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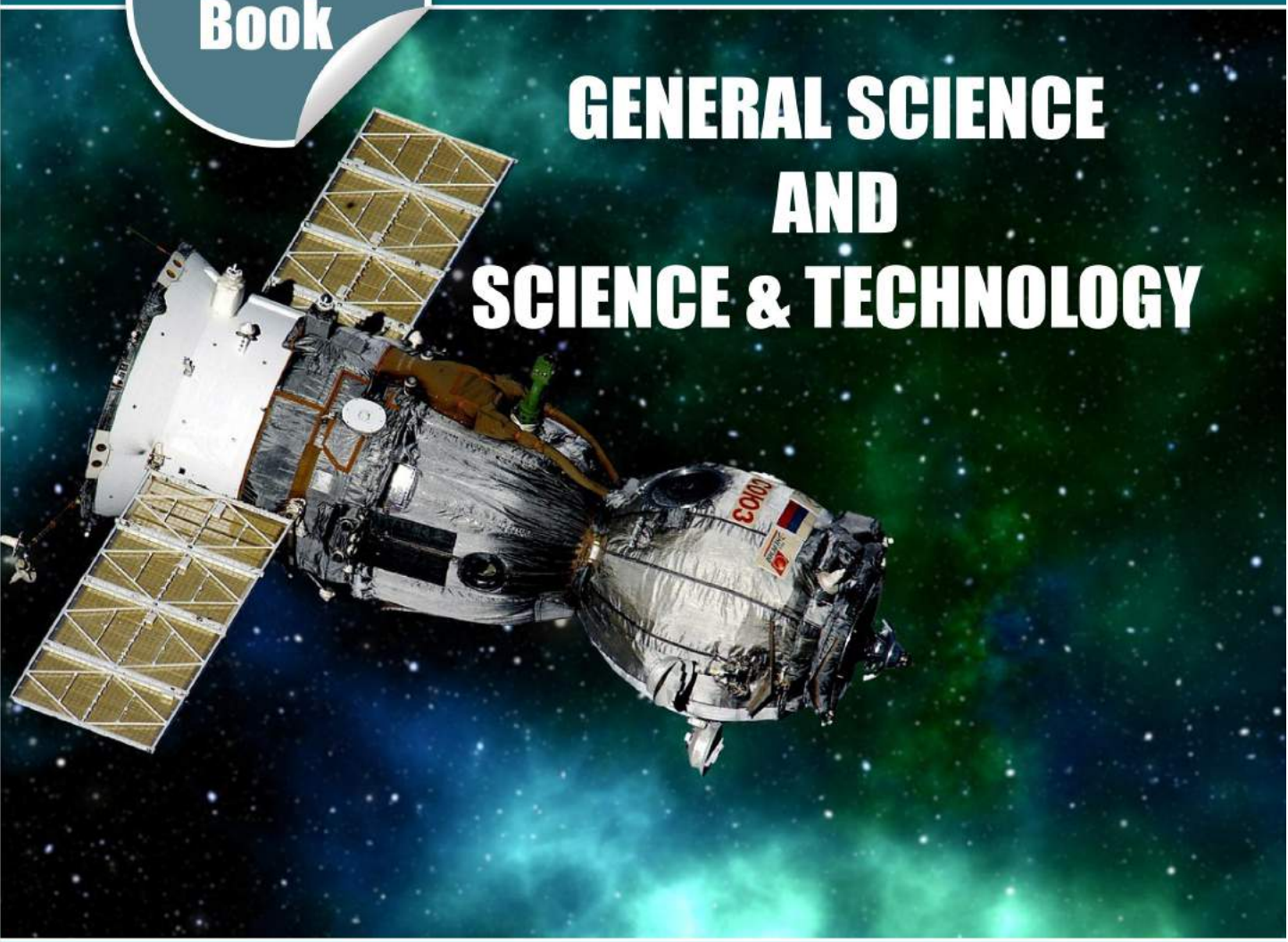
Quick Book

GENERAL SCIENCE AND SCIENCE & TECHNOLOGY



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General Science and Science & Technology

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1 Units and Measurement

The science of measurement has been known to the humankind for a very long time, with various civilisations deriving their own units. The Indian measurement of time, for instance, is widely recognised as the oldest in the world.

STANDARDISATION OF MEASUREMENT

Historical Background

- In 1875, with the creation of the International Bureau of Weights and Measures (BIPM), measurement began to be standardised internationally. A treaty called the Metre Convention was signed, leading to international standards.
- The BIPM reports to the General Conference on Weights and Measures (CGPM), to which India became a signatory in 1957.
- In 1960, the 11th CGPM formally defined and established the International System of Units (SI). Since then the SI has been periodically updated to take account of advances in science and the need for measurements in new domains.

The SI System of Units

- The units for the fundamental or base quantities are called fundamental or base units. The units of all other physical quantities can be expressed as combinations of the base units. Such units are called derived units. A complete set of both the base units and derived units is known as the system of units.
- The system of units which is at present internationally accepted for measurement is the *Système Internationale d' Unites* (French for International System of Units), abbreviated as SI.
- The SI system consists of 7 base units. The units and their physical quantities are the second for time, the metre for length, the kilogram for mass, the ampere for electric current, the kelvin for temperature, the mole for amount of substance, and the candela for luminous intensity.
- Of the seven base units, four were not based on the constants of physics: the ampere (current), kelvin (temperature), mole (amount of substance) and kilogram (mass).
- In 2018, the General Conference on Weights and Measures (CGPM) redefined the SI, by changing the definition of these four units. The new definitions replaced the artifact based units with the 'universal constants' based units. It enables world-wide coherence of measurements.
- In India, CSIR-National Physical Laboratory (CSIR-NPL) takes care of setting meteorology standards.

NOTE: Metrology is the science of measurement. It is not just the system by which we measure the world; it is also the system by which scientists conduct their observations. It needs to be precise, and it needs to be constant.

SI Base Units

Kilogram (kg): the unit of mass

- It is defined by taking the fixed numerical value of the **Planck constant (h)** which is defined as equal to $6.62607015 \times 10^{-34}$ joule second.
- The Planck constant (the ratio of energy to frequency of a photon) is usually measured in joule seconds, but this can also be expressed as kilogram square metres per second (Kg m^2s^{-1}). Since the second and the metre were already defined, the kilogram would then be determined by measurements of Planck's constant.
- The kilogram had been defined since 1889 by a shiny piece of platinum-iridium kept in a special glass case housed at the headquarters of the International Bureau of Weights and Measures (BIPM), Paris.
- However, the prototype did not always weigh the same. It picked up microparticles of dirt and was affected by the atmosphere. Sometimes it needed cleaning, which affected its mass.
- With the new definition, while the extra accuracy will be a boon to scientists, for the average consumer buying flour or bananas, there will be absolutely no change whatsoever.

2 Motion and Force

Motion and force are one of the most important things in our lives. They make things move and/or stay still. The world around us is full of motion, from speeding cars to to gusts of wind. Something moves when pushed or pulled. The pushing and pulling are examples of forces that can speed things up or slow things down.

WHAT IS MOTION?

- A body is said to be in a state of motion if, with the passage of time, it changes its position continuously with respect to an observer (or reference point). Likewise, a body is said to be at rest if, with the passage of time, it does not change its position with respect to an observer (or reference point).
- Rest and motion are relative terms. A body may seem to be at rest with respect to one object, but may appear to be in motion with respect to another object. For example, a moving train is at rest with respect to its co-passengers but is in motion with respect to an observer standing outside.
- If an object covers equal distances in equal intervals of time, it is said to be in uniform motion. When objects cover unequal distances in equal intervals of time, it is said to be in non-uniform motion.

Terms Associated with Motion

Distance

- The total length of path covered by an object is called distance. To describe distance only the numerical value needs to be specified and not the direction of motion.
- The numerical value of a physical quantity is its magnitude. Distance only has magnitude and no direction and, thus, it is a scalar quantity. Distance is always a positive quantity.

Displacement

- The shortest distance measured from the initial to the final position of an object is known as the displacement. Thus, displacement is the shortest distance covered by a body in a definite direction.
- As direction to represent displacement, it is a vector quantity. The magnitude of displacement for a course of motion may be zero but the corresponding distance covered is not zero.

Scalars and Vectors

- **Scalar Quantity:** The physical quantities which are defined by only magnitude and no direction. For example, distance, speed, mass, volume, density, work, energy, power, etc.
- **Vector Quantity:** The physical quantities which are defined by magnitude and direction both. For example, displacement, velocity, force, momentum, etc.

Speed

- Speed is the distance travelled by an object per unit of time. It is how fast an object is moving.

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

- The SI unit of speed is metre per second (m/s).

Velocity

- Velocity is the speed of an object moving in a definite direction.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

- The SI unit of velocity is metre per second (m/s).

Acceleration

- Acceleration is the rate of change of velocity of an object with time.

$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Time Taken}}$$

- The SI unit of acceleration is metre per second^2 (m/s^2).
- The acceleration is taken to be positive if it is in the direction of velocity and negative when it is opposite to the direction of velocity. If the object speeds up it is said to have positive acceleration and if it slows down it is said to have negative acceleration.
- The change in the velocity of an object could be due to change in its magnitude or the direction of the motion or both.

3 Work, Energy and Heat

Heat and work are two different ways of transferring energy from one system to another.

WORK

Concept of Work

- When a constant force (F) acts on an object and the displacement (s) of the object takes place in a straight line in the direction of the force, it is said work (W) is done.

$$\text{Work done} = \text{Force} \times \text{Displacement}$$

$$W = F \times s$$

- Thus, work done by a force acting on an object is equal to the magnitude of the force multiplied by the distance moved in the direction of the force.
- Work is a scalar quantity because it has only magnitude and no direction. The SI unit of work is Joule (J).

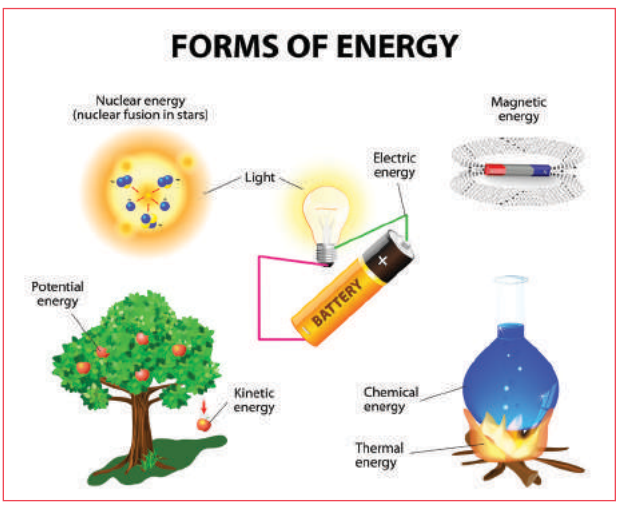
Force and Displacement

- A force acting on an object may not act in the direction in which the object moves. The angle between the force and displacement defines the different kinds of work (positive, negative, or zero) done on the body.
- The work done on an object is said to be **positive** when force and displacement are in the same direction or the angle between the force and displacement is acute (0° - 90°). For example, a baby pulling a toy car parallel to the ground.
- Work done is **negative** when the force acts opposite to the direction of displacement or the angle between force and displacement is obtuse (90° - 180°). For example, when an object is thrown upwards, the force acts in downward direction whereas displacement acts in upward direction.
- Work done is said to be **zero**, when force and displacement are perpendicular to each other or when either force or displacement is zero. For example, when we hold an object and walk, the force acts in downward direction whereas displacement acts in forward direction.

ENERGY

Concept of Energy

- Energy is the capacity of the body to perform a work. The object which does the work loses energy and the object on which the work is done gains energy.
- It is a **scalar quantity** and its SI unit is the same as that of work i.e. **Joule (J).** There are various forms of energy such as mechanical energy, heat energy, chemical energy, electrical energy and light energy.
  - **Heat Energy:** Heat or thermal energy is energy owing to the movement of atoms or molecules.
  - **Light Energy:** Light energy is a form of electromagnetic radiation. Light consists of photons, which are produced when an object's atoms heat up.
  - **Electrical Energy:** This is energy from the movement of charged particles, such as protons, electrons, or ions.



  - **Magnetic Energy:** This form of energy results from a magnetic field.
  - **Chemical Energy:** Chemical energy is released or absorbed by chemical reactions. It is produced by breaking or forming chemical bonds between atoms and molecules.

PRACTICE QUESTIONS

1. What happens to its kinetic energy when an object is taken to high altitude?
   (a) Increases
   (b) Decreases
   (c) Remains same
   (d) None of the above
2. Due to application of 10 N force, an object moves 20 meter along the perpendicular direction of the force.
   What is the amount of work done on the object?
   (a) 200 Joule
   (b) 100 Joule
   (c) 2 Joule
   (d) 0 Joule
3. Which of the following are scalar quantities ?
   1. Energy
   2. Displacement
   3. Power
   4. Work

   Select the correct answer using the codes given below:
   (a) 1 and 2 only
   (b) 2, 3 and 4 only
   (c) 1, 3 and 4 only
   (d) 1, 2, 3 and 4
4. Consider the following statements:
   1. Steam at 100°C and boiling water at 100°C contain same amount of heat.
   2. Latent heat of fusion of ice is equal to the latent heat of vaporization of water.
   3. In an air-conditioner, heat is extracted from the room-air at the evaporator coils and is ejected out at the condenser coils.

   Which of these statements given above is/are correct?
   (a) 1 and 2
   (b) 2 and 3
   (c) Only 2
   (d) Only 3
5. When water is heated from 0°C to 10°C its volume
   (a) increases
   (b) decreases
   (c) does not change
   (d) first decreases and then increases
6. Cloudy nights are warmer compared to cloudless nights, because clouds
   (a) prevent cold waves from the sky from descending on earth
   (b) reflect back the heat given off by earth
   (c) produce heat and radiate it towards earth
   (d) absorb heat from the atmosphere and send it towards earth

Answers

1. (b)	2. (d)	3. (c)	4. (d)	5. (d)
6. (b)				

4 Wave and Sound

Waves are everywhere and we observe different kinds of waves everyday - sound waves, visible light waves, radio waves, earthquake waves and so on.

WAVE

A wave is a transfer of energy and momentum by oscillation or vibration of medium particles from one point to another without the transport of matter. The particles of the medium vibrate at their mean position and do not leave their respective positions.

Key Terms

Time Period (T)

- It is the time required for one complete cycle of vibration to pass a given point.
- Time period (T) = 1/v, where (v) is the velocity.

Frequency (f)

- It is the number of oscillations per unit time. Its S.I. unit is Hertz (Hz).
- Frequency (f) = 1 / Time Period (T).
- An amplitude of a wave can change but frequency of a wave never changes.

***Wavelength* (λ)**

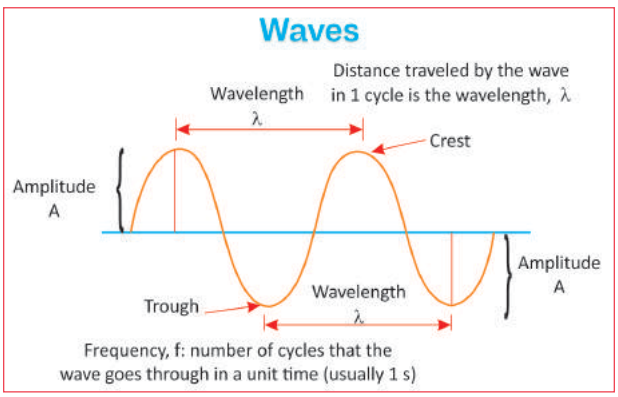
- Wavelength is the distance between two adjacent crests or troughs in a waveform. It is also measured in Meter.
  - Crest is the maximum upward displacement, whereas trough is the maximum downward displacement.
- λ = v/f, here, 'v' is the velocity at which the wave propagates and 'f' is the frequency of the wave.
- Wavelength is inversely proportional to frequency that means if two waves are travelling at the same speed, the wave with a higher frequency will have a shorter wavelength and vice versa.

***Amplitude* (A)**

- The maximum variation in the strength of an electromagnetic wave in one wavelength is called its amplitude.
- In other words, amplitude is the height from the crest to the trough of the wave.
- The energy of a wave is directly proportional the amplitude i.e. more is the energy more will be the amplitude.

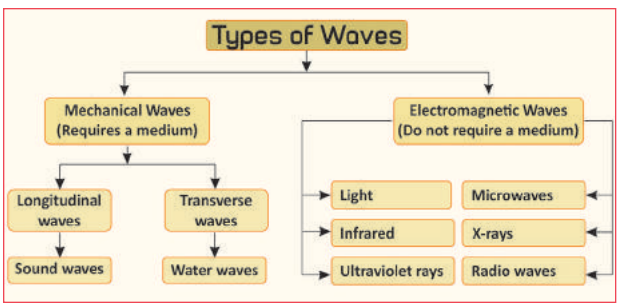
***Velocity* (v)**

- It is the distance (λ) travelled by the wave in one second or time (T),
- Velocity of wave = frequency x wavelength i.e, v=fλ.
- It is determined by the mechanical properties of the medium through which the wave propagates i.e. the velocity of the wave changes as the medium changes.



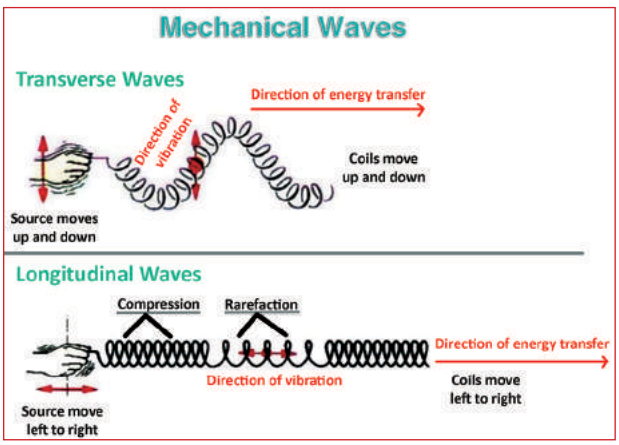
Types of Wave

Based on the orientation of particle motion, direction of energy, and medium of propagation, broadly there are two types of waves: Mechanical Waves and Electromagnetic Waves.



Mechanical Waves

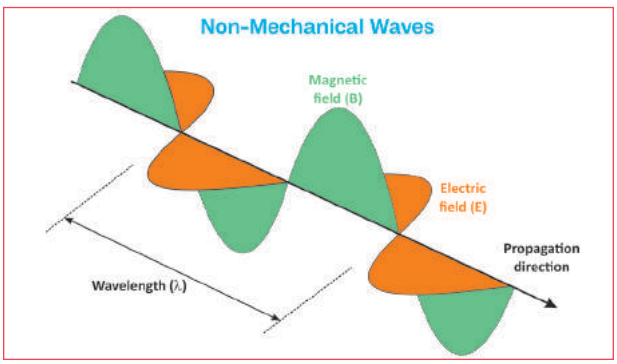
- In mechanical waves the energy transfer takes place by oscillation of physical medium particles such as solid, liquid or gas i.e. it requires a medium to propagate.
- For example, sound is a mechanical wave and hence it requires a medium for its propagation and cannot travel through a vacuum. That's why; we can't hear sound in space.
- The propagation of mechanical waves is possible due to two properties of the medium which are elasticity of the medium and inertia of the medium.
- Mechanical waves are primarily of two types which are:
  - Transverse Wave
  - Longitudinal Wave



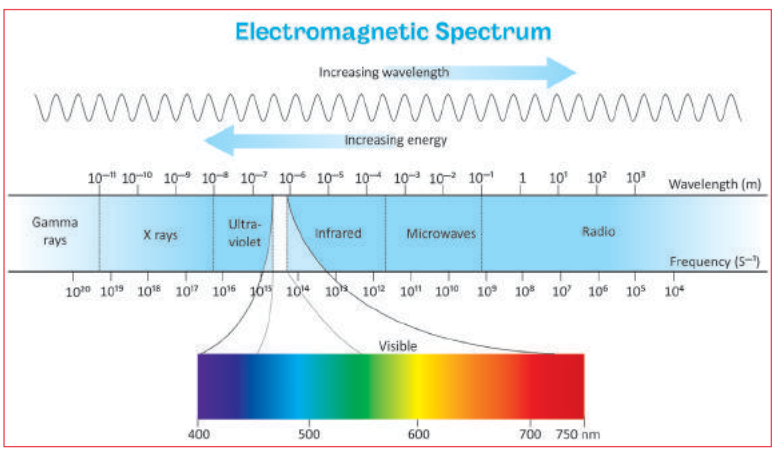
- **Transverse Wave**
  - A wave in which the particles of the medium oscillate or vibrate about their mean position in the direction perpendicular to the direction of propagation of the wave is called a transverse wave.
  - For example, vibrations in strings, ripples on the water surface, and S waves (Secondary waves) in an earthquake etc.
  - Here, the formation of crest and trough takes place. These waves can propagate through solids and liquids, but not through gases because gases do not possess elastic properties.
- **Longitudinal Wave**
  - A longitudinal wave is the wave in which particles of medium oscillate back and forth or parallel in the same direction of wave propagation.
  - Longitudinal waves proceed in the form of compression and rarefaction (expansion) like the stretched rubber band.
  - In a longitudinal wave, at places of compression the pressure and density tends to be maximum, while at places where refraction takes place, the pressure and density are minimum.
  - Examples of longitudinal waves include sound waves, tsunami waves, P waves (Primary waves) in an earthquake, ultrasounds, vibrations in gas, oscillations in spring etc.

