

KNOW MORE • THINK WIDER • STAY AHEAD

A COMPLETE
COMPENDIUM OF
FACTS, EVENTS &
ESSENTIAL
KNOWLEDGE

GATEWAY OF GENERAL KNOWLEDGE

Your Gateway to a World of Knowledge



VOLUME-I

Dr. Abitha Vivekanandan



WIDE RANGE
OF TOPICS



ACCURATE &
UPDATED



FOR STUDENTS
& COMPETITIVE
EXAMS



ENHANCE
AWARENESS
& CONFIDENCE

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GENERAL SCIENCE

Nature of Universe:

Concept	Key Exam Points
The Big Bang	The universe began from a single point of high density and temperature ~13.8 billion years ago.
Galaxies	Our galaxy is the Milky Way (Akash Ganga) , a spiral galaxy. Andromeda is our nearest neighbor.
Stars	The Sun is the closest star. Stars are classified by color/temperature: Blue (Hottest), White (Medium), Red (Coolest).
Asteroids	Found mainly in the Asteroid Belt between the orbits of Mars and Jupiter .
Dwarf Planets	Ceres is the only dwarf planet located in the asteroid belt. Pluto, Eris, Haumea, and Makemake are others.

- **Light Year:** The distance light travels in one year (approx 9.46×10^{12} km).
- **Astronomical Unit (AU):** The average distance between the Earth and the Sun (approx 150 million km).
- **Constellations:** There are **88** officially recognized constellations (e.g., Ursa Major/Saptarishi).
- **Sun's Composition:** Primarily **Hydrogen** (approx 71%) and **Helium** (approx 27%).

Measurement of Physical Quantities

Physical Quantities

A physical quantity is any property of a material or system that can be quantified by measurement.

Types of Physical Quantities

- **Fundamental Quantities:** Quantities that cannot be expressed in terms of any other quantities (e.g., Mass, Length, Time).
- **Derived Quantities:** Quantities obtained by multiplying or dividing fundamental quantities (e.g., Area, Volume, Velocity, Force).

SI Units (The International System of Units)

The SI system is the standard used globally. There are **7 Base Units** you must memorize:

Physical Quantity	SI Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electric Current	ampere	A
Luminous Intensity	candela	Cd
Amount of Substance	mole	Mol

Note: There are two supplementary units: **Radian** (for plane angles) and **Steradian** (for solid angles).

Important Derived Units

- **Force:** Newton (N) or kg m/s^2
- **Pressure:** Pascal (Pa) or N/m^2
- **Energy/Work:** Joule (J) or N. m
- **Power:** Watt (W) or J/s
- **Frequency:** Hertz (Hz)
- **Electric Charge:** Coulomb (C)

Astronomical Units (Large Distances)

For measuring distances in space, standard units like meters are too small.

- **Astronomical Unit (AU):** The mean distance between the Earth and the Sun.
 - 1 AU approx 1.496 times 10^{11} m.
- **Light Year:** The distance traveled by light in a vacuum in one year.
 - 1 light year approx 9.46 times 10^{15} m.
- **Parsec (Parallactic Second):** Used to measure distances outside the solar system.
 - 1 parsec approx 3.26 light years.

Measuring Instruments

Expect questions on the purpose of specific tools:

- **Vernier Caliper:** Measures the diameter of small spherical objects or the internal/external diameter of tubes (Accuracy: 0.1 mm).
- **Screw Gauge:** Measures the diameter of thin wires or thickness of metal sheets (Accuracy: 0.01 mm).
- **Common Balance:** Measures mass by comparing it with a standard mass.
- **Spring Balance:** Measures the **weight** of an object (based on Earth's gravity).

Mass vs. Weight

Feature	Mass	Weight
Definition	Quantity of matter contained in a body.	The gravitational force acting on a body.
Formula	M	$W = m \times g$
SI Unit	Kilogram (kg)	Newton (N)
Nature	Scalar (constant everywhere).	Vector (varies by location/ gravity).

