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.

- 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.*

- *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).*

- *Divergent Evolution: Related species evolve different traits, leading to new species, often due to different environmental pressures (e.g., polar bear and grizzly bear).*
- *Coevolution: Two or more species reciprocally influence each other's evolution (e.g., predator-prey relationships, plant-pollinator interactions).*
- *Punctuated Equilibrium: Evolutionary change characterized by long periods of stasis (no change) interspersed with brief periods of rapid speciation.*

- *Mass Extinctions: Rapid, widespread decrease in Earth's biodiversity.*
  - *The "Big Five" Mass Extinctions:*
    1. *Late Ordovician: (Approx. 443 Ma) Global cooling, glaciation, sea-level fall.*
    2. *Late Devonian: (Approx. 372 Ma) Ocean anoxia, climate cooling, possibly bolide impacts.*
    3. *Permian-Triassic (P-T/Great Dying): (Approx. 252 Ma) Largest extinction event; linked to Siberian Traps volcanism, massive CO2 release, global warming, ocean anoxia, ocean acidification.*
    4. *Late Triassic: (Approx. 201 Ma) Volcanism (Central Atlantic Magmatic Province - CAMP), climate change.*
    5. *Cretaceous-Paleogene (K-Pg): (Approx. 66 Ma) Wiped out non-avian dinosaurs; linked to Chicxulub asteroid impact and Deccan Traps volcanism.*
  - *Causes of Mass Extinctions (General): Large Igneous Province (LIP) volcanism, asteroid impacts, drastic climate change (global warming/cooling), sea-level fluctuations, ocean anoxia, ocean acidification.*
  - *Sixth Mass Extinction (Anthropocene): Ongoing extinction event driven by human activities (habitat destruction, climate change, pollution, invasive species, overexploitation).*

- *Dodo and Ecological Interdependence: The extinction of the Dodo (Raphus cucullatus), a flightless bird endemic to Mauritius around 1662, is a classic example of the ecological impact of species loss. Its extinction severely hindered the germination of seeds from the Calvaria Tree (Sideroxylon grandiflorum or tambalacoque) because the seeds required passage through the Dodo's digestive tract for scarification (breaking dormancy) to germinate.*

Mechanisms of Evolution: Mutation, recombination, gene flow, genetic drift (founder effect, bottleneck effect).

- *Mutation: Sudden, heritable change in the DNA sequence (genetic material), serving as the primary source of new alleles and genetic variation.*
- *Mutation Theory of Evolution: Enunciated by Hugo de Vries, proposing that evolution occurs through large, sudden, and discontinuous changes called 'saltation' (single-step large mutation), which contrasts with Darwin's gradualism.*
- *Recombination: Reshuffling of existing genetic material through processes like crossing over and independent assortment during meiosis, creating new combinations of alleles.*
- *Gene Flow (Migration): Transfer of alleles between populations due to the movement of individuals or gametes, which tends to increase genetic similarity between populations and can introduce new alleles.*
- *Genetic Drift: Random fluctuations in allele frequencies from one generation to the next, particularly impactful in small populations; can lead to the loss or fixation of alleles, thus reducing genetic variation within populations.*
- *Founder Effect: A type of genetic drift where a new population is established by a small number of individuals (founders) from a larger population; the new gene pool may not be representative of the original population, often leading to reduced genetic diversity and unique allele frequencies.*

- *Bottleneck Effect: A type of genetic drift occurring when a population undergoes a drastic reduction in size due to a catastrophic event (e.g., natural disaster, disease); the surviving population's gene pool may have significantly altered allele frequencies and reduced genetic diversity compared to the original, larger population.*

Modern Synthetic Theory of Evolution (Neo-Darwinism): Genetic basis of variation, role of population genetics.

- *Modern Synthetic Theory of Evolution (Neo-Darwinism) integrates Darwinian natural selection with Mendelian genetics.*
- *It defines evolution as a change in allele frequencies within a population over generations.*
- *Genetic basis of variation: Primary sources are gene mutations, chromosomal aberrations, and genetic recombination (crossing over).*
- *Mutation: Random, heritable changes in DNA, providing raw material for evolution.*
- *Hugo de Vries: Proposed the Mutation Theory, suggesting that evolution occurs through sudden, large changes (saltation).*
- *Recombination: Shuffling of existing alleles during sexual reproduction (meiosis).*
- *Role of Population Genetics: Studies genetic variation within populations and how forces like natural selection, genetic drift, gene flow, and mutation change allele and genotype frequencies in a gene pool.*
- *Hardy-Weinberg principle describes genetic equilibrium in the absence of evolutionary forces.*
- *Charles Darwin: Proposed the Theory of Evolution primarily by Natural Selection.*
- *Beadle and Tatum: Proposed the "one gene one enzyme" hypothesis, linking genes to specific protein (enzyme) synthesis.*
- *Jacob and Monod: Proposed the Operon concept, explaining gene regulation in prokaryotes (e.g., Lac Operon).*

Natural Selection: Types (directional, stabilizing, disruptive), sexual selection, adaptive radiation.