Non-Mechanical Waves

- Non-mechanical waves are those waves that do not require a medium for the transfer of their energy.
- It is generated by mutual oscillation of electric and magnetic fields perpendicular to each other i.e. waves are transverse in nature.
- Such waves are also called electromagnetic (EM) waves and they can even travel in vacuum with the speed of light (3x 108 m/s or 3 lakh km/sec).
- For example, light, X-rays, and radio waves, etc.



- The visible light from the sun is in between Infrared (IR) and Ultra-violet (UV) in the electromagnetic spectrum.



5 Fluid Mechanics

Fluid is any substance that has the ability to flow and has no fixed shape. Water, blood, mercury, air, gasoline and any other gas or liquid are examples of fluid.

KEY TERMS

Thrust

- When an object is submerged in a liquid at rest, the fluid exerts a force on its surface. It is called thrust of the liquid.
- The force is applied perpendicular to the surface of an object.
- For example, pushing an empty can into water experiences the thrust.
- Thrust is a **vector quantity** and is measured in **Newton (N)**.

Pressure

- The thrust experienced per unit area of the surface of a liquid at rest is called pressure.

$$\text{Pressure} = \frac{\text{thrust}}{\text{area}} \text{ or } \frac{F}{A}$$

- Pressure is a scalar quantity and its SI unit is **Pascal (Pa) or** Nm^{-2}**.**
- There is an inverse relation between pressure and area. The same force acting on a smaller area exerts larger pressure and on a larger area it exerts smaller pressure.
- This is the reason why a nail has a pointed tip, knives have sharp edges and buildings have wide foundations.

Density

- Density of a fluid is defined as the ratio of mass of the fluid to its volume. In other words, density of a substance is its mass per unit volume. The SI unit of density is kg/m^3.
- The density of liquid mostly remains constant, while density of gases are dependent on pressure and temperature.
- The density of water increases with decreasing temperature, reaching a maximum at 4.0° C, and then decreases as the temperature falls below 4.0° C. This behavior of the density of water explains why ice forms at the top of a body of water.

Fluid	Density (g/m)	Solid	Density (g/cm^3)
hydrogen	0.00009	Styrofoam	0.005
helium	0.0002	cork	0.24
air	0.0013	oak	0.70
oxygen	0.0014	sugar	1.59
carbon dioxide	0.002	salt	2.16
ethyl alcohol	0.79	aluminum	2.70
machine oil	0.90	iron	7.87
water	1.00	nickel	8.90
seawater	1.03	copper	8.92
glycerol	1.26	lead	11.34
mercury	13.55	gold	19.32

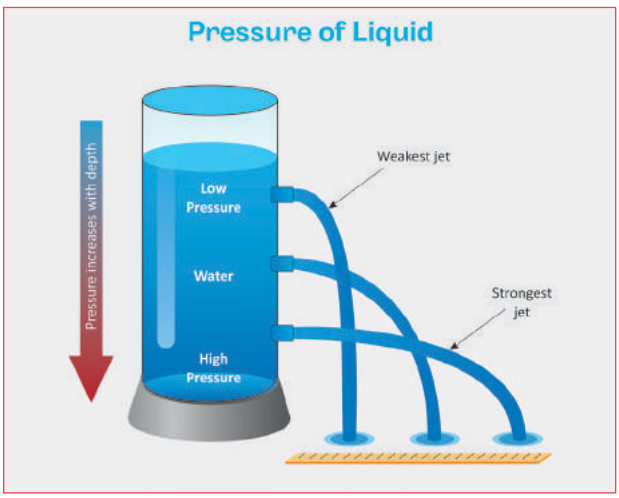
PROPERTIES OF FLUID

Pressure and Fluid

- Fluids exert pressure in all directions over the inner walls of a container in which they are kept. This pressure is the same at the same horizontal level i.e. for the same horizontal surface any liquid at rest exerts the same pressure at all points and in every direction.
  - For example, if a number of holes are made in a plastic bag or a container after it is filled with liquid, the liquid will be released from every hole at the same horizontal level with the same amount of pressure.
- The pressure at any point in the liquid is directly proportional to:
  - Depth below the surface,
  - Density of liquid and
  - Acceleration due to gravity.
- So with increase in depth, density and gravity the pressure on the liquid also increases. As the depth of

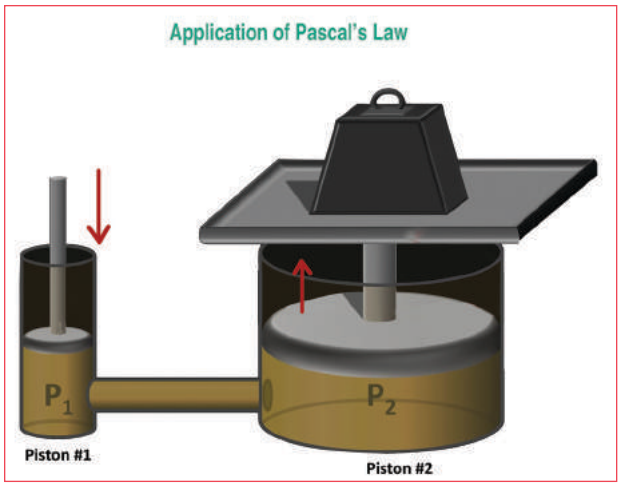
liquid increases the weight of the liquid column pushing down from above increases and hence the pressure also increases.

- Furthermore, as the depth of liquid increases, the sideways pressure on the walls of the vessel gradually increases and it becomes maximum near the bottom of the vessel. That's why the wall of a dam is made thicker at the bottom.



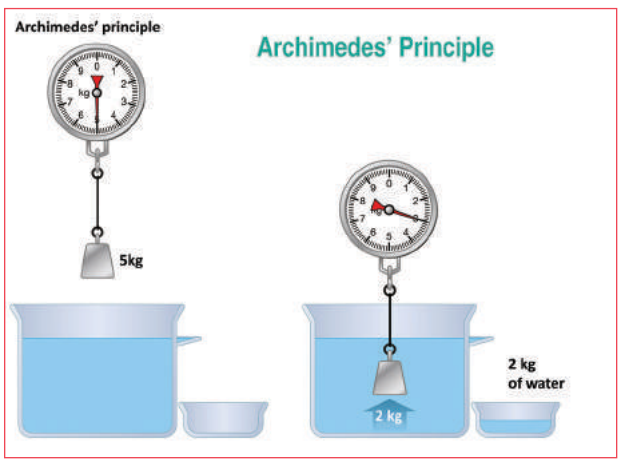
Pascal's Law

- Pascal was a French philosopher and mathematician. He formulated the famous Pascal's law of hydraulics regarding transmission of pressure through fluids.
- It states that the pressure applied to an enclosed liquid is transmitted undiminished to every portion of the liquid and the walls of the containing vessels. In other words, the external static pressure applied on a confined liquid is distributed or transmitted evenly throughout the liquid in all directions.
- Even if a small force is applied at any point on a confined mass of a liquid, it will appear as a large force on the walls of the container.
- Hydraulic lift, hydraulic brakes are applications of Pascal's law.
- Pressure is equal to the force divided by the area on which it acts. In a hydraulic system a pressure exerted on a piston produces an equal increase in pressure on another piston in the system. If the second piston has an area 10 times that of the first, the force on the second piston is 10 times greater, though the pressure is the same as that on the first piston.



Archimedes' Principle

- According to the Archimedes' Principle, when a body is partially or wholly immersed in a liquid, it loses some of its weight. The loss in weight of the body in the liquid is equal to the weight of the fluid displaced by the body.
- For a body immersed in liquid, the upward force exerted by the liquid is called **buoyancy** which is also known as buoyant force.
- This principle is used in designing ships and submarines. Lactometers, which are used to determine the purity of a sample of milk and hydrometers used for determining density of liquids, are based on it.



Types of Buoyancy

- Positive Buoyancy (**object is lighter than the fluid it displaces**): The object will float at surface because the buoyant force is greater than the object's weight. For example, a swimmer experiences a great amount of buoyant force.

6 Light and Optics

As a branch of Physics, Optics studies the behaviour and properties of light, including its interactions with matter.

PROPERTIES OF LIGHT

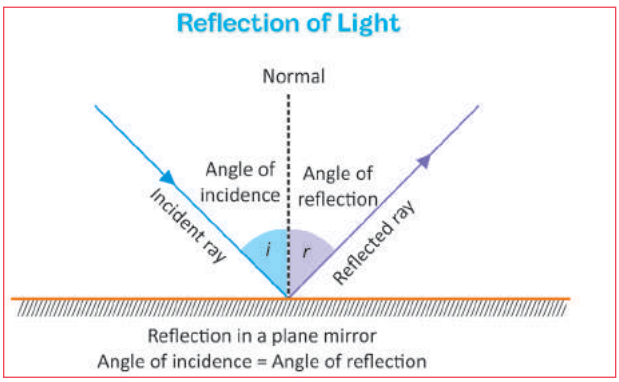
- Light is a form of energy which is propagated in the form of electromagnetic waves.
- Light travels in a straight line and is usually represented as a ray of light.
- Its wavelength ranges from 390 to 700 nm and based on wavelengths in the visible spectrum, the colours present in the light are differentiated into red, orange, yellow, green, cyan, blue and violet.
- The speed of light is maximum in vacuum and its value is $3x10^8$ m/s (approx.).
- Light can behave as **ray** (reflection, refraction and diffusion), **wave** (interference, diffraction and polarization) and **particle** (photoelectric effect).
- When light interacts with matter or a substance three things can happen:
  - **Reflection:** Reflection of the light bounces the energy back into the same medium that it came from.
  - **Transmitted through:** The light can travel through the new material while undergoing varying degrees of interaction with the molecules of the substance.
  - **Absorbed:** The light energy can be completely absorbed into the molecules of the substance and turned into heat.

Categorization of materials based on how light interacts

- **Opaque object:** It absorbs and/or reflects all light i.e. light cannot get through.
- **Transparent object:** It allows light to travel through in straight lines. Objects can be transparent to some colors or frequencies of light and opaque to others. For example, regular standard glass is transparent to visible light, but is opaque to UV and IR light.
- **Translucent object:** It scatters light in all directions as it passes through. Our atmosphere is translucent to visible light.

REFLECTION OF LIGHT

When a ray of light falls on any surface, a part of the light is sent back to the same medium. This phenomenon where the incident light falling on a surface is sent back to the same medium is known as reflection.



Laws of Reflection

- The angle of incidence is equal to the angle of reflection.
- The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.
- These laws of reflection are applicable to all types of reflecting surfaces including spherical surfaces.

Mirror

Important Terms

- **Principal Axis:** A line drawn to the exact center of the mirror and perpendicular to the mirror at that point is called the principal axis.
- **Focal Point:** The point where the incident rays which are parallel to the principal axis converge to form an image or appear to be emerging from.
- **Focal Length:** The distance along the principle axis from the mirror to the focal point is called the focal length (f). The focal length is also exactly one-half of the radius of curvature of the spherical mirror.
- **Centre of Curvature:** Centre of curvature is the centre of the sphere of which the mirror forms a part. Centre of curvature is represented by C on the principal axis.

7 Universe

The universe is commonly defined as the totality of existence, including planets, stars, galaxies, the contents of intergalactic space, and all matter and energy.

Big Bang Theory

- Alternatively called the expanding universe hypothesis, the big bang is about how the universe began. The theory suggests that the universe began as just a single point, then expanded and stretched to grow as large as it is right now. It inflated over the next 13.8 billion years to the cosmos that we know today.
- This creation of the universe that occurred about 13.8 billion years ago has had a profound influence on the birth, life, and death of galaxies, stars, and planets.

COMPONENTS OF UNIVERSE

The universe consists of both physical components (subatomic particles like electrons, protons to galactic superclusters) and non-physical components (light, gravitation, space etc.). The universe is replete with a large number of naturally occurring physical entities, association, or structure also known as celestial bodies.

Galaxy

A galaxy is a huge collection of gas, dust, and billions of stars and their solar systems, all held together by gravity. Nearly all large galaxies including Milky Way Galaxy are thought to also contain supermassive black holes at their centers.

Types of Galaxies

- **Irregular galaxies :** These galaxies have no distinct shape or structure. They seem to be arranged haphazardly without any bulge or flat disk.
- **Spiral galaxies:** A spiral galaxy has a flat, spinning disk with a central bulge surrounded by spiral arms. The bulge is concentrated with old stars while extended spiral arms have more gas, dust, and younger stars. Our Milky Way Galaxy is a spiral galaxy.
- **Elliptical galaxies:** In these galaxies stars are distributed uniformly through their elongated structure giving it a cigar-like shape structure.

Active Galactic Nucleus (AGN)

- AGNs are centrally located regions in the galaxies which give out extremely bright light. The light is usually brighter than the entire galaxy.

8 Building Blocks of Matter

Atoms are the basic building blocks of ordinary matter. Atoms can join together to form molecules, which in turn form most of the objects around us.

ATOM

- Atoms are the **fundamental** building blocks of all matter. An atom is the smallest particle of the element that cannot usually exist independently and retain all its chemical properties.
- The term "atom" comes from the Greek word for indivisible, however with research it has been proved that atoms are made up of three more particles.

Constituents of an Atom

- An atom consists of three fundamental subatomic particles - Electron, Proton and Neutron.
- The protons and the neutrons make up the center of the atom called the nucleus and the electrons move around the nucleus in a small cloud.
- The electrons carry a negative charge and the protons carry a positive charge. In a normal (neutral) atom the number of protons and the number of electrons are equal.

Electron	Proton	Neutron
❒ It was discovered by J.J. Thomson. ❒ Electrons have a negative charge. ❒ It has a very small mass as compared with that of a neutron or proton.	❒ E. Rutherford had discovered a positively charged centre in an atom. ❒ Protons are positively charged and found within the nucleus. ❒ Protons are slightly smaller in mass than neutrons.	❒ James Chadwick discovered neutrons. ❒ Neutrons have no charge. ❒ These are found within all atomic nuclei (except for hydrogen).

Identification of Elements

Atomic Number

- Atomic number is the total number of protons existing in the nucleus of an atom. It is represented by Z.
- For example, carbon has six protons present in the nucleus. Hence, carbon has atomic number 6.

Mass Number

- It is the sum of the total number of protons and neutrons present in the nucleus of an atom. Mass number is indicated by the symbol A.
- For example, aluminium has 13 protons and 14 neutrons, hence its mass number is 27.

Variants of Elements

Isotopes

- They are the atoms of the same element having different numbers of neutrons but the same number of protons and electrons.
- For example, take the case of hydrogen atom; it has three atomic species, namely protium, deuterium and tritium. The atomic number of each one is 1, but the mass number is 1, 2 and 3, respectively.
- The chemical properties of isotopes are similar but their physical properties are different.
- Some isotopes have special properties which find them useful in various fields such as
  - An isotope of uranium is used as a fuel in nuclear reactors.
  - An isotope of cobalt is used in the treatment of cancer.
  - An isotope of iodine is used in the treatment of goitre.

Isobars

- Atoms of different elements having different atomic numbers but the same mass number are known as isobars.

9 Matter and Classification

Everything around us is made of matter - our clothes, the trees, even the water we drink.

WHAT IS MATTER?

Anything that has mass and takes up space is called matter. Everything in the universe is built up of matter and everything is matter. According to modern physics, matter consists of various types of particles, each with mass and size.

Particles of Matter

- All particles of matter have spaces between them.
- The particles can be atoms or combinations of atoms that are bonded.
- The particles continuously move due to the kinetic energy they possess. This energy increases with the increase in temperature which results in faster movement of these particles.
- Particles of matter intermix with each other by getting into the spaces between the particles. This intermixing is called diffusion.
- Particles of matter are bound by a force that acts between them hence keeping them together. The strength of this force of attraction varies from one kind of matter to another.

PHYSICAL CLASSIFICATION OF MATTER

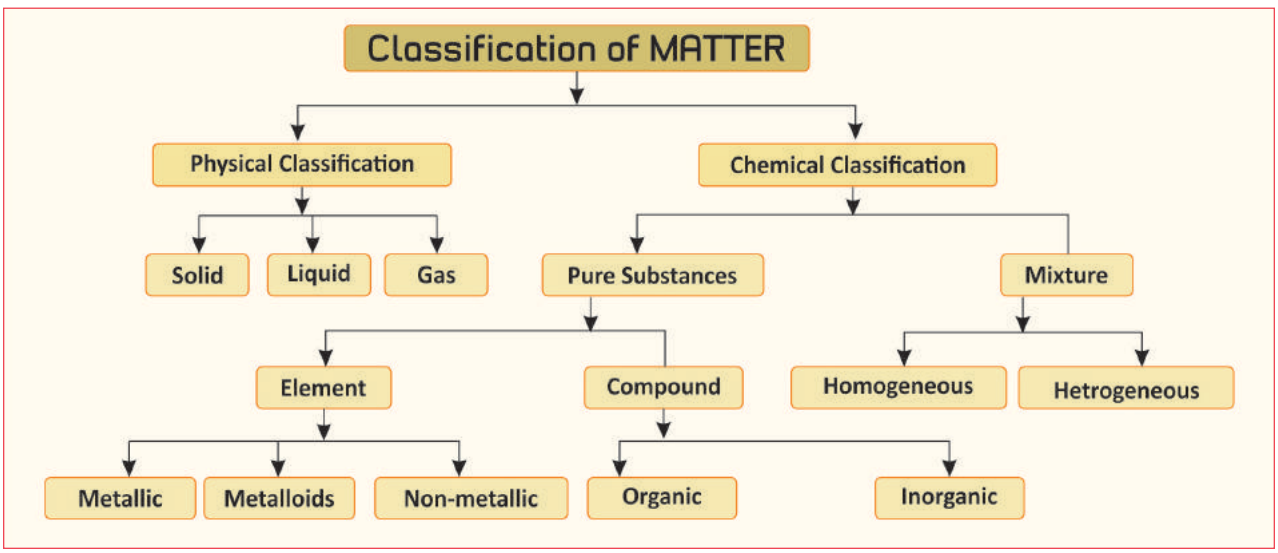
States of Matter

The Solid State

- In a solid, the constituent particles are closely packed and have the strongest force of attraction.
- These have a definite shape, distinct boundaries and fixed volumes i.e. negligible compressibility.
- Solids have a tendency to maintain their shape when subjected to outside force. Beyond a limit, they may break under force but it is difficult to change their shape.

The Liquid State

- In a liquid, the constituent particles are relatively less closely packed and have the lesser force of attraction.
- Liquids have no fixed shape but have a fixed volume.
- They take up the shape of the container in which they are kept.



- Examples include, separation of mixture of methyl alcohol and water.

Fractional Distillation

- It is used when two or more miscible liquids have a difference in boiling point of less than 25 K.
- The process is similar to that of distillation as only a fractionating column is added (it is a tube containing glass beads) which provides surface for the vapours to cool and condense.
- For example, the separation of different gases from air, separation of petrol, diesel, kerosene, heavy oil from crude petroleum.

Crystallization

- Crystallization is a process that separates a pure solid in the form of crystals from a solution.
- In this process, impure solid is heated with a solvent to its boiling point and the hot solution is filtered.
- Then, the filtrate is cooled slowly when pure solid crystallizes out. Examples include, purification of salt from sea water, separation of crystals of alum (phitkari) from impure samples.

Chromatography

- Chromatography is the technique used for separation of components of a mixture that dissolves in the same solvent.
- For example, dye composed of two or more colours. The coloured component that is more soluble in water rises faster and in this way the colours get separated.

Physical and Chemical Changes

Physical Changes

- The properties like colour, hardness, rigidity, fluidity, density, melting point, boiling point etc. are called the physical properties.
- The conversion of states of matter is a physical change because these changes occur without a change in composition and no change in the chemical nature of the substance.
- For example, ice, water and water vapour all look different and display different physical properties, they are chemically the same.

Chemical Changes

- The properties like inflammability, odour etc. are called chemical properties.
- Chemical change is when a substance undergoes change in its chemical properties by reacting with another substance.
- For example, burning wood, souring milk, digesting food, cooking an egg, rusting of iron, etc.

PRACTICE QUESTIONS

1. Consider the following statements about pure substance?
   1. They contain only one kind of particle.
   2. They may be compound or mixture.
   3. They have the same composition throughout.
   4. They can be exemplified by all elements other than nickel.

