Chapter-2

Paths of Evolution

Case Study: Antibiotic Resistance in Bacteria

The 1966 Observation: A young man diagnosed with tuberculosis (TB) was initially treated with several antibiotics and a specific antibiotic for 33 weeks. Ten months later, he was confirmed cured. However, two months after treatment, the disease relapsed, and he died within 10 days due to breathing difficulty.

•Scientific Finding: DNA comparison revealed that a mutation in a specific gene made the bacteria resistant to antibiotics. These mutated bacteria multiplied even in the presence of the medicine.

Analysis and Findings:

- Initial Treatment: Several antibiotics for 6 weeks and a specific antibiotic for 33 weeks.
- Why treatment failed the second time: The bacteria acquired resistance through genetic mutation.
- Impact of Transmission: If these bacteria transmit this ability to next generations, it leads to the formation of multi-drug resistant strains.

Antimicrobial Resistance and Superbugs

Superbugs are bacteria that are resistant to multiple antibiotics. This resistance, caused by mutations, can be transmitted to subsequent generations. Over time, the proportion of resistant bacteria increases, making common antibiotics ineffective.

Lamarckism (Theory of Inheritance of Acquired Characters)

Proposed by Jean Baptiste Lamarck

Key Indicators:

- Change in environment.
- Formation of acquired characters (Use and Disuse of organs).
- Inheritance of acquired characters.

• Survival of organisms with changed characters.

The Example of the Giraffe

1. Giraffes with short necks fed on ground-level grass.

2. As food became scarce, they stretched their necks to reach higher branches.

3. The neck elongated over time (acquired character).

4. These characters were transmitted through generations, leading to modern long-necked giraffes.

Charles Robert Darwin (1809 – 1882)

•The English naturalist Charles Darwin's 'Theory of Natural Selection' or Darwinism marked the foundation for the perspectives of modern evolution.

•The HMS Beagle: In 1831, at age 22, he embarked on a five-year voyage for cartographical purposes. He explored areas including South America, Australia, and the Galapagos Islands.

Key Influences:

• Thomas Malthus: Argued that food production cannot keep pace with population growth.

• Alfred Russell Wallace: His papers on evolution prompted Darwin to publish his findings in the book "On the Origin of Species" (1859).

Darwin's Theory of Natural Selection

Darwin explained the evolution of new species through the following five points:

- .Over production: Organisms produce more offspring's than environment can support.
- Variations: Organisms show differences in features (size, immunity, etc.). Variations can be favourable or harmful.

- Struggle for existence: Limitation of food, shelter, and mates leads to competition.
- Survival of the fittest: Organisms with favourable variations survive, reproduce, and create new generations.
- Natural selection: Favourable variations are passed on. Accumulated variations over time lead to the creation of new species.

Galapagos Finches

Darwin observed 14 species of finches. Their major difference was the shape and size of the beak, which adapted based on food availability:

• Seed-eating finches: Ground dwellers with beaks suited for seeds.

• Cactus-eaters: Beaks adapted to inhabit and eat cactus.

• Insect-eaters: Tree finches with insectivorous beaks.

Feature	Lamarckism	Darwinism
Initial State	Giraffes of earlier periods possessed short necks.	Giraffes with necks of varying length existed.
Process	Giraffes began to stretch their neck to obtain food.	Only the giraffes with longer necks survived the competition.
Result	By continuous use, giraffes with longer necks emerged.	Only the giraffes with longer necks survived and became new species.
Inference	Environment causes variations in organisms.	Environment selects the favourable variations in organisms.