- *Natural Selection: Differential survival and reproduction of individuals based on heritable phenotypic differences, leading to an increase in frequency of advantageous traits in a population over generations.*
- *Types of Natural Selection:*
  - *Directional Selection: Favors one extreme phenotype, shifting the population's trait average towards that extreme over generations.*
    - *Example: Industrial melanism in peppered moths, development of antibiotic/pesticide resistance, loss of limbs in snakes (natural selection favoring reduced or absent limbs for adaptation to burrowing life).*
  - *Stabilizing Selection: Favors intermediate phenotypes and acts against extreme variations, reducing phenotypic diversity around the mean.*
    - *Example: Human birth weight (intermediate weight babies have highest survival rates).*
  - *Disruptive Selection: Favors both extreme phenotypes over intermediate ones, potentially leading to a bimodal trait distribution and eventually speciation.*
    - *Example: Beak size in African finches (specialized for different seed types).*
- *Sexual Selection: A specific form of natural selection where individuals compete for mates, favoring traits that increase mating success, even if they may decrease survival.*
  - *Often results in sexual dimorphism (distinct phenotypic differences between sexes).*
  - *Intrasexual Selection: Competition within one sex for access to mates (e.g., male-male combat).*
  - *Intersexual Selection: Mate choice, typically by one sex (often females) choosing mates based on specific de-*

sirable traits (e.g., peacock's tail display).

- *Adaptive Radiation: Rapid evolutionary diversification of a single ancestral lineage into multiple new species, each adapted to occupy different ecological niches.*
    - *Typically occurs when a species colonizes a new environment with abundant unoccupied ecological opportunities.*
    - *Examples: Darwin's finches on the Galapagos Islands, Australian marsupials, Hawaiian honeycreepers.*

Origin of Life: Chemical evolution, abiogenesis, Oparin-Haldane hypothesis, Miller-Urey experiment.

- ***Abiogenesis:** The process by which life arose from non-living matter.*
- ***Chemical Evolution (Chemogeny):** Gradual process where simple inorganic molecules on early Earth underwent chemical reactions to form complex organic molecules.*
- ***Oparin-Haldane Hypothesis (1920s):***
    - *Life originated in a primitive Earth atmosphere that was reducing (lacked free O2) and contained methane (CH4), ammonia (NH3), water vapor (H2O), and hydrogen (H2).*
    - *Energy sources (UV radiation, lightning, volcanic activity) converted these inorganic molecules into simple organic ones (e.g., amino acids, sugars).*
    - *These organic molecules accumulated in the oceans, forming a "primordial soup" or "hot dilute soup."*
    - *Further reactions led to complex organic polymers (proteins, nucleic acids) and eventually self-replicating structures (coacervates/protobionts).*
- ***Miller-Urey Experiment (1953):***
    - *Simulated primitive Earth conditions to test the Oparin-Haldane hypothesis.*
    - ***Setup:** A closed apparatus with water (simulating oceans), methane, ammonia, hydrogen (simulating early atmosphere), and electrodes for electrical discharges (simulating lightning).*
    - ***Results:** After a week, various amino acids (e.g., glycine, alanine), sugars, and other simple organic compounds were formed.*
    - ***Conclusion:** Demonstrated that organic molecules, essential building blocks for life, could be synthesized abiotically under conditions believed to exist on early Earth.*
- ***Microlightning:** A phenomenon referring to tiny sparks that occur within water droplets, proposed by some recent studies as a potential energy source for the abiotic synthesis of organic molecules leading to the origin of life.*

Speciation: Modes of speciation (allopatric, sympatric), reproductive isolation mechanisms.

- *Speciation: Evolutionary process leading to the formation of new and distinct species from ancestral ones.*
- *Species Definition: A group of populations whose members can interbreed in nature and produce viable, fertile offspring.*
- *Reproductive Isolation: The existence of biological factors (barriers) that prevent members of two species from interbreeding and producing viable, fertile offspring. This is central to the origin of new species.*
- *Modes of Speciation:*
    - *Allopatric Speciation:*
        - *Occurs when populations are geographically separated by a physical barrier (e.g., mountain range, river, ocean).*
        - *Gene flow is interrupted, allowing separate populations to diverge independently due to mutation, natural selection, and genetic drift.*
        - *Reproductive isolation evolves as a byproduct of this divergence.*
    - *Sympatric Speciation:*
        - *Occurs in populations that live in the same geographic area; no physical barrier to gene flow.*

- *Mechanisms leading to reproductive isolation within the same range:*
  - *Polyploidy: Presence of extra sets of chromosomes, especially common in plants, leading to immediate reproductive isolation.*
  - *Habitat Differentiation: Subpopulation exploits a new niche or resource (e.g., feeding on different host plants).*
  - *Sexual Selection: Non-random mate choice based on specific traits can lead to reproductive barriers.*