   Which of the statements given above is/are correct?
   (a) 1 and 2 only
   (b) 1 and 3 only
   (c) 3 and 4 only
   (d) 2 and 3 only
2. Which of the following are homogeneous in nature?
   1. Ice 2. Wood
   3. Soil 4. Air

   Select the correct answer using the code given below.
   (a) 1 and 3 only
   (b) 2 and 4 only
   (c) 1 and 4 only
   (d) 3 and 4 only
3. In a sugar solution
   (a) Sugar is solute, water is solvent
   (b) Sugar is solvent, water is solute
   (c) Both are solutes
   (d) Both are solvents
4. A heterogeneous mixture made of a liquid and solid particles that settles
   (a) Compound
   (b) Colloid
   (c) Solution
   (d) Suspension
5. The scattering of light by colloid is called
   (a) Suspension
   (b) Tyndal effect
   (c) Colloid
   (d) Air pollution

Answers				
1. (b)	2. (c)	3. (a)	4. (d)	5. (b)

10 Periodic Table and Chemical Reactions

The periodic table is a tabular display of the chemical elements. The modern periodic table provides a useful framework for analyzing chemical reactions.

PERIODIC TABLE

The periodic table, also known as the periodic table of elements, is a tabular display of the elements based on certain chemical properties. Dmitri Mendeleev is said to be the father of the periodic table (published in 1869). He arranged all the known elements in increasing order of atomic mass.

Modern Periodic Table

In 1913, Moseley proved that atomic number is a very important property of an element because the physical and chemical properties of the elements are periodic functions of their atomic numbers. After that, Neil Bohr made the modern periodic table using atomic numbers. Presently, the periodic table consists of 118 elements.

Important Concepts

- In the modern periodic table, the elements are listed in order of increasing atomic number. The atomic number is the number of protons in the nucleus of an atom. The number of protons determines how many electrons surround the nucleus, and it is the arrangement of these electrons that determines most of the chemical behaviour of an element.
- The horizontal rows are called 'periods' and the vertical columns are called 'groups'. The number of electrons in a period increases as one moves down the periodic table. Elements in the same group have identical valence electron configurations and consequently behave in a similar fashion chemically. For instance, all the group 18 elements are inert gases.
- The structure of the table shows periodic trends and the organization of the modern periodic table can be used to derive relationships between the various element properties, and also to predict chemical properties and behaviours of undiscovered or newly synthesized elements.
- The properties of elements depend on the number of valence electrons. Elements having the same valence electrons are grouped together. Thus, elements in a group have similar properties.
  - **Valence electrons** are those electrons that reside in the outermost shell surrounding an atomic nucleus. These are the electrons that can be gained or lost during a chemical reaction.
- While the period number indicates the number of shells, the group number indicates the number of valence electrons in the outermost shell. For example, Sodium (Na) resides in Period 3, Group 1, which implies that it has 3 shells and a single electron in its valence shell.

Characteristics of Modern Periodic Table

- **Period**
  - There are seven periods numbered as 1, 2, 3, 4, 5, 6 and 7.
  - The first period is the shortest period and contains only two elements, H and He.
  - The second and third periods contain 8 elements and the fourth and fifth periods contain 18 elements.
  - The sixth period contains 32 elements and is a very long period and the seventh period is incomplete.
- **Group**
  - There are eighteen groups numbered as 1, 2, 3, 4, 5, ... 13, 14, 15, 16, 17, 18.
  - Group 1 is on the extreme left and contains alkali metals.
  - Group 18 is on the extreme right and contains noble gases.
- **Valency**
  - Across a period, valency increases till group 14 and then decreases from group 15 to 18.
  - Down the group, valency remains constant.
- **Metallic Character**
  - In the Modern Periodic Table, a zig-zag line separates metals from non-metals. The borderline elements

11 Acids, Bases and Salts

Many acids and bases are present naturally in our food due to which we experience sour and bitter taste respectively. The reaction between these acids and bases result in the formation of salt and water.

ACIDS

Acids are chemical agents that donate protons, accept electrons and/or release hydrogen (H^+) ions when dissolved in water. The concentration of hydrogen ions determines the level of acidity, more hydrogen ions means higher its acidity and the lower the pH.

Properties of Acids

- Acid is a compound which yields hydrogen ion (H^+), when dissolved in water.
- It tastes sour (e.g. vinegar or lemon juice).
- It turns blue litmus paper to red in colour.
- It corrodes metal surfaces quickly.
- Generally, all acids readily react with metals to release hydrogen gas. For example, zinc reacts with hydrochloric acid to form zinc chloride and hydrogen gas.
- Acids react with limestone ($CaCO_3$) to produce carbon dioxide.

NOTE: Litmus is a natural indicator, turmeric is another such indicator. To illustrate, a stain of curry on a white cloth becomes reddish-brown when soap, which is basic in nature, is scrubbed on it. It turns yellow again when the cloth is washed with plenty of water.

Classification of Acids

On the Basis of Source

- **Organic Acid:** Acid retrieved from organic materials such as plants and animals.
- **Inorganic Acid:** Inorganic acids (mineral acids) are the acids which are derived from one or more inorganic compounds. For example, Carbonic acid (H_2CO_3), Hydrochloric acid (HCl), Phosphoric acid (H_3PO_4), Perchloric acid ($HClO_4$), Nitric acid (HNO_3) & Sulphuric acid (H_2SO_4), etc.

Acids	Source
Acetic Acid	Vinegar
Citric Acid	Citrus fruits such as lime, orange
Formic Acid	Ant stings, Venom of bee
Lactic Acid	Curd
Oleic Acid	Olive oil
Tartaric Acid	Tamarind
Oxalic Acid	Spinach, Tomato
Ascorbic Acid	Amla, Orange

On the Basis of Strength

The strength of an acid depends on its concentration of the hydrogen ions (H^+) present in a solution.

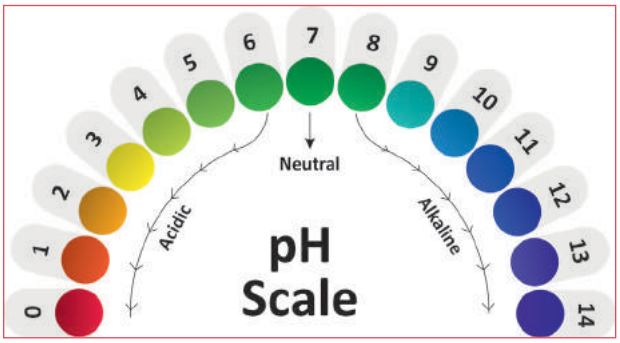
- **Strong Acids**: A greater number of hydrogen ions means greater strength of the acid. An acid which can be dissociated completely or almost completely in water is known as a strong acid. Their aqueous solution conducts the electric current to a large degree and they are considered as strong electrolytes. For example, sulphuric acid (H_2SO_4), nitric acid (HNO_3), hydrochloric acid (HCL), etc.
- **Weak Acids:** Lower number of hydrogen ions means that the acid is weak. An acid that doesn't dissociate completely or dissociates negligibly in water is known as a weak acid. Their aqueous solution conducts the electric current to a small degree and they are considered as weak electrolytes. For example, citric acid ($C_6H_8O_7$), acetic acid (CH_3COOH), etc.

On the Basis of Concentration

The concentration of the acid depends on the number of hydrogen ions that it produces in water.

- **Concentrated Acid:** An aqueous solution that has a relatively high percentage of acid dissolved in it, is called concentrated acid. For example, concentrated hydrochloric acid, concentrated sulphuric acid, concentrated nitric acid, etc.

- The pH of a neutral solution is 7. Values less than 7 on the pH scale represent an acidic solution.
- As the pH value increases from 7 to 14, it represents an increase in OH^- ion concentration in the solution, that is, an increase in the strength of alkali.



Importance of pH in Everyday Life

- Our body works within the pH range of 7.0 to 7.8. Living organisms can survive only in a narrow range of pH change. The optimal pH range for most plants is between 5.5 and 7.0.
- When pH of rain water is less than 5.6, it is called acid rain. When acid rain flows into the rivers, it lowers the pH of the river water. The survival of aquatic life in such rivers becomes difficult.
- Hydrochloric acid helps in digestion without harming the stomach. Sometimes during indigestion too much acid is released which causes pain and irritation. People use bases called antacids which neutralise the excess acid. Magnesium hydroxide (Milk of magnesia), a mild base, is often used for this purpose.
- When the pH of mouth reaches lower than 5.5, the hardest substance in the body i.e. tooth enamel starts getting eroded.
- Plants and animals use acids for self defence. For example, bee-sting leaves an acid which causes pain and irritation. Stinging hair of nettle leaves inject methanoic acid causing burning pain.

SALTS

Salt is an ionic compound made up of two groups of ions which are oppositely charged. The ion with a positive charge is called a cation, and the one with a negative charge is called an anion. The salt must have an overall electrical charge of zero - that is, an equal balance between positive charge and negative charge.

Properties of Salt

- Salts are formed through the process of neutralisation by the reaction of both acid and base.
- The acidic and basic nature of salts depends on the acid and base combined in neutralization reaction.
- If the salt is made up of a strong acid and a strong base then its pH value is neutral i.e. 7 whereas salts of a strong acid and weak base are acidic with a pH value less than 7. Those of a strong base and weak acid are basic in nature, with pH value more than 7.

Common Salts

- **Sodium Chloride (NaCl):** The common salt is an important raw material for manufacture of various materials of daily use, such as sodium hydroxide, baking soda, washing soda, bleaching powder etc.
- **Bleaching Powder [$Ca(ClO)_2$]:** Bleaching powder is produced by the action of chlorine on dry slaked lime [$Ca(OH)_2$]. It is used for:
  - Bleaching cotton and linen in the textile industry.
  - Bleaching wood pulp in paper factories and for bleaching washed clothes in laundry.
  - As an oxidising agent in many chemical industries.
  - For disinfecting drinking water to make it free of germs.
- **Baking Soda** ($NaHCO_3$)**:** Baking Soda also known as sodium hydrogen carbonate is produced using sodium chloride as one of the raw materials. It is used as:
  - Ingredient in antacids. Being alkaline, it neutralises excess acid in the stomach and provides relief.
  - It is also used in soda-acid fire extinguishers.
- **Washing Soda** ($Na_2CO_3.10H_2O$): Also known as Sodium carbonate, it is obtained by heating baking soda; and recrystallisation of this sodium carbonate gives washing soda. It is used:
  - In glass, soap and paper industries.
  - In manufacture of sodium compounds such as borax.
  - As a cleaning agent for domestic purposes.
  - For removing permanent hardness of water.

12 Metals and Non-Metals

An element is a substance that cannot be broken into more simpler substances. Elements are classified into different categories such as metals, non-metals and metalloids.

METALS

A metal is an element that readily forms positive ions (cations) and has metallic bonds. The more reactive a metal, the greater tendency it has to form a positive ion in a chemical reaction.

Properties of Metal

Physical Properties of Metal

- **Ductility:** Metals are ductile as they can be drawn into thin wires. For example, copper, aluminum, gold etc. are drawn into thin wires. Gold is the most ductile metal.
- **Lustre:** Metals have a shining surface which is called metallic lustre. For example, gold, silver etc.
- **Hardness:** Metals are generally hard and remain solid at room temperature. However, alkali metals (lithium, sodium, potassium) are so soft that they can be cut with a knife. Further, mercury is liquid at room temperature
- **Malleability:** Metals are malleable, that is they can be beaten into thin sheets. For example, silver metal is beaten to make silver foil.
- **Conductivity**: Metals are good conductors of heat and electricity. For example, iron or copper. However, lead and mercury are poor conductors of heat.
- **Sonorous**: Metals, except mercury, are sonorous i.e. they produce a sound on striking a hard surface.
- **Melting and Boiling Points:** Metals have high melting and boiling points. For example, iron has a melting point at 1,538 °C. However, gallium and caesium have very low melting points and can melt if kept on the palm.

Chemical Properties of Metals

- **Reaction with Oxygen**
  - Metals combine with oxygen to form metal oxides.

    Metal + Oxygen → Metal oxide.
  - For example, copper combines with oxygen to form copper oxide ($2Cu + O_2 \rightarrow 2CuO$). However, metals such as gold and silver do not react with oxygen.
  - The reactivity in metals with oxygen also varies, for example, metals such as sodium and potassium are kept in kerosene oil as they are very reactive. They catch fire if kept in open.
  - Metal oxides are generally basic in nature. However some metal oxides show both acidic and basic behaviour and are called amphoteric oxides. For example, aluminium oxide (Al_2O_3), zinc oxide (ZnO), lead oxide (PbO) etc.
- **Reaction with Water**
  - Metals react with water (H_20) to produce a metal oxide and hydrogen gas or metal hydroxide. For example, sodium oxide and potassium oxide dissolve in water to produce alkalis NaOH and KOH respectively.
  - However, all metals do not react with water. For example, gold, silver and lead.
  - The reactivity in metals with respect to water also varies; for example, magnesium reacts with hot water while aluminium, iron and zinc react with steam.
- **Reaction with Acid**
  - Metals react with acids to give salt and hydrogen gas. For example,

    Nitric acid + Calcium → Calcium Nitrate + Hydrogen.
  - However all metals do not react in the same manner. **Aqua Regia** is a mixture of two acids, hydrochloric acid and nitric acid that dissolves Gold.
- **Reaction with other Metal Salts**
  - It will follow a displacement reaction, a more reactive metal can displace a less reactive metal from its salt solution. The reaction is often known as metal displacement reaction.
  - **For example,**

    Iron + Copper Sulphate → Iron Sulphate + Copper

13 Cells and Tissues

Cell and tissue are two organizational units of organisms and they perform specific functions in our body.

CELL - THE FUNDAMENTAL UNIT OF LIFE

Characteristics of Cell

- Cell is the basic, structural and functional unit of life.
- All organisms are composed of cells. Every biological activity in living beings is carried out through cells.
- The size of a cell is extremely small (from 1 to 100 micrometer).
- A single cell may constitute a whole organism as in Amoeba, Chlamydomonas, Paramoecium and bacteria. These organisms are called unicellular organisms.
- In multicellular organisms, many cells group together in a single body and assume different functions in it to form various body parts. Examples include some fungi, plants and animals.
- The shape and size of cells are related to the specific function they perform.
  - Some cells like Amoeba have changing shapes.
  - In some cases the cell shape could be fixed and peculiar for a particular type of cell; e.g. nerve cells.

Scientists and Discoveries	
Robert Hooke	Discovered and coined the term "cell" (1665).
Anton Van Leeuwenhoek	Discovered the free living cells or single-cell organisms (1674).
Robert Brown	Discovered nucleus in the cell (1831)
Schleiden, Schwann and Virchow	Developed the **unified cell theory** (1838-55): - All living things are composed of one or more cells. - The cell is the basic unit of life. - New cells arise from pre-existing cells.

- Each such cell has got certain specific components within it known as cell organelles. For example, mitochondria, endoplasmic reticulum etc. Each kind of cell organelle performs a special function.

Components of Cell

Cell Wall

- Plant cells have a rigid outer layer made up of cellulose, known as cell wall. Animal cells are devoid of cell walls.
- It not only gives shape to the cell and protects the cell from mechanical damage and infection, but also helps in cell to cell interaction and provides barriers to undesirable molecules.

Plasma Membrane

- Cell membrane or plasma membrane is the outermost covering of the cell that separates the contents of the cell from its external environment.
- It is selectively permeable and regulates the entry and exit of some materials in and out of the cell.
- The plasma membrane is flexible and is made up of organic molecules called lipids and proteins.

Protoplasm and Cytoplasm

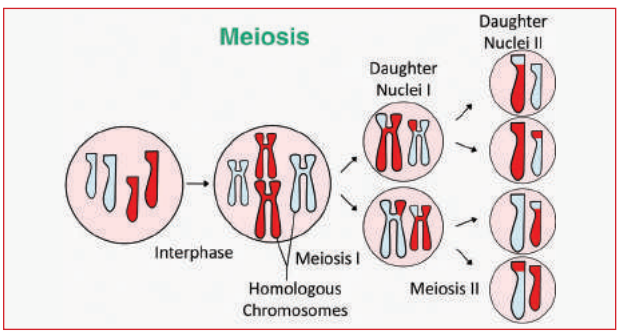
- It is the living part of the cell.
- It is a colloid present within the plasma membrane.
- The part of the protoplasm that lies outside and around the nucleus is called **cytoplasm**.
- Cytoplasm contains various organelles like mitochondria, golgi bodies, ribosomes, etc.

Nucleus

- It is the control center of the cell and plays a central role in cellular reproduction. It is enclosed by a porous membrane known as the nuclear membrane.
- The major components of nucleus include:
  - **Nucleoplasm**: It is part of the protoplasm that lies within the nucleus.
  - **Nucleolus**: It is concerned with producing and assembling the cell's ribosomes. It is rich in protein and ribonucleic acid (RNA).
  - **Chromatin**: It makes up a chromosome that consists of deoxyribonucleic acid (DNA) which carries the cell's genetic instructions.

example, in humans the chromosome number is reduced from 46 to 23 to form sperm and egg cells. However, when the sperm and egg cells unite at conception, each contributes 23 chromosomes so the resulting embryo will have the usual 46.

- It allows genetic variation as each new cell contains a unique set of genetic information.
- During meiosis, a small portion of each chromosome breaks off and reattaches to another chromosome. This process is called crossing over or genetic recombination.

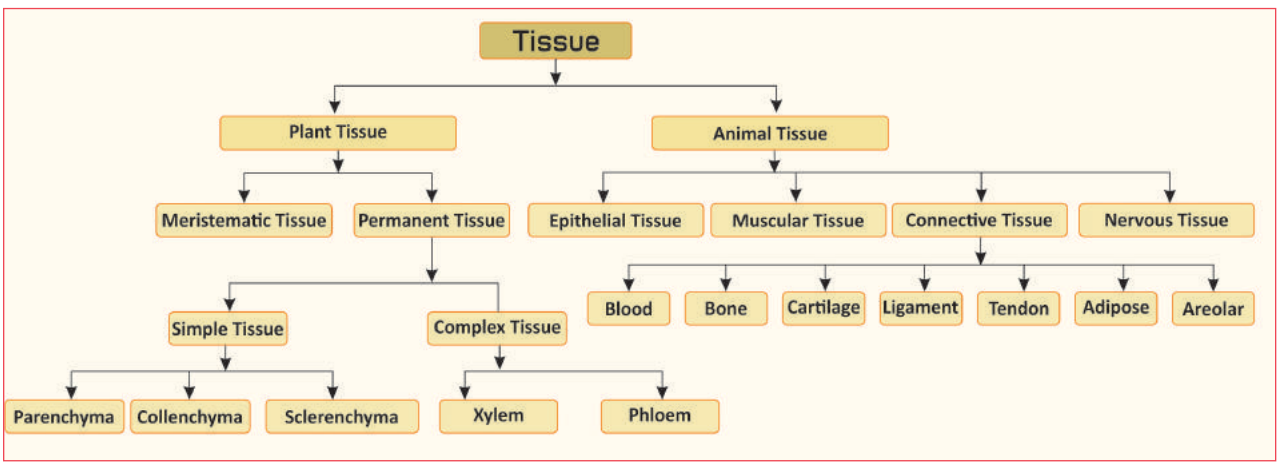


- **Significance of Meiosis**
  - Conservation of specific chromosome number of each species.
  - Increases the **genetic variability** in the population of organisms from one generation to the next. Variations are very important for the process of evolution.

TISSUE - THE CLUSTER OF CELLS

What are Tissues?

- In unicellular organisms, a single cell performs all basic functions. For example, Amoeba. But in multicellular organisms there are millions of cells. A particular function is carried out by a cluster of cells at a definite place in the body. This cluster of cells is called a tissue.
- Groups of similar cells form tissues that share both the structure and function. Different types of tissues can also be arranged together to form organs which in turn form organ systems. Blood, phloem and muscle are all examples of tissues.



Plant Tissue

Meristematic Tissue

- Meristematic tissues have the capability of division and therefore enable the plant to grow and constitute into different parts.
- These tissues are found in the regions of plant growth, such as apical tissues, buds, nodes, side of branches etc.
- Apart from growth, these tissues are also responsible for elongation and thickness in the plant.
- These tissues have live cells, dense cytoplasm, thin cell walls and prominent nuclei. However, they lack vacuoles.

Permanent Tissue

- Permanent tissues are made up of those tissues which are in a mature stage and have lost the power of division.
- These tissues have stopped growing and have attained permanent shape, size and definite function.
- These tissues can be live or dead and they have thick cell walls.
- Permanent tissue can be further divided into:
  - **Simple Permanent Tissue**: Tissues made of similar types of cells.
  - **Complex Permanent Tissue**: Tissues made of more than one type of cell.

14 Classification of Organisms

The diversity amongst the living organisms of earth has evolved over millions of years. This great diversity makes it nearly impossible to study all the living organisms individually. Therefore, classification of living organisms is done based on similarities and some common observable categories known as taxa and the process of classification is termed as taxonomy.