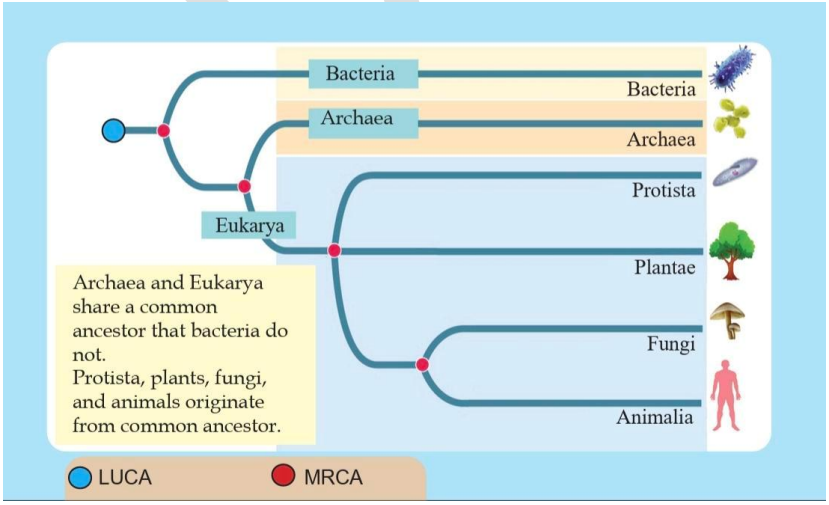
Comparison of Lamarckism and Darwinism

Neo Darwinism

- Darwin's theory was criticized because he had no idea about the genetic basis of variations and inheritance. With discoveries in genetics, Neo Darwinism was form.
- • Darwinism became uncritically rationalised as more evidences and further studies from the fields of population genetics, palaeontology, environmental science, etc. were added to Darwinism to form Neo Darwinism

Speciation and Evolutionary Tree

- Speciation is the process in which new species arise from a common ancestor.
- Key Concepts:
- LUCA: Last Universal Common Ancestor (the ancestor from which all species descended).
- MRCA: Most Recent Common Ancestor.
- Process of Speciation:
    1. Members of a population produce offspring with differences but remain one species.
    2. Isolation (ecological or other factors) leads to accumulation of variations over time.
    3. Members become unable to reproduce mutually, evolving into different species.



Evidences of Evolution

1.Molecular Biology

Evolutionary relationships can be found by comparing nucleotide sequences in DNA and amino acid sequences in proteins (e.g., Haemoglobin beta chain).

• Chimpanzee: 0 amino acid difference from humans.

• Gorilla: 1 amino acid difference from humans.

• Rat: 31 amino acid differences from humans.

2.Comparative Anatomy

Similarities in internal structures (forelimbs of humans, cats, flippers of whales, wings of bats) validate evolution, though they differ in function and external structure.

3.Fossil Evidences

Fossils are remains or traces of ancient organisms.

• Organic evolution is gradual (e.g.The ancestors of horses had shorter legs Than the ones in Out times.).

• Connecting links (e.g., Archaeopteryx possesses features of both reptiles and birds).

• Evidence of extinct species (e.g., Dinosaurs, Mammoths).

Human Evolution

Humans belong to the group of Primates. Common characteristics include binocular vision and a thumb that can be opposed to other fingers.

Human Evolutionary Tree

Anthropoidea Categories:

• Cercopithecoidea: Small sized brain, having tail (Monkeys).

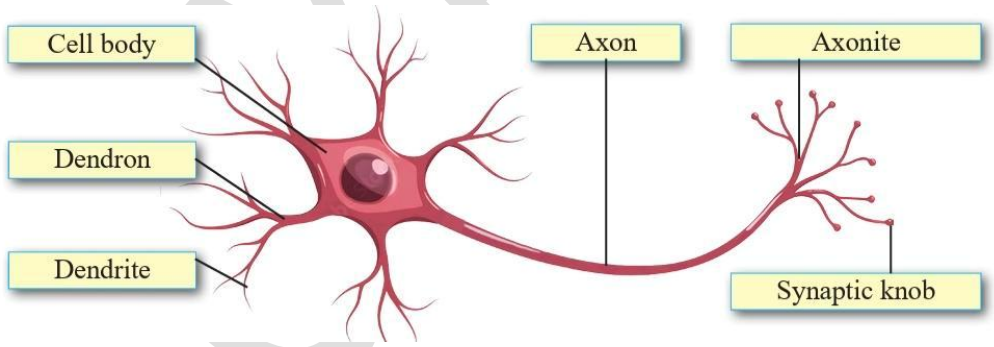
• Hominoidea: Big sized brain, without tail (Gibbon, Orangutan, Gorilla, Chimpanzee, Human).

Stages in Human Evolution

Species	Cranial Capacity	Key Characteristics
Sahelanthropus tchadensis	350 cm^3	First link in human evolutionary series; fossils from Chad, Africa.
Australopithecus	450 cm^3	Bipedalism confirmed; fossils from Africa.
Homo habilis	600 cm^3	Made tools with stones; lived in small groups; began hunting.
Homo erectus	900 cm^3	Walked upright on two legs; used stone weapons; omnivores.
Homo neanderthalensis	1450 cm^3	Sloping forehead; thick eye brows; buried dead bodies.
Homo sapiens	1350 cm^3	Modern man; acquired technology, agriculture,

The Human Nervous System

Consists of the brain, spinal cord, nerves, and receptors.