Rules for Writing SI Units

1. Units named after scientists are **not** capitalized when written in full (e.g., newton, watt).

2. Symbols for units named after scientists **are** capitalized (e.g., N, W).
3. Symbols for other units are written in lowercase (e.g., m, kg).
4. No full stops or punctuation marks should be used at the end of symbols.
5. Units should never be written in plural form (e.g., 10 kg, not 10 kgs).

Laws of Motion and Force

Force is any influence that causes an object to undergo a certain change, either concerning its movement, direction, or geometrical construction.

Newton's Laws of Motion

- **First Law (Law of Inertia):** An object remains in a state of rest or uniform motion unless acted upon by an external force.
 - *Example:* Passengers leaning forward when a bus stops suddenly.
- **Second Law (Law of Force):** The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of the force.

$$F = ma$$

(Where F is Force, m is mass, and a is acceleration).

- **Third Law:** For every action, there is an equal and opposite reaction.
 - *Example:* Recoil of a gun or the flight of a rocket.

Important units

S.I. Unit of Force: Newton (N).

C.G.S. Unit: Dyne ($1 \text{ N} = 10^5 \text{ dynes}$)

Pressure

Pressure is defined as the physical force exerted on an object per unit area.

Formula and Principles

- **Formula:** $P = F/A$ (Pressure = Force/Area).
- **S.I. Unit:** Pascal (Pa) or N/m^2 .

- **Pascal's Law:** Pressure applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and to the walls of the containing vessel.
 - *Applications:* Hydraulic brakes, hydraulic lifts.
- **Atmospheric Pressure:** Measured using a **Barometer** (invented by Torricelli). A sudden fall in barometric height indicates an approaching storm.

Energy

Energy is the capacity to do work. It is a scalar quantity.

Forms of Mechanical Energy

1. Kinetic Energy (K.E.): Energy possessed by a body by virtue of its motion.

$$\text{K.E.} = \frac{1}{2} mv^2$$

2. Potential Energy (P.E.): Energy possessed by a body by virtue of its position or configuration.

$$\text{P.E.} = mgh$$

(Where g is acceleration due to gravity, approx. 9.8 m/s^2).

Law of Conservation of Energy

Energy can neither be created nor destroyed; it can only be transformed from one form to another. The total energy of an isolated system remains constant.

Work and Power

- **Work:** Done when a force produces motion ($W = F \times d$). Unit: Joule (J).
- **Power:** The rate of doing work ($P = W/t$). Unit: Watt (W).
- **Horsepower (hp):** $1 \text{ hp} = 746 \text{ Watts}$

Quantity	S.I Unit	Formula
Force	Newton (N)	$F = m \times a$
Pressure	Pascal (Pa)	$P = F/A$
Power	Watt	$P = W/t$

Energy	Joule	K.E + P.E
Work	Joule	$W = F \times S$

Everyday Application of Basic Principles In:

I. Mechanics

Mechanics deals with motion, force, and energy. It is the foundation of physical labor and transport.

- **Friction:** Essential for walking without slipping and for car brakes to stop a vehicle.
- **Inertia (Newton's First Law):** Why you jerk forward when a bus suddenly stops.
- **Centripetal Force:** Allows a cyclist to bend inward while taking a sharp turn.
- **Simple Machines:** Using a bottle opener (lever) or a pulley to draw water from a well.

II. Electricity and Magnetism

These two are deeply intertwined (Electromagnetism) and form the backbone of modern infrastructure.

- **Heating Effect (Joule's Law):** Used in electric irons, toasters, and water heaters.
- **Magnetic Effect:** Used in calling bells and electric motors (fans, washing machines).
- **Electromagnetic Induction:** The principle behind **transformers** that step down voltage for home use and **generators** that produce power.
- **Magnetic Levitation:** Used in high-speed Maglev trains.

III. Light (Optics)

Light allows us to perceive the world through reflection, refraction, and dispersion.

- **Total Internal Reflection:** The technology behind **Optical Fibers** providing high-speed internet.

- **Refraction:** Why a lemon looks larger in a glass of water or why stars twinkle.
- **Scattering:** Why the sky appears blue (Rayleigh scattering) and the sun looks red during sunrise/sunset.
- **Lenses:** Correcting vision (Convex for long-sightedness, Concave for short-sightedness).