CATEGORIES BASED ON DIFFERENT TAXA

The classification involves a hierarchy of characteristics in which each hierarchy represents a rank or category. There are seven main sub-groups used in any plan of classification.

Kingdom
Phylum (for animals) / **Division** (for plants)
Class
Order
Family
Genus
Species

Kingdom

- All living things are divided into five kingdoms based on how they obtain their food, the types of cells that make up their body, and the number of cells they contain.
- The five kingdoms are Monera, Protista, Fungi, Plantae, and Animalia.

Phylum or Division

- The phylum in the classification of living organisms helps to find some kind of physical similarities among organisms within a kingdom.
- For example, class mammalia belongs to the phylum Chordata. These organisms are vertebrates, meaning they have a backbone. The phylum Arthropoda contains the insects, crustaceans, and spiders. Arthropods have jointed legs, hard exoskeletons, and segmented body parts.
- The Plant Kingdom is broken down into divisions instead of phylum. These divisions contain plants that are similar in physical appearance.

Class

- Mammals, birds, fish, reptiles, along with amphibians represent different classes.
- The major differences among these classes have to do with how organisms bear their young ones. Some animals give birth, while others lay eggs.
- Humans are in the mammal class because they give birth to young ones and feed milk to infants. Other mammals such as horses and whales share this characteristic with humans.

Order

- Order consists of families sharing a set of similar nature or character.
- For example, humans belong to the order Primates and other mammals in this order share common characteristics of a Primate (like opposable thumb, highly intelligent, strong bond between mothers and babies).

Family

- Family is a taxonomic group of one or more genera (plural of genus), especially sharing a common attribute.
- Organisms belonging to the same family would have evolved from the same ancestors and share relatively common characteristics.
- For example, genus Panthera, comprising lion, tiger, and leopard is put along with genus Felis (cats) in the same family and humans belong to the Hominidae family which is also shared with orangutans, gorillas, and chimpanzees.

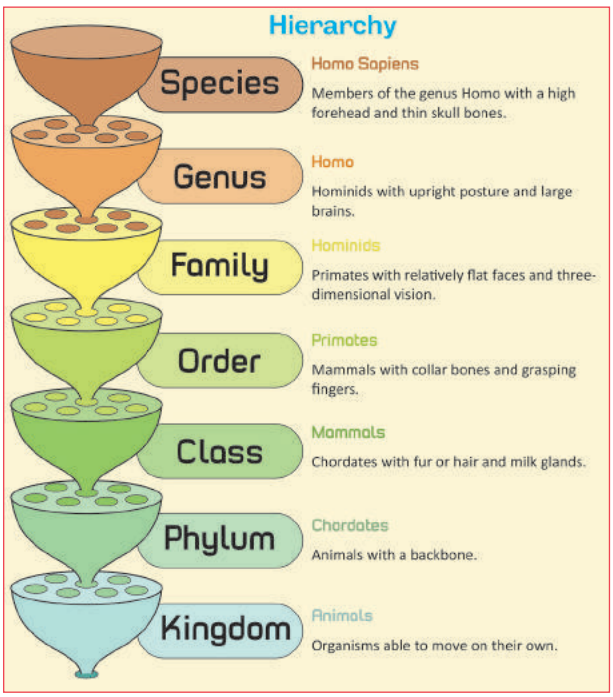
Genus

- Genus comprises a group of related species which has more characters in common in comparison to species of other genus.

- For example, genus Panthera used to denote species such as Lion (*Panthera leo*), Tiger (*Panthera tigris*) and Leopard (*Panthera pardus*) which have several common features among them.
- Humans belong to the genus Homo. We are the only surviving members of this genus. All other members, viz. the Neanderthals are now extinct.

Species

- Species is the basic unit of classification.
- Taxonomic studies consider species as a group of individuals which resemble in their morphological and reproductive characters and interbreed among themselves and produce fertile offspring.
- For example, human beings belong to species sapiens and genus Homo thus *Homo sapiens*.



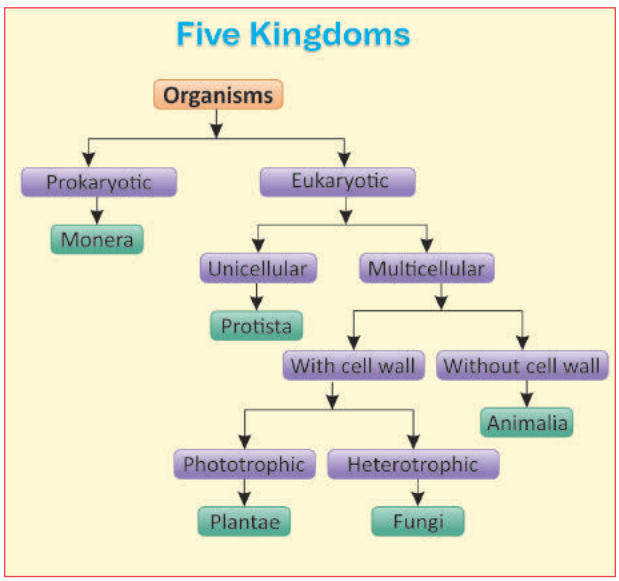
Naming Convention for Living Organisms

- While naming an organism, the whole hierarchy of groups it belongs to is not listed out. Instead, it is limited to writing the name of the genus and species of that particular organism.
- Both these names - genus and species - are used in Latin forms.
- The name of the genus begins with a capital letter while the name of the species begins with a small letter.
- When printed, the scientific name is given in italics while when handwritten, the two have to be underlined separately.

THE FIVE KINGDOMS

R.H. Whittaker, an American taxonomist, divided all the organisms into 5 kingdoms: Monera, Protista, Fungi, Plantae and Animalia. The classification is based on the following criteria:

- Complexity of Cell Structure – Prokaryote to Eukaryote
- Mode of Nutrition – Autotrophs and Heterotrophs
- Body Organization – Unicellular or Multicellular
- Phylogenetic or Evolutionary Relationship



Monera

- This kingdom includes all prokaryotic organisms, i.e., mycoplasma, bacteria, actinomycetes (filamentous bacteria) and cyanobacteria (blue green algae).
- All organisms of this kingdom are microscopic and unicellular.
- They do not possess a true nucleus and also lack membrane bound organelles.
- The mode of nutrition of the organisms can be either by synthesising their own food (autotrophic) or getting it from the environment (heterotrophic).

Protista

- This kingdom includes diatoms and protozoans and are usually found in Aquatic habitats.
- They have a eukaryotic cell organization and are unicellular.

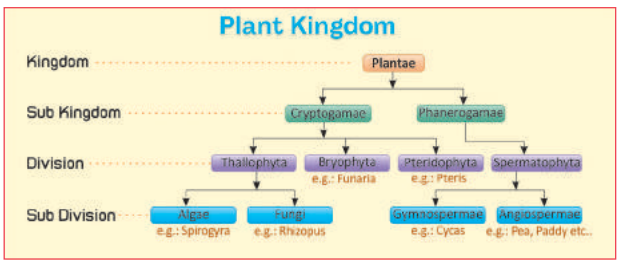
15 Plant Kingdom - Plantae

Plant Kingdom, in simple terms, is a basic group that includes plants. It is one of the five kingdom classification of organisms - the other being Monera, Protista, Fungi and Animalia.

CLASSIFICATION

Plants are multicellular organisms that have cell walls and have an autotrophic mode of nutrition facilitated by presence of chlorophyll (green colour pigment) essential for photosynthesis. All the plants fall under the plant kingdom which can be further classified into subgroups on the basis of:

- **Plant Body**: Whether the body has well-differentiated structures or not.
- **Vascular System**: Whether the plant has a vascular system for transportation of substances or not.
- **Seed Formation**: Whether the plant bears seeds or not; if it does, then whether it is enclosed within fruits or not.

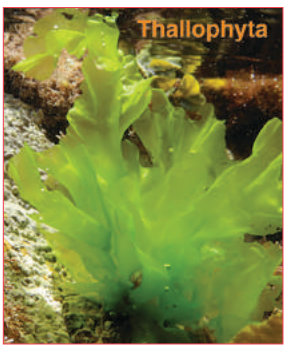


Cryptogams

The word 'crypto' means concealed, secret. Thus, cryptogams have hidden reproductive organs and they do not produce flowers or seeds. They have naked embryos that are called spores. Cryptogams can be further classified into Thallophyta, Bryophyta and Pteridophyta.

Thallophyta

- Plants have undifferentiated bodies i.e. there is no differentiation of root, stem and leaves.
- Vascular systems (Xylem or Phloem) for transportation of water, minerals, and food are also absent.
- These are single-celled, have simple sex organs and there is no embryo formation after fertilization.
- Spirogyra, Chara, Ulothrix, etc. are some of the examples.
- Thallophyta can be further divided as Algae, Fungi and Lichens.



- **Algae:** These are green undifferentiated plants possessing chlorophyll. They prefer moist conditions and can make their own food.
- **Fungi:** These are non-green, undifferentiated plants. They do not have chlorophyll and grow on dead and decaying matter as saprophytes. For example, moulds and mushrooms.
- **Lichens:** Lichens are a group of plants that have symbiotic relation between algae and fungi. They grow on rocks, dead wood etc.

Bryophyta

- These plants are also called **amphibians** of the plant kingdom as these live on land, but for reproduction and fertilization, they need water.
- The plant body is commonly differentiated to form stem and leaf-like structures, however the true root or shoot system is not developed.
- Mosses, liverworts, hornworts are some common examples of Bryophytes.

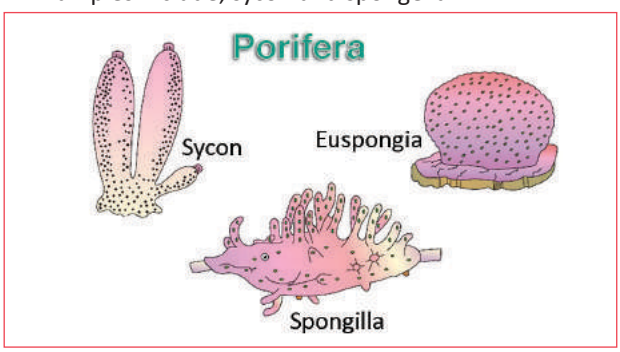
16 Animal Kingdom - Animalia

The eukaryotic, multicellular, heterotrophic organisms lacking a cell wall are included in this kingdom. Further classification of the animal kingdom is based on the extent and type of body design differentiation.

CLASSIFICATION OF THE ANIMAL KINGDOM

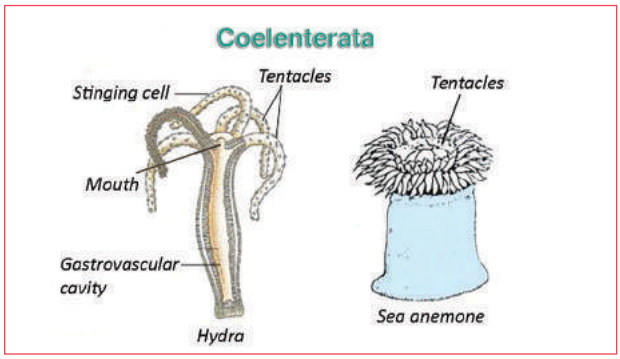
Porifera

- Porifera includes organisms with pores which are commonly called sponges.
- Sponges are primitive multicellular animals and have cellular level of organisation where individual cells instead of tissues perform different functions.
- They are mainly found in marine habitats.
- These are non-motile animals attached to some solid support.
- They have a canal type system in the body for transport of water which brings food and oxygen.
- These animals are covered with a hard outside layer or skeleton.
- The body design involves very minimal differentiation and division into tissues.
- Examples include, sycon and spongella.



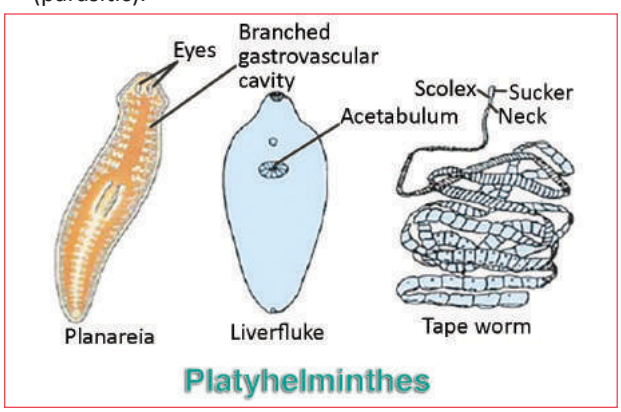
Coelenterata (Cnidaria)

- These animals are aquatic and diploblastic.
- They exhibit more body design differentiation than sponges. There is a cavity in the body.
- Some of these species live in colonies (corals), while others have a solitary like–span (Hydra).
- For example, jellyfish and sea anemones.

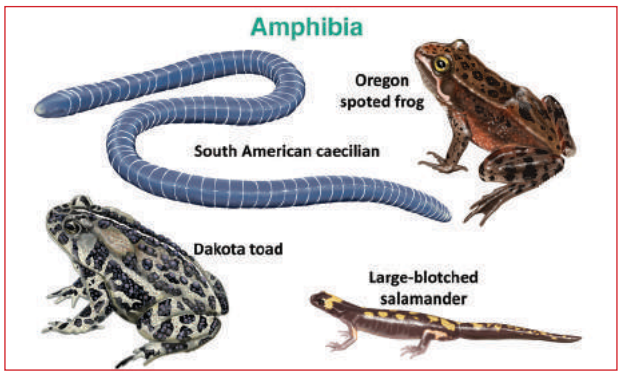


Platyhelminthes

- The organisms in phylum platyhelminthes are triploblastic (three layers of cell) and are bilaterally symmetrical, meaning that the left and the right halves of the body have the same design.
- There is some degree of tissue formation, however, there is no true internal body cavity or coelom, in which well developed organs can be accommodated.
- The body is flattened dorsoventrally (meaning from top to bottom), which is why these animals are called flatworms. They are either free-living or parasitic.
- For example, planarians (free-living) and liverflukes (parasitic).

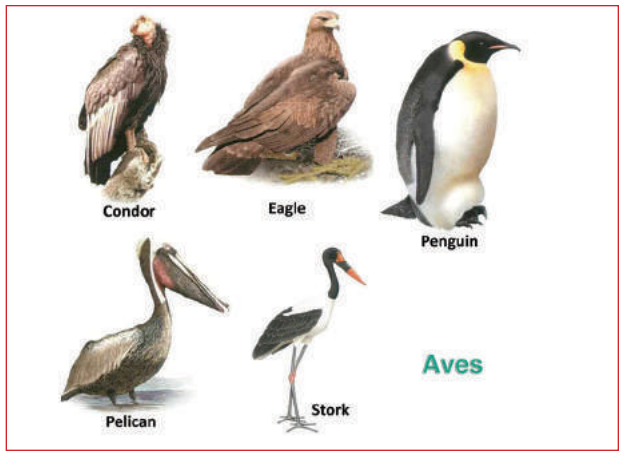


- They lay eggs, and respiration in these animals takes place either through lungs or gills.
- All the animals under this group are cold blooded.
- Examples, frogs, toads and salamanders.



Aves

- These are **warm-blooded** animals and have a four-chambered heart.
- While their forelimbs are modified into wings to fly, hind limbs are adapted for walking, perching, and swimming.
- There is an outside covering of feathers and they lay eggs.
- Respiration takes place through lungs.
- All birds fall in this category.



Mammals

- These are warm-blooded animals with four-chambered hearts.
- They have mammary glands for the production of milk to nourish their young.
- Their skin has hairs as well as sweat and oil glands.
- Most mammals familiar to us produce live young ones.
- However, a few of them, like the platypus and the echidna lay eggs, and some, like kangaroos give birth to very poorly developed young ones.
- For example, elephants, humans, whales, and bats.

PRACTICE QUESTIONS

1. Among the following organisms, which one does not belong to the class of other three?
   (a) Jellyfish
   (b) Whale
   (c) Frog
   (d) Shark
2. Select the correct pair (class-organism)
   (a) Vertebrate- spider
   (b) Mollusca- butterflies
   (c) Echinodermata- earthworms
   (d) Coelenterata- jellyfish
3. Mollusca is characterized by
   (a) Presence of hard exo-skelaton and segmented body
   (b) Absence of exo-skeleton but presence of segmented body
   (c) Exclusively aquatic in nature
   (d) None of the Above
4. Which of the following is not an egg laying Vertebrate?
   (a) Shark
   (b) Tuna
   (c) Whale
   (d) Salamander
5. Which of the following is not a true amphibian animal?
   (a) Tortoise
   (b) Salamander
   (c) Toad
   (d) Frog

Answers				
1. (a)	2. (d)	3. (a)	4. (c)	5. (a)

17 Systems of Human Body

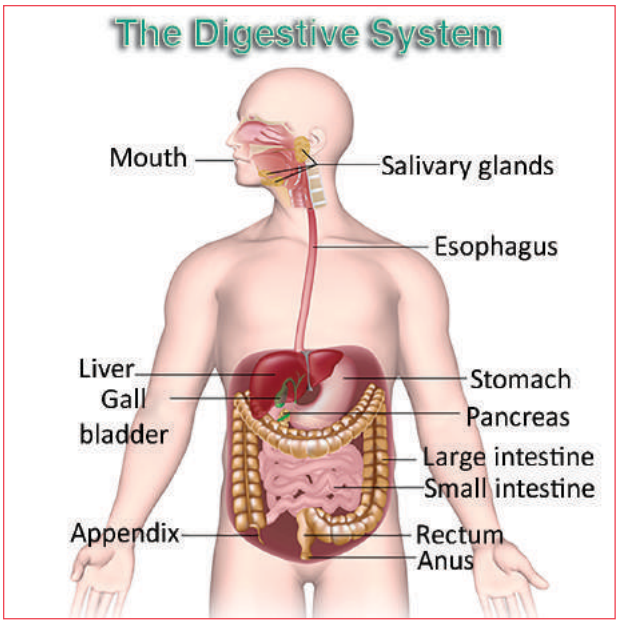
Human body consists of several organs that work together to form an integrated organ system. These systems in the human body carry out specific functions necessary for everyday living and which are necessary to make a complete and functional organism. Some of the major organ systems are circulatory, respiratory, digestive, excretory, nervous and endocrine. Apart from these, the immune, integumentary, skeletal, muscle and reproductive systems are also part of the human body.

DIGESTIVE SYSTEM

The human digestive system is a series of organs that converts food into essential nutrients that are absorbed into the body and removes unused material out of the body.

Processes Involved in Digestive System

- The digestive process is carried through an alimentary canal (gastrointestinal tract), a pathway by which food enters the body and solid wastes are expelled. The gastrointestinal tract includes the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus.
- The liver and pancreas also play a role in the digestive system because they produce digestive juices.
- **The processes involved in the digestive system are:**
  - **Ingestion**: It refers to the intake of food.
  - **Digestion**: It refers to the breakdown of food into small molecules to make it soluble.



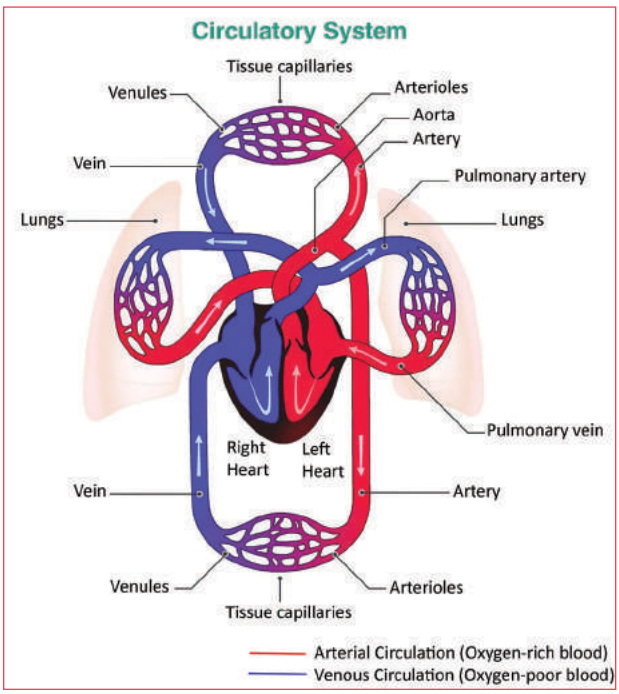
  - **Absorption**: The digested food is absorbed into the blood system by intestinal villi, the finger-like projections that line the small intestine.
  - **Assimilation**: It refers to the passage of the digested food molecules into cells in the body.
  - **Egestion**: Food that cannot be digested or absorbed, leaves the body.

