Homo erectus (~1.9 MYA - 143,000 years ago): First to leave Africa, controlled fire, Acheulean tools (hand axes), brain size 800-1200 cc.*
- *Homo neanderthalensis (~400,000-40,000 years ago): Europe/Asia, Mousterian tools, larger brain than modern humans (avg. 1200-1700 cc), complex culture.*
- *Homo sapiens (~300,000 years ago - present): Originated in Africa, complex culture, language, advanced tools, brain size 1300-1400 cc.*
- *Key Evolutionary Changes:*
- *Bipedalism:*
- *Defined hominins, evolved ~6-7 MYA.*
- *Advantages: Free hands for carrying/tool use, improved visibility, thermoregulation, efficient long-distance travel.*
- *Skeletal adaptations: Foramen magnum repositioning, S-shaped spine, bowl-shaped pelvis, angled femurs, arched feet.*
- *Brain Size:*
- *Gradual increase, significant growth in Homo genus.*
- *Australopithecus (400-500 cc) → H. habilis (600-750 cc) → H. erectus (800-1200 cc) → H. sapiens (1300-1400 cc).*
- *Associated with complex cognition, language development, and problem-solving.*
- *Tool Use:*
- *Earliest undisputed evidence: Homo habilis with Oldowan stone tools (simple choppers, flakes) ~2.8 MYA.*
- *H. erectus developed Acheulean tools (hand axes).*
- *H. neanderthalensis used Mousterian tools (prepared core technique).*
- *H. sapiens developed advanced Upper Paleolithic tools (blades, bone, antler), composite tools, and art.*
- *Impact: Enhanced hunting/scavenging, food processing, defense, and manipulation of environment, driving further cognitive evolution.*

Macroevolution: Major evolutionary trends, mass extinctions and their causes.

- *Macroevolution: Evolutionary change occurring at or above the species level; large-scale patterns over geological time.*
- *Major Evolutionary Trends:*
    - *Adaptive Radiation: Diversification of a single ancestral species into multiple species, each adapted to a different ecological niche (e.g., Darwin's finches).*
    - *Convergent Evolution: Unrelated species independently evolve similar traits due to similar environmental pressures (e.g., wings in birds and bats).*