IV. Sound (Acoustics)

Sound is a longitudinal wave that requires a medium to travel.

- **Reflection of Sound:** Used in **SONAR** (to map the ocean floor) and **Stethoscopes** (multiple reflections of a heartbeat).
- **Doppler Effect:** The change in pitch of an ambulance siren as it moves toward or away from you.
- **Ultrasonics:** Used in sonography (ultrasound scans) and for cleaning delicate jewelry.

V. Heat (Thermodynamics)

Heat is the transfer of energy due to temperature differences.

- **Thermal Expansion:** Why gaps are left between railway tracks (to prevent buckling in summer).
- **Convection:** The mechanism behind land and sea breezes, and how a room is cooled by an air conditioner.
- **Evaporation:** Why you feel cool when sweat evaporates from your skin (cooling effect).
- **Radiation:** How we receive heat from the sun through the vacuum of space.

VI. Nuclear Physics

While it sounds complex, nuclear physics has vital “peaceful” applications.

- **Nuclear Power:** Fission reactions in power plants (like Kudankulam or Kalpakkam in Tamil Nadu) generate massive amounts of electricity.
- **Radioisotopes:**
 - **Cobalt-60** is used in cancer radiotherapy.
 - **Iodine-131** is used to treat thyroid disorders.

- **Carbon-14** is used in “Carbon Dating” to find the age of ancient artifacts (crucial for history/archaeology).
- **Smoke Detectors:** Often use Americium-241 (an alpha emitter) to detect smoke particles.

Field	Key Principle	Common Device
Mechanics	Pascal’s Law	Hydraulic Brakes
Electricity	Joule’s Heating	Electric Fuse
Magnetism	Induction	Induction Stove
Light	Total Internal Reflection	Endoscope
Sound	Echo/Reflection	SONAR
Heat	Expansion	Bimetallic Strip (Thermostat)
Nuclear	Fission	Nuclear Reactor

Elements and Compounds

Elements are pure substances made of one type of atom (e.g., O, Fe), while compounds are formed by chemically combining two or more elements in a fixed ratio (e.g., (H₂O), (NaCl). Total elements identified are 118.

Elements:

- Substances made of the same type of atoms.
- Divided into metals, non-metals, and metalloids.
- Arranged in the Periodic Table based on atomic number.
- Smallest particle: Atom.

Classification of Elements:

- **Metals:** Lustrous, malleable, ductile, and good conductors (e.g., Copper, Gold, Iron).
- **Non-metals:** Dull, brittle, and poor conductors (e.g., Oxygen, Nitrogen, Sulfur).

- **Metalloids:** Exhibit properties of both metals and non-metals (e.g., Boron, Silicon, Germanium).
- **Total Elements:** There are currently **118** known elements. 92 occur naturally, while the rest are man-made.
- **Symbolism:** Jacob Berzelius devised the modern system of using letters for symbols (e.g., *Au* for Gold, *Ag* for Silver).

Compounds:

- A compound is a pure substance formed when two or more elements combine **chemically** in a **fixed proportion by mass**.
- Properties differ from their constituent elements (e.g., hydrogen and oxygen are gases, but water is liquid).
- Smallest particle: Molecule.
- Examples: Water (H_2O), Common Salt ($NaCl$), Sugar ($C_{12}H_{22}O_{11}$), Sand (SiO_2).
- The properties of a compound are entirely different from its constituent elements (e.g., Hydrogen is flammable and Oxygen supports combustion, but their compound, H_2O , extinguishes fire).
- Can only be separated into elements by chemical or electrochemical reactions.

Classification:

- **Inorganic Compounds:** Obtained from non-living sources like rocks and minerals (e.g., Chalk, Baking Soda).
- **Organic Compounds:** Obtained from living sources like plants and animals (e.g., Protein, Carbohydrates).

Comparison: Elements vs. Compounds

Feature	Element	Compound
Composition	Made of only one kind of atom.	Made of more than one kind of atom.
Representation	Represented by a Symbol (e.g., Na).	Represented by a Formula (e.g., NaCl).