Ingestion → Digestion → Absorption → Assimilation → Egestion

Digestive System: Organs and Functions

Major Organs Involved in Digestive System	Functions
Buccal Cavity/Oral Cavity	❒ The digestive system begins in the mouth, which is connected to the buccal cavity that helps to take the food inside by the process of ingestion. ❒ The buccal cavity or oral cavity includes teeth, tongue, and palate. Palate is the roof of the mouth. It separates the mouth and the nose. ❒ Teeth that are attached to the buccal cavity break down the food into smaller pieces, while the salivary glands in the mouth secrete saliva that breaks down complex starches into simple sugars. ❒ The tongue besides its regular function of talking and detecting different tastes also aids in this digestive function by mixing the saliva with food and helping in swallowing the food.

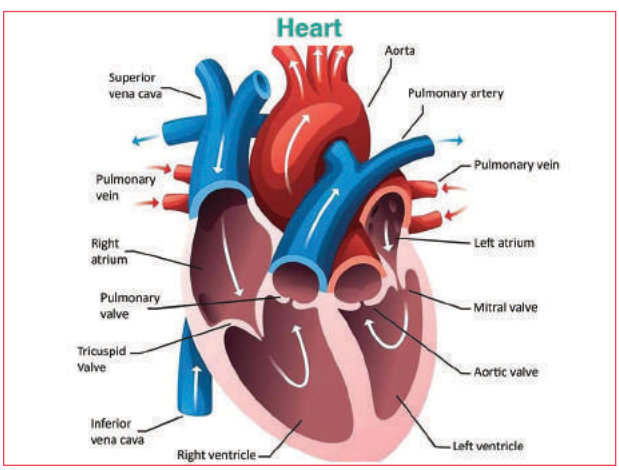
- Through this transport mechanism, it also provides nourishment, helps in fighting diseases, stabilizes temperature and pH, and maintains homeostasis, or the state of balance among all its systems.



Major Components of Circulatory System

Heart

- The heart lies at the center of the circulatory system. It pumps blood through the rest of the network.
- It is a hollow muscle made up of four chambers i.e. the left and right atriums **(receives the blood entering the heart)** make up the two chambers at the top, and the left and right ventricles **(pump blood out of the heart)** form the two chambers at the bottom.



- The chambers are separated by one-way valves to ensure that blood flows in the correct direction.

Arteries

- Arteries carry blood from the heart to various body parts.
- All arteries carry oxygenated blood from the heart except the pulmonary artery.
- Arteries have thick elastic muscular walls; they do not have valves and blood in them flows under high pressure.
- The arteries that carry oxygenated blood to the muscle of the heart are called coronary arteries.

Veins

- Veins are blood vessels that carry blood from the various body parts to the heart.
- All veins carry deoxygenated blood from the various body parts except the pulmonary vein.
- They have thin non-elastic walls and they consist of valves to prevent the backward flow of blood.
- Blood flows under low pressure in the veins.

Pulmonary Artery and Veins

- Like all arteries, the pulmonary artery pumps blood away from the heart. However, it is a blood vessel which delivers deoxygenated blood to the lungs. In the lungs, the blood takes on oxygen and then is pumped back to the heart to be circulated throughout the rest of the body.
- Like all veins, the pulmonary veins carry blood to the heart. However, it transfers oxygenated blood from the lungs to the heart.

Blood

- Blood is a constantly circulating fluid that acts as the transport media of nearly everything within the body.
- It transports hormones, nutrients, oxygen, antibodies, waste materials and other important things needed to keep the body healthy.

Functioning of Circulatory System

First Phase: Cardiovascular System

- Blood circulation starts when the heart relaxes between two heartbeats. The blood flows from both atria into the ventricles, which then expand.
- The following phase is called the ejection period, which is when both ventricles pump the blood into the large arteries.

18 Nutrition

A nutrient is anything that provides nourishment essential for growth and the maintenance of life. This includes macronutrients such as protein, carbohydrate, fat and water and micronutrients such as vitamins, minerals, dietary fibre or roughage. Macronutrients are eaten in large amounts and they provide energy to the body while micronutrients are taken in small doses and are vital to healthy development, disease prevention, and wellbeing.

MACRONUTRIENTS

Carbohydrates

- Carbohydrates are organic compounds made up of carbon, hydrogen and oxygen in the ratio of 1:2:1.
- Carbohydrates are digested and broken down into glucose before entering the bloodstream. Glucose in the blood is taken up into the body's cells and used to produce a fuel molecule called adenosine triphosphate (ATP). Cells can then use ATP to power a variety of metabolic tasks.
- One of the primary functions of carbohydrates is to provide the body with energy and are essential for proper body function.
- The main sources of carbohydrates are cereals like wheat, rice, maize, pasta, bread, fruit, potatoes, sugar rich foods etc.
- On the basis of the number of their chemical structure and the number of forming units, carbohydrates can be classified into simple and complex carbohydrates.

Simple Carbohydrate

- Simple carbohydrates are made from one or two sugar molecules which are broken down quickly by the body to be used as energy.
- They are found naturally in foods such as fruits, milk, and milk products. They are also found in processed and refined sugars such as candy, syrups, and soft drinks.
- Simple carbohydrates can be further classified into monosaccharides and disaccharides.
  - ***Monosaccharides*** are simple sugars made up of one sugar molecule. For example, glucose, fructose, and galactose.
  - ***Disaccharides*** are made up of two sugar molecules bonded together. For example, sucrose (table sugar), lactose, and maltose.

NOTE:

- **Glucose** ($C_6H_{12}O_6$) is the simplest form of carbohydrate. During respiration, glucose breaks into CO_2 and H_2O with the release of energy.
- **Fructose** is the sweetest sugar and is commonly found in fruits.
- **Sucrose** is common table sugar. It is digested rapidly, but has a relatively low glycemic index due to its content of fructose, which has a minimal effect on blood glucose.
  - The glycemic index is a value (zero to 100) assigned to a food based on how slowly or quickly that food after consumption causes increase in blood glucose levels.
- **Lactose** is a disaccharide composed of galactose and glucose. Lactose makes up around 2-8% of milk (by weight).
- **Maltose** is a disaccharide formed from two units of glucose. It is commonly found in barley grains.

Complex Carbohydrate

- Complex carbohydrates also known as polysaccharides are formed by three or more linked sugars with extensive branching. They take time longer than others to break down.
- They are abundantly found in lentils, beans, peanuts, potatoes, peas, corn, whole-grain bread, cereals, etc.
- **Examples of complex carbohydrates include:**
  - **Starch:** Starch is formed by units of glucose and is the storage form of carbohydrates in plants. It is found in bread, potatoes, rice, cereals, etc.
  - **Cellulose**: Cellulose, the principal structural component of plants, is a complex polysaccharide comprising many glucose units linked together.
  - **Glycogen:** Glycogen is called animal starch. It is formed in the liver and muscles of higher animals and is stored as an energy source.

❒ However, it is tougher to shuttle vitamins from food and other sources into our body because cooking, storage, and simple exposure to air can inactivate these more fragile compounds.

Vitamin	Function	Source	Deficiency Diseases
Vitamin-A (Retinol)	Needed for vision, healthy skin and mucous membranes, bone and tooth growth, immune system health	Milk, eggs, cheese, green vegetables, carrots, fish liver oil	Colour blindness, xerophthalmia, night blindness
Vitamin-B1 (Thiamine)	Needed for energy metabolism and nerve function	Whole-grain or enriched breads and cereals, legumes, nuts and seeds	Beri-beri
Vitamin-B2 (Riboflavin)	Needed for energy metabolism, normal vision and skin health	Meat, milk, green vegetables	Cracking of skin and tongue, reddish eye
Vitamin-B3 (Niacin)	Needed for energy metabolism; important for nervous system, digestive system, and skin health	Meat, milk, tomatoes, nuts	Mental retardness, whitening of hair
Vitamin-B5 (Pantothenic acid)	Needed for energy metabolism	Potato, tomato, nuts, leafy vegetables, meat	Fatigue, insomnia, depression
Vitamin-B6 (Pyridoxine)	Needed for protein Metabolism and helps in making red blood cells	Meat, liver, grains	Skin diseases
Vitamin B7 (Biotin)	Needed for energy metabolism	Meat, eggs, liver, milk	Paralysis, hair fall, skin or nail problems
Vitamin B9 (Folic acid)	Needed for making DNA and new cells, especially red blood cells	Pulses, eggs	Anaemia, birth defects
Vitamin B12 (Cyanocobalamin)	Needed for making new cells; important for nerve function	Fish, meat, eggs, and dairy products	Anaemia, neurological impairments, stomach/ intestine problems
Vitamin C (Ascorbic acid)	Needed for protein metabolism; important for healthy immune system; aids in iron absorption	Fruits & vegetables, especially citrus fruits like lemons, oranges, tomato, potato, papayas, mangoes	Scurvy
Vitamin D	Builds healthy bones and required for muscle and nerve functions	Salmon, sunlight	Bone diseases, including rickets
Vitamin E (Tocopherol)	It is an antioxidant and protects cell walls	Leafy vegetables, milk, butter, sprouted wheat	Muscular swelling; sterility (less fertility)
Vitamin K (Phylloquinone)	Needed for proper blood clotting	Green leafy vegetables, cabbage, tomato, milk	Non-clotting of blood

Dietary Fibre or Roughage

Dietary fibre is the indigestible portion of food derived from plants. It cannot be digested by our body's enzymes, but helps food pass from the gut and prevents constipation. Food rich in fibre includes wholemeal bread, bran, cereals, fresh fruit and vegetables.

19 Human Diseases

Disease can be defined as any abnormality or failure of the body to function properly. It may also be defined as a disorder in the physical, physiological, psychological or social state of a person caused due to nutritional deficiency, physiological disorder, genetic disorder, pathogen or any other reason. Diseases can broadly be classified into communicable (or infectious) diseases and non-communicable (or noninfectious) diseases.

COMMUNICABLE DISEASES

- A communicable disease is one which can be transmitted from an infected person to a healthy person.
- It is caused by some biological agents or pathogens, such as viruses, bacteria, protozoans and helminths (worms).
- It spreads from one person to another through contact, water, air, food, or through insecticides, and animals.
- The first symptoms of the disease may appear immediately or after its incubation period (the period between the entry of germs and the appearance of the first symptoms of the disease).

Communicable Disease caused by Bacteria

Disease	Name of Bacteria	Mode of Transmission	Symptoms
Diphtheria	*Corynebacterium diphtheriae*	Through air (droplet infection)	Affects the throat, difficulty in respiration and suffocation
Pertussis (Whooping Cough)	*Bordetella pertussis*	By discharge from the throat of an infected person	Continuous coughing
Tetanus	*Clostridium tetani*	By bacteria in soil through wounds	High fever, spasms in body, locking of jaws
Cholera	*Vibrio cholerae*	Flies, food, faeces, carriers	Continuous stool and vomiting
Typhoid	*Salmonella typhi*	Flies, food	Continuous fever, reddish eruptions on chest & abdomen
Pneumonia	*Streptococcus pneumoniae*	Respiratory secretions from patients, contact with air	High fever, inflammation of lungs, fatigue
Tuberculosis	*Mycobacterium tuberculosis*	Coughing	General weakness, regular fever, coughing, bloodstained sputum
Syphilis	*Treponema pallidum*	Direct contact, sexually transmitted	Ulcer on genitals, lips, tongue, nipple; skin rash; fever
Gonorrhoea	*Neisseria gonorrhoeae*	Sexual contact	Pain in passing urine, discharge of pus, pain
Leprosy	*Mycobacterium leprae*	Long and close contact with the infected person	Spots on the body and nerves are affected
Meningitis	*Streptococcus pneumoniae*	Contact	High fever; inflammation of the meninges, the three membranes that cover the brain and spinal cord

NOTE: Pneumonia can be caused by a wide variety of bacteria, viruses and fungi in the air we breathe.

- Common causes of viral pneumonia are influenza and respiratory syncytial virus (RSV).
- A common cause of bacterial pneumonia is *Streptococcus pneumoniae* (pneumococcus).
- Fungal pneumonia (caused by *Pneumocystis jirovecii*) is most common in people with chronic health problems or weakened immune systems, and in people who are exposed to certain fungi.

Meningitis can be caused by many different pathogens including bacteria, fungi or viruses, but the highest global burden is seen with bacterial meningitis.

20 Genetics

Genetics deals with the inheritance as well as the variation of characters from parents to offspring. While inheritance is the process by which characters are passed on from parents to progeny and it is the basis of heredity, variation is the degree by which progeny differs from their parents.

INHERITANCE

Gregor Mendel also known as the father of genetics, through his work on pea plants, proposed the fundamental laws of inheritance in 1866. Observations made by Mendel:

- Something stably passed down, unchanged, from parent to offspring through the gametes, over successive generations. These things were called 'factors' or genes, as we call today.
- Genes, therefore, are the units of inheritance. They contain the information that is required to express a particular trait in an organism. Genes come in pairs and are inherited as distinct units, one from each parent.
- Genes which code for a pair of contrasting traits are known as alleles i.e. they are slightly different forms of the same gene.

Mendel's Laws of Inheritance

- **The Law of Dominance**: This law states that when two contrasting genes for a character come together in an organism, only one is expressed externally and shows visible effect. It is called dominant and the other gene of the pair which does not express and remains hidden is called recessive.
- **The Law of Independent Assortment**: Genes for different traits are sorted separately from one another so that the inheritance of one trait is not dependent on the inheritance of another.
- **The Law of Segregation**: Each inherited trait is defined by a gene pair. Parental genes are randomly separated to the sex cells so that sex cells contain only one gene of the pair. Offspring therefore inherits one genetic allele from each parent when sex cells unite in fertilization.

NOTE: Genotype & Phenotype: The genes that we have in our body make up our genotype. This genotype then determines our physical appearance, which is called phenotype. In other words, genotype is the genetic makeup and phenotype is the physical appearance.

Sex Determination in Humans

- Many genes are linked to sexes and are called sex-linked genes. The two sexes (male and female) have a set of chromosomes which are common, and another set which is different.
- The chromosomes which are involved in the determination of the sex of an individual are called sex chromosomes. Thus, these are different in two sexes. The other chromosomes are called autosomes. Human beings have 22 pairs of autosomes and one pair of sex chromosomes.
- All the ova formed by females are similar in their chromosome type (22+X). Therefore, females are homogametic. The male gametes or sperm produced by human males are of two types, (22+X) and (22+Y). Human males are, therefore, heterogametic.
- During spermatogenesis among males, two types of gametes are produced. 50% of the total sperm produced carry the X-chromosome and the rest 50% has Y-chromosome. Females, however, produce only one type of ovum with an X-chromosome.
- There is an equal probability of fertilisation of the ovum with the sperm carrying either X or Y chromosome. In case the ovum fertilises with a sperm carrying X-chromosome the zygote develops into a female (XX) and the fertilisation of ovum with Y-chromosome carrying sperm results into a male offspring.

Molecular Basis of Inheritance

Genetic Material

- Genetic material is the medium which is responsible for the transfer of hereditary characteristics from one generation to another.
- For a molecule to act as a genetic material, it must fulfill the following criteria:
  - It should be able to generate its replica (replication).
  - It should be chemically and structurally stable.

21 Space Science

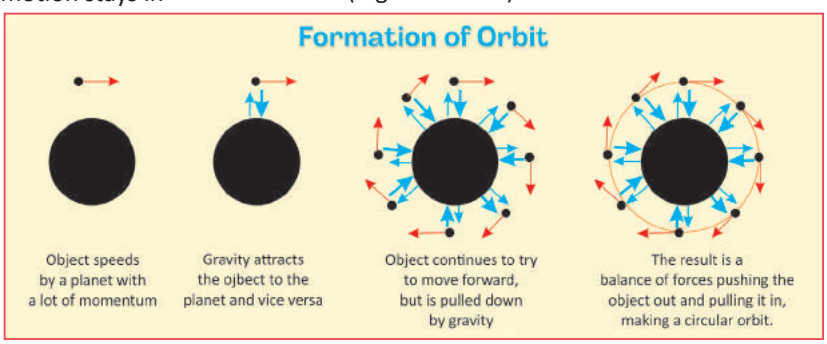
Space science encompasses all of the scientific disciplines that involve space exploration and study of natural phenomena and physical bodies of outer space. It makes us look outwards from our planet, to the stars and beyond.

ORBIT

An orbit is a regular and repeating curved trajectory of an object in space. An object in an orbit is called a Satellite. In our solar system, the Earth rotates around the Sun, as do the other eight planets. They all travel on or near the orbital plane, an imaginary disk-shaped surface in space.

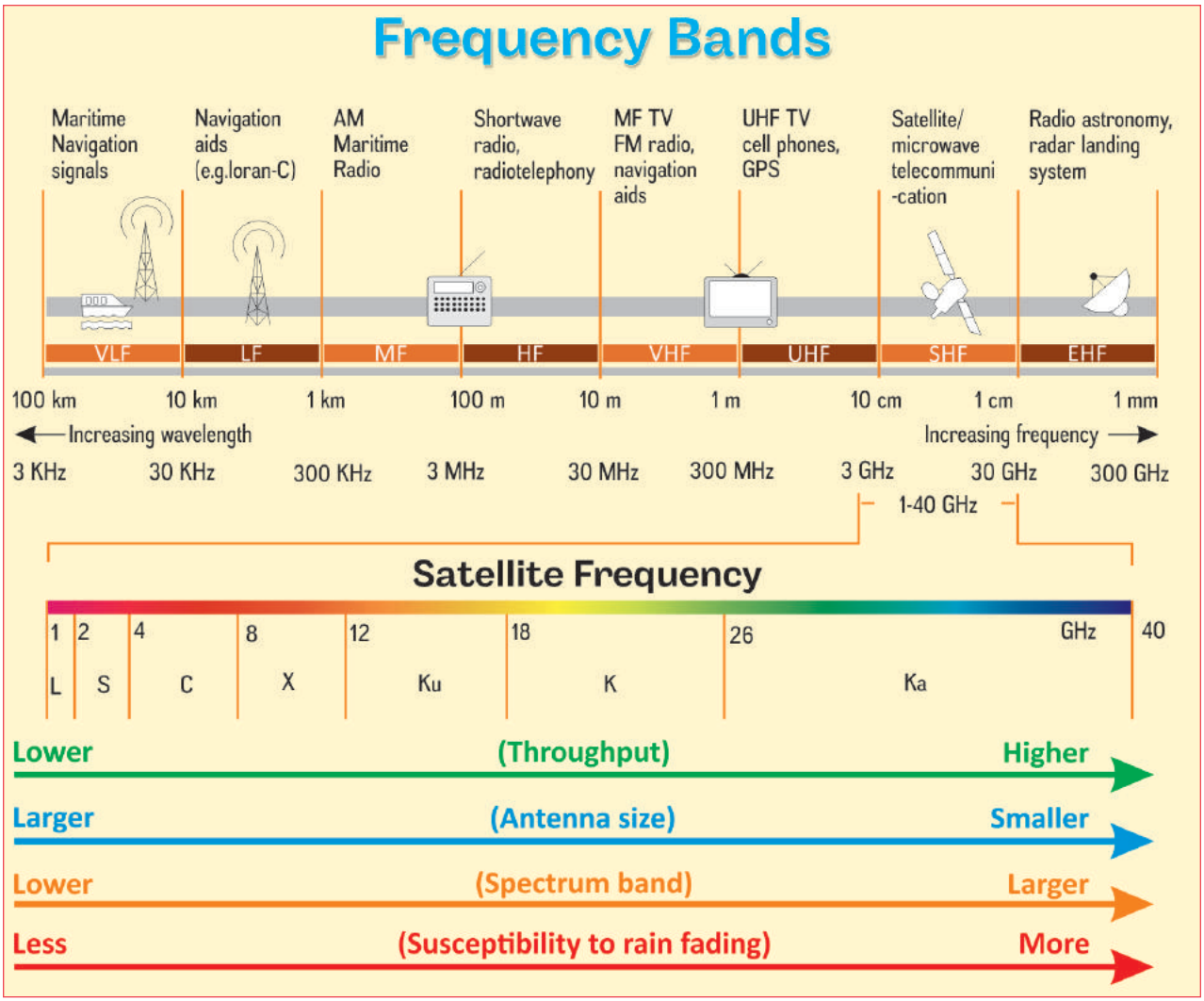
How an Orbit is Formed?

- Orbits are the result of a perfect balance between the forward motion of a body in space, like a planet, and the pull of gravity on it from another body in space, such as a star.
- As per Newton's First Law, an object in motion stays in motion with the same speed and in the same direction unless acted upon by an external force. However, the gravity of another body in space pulls it in.
- When an object is released into space, it follows a straight trajectory, but due to the gravity of a second object like Earth, the object is pulled towards it and the trajectory attains a curved shape.
  - If the momentum of this object is too strong, the object will speed past the other one and not enter in an orbit around the second object.
  - If momentum is much weaker than the pull of gravity, the object will be pulled in and crash.
  - When these forces are balanced, the object is always falling toward the other object.
- **Orbital velocity** is the velocity needed to achieve balance between gravity's pull on the satellite and the inertia of the satellite's motion i.e. the satellite's tendency to keep going. This is approximately 17,000 mph (27,359 kph) at an altitude of 150 miles (242 km).
- Without gravity, the satellite's inertia would carry it off into space. Even with gravity, if the intended satellite goes too fast, it will eventually fly away. On the other hand, if the satellite goes too slowly, gravity will pull it back to Earth.
- The orbital velocity of a satellite also depends on its **altitude** above Earth. Nearer the Earth, faster the required orbital velocity. In other words, satellites that have higher orbits have slower orbital velocities.
- Moreover, the higher the orbit, the longer the satellite can stay in orbit. At lower altitudes, a satellite runs into traces of Earth's atmosphere, which creates drag. The drag causes the orbit to decay until the satellite falls back into the atmosphere and burns up. At higher altitudes, the vacuum of space is nearly complete and there is almost no drag and a satellite can stay for centuries (e.g. the moon).