Structure of Neuron

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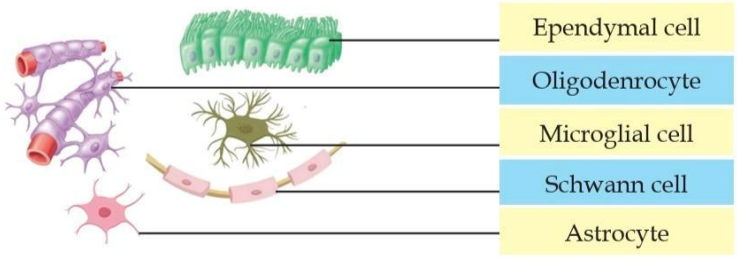
- Cell body (Cyton): Centre of the neuron. Contains cytoplasm, nucleus, and cell organelles.
- Dendron: Short fibers arising from the cell body.
- Dendrite: Branches of Dendrons. Receive messages from adjacent neurons.
- Axon: Longest fiber from the cell body. Carries impulses to the axonites.
- Axonite: Branches of the Axon.

- Synaptic knob: Tip of the axonite. Contains neurotransmitters (e.g., Acetylcholine) to transfer chemical messages.

Neuroglial Cells&Myelin Sheath

•Neuroglial cells: More than half of the nervous system.

• Do not transmit impulses.

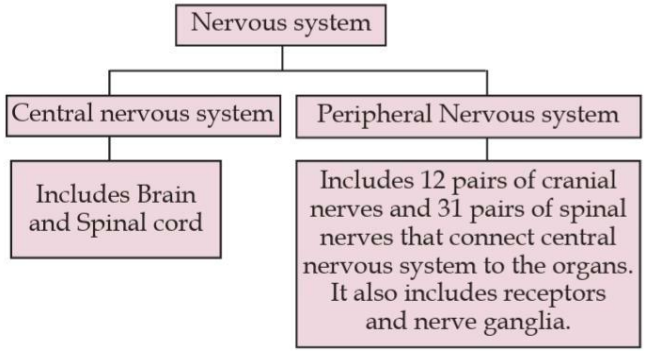


•Functions: Bring nutrition, eliminate wastes, act as defence cells

•Myelin Sheath: Shiny white fat layer covering the axon. Made of Schwann cells (in nerves) or Oligodendrocytes (in CNS).

Functions of Myelin Sheath:

- Increases speed of transmission.
- Acts as an insulator.
- Provides nourishment and protection to the axon.



Brain

Parts of the Brain and Their Features

- Cerebrum: The largest part of the brain. The outer part where the grey matter is seen is called the cortex and the inner part where white matter is seen is called medulla. Plays an important role in problem solving, planning and voluntary movements. Centre of memory, intelligence, thinking and imagination. Provides various sensory experiences.
- Cerebellum: The second largest part of the brain. Seen behind and below the Cerebrum. Helps to maintain equilibrium of the body by coordinating muscular activities.
- Thalamus: Seen in the inner part of the brain. Acts as the relay station of messages to and from the cerebrum. Pain killers act on this part of the brain.
- Hypothalamus: Helps in maintaining homeostasis by regulating body temperature, hunger, thirst and emotions.

2. The Brain Stem

The brain stem consists of the Mid brain, Pons, and Medulla oblongata.

- ▪ Mid brain: Initial assessment of messages regarding vision and hearing. This part has a role in the movement of eyes and eye brows.
- ▪ Pons: Coordinates the muscular activities of the eye and the face. Regulates the rate of ventilation.
- ▪ Medulla oblongata: Controls involuntary activities like heartbeat, ventilation, vomiting, cough, sneezing etc.

Protection of Nervous System

1.Meninges: Three-layered protective membrane covering brain and spinal cord.

2.Cerebrospinal Fluid (CSF): Fluid filled in meningeal layers and central canal.

Functions:

• Provides oxygen/nutrients,

•eliminates wastes,

•regulates pressure,

•protects from injuries.

Spinal Cord

Continuation of Medulla Oblongata. Protected by the vertebral column.

- Dorsal root: Transmits messages from body parts to the spinal cord (Sensory).
- Ventral root: Transmits instructions from spinal cord to body parts (Motor).
- Central canal: Middle part filled with CSF.