Feature	Element	Compound
Separation	Cannot be broken down further.	Can be broken down by chemical means.
Properties	Has unique physical/chemical traits.	Properties differ from constituent elements.

• Common Names and Formulas:

- **Quick Lime:** Calcium Oxide (CaO)
- **Slaked Lime:** Calcium Hydroxide (Ca(OH)₂)
- **Baking Soda:** Sodium Bicarbonate (NaHCO₃)
- **Washing Soda:** Sodium Carbonate (Na₂CO₃)
- **Bleaching Powder:** Calcium Oxychloride (CaOCl₂)
- **Vitriol of Mars (Green Vitriol):** Ferrous Sulphate (FeSO₄ . 7H₂O)

Note on Mixtures: Unlike compounds, **mixtures** (like air or sea water) are physically combined in any proportion and retain the properties of their components.

Abundance of Elements

- **In the Universe:** Hydrogen is the most abundant, followed by Helium.
- **In the Earth's Crust:** Oxygen is the most abundant, followed by Silicon and Aluminum.
- **In the Human Body:** Oxygen (~65%), Carbon (~18%), and Hydrogen (~10%).

Fundamental Concepts & Definitions:

- **Atom:** Smallest unit of an element that retains its properties.
- **Molecule:** Two or more atoms chemically bonded.
- **Valency:** Combining power of an element, based on hydrogen atoms.
- **Mixture:** Contains two or more substances that are *not* chemically combined (e.g., air, sea water).

Most abundant element in Earth's Crust: Oxygen (46.6%)

Formula of Rust : Fe₂O₃ . xH₂O (hydrated iron oxide)

Gas used in Photosynthesis : Carbon dioxide (CO₂)

Sublimation example : Iodine, Camphor, Ammonium Chloride

Ratio of H:O in water by mass: 1:8

- Compounds have fixed melting and boiling points; mixtures do not
- Compounds can be decomposed into elements only by chemical and electrochemical methods.

Acids

The word “acid” comes from the Latin word *acidus*, meaning **sour**.

- **Definition:** According to Svante Arrhenius, an acid is a substance that releases hydrogen ions (H^+) or hydronium ions (H_3O) when dissolved in water.
- **Properties:**
 - Sour taste.
 - Turns **blue litmus paper red**.
 - Corrosive in nature (strong acids).
 - React with metals to produce **Hydrogen gas** (H_2).

Classification of Acids

Basis	Types	Examples
Source	Organic (Plants/Animals)	Citric acid, Tartaric acid
	Inorganic (Minerals)	HCl, H_2SO_4 , HNO_3
Basicity	Monobasic	HCl (replaces 1 H^+)
	Dibasic	H_2SO_4 (replaces 2 H^+)
Ionization	Strong Acids	H_2SO_4 (ionizes completely)
	Weak Acids	CH_3COOH (ionizes partially)

Bases

Bases are chemical substances that are bitter in taste and soapy to touch.

- **Definition:** Substances that release hydroxide ions (OH^-) in water.
- **Alkalis:** Bases that are soluble in water are called Alkalis (e.g., NaOH , KOH). **Note:** All alkalis are bases, but not all bases are alkalis.
- **Properties:**
 - Bitter taste.
 - Turns **red litmus paper blue**.
 - React with acids to form salt and water (Neutralization).

Common Bases and Their Uses

- **Magnesium Hydroxide ($\text{Mg}(\text{OH})_2$):** Used as an antacid (Milk of Magnesia) to treat acidity.
- **Sodium Hydroxide (NaOH):** Used in making soaps.
- **Calcium Hydroxide ($\text{Ca}(\text{OH})_2$):** Used in whitewashing buildings.

The pH Scale

Developed by **S.P.L. Sorensen**, the pH scale measures the acidity or alkalinity of a solution.

- **Range:** 0 to 14.
- **pH < 7:** Acidic (Lower the value, stronger the acid).
- **pH = 7:** Neutral (Pure water).
- **pH > 7:** Basic/Alkaline (Higher the value, stronger the base).