Shapes of Orbit

- Orbits come in different shapes. Orbits are usually elliptical, which means they are an ellipse, similar to an oval. For the planets, the orbits are almost circular. The orbits of comets have a different shape. They are highly eccentric or squashed. They look more like thin ellipses than circles.
- In a circular orbit, the speed of a satellite is not impacted by gravitational force because the force is always



L band (1–2 GHz)

- This band is used for low Earth orbit satellites, military satellites, and terrestrial wireless connections like GSM mobile phones.
- Due to a wider beam width of L-band, the pointing accuracy of the antenna does not have to be as accurate as the higher bands.
- This band is less affected from rain fading.

S band (2–4 GHz)

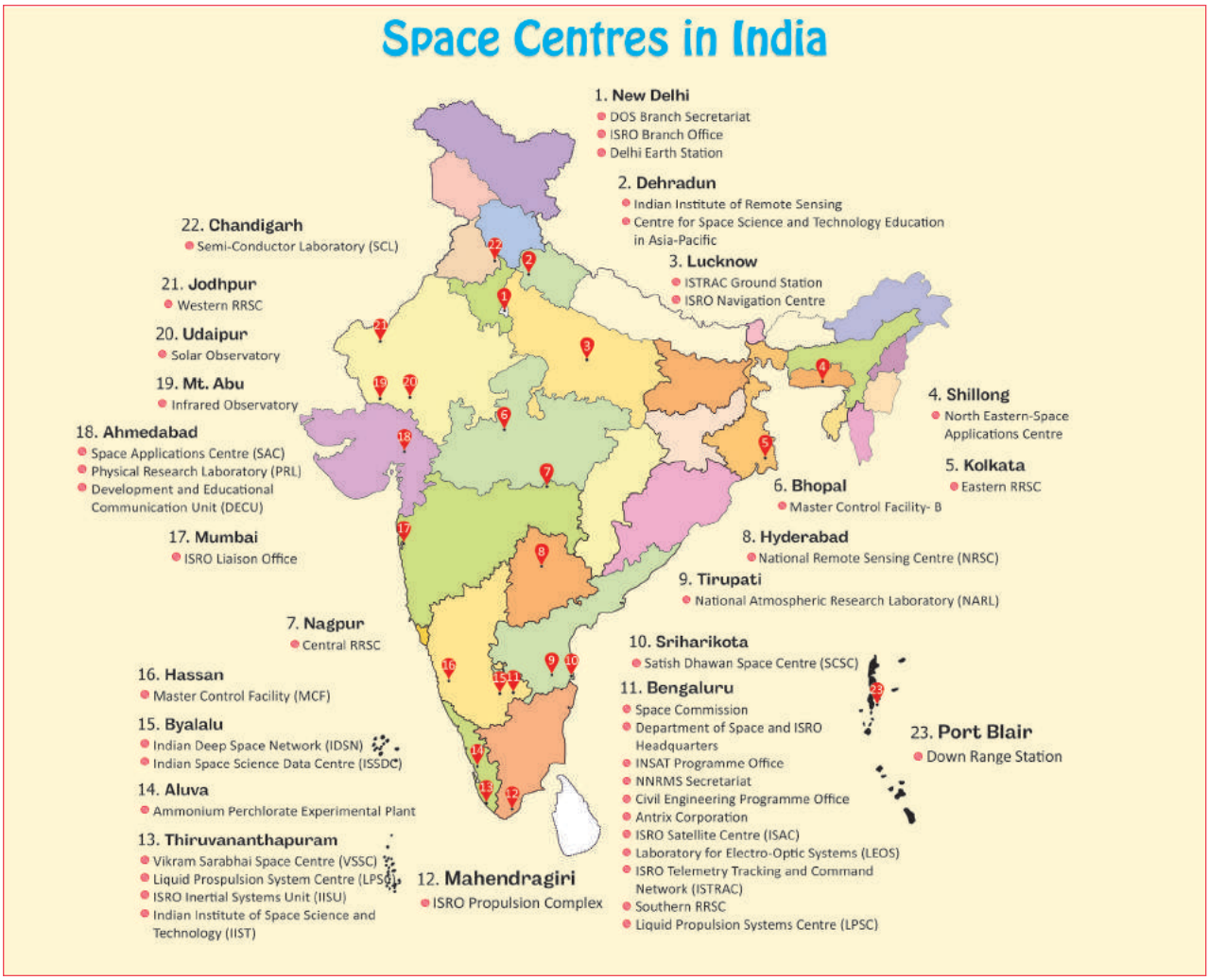
- S-band is used for satellite television, radio broadcasting and mobile broadband services.
- NASA uses this frequency band for communication with the International Space Station.
- It is less susceptible to rain fading compared to Ku and Ka bands.

C band (4–8 GHz)

- It is used for satellite communications, fixed-satellite television and data services (including broadcasting).
- It has wider and global coverage, lower propagation delay, and less attenuation compared to other bands.
- The C-band is preferred over the Ku-band in tropical rainfall areas for satellite communications as it is less susceptible to rain fading than Ku-band.
- This band requires antennas of large size. For example, large white domes (antennas) are mounted on top of the cruise ships and commercial vessels.

X band (8–12 GHz)

- X-band is used in radar applications. It supports detection of smaller particles in a radar by using smaller antennas.



- Space Application Centre (SAC), Ahmedabad: Development of sensors for communication and remote sensing satellites and application aspects of space technology.
- National Remote Sensing Centre (NRSC), Hyderabad: It carries out reception, processing and dissemination of data from remote sensing satellites.

- ISRO is headquartered in Bengaluru. Chairman of ISRO also serves as the Secretary of the Department of Space and the Chairman of Space Commission.

Indian Launch Vehicles

Evolution of Launch Vehicles in India

- Launch Vehicle or Launcher is a multistage rocket powered space transport system, used to send satellites, manned spaceships, space stations or space probes into an orbit.
- The launching of the first sounding rocket from Thumba (Kerala) on 21 November 1963, marked the beginning of the Indian Space Programme. Sounding rockets are used for probing the upper atmospheric regions and for space research.
- They also serve as platforms to test prototypes intended for use in launch vehicles and satellites.
- Development of launch vehicles in India can be categorised in 4 generations:
  - **1st Generation:** Satellite Launch Vehicle (SLV)
  - **2nd Generation:** Augmented Satellite Launch Vehicle (ASLV)
  - **3rd Generation:** Polar Satellite Launch Vehicle (PSLV)
  - **4th Generation:** Geosynchronous Satellite Launch Vehicle (GSLV)

22 Sources of Energy

Modern civilization is possible because people have learned how to change energy from one form to another and then use it to do work.

ENERGY

Energy is defined as the ability to do work. It comes in different forms including thermal (heat), radiant (light), kinetic (motion), electrical, chemical, nuclear etc.

Key Concepts

Sources of Energy

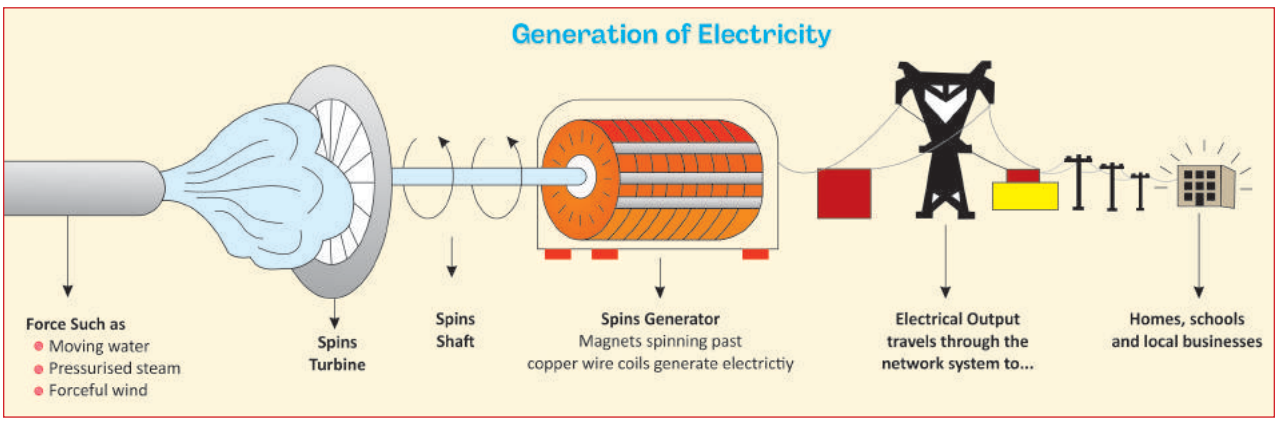
- The source of energy is divided into two groups on the basis of source and accessibility:
  - **Renewable energy:** It can be easily or constantly replenished like solar energy, wind energy, etc.
  - **Non-renewable energy:** It is available in limited amounts and takes a long time to replenish like petroleum, coal, natural gas, etc.

Law of Conservation of Energy

- The Law of Conservation of Energy states that energy can neither be created nor destroyed; energy can only be transformed from one form to another.
- For example, turning on a light bulb would seem to produce energy; however, it is electrical energy that is converted to light energy.

Turbine and Electric Generator

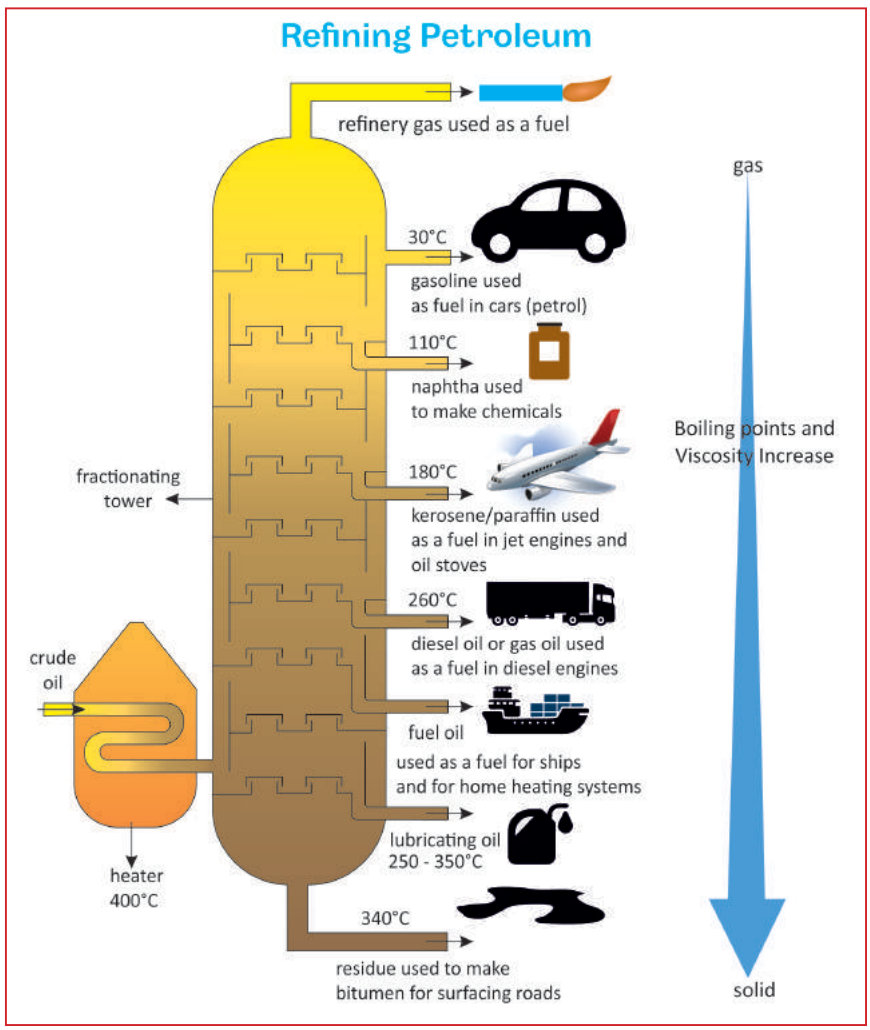
- Steam is pushed into the turbine through nozzles, which spins the blades mounted on a shaft. In scientific terms, energy created by steam is converted to mechanical energy which rotates the blades of a turbine.
- A generator can be described as a machine by which mechanical energy is transformed into electrical energy. The coiled wires used in a generator spin inside a magnetic field which causes an electric current to flow through the wire.
- Electric generators work on the principle of electromagnetic induction. A conductor coil (a copper coil tightly wound onto a metal core) is rotated rapidly between the poles of a horseshoe type magnet. The conductor coil is connected to a shaft of a mechanical energy source (turbine).
- Electromagnetic induction is a current produced because of voltage production (electromotive force) due to a changing magnetic field. This either happens when a conductor is set in a moving magnetic field or when a conductor is always moving in a stationary magnetic field.
- When the coil rotates, it cuts the magnetic field which lies between the two poles of the magnet. The magnetic field will interfere with the electrons in the conductor to induce a flow of electric current inside it.



- **Cyclic Steam Stimulation (CSS)**
  - Under this method, steam is pumped down in a vertical well to soak or liquefy the bitumen (dense, highly viscous, petroleum-based hydrocarbon), which is then pumped to the surface through the same well.
- **Toe-to-Heel Air Injection (THAI)**
  - THAI is the newest heavy oil extraction process used in horizontal wells.
  - Under this method, air is injected into a well at the "toe", the farthest end from the surface bore hole.
  - With air in the reservoir, a fire can be ignited, which will burn the heavier oil components and even upgrade some bitumen into lighter oil.
  - Because the air was injected at the toe, the fire burns toward the open end of the well, hence the name toe-to-heel.
  - As the amount of oxygen in the well is limited to that which is introduced, the fire is self-limiting, burning out when all the injected oxygen has been used.
- **Oil Rigs**
  - On land, oil can be drilled with an apparatus called an oil rig or drilling rig - a structure with equipment for drilling an oil well.
  - The term "rig" generally refers to the complex equipment that is used to penetrate the surface of the Earth's crust.
- **Offshore Drilling**
  - Drilling offshore usually uses the same drilling techniques as onshore, but requires a massive structure (called oil platforms).
  - The drilling structures are so designed that they could withstand difficult conditions such as freezing sea water temperatures and strong sea bed currents with pressures enough to crack even high tensile metals.
  - The type of oil rig (a structure with drilling equipment) used in offshore drilling depends on the depth of location, the type of oil, and prevailing conditions.

Refining Petroleum

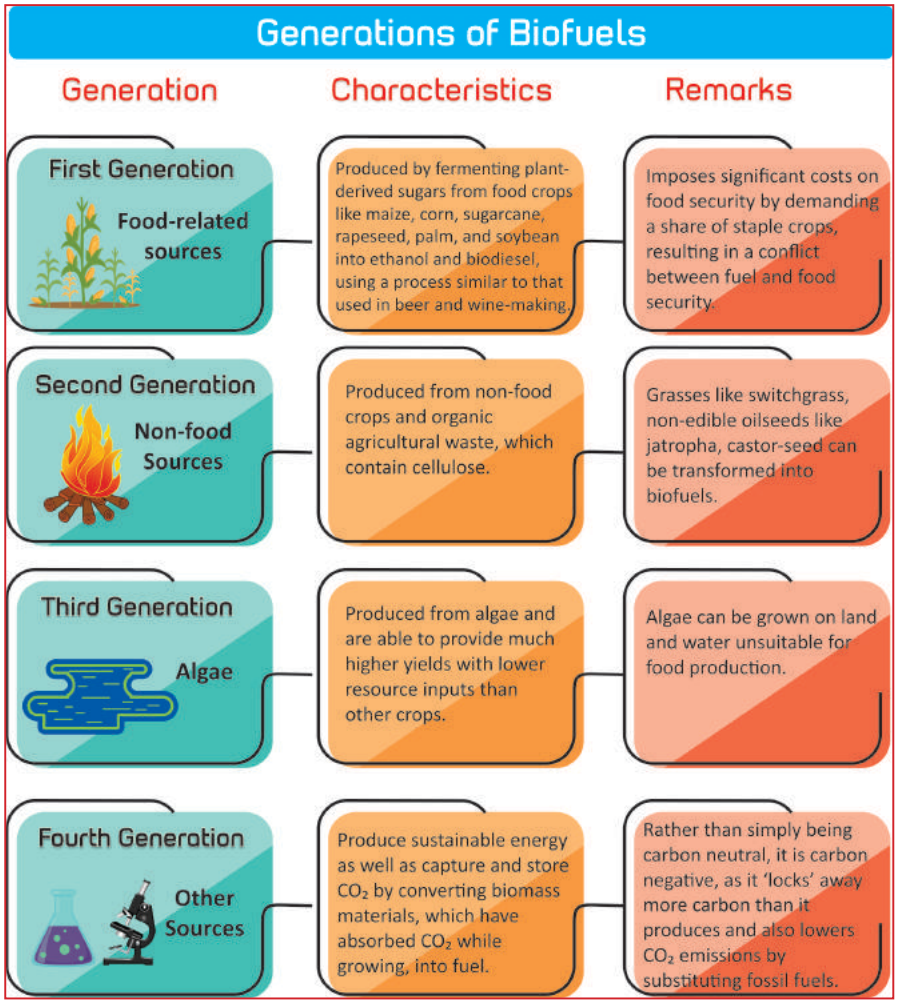
- In addition to hydrocarbons, petroleum may contain impurities such as sand, water, sulfur compounds, oxygen, nitrogen, carbon dioxide and traces of metals.
- Refining petroleum is the process of converting crude oil into petroleum products, such as gasoline (petrol), kerosene, lubricating oil, etc.
- Refining is done by heating the crude oil in a distillation tower that has trays and temperatures set at different levels.
- Hydrocarbons in crude oil have different boiling temperatures. When the oil is heated, vapors from the different elements rise to different levels of the tower before condensing back into a liquid on the tiered trays.



- This biofuel not only captures and stores carbon dioxide from the atmosphere but it also reduces CO_2 emissions by replacing fossil fuels.

Major Types of Biofuels

- **Bioethanol**
  - Bio-ethanol is a renewable fuel produced by the fermentation of grain (1st generation) or from advanced technology by using agricultural waste, wood chips, and waste paper (2nd generation).
  - When mixed with petrol, it improves the combustion performance and lowers the emissions of carbon monoxide and sulphur oxide.
  - India's National Biofuel Policy 2018 has stipulated an ethanol blending target of 10% by 2022 and 20% by 2030. India's average blending of ethanol in petrol was 5.8% in 2019.
- **Biodiesel**
  - Biodiesel is a renewable fuel derived from vegetable oils like soybean oil, palm oil, vegetable waste oils, and animal fats.
  - Biodiesel is produced through a chemical process called transesterification.
  - India's National Bio-fuel Policy 2018 has stipulated a biodiesel blending target of 5% by 2030.



Waste to Energy

Waste to Energy (WTE) or energy-from-waste is the process of generating energy in the form of electricity and/or heat through a number of processes such as incineration, gasification, pyrolysis, etc. It is a vital part of a sustainable waste management chain and is fully complementary to recycling.

Incineration

- Incineration is the process of direct controlled burning of waste in the presence of oxygen at temperatures of about 800°C and above, liberating heat energy, gases and inert ash.
- This controlled combustion of garbage reduces it to incombustible matter such as ash and waste gas.
- In this process, net energy yield depends upon the density and composition of the waste.
- Incineration, also called thermal treatment of waste, reduces the mass of the waste by 95%.
- The process is often considered as harmful to the environment as it releases harmful gases.

Pyrolysis

- Pyrolysis is the thermo-chemical decomposition of organic material, at elevated temperatures (>400°C) in the absence of oxygen.
- The process involves the simultaneous change of chemical composition and physical phase that is irreversible.