Transmission of Impulses

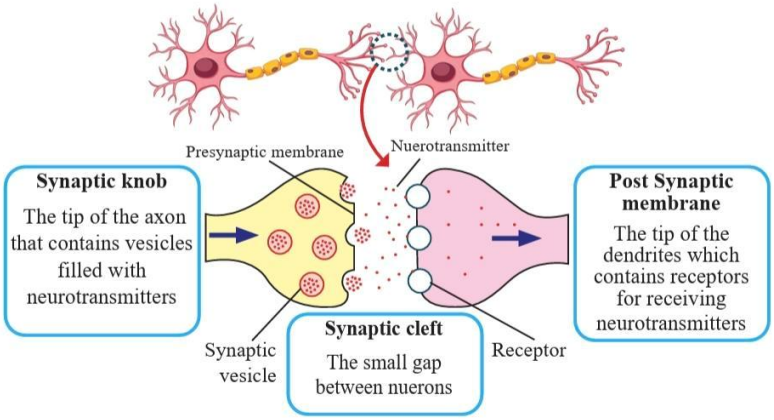
Impulses are messages transmitted through neurons. All cells, including neurons, have an electric charge.

Process:

- The inner side of the cell membrane has a negative charge, and the outer side has a positive charge when not stimulated.
- When stimulated, positive ions from outside enter the cell, causing a temporary charge variation (depolarization).
- This charge variation stimulates the adjacent part, and the impulse travels as a wave of electric charges.

Synaps

A synapse is the junction where an impulse is transferred from one neuron to another, or to a muscle/gland cell.



Parts of Synapse:

- Synaptic knob: Tip of the axon containing vesicles with neurotransmitters.
- Synaptic cleft: The small gap between neurons.
- Post-synaptic membrane: The tip of the dendrite/muscle cell with receptors for neurotransmitters.

Significance: Synapses ensure impulses travel in only one direction and help regulate the speed of transmission.

Neocortex

•The cerebral cortex of mammals is modified into a complex six-layered structure called the neocortex. It is highly developed in humans (approx. 16 billion neurons).

•Functions: Advanced mental processes such as thinking, decision-making, learning, and recalling.

Types of Nerves:

Nerve	Building Block	Function
Sensory nerve	Sensory neuron	Transmits impulses from sense organs to CNS.
Motor nerve	Motor neuron	Transmits instructions from CNS to muscles/glands.
Mixed nerve	Sensory and motor neurons	Transmits impulses to and from the CNS.

5. Autonomous Nervous System

The ANS regulates body activities independently of conscious control. It consists of the Sympathetic and Parasympathetic systems.

Organ/Part	Sympathetic System	Parasympathetic System
Pupil	Dilates	Constricts
Salivary gland	Decreases production	Increases production
Heartbeat	Increases	Decreases
Bronchiole	Expands	Constricts
Stomach/Intestine	Slows down digestion/peristalsis	Stimulates digestion/peristalsis
Adrenal gland	Increases hormone production	No direct influence
Urinary bladder	Retains urine	Empties

Reflex Action

•Reflex actions are spontaneous and involuntary responses to stimuli. They can be spinal reflexes (controlled by spinal cord) or cerebral reflexes (controlled by brain).

•Reflex Arc: The pathway of impulses in a reflex action.

Parts of a Reflex Arc:

1. Receptor: Detects stimulus.

2. Sensory neuron: Carries impulse to spinal cord.

3. Inter neuron: Processes impulse and triggers motor neuron.

4. Motor neuron: Carries instruction to muscle.

5. Effector (Muscle): Performs the response.

Healthcare and Protection of the Nervous System

- Safety measures: Use a helmet while riding a motor bike and a seat belt while driving. Take necessary precautions while playing.
- Workplace safety: Those engaged in jobs with the risk of brain injuries must use safety equipments such as helmets.
- Infection control: Avoid taking bath in stagnant water as it may cause infections.
- Healthy habits: Avoid smoking, alcohol consumption, and drug abuse. Engage in regular exercises.
- Adequate sleep: It is essential to sleep for at least 8-10 hours a day. Lack of sleep can affect brain function, leading to memory loss, anxiety, difficulty in learning, and hindered emotional development.

Organism	Nervous System Peculiarities
Hydra	A neural network with no control center is seen.
Planaria	A pair of nerve ganglia in the head region coordinates the instructions.
Insects	Neurons in the head region unite to evolve into a clear and somewhat developed brain. Ganglia of paired nerve fibers emerging from this are seen in each segment.