Important pH Values:

- Human Blood: **7.35 – 7.45** (Slightly basic)
- Gastric Juice: **1.0 – 3.0**
- Milk: **6.5**
- Sea Water: **8.5**

Salts

Salts are the products of the **Neutralization Reaction** between an acid and a base.



Types and Uses of Salts

Salt Name	Chemical Formula	Common Use
Common Salt	NaCl	Daily food preservative.
Washing Soda	Na ₂ CO ₃	Softening hard water; cleaning agent.
Baking Soda	NaHCO ₃	Making cakes; fire extinguishers; antacid.
Bleaching Powder	CaOCl ₂	Disinfectant; bleaching cotton.
Plaster of Paris	CaSO ₄ . 1/2H ₂ O	Setting fractured bones; making casts.
Epsom Salt	MgSO ₄ 7H ₂ O	Medicine (laxative); agriculture.

Indicators

Indicators change color to show whether a substance is an acid or a base.

Indicator	Color in Acid	Color in Base
Litmus Paper	Red	Blue
Phenolphthalein	Colorless	Pink
Methyl Orange	Pink/Red	Yellow
Turmeric	Yellow	Reddish-brown

Petroleum Products

Petroleum (Crude Oil) is known as “**Black Gold.**” It is a complex mixture of hydrocarbons separated through **Fractional Distillation**.

- **LPG (Liquefied Petroleum Gas):** Mainly **Propane and Butane**.
Used as domestic fuel. To detect leaks, a pungent-smelling chemical called **Ethyl Mercaptan** is added.
- **CNG (Compressed Natural Gas):** Primary component is **Methane**.
It is an eco-friendly fuel for vehicles.
- **Fractional Distillation Products:**

- **Petrol (Gasoline):** Fuel for light vehicles.
- **Kerosene:** Jet fuel and domestic stoves.
- **Diesel:** Heavy motor vehicles.
- **Bitumen:** Used for road surfacing and paints.

Fertilizers and Pesticides

Fertilizers

Plants need three primary nutrients: **N (Nitrogen)**, **P (Phosphorus)**, and **K (Potassium)**.

- **Urea:** The most common Nitrogenous fertilizer (46% Nitrogen).
- **Superphosphate of Lime:** A Phosphatic fertilizer.
- **Potassium Chloride (Muriate of Potash):** A Potassic fertilizer.
- **Bio-fertilizers:** Nitrogen-fixing bacteria like **Rhizobium** (found in leguminous plants) and **Azotobacter**.

Pesticides

- **Insecticides:** DDT (Dichlorodiphenyltrichloroethane), Malathion.
- **Fungicides:** Bordeaux mixture (mixture of Copper sulphate and Lime).
- **Rodenticides:** Zinc Phosphide (used to kill rats).

Metallurgy

Metallurgy is the process of extracting pure metals from their ores.

- **Minerals vs. Ores:** All ores are minerals, but all minerals are not ores.
- **Key Ores:**
 - **Aluminium:** Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$).
 - **Iron:** Haematite (Fe_2O_3), Magnetite (Fe_3O_4).
 - **Copper:** Copper Pyrites (CuFeS_2).

Important Alloys

Alloys are homogeneous mixtures of metals.

- **Brass:** Copper + Zinc ($\text{Cu} + \text{Zn}$).
- **Bronze:** Copper + Tin ($\text{Cu} + \text{S}$).

- **Stainless Steel:** Iron + Carbon + Chromium + Nickel.
- **Amalgam:** An alloy where one of the metals is **Mercury**.

Food Adulterants

Adulteration is the addition of inferior substances to food to increase weight or profit. This is a common “Science in Daily Life” topic.

Food Item	Common Adulterant	Health Impact
Milk	Water, Starch, Detergent	Reduced nutrition, stomach issues.
Turmeric Powder	Lead Chromate, Metanil Yellow	Carcinogenic (Cancer-causing).
Chilli Powder	Brick powder, Rhodamine-B	Digestive disorders.
Honey	Molasses, Sugar syrup	Diabetes risk.
Black Pepper	Dried Papaya seeds	Stomach irritation.
Green Vegetables	Malachite Green (dye)	Toxic to the liver.