- *Reproductive Isolation Mechanisms (Barriers to Gene Flow):*
  - *Pre-zygotic Barriers (prevent mating or fertilization from occurring):*
    - *Habitat Isolation: Species live in different habitats within the same geographic area.*
    - *Temporal Isolation: Species breed during different times (seasons, day/night).*
    - *Behavioral Isolation: Unique courtship rituals or signals prevent interspecies mating.*
    - *Mechanical Isolation: Morphological differences prevent successful completion of mating.*
    - *Gametic Isolation: Sperm of one species cannot fertilize eggs of another (e.g., incompatible receptors on gamete surfaces).*
  - *Post-zygotic Barriers (prevent hybrid zygote from developing into a viable, fertile adult):*
    - *Reduced Hybrid Viability: Hybrid offspring fail to develop or survive to adulthood.*
    - *Reduced Hybrid Fertility: Hybrid offspring are sterile (e.g., mules from horse and donkey).*
    - *Hybrid Breakdown: First-generation hybrids are viable and fertile, but subsequent generations become feeble or sterile.*

Theories of Evolution: Lamarckism and Darwinism, their postulates and criticisms.

- *Theories of Evolution: Attempt to explain the mechanism of how life forms change over generations.*
- *Lamarckism (Theory of Inheritance of Acquired Characters):*
  - *Propounded by Jean-Baptiste Lamarck in 1809 ("Philosophie Zoologique").*
  - *Postulates:*
    1. *Internal Vital Force: Organisms constantly tend to increase in size.*
    2. *Environmental Influence & New Needs: Changes in environment create new needs, leading to changes in habits/behavior.*
    3. *Use and Disuse of Organs: Organs used more frequently develop better; disused organs degenerate or disappear (e.g., giraffe's long neck, loss of limbs in snakes).*
    4. *Inheritance of Acquired Characters: Characters acquired during an individual's lifetime (due to use/disuse or environmental influence) are passed on to offspring.*
  - *Criticisms:*
    - *Lack of scientific evidence for the inheritance of acquired characters.*
    - *August Weismann's germplasm theory disproved it: somatic changes are not inheritable (e.g., cutting mice tails for generations did not result in tailless offspring).*
- *Darwinism (Theory of Natural Selection):*
  - *Propounded by Charles Darwin in 1859 ("On the Origin of Species by Means of Natural Selection").*

- Alfred Russel Wallace independently proposed similar ideas (co-discoverer).
- Influences on Darwin & Wallace:
  - Thomas Robert Malthus's "An Essay on the Principle of Population" (1798): Highlighted the struggle for existence due to population growth outstripping resources.
  - Charles Lyell's geological studies (uniformitarianism).
  - Artificial selection in domestic animals.
- Postulates (Key points of Natural Selection):
  1. Overproduction (Prodigality of Production): Organisms produce more offspring than can survive.
  2. Struggle for Existence: Competition among individuals for limited resources, space, and mates.
  3. Variation and Heredity: Individuals within a population exhibit variations, some of which are heritable.
  4. Survival of the Fittest (Natural Selection): Individuals with favorable heritable variations (adaptations) are better suited to their environment, survive longer, and reproduce more successfully. Nature "selects" these advantageous traits.
  5. Origin of New Species: Accumulation of favorable variations over long periods, leading to divergence and the formation of new species.
- Criticisms:
  - Did not explain the origin or mechanism of variations.
  - Did not explain how variations are inherited (Mendel's work on genetics was unknown to Darwin).
  - Overemphasized small, continuous variations, neglecting sudden, large changes (mutations).
  - Did not distinguish between somatic and germinal variations.
- Modern Synthesis (Neo-Darwinism): Integrates Darwinian natural selection with Mendelian genetics, mutation theory, genetic drift, and gene flow to provide a more complete understanding of evolution.

- Hugo de Vries: Associated with the Mutation Theory, which posits that evolution occurs through sudden, large, discontinuous heritable changes (mutations), providing the raw material for natural selection.

3. Taxonomy

Chemotaxonomy and Cytotaxonomy

- Chemotaxonomy: Classification based on chemical constituents (e.g., proteins, nucleic acids, amino acids, pigments, secondary metabolites).
- Chemoautotrophs: Organisms that synthesize organic compounds using energy derived from the oxidation of inorganic chemical compounds (electron donors), not light.
- Chemoautotrophic energy source: Oxidation of inorganic electron donors such as hydrogen sulfide (H_2S), ammonia (NH_3), nitrites (NO_2^-), ferrous iron (Fe^{2+}), or hydrogen gas (H_2).
- Carbon source for chemoautotrophs: Typically CO_2 (autotrophic).
- Habitat for chemosynthetic bacteria: Common near deep-sea hydrothermal vents, where they oxidize H_2S.
- Sulfolobus acidocaldarius: A thermoacidophilic archaeon that thrives in hot, acidic environments.
- Litmus: A pH indicator dye obtained from lichens (e.g., Roccella, Dendrographa species).
- Cytotaxonomy: Classification based on cytological characters, primarily chromosome