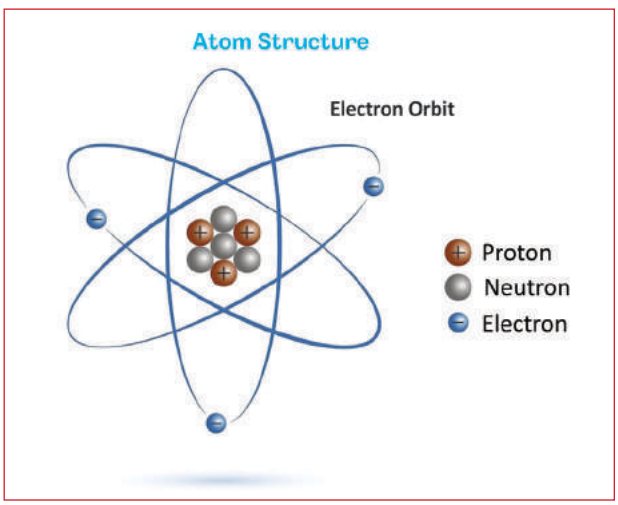
23 Nuclear Technology

The energy released due to the change in nucleus of an atom is termed as nuclear energy and the technology that manipulates such changes in the nucleus of radioactive elements and transforms into energy is known as nuclear technology. The energy released due to the changes in the nucleus of atoms is normally caused by either nuclear fusion or nuclear fission.

KEY CONCEPTS

Atom

- An atom is the fundamental constituent of matter, which is made up of three subatomic particles i.e. protons, neutrons, and electrons.
- The proton with a positive electric charge and neutron with no charge forms the nucleus of an atom and the electron with negative charge revolves around the nucleus.



Radioactive Decay

- Radioactive decay is the spontaneous breakdown of an atomic nucleus resulting in the release of energy from the nucleus. This emission of energy is in the form of ionizing radiation which can include alpha rays, beta rays and/or gamma rays.
- Some elements in the periodic table take stable forms and some others take unstable forms. Unstable forms emit ionizing radiation and are radioactive. Elements that emit ionizing radiation are called radionuclides or radioactive isotopes (radioisotopes).
- When it decays, a radionuclide transforms into a different atom - a decay product. The atoms keep transforming to new decay products until they reach a stable state and are no longer radioactive.

Radiation and its Types

- Radiation is a form of energy given off by matter in the form of rays or high-speed particles. It emanates from unstable atoms that undergo radioactive decay. It can also be produced by machines.
- There are two kinds of radiation depending on the energy of the radiated particles: non-ionizing radiation and ionizing radiation.
- Non-ionizing radiation has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons from atoms. For example, radio waves, visible light and microwaves.
- Ionizing radiation is more powerful. It has so much energy that it can knock electrons out of atoms. It can affect the atoms in living things, so it poses a health risk by damaging tissue. Ionizing radiation comes from x-ray machines, cosmic particles and radioactive elements (due to radioactive decay).

Types of Ionising Radiation

Alpha rays (∝)

- Alpha particles, also called alpha rays or alpha radiation are made up of 2 protons and 2 neutrons from the atom's nucleus.
- Alpha particles come from the decay of the heaviest radioactive elements, such as uranium, radium and polonium.
- Alpha particles are very energetic, yet due to being so heavy they use up their energy over short distances and fail to travel very far from the atom.

24 Biotechnology and Applications

Biotechnology is the technology based on biology that utilizes living organisms and biological systems or processes to develop different products.

BIOTECHNOLOGY

The Convention on Biological Diversity (CBD) defines biotechnology as any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.

Classification of Biotechnology

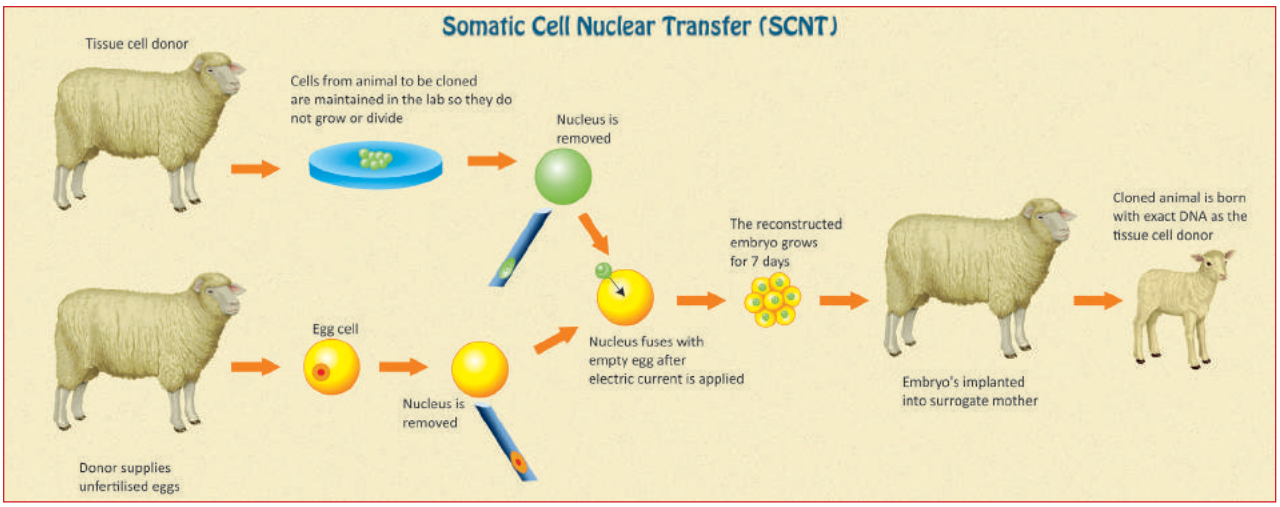
- **Green Biotechnology**: It is the use of genetically altered plants or animals to produce more environment friendly farming solutions as an alternative to traditional agriculture, horticulture and animal breeding processes. It is used to make plants more resistant to pests and diseases, and tolerant to environmental stresses such as drought, flood etc.
- **Red Biotechnology**: It refers to the use of biotechnology for the improvement of medical processes and development of pharmaceutical products like antibiotics, vaccines, etc.
- **White Biotechnology**: Also known as industrial biotechnology, it relates to adaptation and modification of the biological organisms and processes for the production of goods and services. It makes the use of enzymes and microorganisms for the production of value-added chemicals and products.
- **Blue Biotechnology**: Also known as marine biotechnology, it comprises the efforts that involve the marine resources, either as the source or target of biotechnology applications.
- **Grey Biotechnology:** It relates to the development, use and regulation of the biochemical potential of microorganisms and plants for maintenance of biodiversity, environmental applications and removal of pollutants.
- **Black Biotechnology:** It is associated with biological weapons or bioterrorism and biowarfare using microorganisms, and toxins to cause diseases and death in humans, animals, and crops.

Key Concepts

Genetic Material

- Genetic material is the medium which is responsible for the transfer of hereditary characteristics from one generation to another. For a molecule to act as a genetic material, it must fulfill the following criteria:
  - It should be able to generate its replica (Replication).
  - It should be chemically and structurally stable.
  - It should provide the scope for slow changes (mutation) that are required for evolution.
- DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) are the two types of nucleic acids found in living systems. DNA acts as the genetic material in most of the organisms. RNA, though also acts as a genetic material in some viruses, mostly functions as a messenger.
- DNA is referred to as universal genetic material. It is a long polymer of deoxyribonucleotides. The length of DNA is usually defined as the number of base pairs (pairs of nucleotides) present in it. DNA has a Double Helical structure.
- Each nucleotide has three parts: a sugar molecule, a phosphate molecule, and a structure called a nitrogenous base. The nitrogenous base is the part of the nucleotide that carries genetic information. The bases found in DNA come in four varieties: adenine, cytosine, guanine, and thymine - often abbreviated as A, C, G, and T.
- The order of the nucleotide bases arranged in the polynucleotide chain determines the genetic instructions. A gene is a sequence stretch of nucleotides which encodes a specific protein. Humans have thousands of genes in their total DNA molecules. The entire nuclear DNA is called the genome of an organism.

- **Somatic Cell Nuclear Transfer (SCNT)**
  - Somatic cell nuclear transfer (SCNT) is a laboratory technique to create ovum with a donor nucleus.
  - It involves transferring the nucleus of a somatic cell (a body cell other than a sperm or egg cell), which includes its DNA from the organism selected to be cloned, into an egg whose nucleus is removed.
  - After being inserted into the egg, the somatic cell nucleus is reprogrammed by the host cell. The egg after fertilization starts splitting and begins to form identical embryos which is then transferred or implanted into a surrogate mother.
  - Somatic cloning may be used to generate multiple copies of genetically elite farm animals to preserve endangered species, for regulation of development, for protection from genetic diseases etc.
- Cloning helps to produce the best grade of livestock animals with special qualities for efficient production of high-quality milk or meat.
- In India, the cloning of buffalo is well established and clones of the Murrah, the best dairy breed of buffalo, have been produced.



APPLICATIONS OF BIOTECHNOLOGY

In the Field of Agriculture

Bt Cotton

- Bt Cotton is a transgenic plant which is tolerant of bollworm, a serious pest in the cotton growing areas.
- It was created by genetically altering the cotton genome with the gene of the bacterium *Bacillus thuringiensis*, a soil-dwelling bacteria.
- This transgene inserted into the plant's genome produces toxin crystals that the plant would not normally produce, which when ingested by a certain population of organisms, dissolves the gut lining, leading to the organism's death.
- It, thus, eliminated the need for chemical pesticides and improved the overall productivity. However, in 2015, Bt cotton which was supposed to be pests resistant, was affected by whitefly attack in Punjab.
- Bt Cotton was developed by researchers at Monsanto (US) and is the first and only transgenic crop approved by the Genetic Engineering Approval Committee (GEAC) for commercial cultivation in India.

Bt Brinjal

- Bt Brinjal is a transgenic brinjal created by inserting a gene Cry1Ac from the soil bacterium *Bacillus thuringiensis* into Brinjal to make it pest resistant.
- It gives Bt brinjal resistance against pests like the moth species shoot borer and fruit borer.
- Bt Brinjal is also the first Genetically Modified (GM) food crop in India which is developed by Maharashtra Hybrid Seed Company Ltd. (Mahyco), a leading Indian seed company, in collaboration with American multinational, Monsanto.
- The Genetic Engineering Appraisal Committee (GEAC) had cleared the Bt Brinjal for commercial cultivation, however the Ministry of Environment, Forest and Climate Change has put a moratorium on its release in 2010, waiting for more public consultations across the country.

25 Defence Technology

The Ministry of Defence (MoD) provides the policy framework and wherewithal to the Armed forces to discharge their responsibilities towards defence of the country. Under the MoD, the Defence Research and Development Organization or DRDO was set up in 1958 as a supreme body for defence research and development programmes. With a responsibility of developing India's defense technology, DRDO has provided the country with an array of tactical battlefield systems.

MISSILE SYSTEM

A missile is a self-propelled guided unmanned rocket designed to carry the payload (warhead) to a designated point with the aim of destroying targets.

Components of a Missile

- Sir Isaac Newton stated in his Third Law of Motion that "every action is accompanied by an equal and opposite reaction". A rocket operates on this principle. The continuous ejection of a stream of hot gases in one direction causes a steady motion of the rocket in the opposite direction.
- A rocket is called a launch vehicle when it is used to launch a satellite or other payload into orbit or deep space. A rocket becomes a missile when the payload is a warhead and it is used as a weapon.
- The main components of a missile are the warhead, the means of propulsion, a guidance system and aerodynamic features like air wings and fins.

Warhead

- The basic function of any weapon is to deliver a destructive force on an enemy target - an objective achieved by the missile's warhead.
- In simple terms, a warhead can be thought of as a bomb. It is the explosive or toxic material that is delivered by a missile or torpedo.
- Warheads can be conventional or nuclear.
  - **Conventional:** Explosives such as gunpowder store significant energy within their molecular bonds. This energy can be released by a trigger, such as an electric spark.
  - **Nuclear:** It comprises radioactive materials which when triggered exhibits huge radioactivity. A runaway nuclear fission (fission bomb) or nuclear fusion (Thermonuclear weapon) reaction causes immense energy release. These are generally designed for mass annihilation.
- The warhead is the primary element of the weapon; it accomplishes the desired end result - effective damage to the target.

Propulsion

- The propulsion system in a missile is required to achieve terminal conditions like range, speed and warhead carrying capability.
- Most current long-range missiles consist of two or more rockets or stages that are stacked on top of each other. The first stage is the one that lifts the missile off the launch pad. When the first stage runs out of propellant or has reached the desired altitude and velocity, its rocket engine is turned off and it is separated so that the subsequent stages do not have to propel unnecessary mass.
- There are three categories of chemical propellants for rocket engines: liquid propellant, solid propellant, and hybrid propellant. The propellant for a chemical rocket engine usually consists of a fuel and an oxidizer.
- Liquid propellant rocket engines burn two separately stored liquid chemicals, a fuel and an oxidizer, to produce thrust. Advantages of liquid propellant rockets include the highest energy per unit of fuel mass, variable thrust, and a restart capability. Disadvantages include requirements for complex storage containers and precise fuel and oxidizer injection metering.
- Solid propellant rockets are basically combustion chamber tubes packed with a propellant that contains

AIRCRAFTS AND HELICOPTERS

Fighter Jets

Tejas

- Tejas (meaning radiant) is India's first indigenously designed and developed 4th generation Light Combat Aircraft (LCA).
- It is single seat, single engine supersonic, lightweight, all weather, multi-role, air superiority fighter designed for air-to-air, air-to-ground and air-to-sea combat roles.
- It is the smallest and lightest Multi-Role Supersonic Fighter Aircraft of its class and is fitted with a Radar Warner and Jammer equipment. For this it uses Unified Electronic Warfare Technology.
- Tejas is capable of flying non-stop to destinations over 1700 km away.

Rafale

- Rafale is a twin-engine Medium Multi-Role Combat Aircraft (MMRCA) manufactured by Dassault Aviation, a French firm.
- Rafale fighter jets are capable of performing a wide range of combat roles including air supremacy, aerial reconnaissance, ground support, in-depth strike, anti-ship strike and nuclear deterrence among others.
- It is a long range weapon carrier and has a decisive edge with better sensors and weapons.

Sukhoi SU -30MKI

- It is the most-advanced multi-role fighter in the IAF capable of conducting air to air and air to ground strikes.
- The Sukhoi Su-30MKI is a twinjet multi-role air superiority fighter developed by Russia's Sukhoi and built under licence by India's Hindustan Aeronautics Limited for the Indian Air Force.
- It can fly upto 1,500 km without having to refuel mid-air.
- These fighter jets are equipped with the air variant of the BrahMos cruise missile.

Mirage 2000

The Mirage 2000 is a multi-role, single-engine fourth-generation jet fighter manufactured by Dassault Aviation of France. Mirage 2000 can carry laser guided bombs and air-to-air and air-to-surface missiles.

Mig-29

- The Mikoyan MiG-29 is multi-role fighter aircraft of the Indian Air Force designed in the Soviet Union.

Jet Fighter Generations

1st Gen Jet fighters (1940s-1950s)
Used turbojets for propulsion instead of earlier piston-driven aircraft, e.g. Messerschmitt-Me262, Mystere-IV, MiG-15 etc.

2nd Gen fighters (1950s-196s)
Integrated new technologies, swept or delta wings and guided missiles for BVR (beyond visual range) combat, e.g. MiG-21, Sukhoi-7, F-104 Starfighter etc.

3rd Gen fighters (1960-1970s)
Inducted improved radars, missiles and avionics, e.g. Mirage-III, MiG-25, F-4 Phantom-II etc.

4th Gen fighters (1970s-1990s)
Incorporated fly-by-wire controls and multi-role capabilities, e.g. Mirage-2000, MiG-29, Sukhoi-27, Tornado, F-16 Fighting Falcon etc.

4.5 Gen fighters (1990s-onwards)
Use more advanced avionics and electronics, with some stealth, e.g. (Sukhoi-30MKI, Gripen, Eurofighter Typhoon, F-16F Desert Falcon, F/A-18 Super Hornet etc.

5th Gen fighters
Multi-role or swing-role but also incorporate advanced stealth technology, composite materials, supercruise (achieve supersonic cruise speeds without use of afterburners), thrust-vectoring and multi-sensor integrated

avionics. Only fully-operational 5th gen fighter at present is the American F/A-22 'Raptor'.
Two FGFA in pipeline are American F-35 'Lightning-II' Joint strike Fighter and Russian Sukhoi T-50 or PAK-FA.

26 Robotics and Automation

Robotics is the intersection of science, engineering and technology that produces machines, called robots, that substitute for (or replicate) human actions.

ROBOTICS

Robotics technology is dedicated to the design, construction and use of mechanical robots and other intelligent machines.

Technology behind Robotics

Controller Technology

- Digital computer that includes both the hardware and the software, acts as a controller to the robot.
- This controller functions like the human brain. With the help of a controller, the robot is able to carry out the assigned tasks.
- It directs and controls the movement of the manipulator and the end-effector.

Manipulator and End-effector

- Manipulator is a series of sliding or jointed segments put together to form an arm-like structure in a robot. It is capable of automatically moving objects within a given number of degrees of freedom.
- The base of the manipulator is fixed to base support of the robot and at its other free end is attached a structure like palm, fingers, called end-effector.
- Controllers of a robot cause manipulators and end-effectors to perform desired operations.
- Actuator is the engine or motor that moves the links into their designated positions. Actuation of the joints, typically by electric motors, causes the robot to move and exert forces in desired ways.

Locomotion Technology

Movement (locomotion) in a robot is provided by the legged and/or wheeled structures supported by the motors.

Artificial Intelligence (AI)

- AI is defined as the ability of a machine to imitate intelligent human behaviour.
- Data modelled from a variety of sources, is the main source of knowledge for AI to make accurate and informed decisions.
- By using AI, a robot is enabled with various functionalities including AI scanners that can predict disease, AI that can clone voices, AI that can listen to emotion, etc.

Sensors

- Sensors are measuring instruments which measure quantities such as position, velocity, force, torque, proximity, temperature, etc.
- **Robotic Vision**
  - LIDAR (from the words "light" and "RADAR"), a wave-based sensor, uses light beams, usually lasers, to create high-resolution 3D point maps.
  - Sensors detect the distance of the target by bouncing the beam off the target and measuring how long the light takes to return to the sensor.
- **Robotic Touch**
  - Capacitive sensing technology (capacitive sensors) that is already used in touchscreen devices, is helping robots feel different surfaces.
- **Robotic Sound**
  - Microphone, an analogue-to-digital conversion unit combined with digital-signal processing, is used in robots to sense the emotional state in a human's voice.

Types of Robots

Pre-programmed Robots

- These robots operate in a simple, controlled environment so that they do not require an Artificial Intelligence (AI) system to function successfully.
- These robots are ones that have to be told ahead of time what to do, and then they simply execute that program. They cannot change their behaviour while they are working.

27 Fundamentals of Nanotechnology

Nanoscience is defined as the study of phenomena and manipulation of materials at atomic and molecular scales. It helps understand and exploit properties that differ significantly from those on a larger scale.

Nanotechnology is the design, characterisation, production and application of structures, devices and systems by controlling shape and size on a nanometer scale. At this scale, the general physical, chemical, electrical and biological properties of a material start behaving in a unique way which opens up new vistas for enquiry and applications.

Fundamental physicist Richard Feynman, is known as father of nanotechnology and in 1974, Professor Norio Taniguchi coined the term nanotechnology in his explorations of ultraprecision machining.

NANOTECHNOLOGY

What is Nanotechnology?

- At the level of atoms and molecules, the ordinary rules of physics and chemistry no longer apply. For example, characteristics of material, such as colour, strength, conductivity and reactivity, can differ substantially from the nanoscale to the macrolevel.
- Nanotechnology involves the processing, separation, consolidation, and deformation of materials at atomic and molecular level. It is the art and science of manipulating matter at the nanoscale to create new and unique materials and products with enormous potential. For example, the use of nanotechnology in manufacturing of polymers based on molecular structure, design of computer chip layouts based on surface science, etc.
- The newly acquired (novel) properties of the materials due to conversion into a nanoscale can be utilized for different useful activities. Thus, it is an enabling technology, relevant for diverse sectors, such as chemicals, consumer products, health, energy, various other industries and the environment.
- Nanotechnology, being an enabling technology of emerging techno-economic paradigm, is still in the nascent phase of its research, development and innovation.
- Nanotechnologies make use of very small objects or artefacts. Nanomaterials are an increasingly important product of nanotechnologies.

NOTE: Nanometre is a unit of length in the metric system. One nanometre equals one-billionth of a metre, and ten times the diameter of a hydrogen atom. The diameter of a human hair is, on average, 80,000 nanometres i.e. a nanometer is 80,000 times thinner than a human hair.

Metric System Prefixes

Prefix	Symbol	Multiplier (Scientific Notation)	Multiplier
Exa	E	10^{18}	1,000,000,000,000,000,000
Peta	P	10^{15}	1,000,000,000,000,000
Tera	T	10^{12}	1,000,000,000,000
Giga	G	10^{9}	1,000,000,000
Kilo	k	10^{3}	1,000
Hecto	h	10^{2}	100
Deka	da	10^{1}	10
Meter	m	10^{0}	1
Deci	d	10^{-1}	0.1
Centi	c	10^{-2}	0.01
Milli	m	10^{-3}	0.001
Micro	μ	10^{-6}	0.000,001
Nano	n	10^{-9}	0.000,000,001
Pico	p	10^{-12}	0.000,000,000,001
Femto	f	10^{-15}	0.000,000,000,000,001
Atto	A	10^{-18}	0.000,000,000,000,000,001

28 Fundamentals of Laser Technology

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. It is an intense, coherent, directional beam of light produced through a process of optical amplification based on the stimulated emission of electromagnetic radiation. In 1917, Albert Einstein predicted the phenomenon of "Stimulated Emission," which is fundamental to the operation of all lasers. In 1960, Theodore H. Maiman, a physicist, built the first laser.