Quick Revision Facts

- **Galvanization:** Coating Iron with **Zinc** to prevent rusting.
- **Bauxite:** India is one of the leading producers of Bauxite; it is the primary ore of Aluminium.
- **Pesticide Residue:** The buildup of chemicals in the food chain is called **Biomagnification**.
- **Fossil Fuels:** Coal and Petroleum are exhaustible natural resources formed over millions of years.

Main Concepts of Life Sciences:

Levels of Biological Organization

Life builds up hierarchically.

Cell → Tissue → Organ → Organ System → Organism

- **The Cell:** The structural and functional unit of life. Know the difference between **Prokaryotes** (primitive, no true nucleus, e.g., Bacteria) and **Eukaryotes** (advanced, well-defined nucleus, e.g., Plant & Animal cells).
- **Key Cell Organelles & Functions:**
 - *Mitochondria:* Powerhouse of the cell (ATP generation).
 - *Chloroplast:* Site of photosynthesis (found only in plants).
 - *Ribosomes:* Protein synthesis factories.
 - *Cell Wall:* Made of cellulose, gives rigidity to plant cells (absent in animal cells).

Major Life Processes (Plant Physiology)

- **Photosynthesis:** The process by which green plants make food using CO₂, water, sunlight, and chlorophyll.
Carbon Dioxide + Water Sunlight/Chlorophyll Glucose + Oxygen
- **Transpiration:** Loss of water in the form of vapor through tiny pores called **stomata** on leaves.

Plant Movements (Tropisms)

- *Phototropism:* Movement towards light (e.g., stem).
- *Geotropism:* Movement towards gravity (e.g., roots).
- *Hydrotropism:* Movement towards water (e.g., roots).
- *Thigmotropism:* Growth response to touch (e.g., climbing vines, tendrils).

Classification of Living Organisms

To study vast biodiversity, organisms are organized systematically. **Taxonomy** is the branch of science dealing with identification, nomenclature, and classification.

1. Taxonomic Hierarchy

Introduced by Carl Linnaeus (known as the **Father of Modern Taxonomy**). The system arranges categories in descending order. **Species** is the basic and smallest unit of classification.

1. **Kingdom** (Broadest)
2. **Phylum** (for animals)/**Division** (for plants)

3. **Class**
4. **Order**
5. **Family**
6. **Genus**
7. **Species** (Most specific)

Binomial Nomenclature: Every organism has a scientific name with two parts: **Genus** (capitalized) and **Species** (lowercase). *Example:* Tiger = *Panthera tigris*, Human = *Homo sapiens*, Paddy = *Oryza sativa*.

2. The Five-Kingdom Classification

Proposed by **R.H. Whittaker (1969)**. Organisms are classified based on cell structure, mode of nutrition, and body organization.

Kingdom	Cell Type	Characteristics	Key Examples
Monera	Prokaryotic	Unicellular; lack a true nucleus; live in extreme environments.	Bacteria, Cyanobacteria (Blue-green algae), Archaeobacteria
Protista	Eukaryotic	Unicellular; mostly aquatic; use pseudopodia, cilia, or flagella for movement.	Amoeba, Paramecium, Euglena
Fungi	Eukaryotic	Mostly multicellular; saprophytic/parasitic (non-photosynthetic); cell wall made of chitin .	Mushrooms, Yeast (unicellular), Penicillium
Plantae	Eukaryotic	Multicellular; autotrophic (photosynthetic); cell wall made of cellulose.	Algae, Mosses, Ferns, Flowering plants
Animalia	Eukaryotic	Multicellular; heterotrophic; no cell wall.	Insects, Birds, Reptiles, Mammals

Sub-Classifications

1. Plant Kingdom (Regnum Plantae)

- **Thallophyta (Algae):** Simple body (thallus), not differentiated into roots, stem, or leaves (e.g., Chara, Spirogyra).
- **Bryophytes:** Called the “**Amphibians of the Plant Kingdom**” because they live on land but need water for reproduction. No vascular tissue (e.g., Funaria, Riccia).
- **Pteridophytes:** First true land plants with vascular tissues (Xylem and Phloem). Seedless (e.g., Ferns).
- **Gymnosperms:** Naked seed-bearing plants; seeds are not enclosed in a fruit (e.g., Cycas, Pinus).
- **Angiosperms:** Flowering plants; seeds enclosed inside fruits. Divided into **Monocots** (single cotyledon, parallel venation like Grass, Paddy) and **Dicots** (two cotyledons, reticulate venation like Neem, Mango).

2. Animal Kingdom (Regnum Animalia)

Divided broadly into Invertebrates (without backbone) and Vertebrates (with backbone).

- **Invertebrate Phyla to remember:** Porifera (Sponges), Coelenterata (Hydra), Platyhelminthes (Flatworms), Aschelminthes (Roundworms), Annelida (Earthworm), **Arthropoda (Largest phylum - Insects, Crabs)**, Mollusca (Snails), and Echinodermata (Starfish).
- **Vertebrates (Chordates):**
 - *Pisces (Fishes):* Cold-blooded, two-chambered heart.
 - *Amphibians (Frogs):* Dual life, three-chambered heart.
 - *Reptiles (Snakes, Lizards):* Crawling, three-chambered heart (except Crocodiles, which have four).
 - *Aves (Birds):* Warm-blooded, pneumatic (hollow) bones, four-chambered heart.
 - *Mammals (Humans, Whales):* Warm-blooded, mammary glands, four-chambered heart.

Origin of Life (Theories)

Understanding how life began on Earth is a fundamental part of evolutionary biology.

Theory of Special Creation: Life was created by a supernatural power (divine creation).

Theory of Spontaneous Generation (Abiogenesis): Life originated from non-living matter spontaneously (e.g., maggots from rotting meat).

Louis Pasteur disproved this with his swan-neck flask experiment, proving *Biogenesis* (life comes only from pre-existing life).

Cosmozoic/Panspermia Theory: Life came from outer space in the form of spores or seeds.

Chemical Evolution of Life (Oparin-Haldane Theory): The most accepted theory. It states that life arose from a series of chemical reactions in the primitive atmosphere.

- **Urey-Miller Experiment (1953):** Recreated the primitive Earth atmosphere (H_2 , CH_4 , NH_3 , and water vapor with electric discharge) in a laboratory and successfully synthesized **amino acids**, proving chemical evolution.

Evidence in Support of Evolution

These evidences prove that different organisms share common ancestors.

Paleontological Evidence (Fossils)

- Fossils are the preserved remains of ancient life found in sedimentary rocks.
- **Archaeopteryx:** A famous connecting link between **Reptiles and Birds**. It had wings and feathers (bird features) but also teeth and a long bony tail (reptile features).

Morphological and Anatomical Evidence

- **Homologous Organs:** Organs that have the **same structural plan and origin but perform different functions**. This indicates **Divergent Evolution** (sharing a common ancestor).
 - *Examples:* Flippers of a whale, wings of a bat, and human hands.
- **Analogous Organs:** Organs that have **different structures and origins but perform similar functions**. This indicates **Convergent Evolution** (adapting to similar environments).
 - *Examples:* Wings of an insect and wings of a bird.
- **Vestigial Organs:** Rudimentary, non-functional organs in an organism that were fully functional in their ancestors.
 - *Examples in humans:* Vermiform appendix, nictitating membrane (third eyelid), wisdom teeth, coccyx (tailbone).

- **Atavism:** The sudden reappearance of an ancestral trait in an individual (e.g., a baby born with a short tail).

Embryological Evidence

- **Biogenetic Law (Recapitulation Theory):** Proposed by **Ernst Haeckel**. It states that “**Ontogeny recapitulates Phylogeny**”.
 - *Meaning:* The developmental stages of an embryo (ontogeny) repeat the evolutionary history of its species (phylogeny). For example, human embryos temporarily develop gill slits, similar to fish.

Theories of Evolution

Three major theories explain the mechanism of evolution:

A. Lamarckism (Theory of Inheritance of Acquired Characters)

Proposed by **Jean-Baptiste Lamarck** in his book *Philosophie Zoologique* (1809).

- **Core Concepts:**
 1. **Internal Vital Force:** Living organisms tend to increase in size.
 2. **Environment and New Needs:** Changes in the environment create new needs, leading to new habits.
 3. **Use and Disuse Theory:** Organs used frequently become highly developed (e.g., Long neck of a giraffe); organs not used degenerate (e.g., Kiwi's flightless wings).
 4. **Inheritance of Acquired Characters:** Characters developed by an organism during its lifetime are passed on to the next generation.
- **Dismissal:** **August Weismann** disproved Lamarckism through his *Germplasm Theory* (cut off the tails of mice for 20 generations; the 21st generation was still born with a tail). Only changes in germ cells (sperm/egg) are inherited, not somatic (body) cells.

B. Darwinism (Theory of Natural Selection)

Proposed by **Charles Darwin** in his book *On the Origin of Species* (1859), based on his

observations aboard the ship **HMS Beagle**.

- **Core Concepts:**

1. **Overproduction (Prodigality of Nature):** Organisms produce more offspring than can survive.
2. **Struggle for Existence:** Due to limited resources, competition arises (Intraspecific, Interspecific, and Environmental struggle).
3. **Universal Occurrence of Variations:** No two individuals are exactly alike. Useful variations help organisms survive.
4. **Survival of the Fittest (Natural Selection):** Nature selects organisms with favourable variations. The term “Survival of the Fittest” was coined by **Herbert Spencer**, but used extensively by Darwin.
5. **Origin of Species:** Favourable variations accumulate over generations, leading to the formation of a new species.

C. Mutation Theory

Proposed by **Hugo de Vries** (1901) based on his experiments on the **Evening Primrose** (*Oenothera lamarckiana*).

- **Core Concept:** Evolution is a jerky, discontinuous process caused by sudden, large heritable changes called **mutations**.
- Unlike Darwin’s gradual variations, de Vries believed mutations are random, directionless, and can create a new species in a single step (**Saltation**).

Modern Synthetic Theory (Neo-Darwinism)

This is the currently accepted view of evolution, combining Darwin’s theory with modern genetics. It identifies five basic factors that drive evolution:

1. **Gene Mutation:** Changes in the chemical structure of a gene.
2. **Chromosomal Aberration:** Changes in the structure or number of chromosomes.
3. **Genetic Recombination:** Shuffling of genes during meiosis (crossing over).
4. **Natural Selection:** Drives differential reproduction (favoring adaptive genotypes).

5. **Reproductive Isolation:** Prevents interbreeding between different populations, leading to speciation.

Human Evolution

Humans belong to the family **Hominidae** under the order Primates.

Ancestor/Stage	Key Characteristics
Ramapithecus	Ape-like, walked semi-erect.
Australopithecus	“Southern Ape”/First man-like primate. Bipedal locomotion (walked on two legs). Found in Africa.
Homo habilis	“Handy Man”. First tool maker. Had a larger brain capacity than Australopithecus.
Homo erectus	“Java Man/Peking Man”. First to stand fully erect, discovered fire.
Neanderthal Man	Lived in caves, used animal hides as clothing, and buried their dead.
Cro-Magnon Man	Domesticated animals, created cave paintings. Direct ancestor of modern man.
Homo sapiens	Modern thinking man. Originated in Africa during the Ice Age. Developed agriculture.

Quick Revision Facts

- **Father of Evolutionary Biology:** Charles Darwin.
- **Connective link between Annelida and Arthropoda:** Peripatus.
- **Living Fossil:** *Limulus* (King Crab), *Ginkgo biloba* (Plant).
- **Hardy-Weinberg Principle:** States that allele frequencies in a population remain constant from generation to generation in the absence of evolutionary influences (like mutation, selection, genetic drift).
- **Industrial Melanism:** The peppered moth (*Biston betularia*) in England is a classic real-time example of **Natural Selection** during the industrial evolution.

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