LASER TECHNOLOGY

Principle of Laser

- A laser is created when the electrons in atoms in special glasses, crystals, or gases absorb energy and become "excited."
- By the process of stimulated emission, an incoming photon of a specific frequency interacts with an excited atomic electron, causing it to drop to a lower energy level. In other words, stimulated emission is the release of energy from an excited atom by artificial means.
- When more atoms occupy a higher energy state than a lower one under normal temperature equilibrium, it is possible to force atoms to return to an unexcited state by stimulating them with the same energy as would be emitted naturally.
- In laser action, the stimulating emission triggers a chain reaction in which the radiation from one atom stimulates another in succession until all the excited atoms in the system have returned to normalcy. In doing so, coherent monochromatic light (light of a single wavelength) is emitted.
- When the excited electrons return to their normal, they emit photons (particles of light) which are all at the same wavelength and are "coherent," making laser beams very narrow, very bright, and capable of focusing into a very tiny spot.

Properties of Laser

- Laser is a powerful source of light having extraordinary properties which are not found in the normal light sources like tungsten lamps, mercury lamps, etc.
- The light emitted from a laser is monochromatic i.e. it is of one wavelength (colour). In contrast, ordinary white light is a combination of many different wavelengths (colours).
- The light from a laser is said to be coherent, which means the wavelengths of the laser light are in phase in space and time. In other words, for a long distance, light waves from a laser travel parallel to each other without spreading.
- Lasers can concentrate a lot of energy over a very small area. This energy intensity remains almost constant over long distances because of low divergence. With this, even the hardest material like diamond can be melted within a fraction of a second.

Difference between Normal Light and Laser Light

Normal Light	Laser Light
The sunlight or other typical light from a lightbulb, is made up of light with many different wavelengths.	Laser light contains only one wavelength (one specific color).
Light from common light sources such as light bulbs spread in all directions.	Light waves from a laser are coherent i.e. for a long distance they travel parallel to each other without spreading.
Normal light comprises the visible light spectrum which is the segment of electromagnetic spectrum that the human eye can view.	The wavelength of laser light is determined by the amount of energy released when the excited electron drops to a lower orbit.

Working of a Laser Device

Gain Medium

- A gain medium (also called laser medium) is a material with a tendency to amplify light with stimulated emission.
- A light with a specific wavelength is amplified (increases power) when it passes through a gain medium.

29 Information and Communication Technology

Information and communications technology (ICT) is an extensional term for information technology (IT) that stresses the integration of telecommunications and computers, as well as storage and audio-visual systems, that enable users to access, store, transmit, and manipulate information.

COMPUTER TECHNOLOGIES

Quantum Computers

- Conventional computers store information as 0s or 1s whereas quantum computers use quantum bits or qubits, which can be a '1' or a '0' or both at the same time. Thus, quantum computers harness the laws of quantum mechanics to process information.
- The "quantum superposition", along with the quantum effects of entanglement makes quantum computers fast and powerful by allowing them to consider and manipulate all combinations of bits simultaneously.
- **Applications**
  - Quantum computers, quickly and efficiently, perform those difficult tasks that are considered impossible or intractable for conventional computers.
  - Analyse and process the data provided by satellites for weather forecast, efficient drug development by testing trillions of different molecular combinations, etc.

Supercomputers

- Supercomputers can be thought of as multiple computers performing parallel processing as they have more than one central processing unit (CPU).
- This allows supercomputers to work faster as they split problems into pieces and work simultaneously on those pieces, thereby solving the larger problem in quick time.
- However, they require an enormous amount of storage to be able to work fast. They are also expensive and are employed for specific applications.
- The performance of supercomputers is measured in FLOPS (Floating Point Operations per Second) instead MIPS (Million Instructions Per Second).
- **Application:**
  - Analysis of data supplied by a network of satellites and ground stations for atmosphere research; processing and decoding of genetic data; accuracy and perfection in landing and taking off of spacecraft; simulating the results of an atomic bomb detonation; etc.

India and Supercomputing

- The Centre for Development of Advanced Computing (C-DAC) embarked on its first High Performance Computing Mission in 1988. Since then, C-DAC has successfully delivered a series of supercomputing systems called **PARAM** (Sanskrit for Supreme). C-DAC has developed the first supercomputer 'Param Shivay' of 833 teraflop capacities, at IIT-BHU. It was inaugurated in 2019.
- The **National Supercomputing Mission** being implemented jointly by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY) consolidates various ongoing efforts into a nationally coordinated collaborative programme. It seeks to build a culture of supercomputing and envisages manufacturing of supercomputing systems in India.

Cloud Computing

- The cloud is just a metaphor for the Internet. In cloud computing, various resources such as servers, applications, data are integrated and made available as a service over the internet.
- Thus, cloud computing refers to storing and accessing data and programs over the Internet rather than on the computer's hard drive.
- It relies on sharing a pool of physical and/or virtual resources, instead of deploying local or personal hardware and software.
- Benefits of cloud computing include reduction of costs (price of deploying applications in the cloud is less), universal or remote access and flexibility (as the users have the option to switch applications as per need).

include and exclude from the warehouse. Data is only loaded into the warehouse when a use for the data has been identified.

- **Benefits of Data Warehouse**
  - **Better data**: Adding data sources to a data warehouse enables organizations to ensure that they are collecting consistent and relevant data from that source. They do not need to wonder whether the data will be accessible or inconsistent as it comes into the system. This ensures higher data quality and data integrity for sound decision making.
  - **Faster decisions**: Data in a warehouse is in such consistent formats that it is ready to be analyzed. Therefore, decision makers no longer need to reply on hunches, incomplete data, or poor quality data and risk delivering slow and inaccurate results.

Data Lake

- A Data Lake holds data in an unstructured way and there is no hierarchy or organization among the individual pieces of data. It can either store a large amount of structured, semi-structured, or unstructured data.
- It is a place to store every type of data from all data sources in its native format with no fixed limits on account size or file. A data lake is basically a data warehouse without the predefined schemas (the way the data is stored).
- The Data Lake democratizes data and is a cost-effective way to store all data of an organization for later processing. Research Analysts can focus on finding meaning patterns in data and not data itself.

Data Localisation

- Data localisation requires companies to store and process data on servers physically located within national borders.
- In other words, data localisation is the process of localising the citizen's data to his/her home country for its processing and storage.
- The main intent behind data localisation is to protect the personal and financial information of the country's citizens and residents from foreign surveillance and give local governments and regulators the jurisdiction to call for the data when required.

Key Terms

Personal Data is the data which helps identify a person, for example name, address etc.

Sensitive Personal Data covers a list of categories such as passwords, finances, health data, sexual orientation, biometrics, caste, and more.

Processing of data refers to the operations done to the data, often in forms of organisation, storage, combining, and more to glean further information.

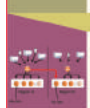
Profiling is any form of processing of personal data that analyses or predicts aspects concerning the behaviour, attributes or interest of a data principal.

Data Principal is the person, company, or entity whose information is being collected.

Data Fiduciary is a person, state, company, or any entity that decides why data should be processed and how it should be processed.

Data Processor is the entity that processes the data. It can be done by a third-party. For example Facebook (the data controller) was hit by controversy over the actions of data processor, Cambridge Analytica.

Right to be Forgotten allows an individual to remove consent for the data collection and disclosure.



Data Localisation relates to regulation about the transfer of data outside national borders.

Data Portability is the ability to access and transfer one's own data. It specifies that the data should be received in a "structured, commonly used and machine readable format".

Personal Data Breach is any unauthorised or accidental disclosure, acquisition, sharing, alteration etc. of personal data that compromises the confidentiality and integrity of data principal.

- This aspect has gained importance after revelations of social media giant Facebook sharing user data with Cambridge Analytica, which is alleged to have influenced voting outcomes.
- Data localisation, thus, bases itself on the full-fledged concept of data sovereignty. Governments across the

30 Artificial Intelligence

Artificial Intelligence (AI) is the science of training machines to perform human tasks. It makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks. AI works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing the software to learn automatically from patterns or features in the data. The term was coined in 1956 by John McCarthy.

WORKING MECHANISM OF ARTIFICIAL INTELLIGENCE

AI is a constellation of technologies that enable machines to perform cognitive tasks like thinking, perceiving, learning, problem solving and decision making. Following are the major subfields of AI:

Cognitive Computing

- It is a subfield of AI having the ultimate goal to simulate human processes through the ability to interpret images and speech and then speak coherently in response.
- The voice message is converted to text, to recognize an individual based on their voice command, and also perform activities based on the command given.
- Cognitive computing learns by studying patterns and suggests humans take relevant action based on its understanding.

Natural Language Processing (NLP)

- It is the ability of computers to analyze, understand and generate human language, including speech.
- It is the subfield of artificial intelligence that is concerned with the interactions between computers and human (natural) languages, in particular how to program computers to process and analyze large amounts of natural language data.

Computer Vision

- Computer vision relies on pattern recognition and deep learning to recognize what's in a picture or video.
- When machines can process, analyze and understand images, they can capture images or videos in real time and interpret their surroundings.
- It is used in a wide range of applications like signature identification, medical image analysis, security systems, etc.

Pattern Recognition

- Artificially intelligent machines can be used for pattern recognition in security software and also in business inventory solutions.
- For example, unlocking the phone through facial recognition.

Machine Learning

- Machine learning is a method of data analysis that automates analytical model building. It involves the use of algorithms to parse data and learn from it, and making a determination or prediction as a result.
- It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention.
- Machine learning models look for data and try to draw conclusions. It allows computers the ability to automatically learn and improve from experience without being explicitly programmed.
- Some example of machine learning applications:
  - Self-driving Google car
  - Online recommendation offers such as those from Flipkart, Amazon Netflix etc.
  - Fraud detection

Deep Learning

- Deep learning, a technique for implementing Machine Learning, is one of the subset of Artificial Intelligence. It is a type of machine learning that trains a computer to perform human-like tasks, such as recognizing speech, identifying images or making predictions.

Appendix - 1

Intellectual Property

Intellectual property refers to creations of the mind: inventions; literary and artistic works; and symbols, names and images used in commerce.

Intellectual Property Rights (IPR)

Intellectual property rights are like any other property right. They allow creators, or owners, of patents, trademarks or copyrighted works to benefit from their own work or investment in a creation.

- These rights are outlined in **Article 27** of the **Universal Declaration of Human Rights**, which provides for the right to benefit from the protection of moral and material interests resulting from authorship of scientific, literary or artistic productions.
- The importance of intellectual property was first recognized in the **Paris Convention for the Protection of Industrial Property (1883)** and the **Berne Convention for the Protection of Literary and Artistic Works (1886**). Both treaties are administered by the **World Intellectual Property Organization (WIPO).**
- **Intellectual property is divided into two categories:**
  - **Industrial Property**: It includes patents for inventions, trademarks, industrial designs and geographical indications.
  - **Copyright:** It covers literary works (such as novels, poems and plays), films, music, artistic works (such as paintings, photographs and sculptures) and architectural designs.

Need of Intellectual Property Rights (IPR)

- **Encourages innovation:** Patents provide incentives to individuals by recognizing their creativity and offering the possibility of material reward for their marketable inventions. These incentives encourage innovation, which in turn enhances the quality of human life.
- **Economic growth**: The promotion and protection of intellectual property spurs economic growth, creates new jobs and industries, and enhances the quality and enjoyment of life.
- **Safeguard the rights of creators**: IPR is required to safeguard creators and other producers of their intellectual commodity, goods and services by granting them certain time-limited rights to control the use made of the manufactured goods.

Patent

- A patent is an exclusive right granted for an invention – a product or process that provides a new way of doing something, or that offers a new technical solution to a problem.
- A patent provides patent owners with protection for their inventions. Protection is granted for a limited period, generally 20 years.
- Patent protection means an invention cannot be commercially made, used, distributed or sold without the patent owner's consent. Patent rights are usually enforced in courts that, in most systems, hold the authority to stop patent infringement. Conversely, a court can also declare a patent invalid upon a successful challenge by a third party.
- Patent owners may give permission to, or license, other parties to use their inventions on mutually agreed terms. Owners may also sell their invention rights to someone else, who then becomes the new owner of the patent.
- Once a patent expires, protection ends and the invention enters the public domain. This is also known as becoming off patent, meaning the owner no longer holds exclusive rights to the invention, and it becomes available for commercial exploitation by others.

Appendix - 2

Science in Everyday Life

Therapeutic Action of Different Classes of Drugs

Drugs are chemicals of low molecular masses which interact with macromolecular targets and produce a biological response. When this biological response is therapeutic and useful, these chemicals are called medicines.

Antacid

- Excess production of acid in the stomach causes irritation, pain and discomfort in the stomach. It can sometimes even result in ulcers. Drugs which are used to balance the acidity in the stomach are called antacids. Bicarbonates of calcium and sodium and salts of aluminium and magnesium are important antacids which are used in the treatment of hyperacidity.
- Acidity is caused when excessive amounts of acids are released in the stomach. The excess acid can damage the natural mucous barrier which protects the stomach and can lead to various diseases of the gastrointestinal tract. Antacids contain alkaline ions that chemically neutralize stomach gastric acid, thus reducing damage and relieving pain.

Antihistamines

- Histamine is an organic nitrogenous compound. It is a chemical found in some of the cells of the body. It performs functions like sending communicating signals to the brain; stimulating the release of stomach acid to help digestion; getting released in the body after injury or allergic reaction as part of immune response, etc. However, when histamine levels get too high or when it is unable to break down properly, it affects one's normal bodily functions.
- Antihistamines are a class of drugs used to treat common allergy symptoms, such as sneezing, watery eyes, hives, and a runny nose because of pollen, dust mites, or animal allergy. These allergies arise due to irregularity in the level of histamine. Examples of antihistamines are Brompheniramine, Cetirizine, Chlorpheniranuine, etc.

Antimicrobials

Antimicrobial drugs are of different types like antibacterial, antiviral, antifungal and antiparasitic. These have a tendency to destroy/prevent development or inhibit the pathogenic action of microbes such as bacteria (antibacterial drugs), virus (antiviral agents), fungi (antifungal agents), or other parasites (anti-parasitic drugs) selectively.

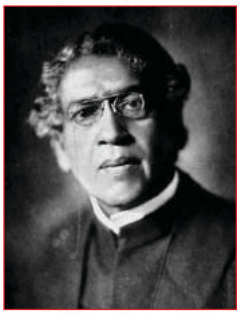
What is Antimicrobial Resistance?

- Antimicrobials are substances used to treat a wide variety of infectious diseases in humans and animals. When microorganisms develop the ability to withstand antimicrobial treatments, then it is called antimicrobial resistance.
- Antimicrobial resistance encompasses resistance to drugs that treat infections caused by microbes, parasites, viruses and fungi.
- Microorganisms that develop antimicrobial resistance are sometimes referred to as "superbugs". As a result of resistance, the medicines become ineffective and infections persist in the body, increasing the risk of spread to others.
- Of all antimicrobial resistance, antibiotic resistance has become one of the biggest threats to global health, food security, and development. A growing number of infections - such as pneumonia, tuberculosis, gonorrhoea, and salmonellosis are becoming harder to treat as the antibiotics used to treat them become less effective.
- Antibiotic resistance occurs naturally, but misuse of antibiotics in humans and animals is accelerating the process.

Scientists of Modern India and their Achievements

Sir Jagadish Chandra Bose (1858- 1937)

- Sir Jagadish Chandra Bose was a biologist, physicist, botanist and an early writer of science fiction.
- He pioneered the investigation of radio and microwave optics, made significant contributions to plant science, and laid the foundations of experimental science in the Indian subcontinent.



- Bose has been recognised as a father of radio and wireless communication.
- **Following is a brief timeline of his scientific activities:**
  - **1894 - 1899**: Created radio-waves as short as 5mm. Such waves are now better known as microwaves and are used in radars, ground and satellite communication, remote sensing and microwave ovens. Also devised a portable apparatus (10" x 12") for the study of their optical properties. It had the earliest waveguide and horn antenna of today's microwave engineering.
    - In 1895, he was the first to demonstrate the wireless transmission and reception of electromagnetic waves at Presidency College (now Presidency University), Kolkata. These waves had a frequency of 60 GHz and travelled a distance of over 23 meters.
  - **1899 - 1902:** Initiated detailed study of coherer leading to his discovery of the common nature of the electrical response to all forms of stimulation, in animal and plant tissues as well as in some inorganic models.
    - Bose also invented the crescograph, a device for measuring the growth of plants. He is also considered the father of Bengali science fiction.
- Inspired by nationalistic ideals, on 30th November 1917, he founded the Bose Institute in Calcutta which was the first interdisciplinary research centre in Asia.
- He was a member from Asia on the International Committee on Intellectual Cooperation of the League of Nations along with Einstein, Curie and Millikan. The Indian Botanic Garden at Shibpur was renamed in his honour in 2009. A crater on the moon is named after him.

Birbal Sahni (1891-1949)

- Birbal Sahni was an Indian paleobotanist who studied the fossils of the Indian subcontinent.
- He also took an interest in geology and archaeology. He founded what is now the Birbal Sahni Institute of Palaeobotany at Lucknow in 1946.

- His major contributions were in the study of the fossil plants of India and in plant evolution.
- He was also involved in the establishment of Indian science education and served as the President of the National Academy of Sciences, India and as an Honorary President of the International Botanical Congress, Stockholm.

Chandrasekhara Venkata Raman (1888-1970)

- Sir Chandrasekhara Venkata Raman was an Indian physicist who worked in the field of light scattering.
- He discovered that when light traverses a transparent material, some of the deflected light changes wavelength and amplitude. This phenomenon was a new type of scattering of light and was subsequently known as the Raman effect (**Raman scattering).**

Appendix - 4

Prestigious Science Awards

G.D. Birla Award for Scientific Research

- The G.D. Birla Award for Scientific Research is an award instituted in 1991 by the K. K. Birla Foundation in honour of the Indian philanthropist Ghanshyam Das Birla.
- It is an annual scientific award bestowed upon Indian scientists below the age of 50, living and working in India for their outstanding scientific research, mostly during the preceding 5 years.
- It carries a cash prize of ₹1.5 lakhs.
- The award is presented for all branches of science including medical science, basic and applied.

Shri Om Prakash Bhasin Awards

- Om Prakash Bhasin Award for Science and Technology is an Indian award, instituted in 1985 by Shri Om Prakash Bhasin Foundation, a New Delhi-based charitable organization to recognize excellence in the areas of science and technology.
- The award, given individually or collectively to a group, is annual in cycle and carries a plaque, a citation and a cash prize of ₹100,000.

Kalinga Prize

- The Kalinga Prize for the Popularization of Science is an award given by UNESCO for exceptional skill in presenting scientific ideas to people.
- It was created in 1952, following a donation from Biju Patnaik, Founder President of the Kalinga Foundation Trust in India.
- The recipient of this annual award must have demonstrated – during a brilliant career as writer, editor, lecturer, film producer, radio/television programme director or presenter – talent in interpreting science and technology for the public.
- The recipient should have striven to emphasize the international importance of science and technology and the contribution they make in improving public welfare, enriching the cultural heritage of nations, and solving problems facing humanity.
- The recipient receives $40,000 and a UNESCO Albert Einstein Silver Medal. The recipient is also awarded the Kalinga Chair, introduced by the Government of India in 2001 to mark the 50th anniversary of the Kalinga Prize.
- The biennial award is jointly financed by the Government of India through the Ministry of Science and Technology, Odisha government and Kalinga Foundation Trust.

Shanti Swarup Bhatnagar Prize

- The Shanti Swarup Bhatnagar Prize for Science and Technology (SSB) is a science award in India given annually by the Council of Scientific and Industrial Research (CSIR) for notable and outstanding research, applied or fundamental, in biology, chemistry, environmental science, engineering, mathematics, medicine and Physics.
- It is one of the highest multidisciplinary science awards in India. It was instituted in 1958 by the Council of Scientific and Industrial Research in honor of Shanti Swarup Bhatnagar, its founder director and recognizes excellence in scientific research in India.
- Any citizen of India engaged in research in any field of science and technology up to the age of 45 years is eligible for the prize. The prize is awarded on the basis of contributions made through work done in India only during the preceding five years of the prize.
- The prize comprises a citation, a plaque, and a cash award of ₹5 lakh. In addition, recipients also receive ₹15,000 per month up to the age of 65 years.

Appendix - 5

Institutions and Bodies

Department of Science and Technology

- The Department of Science and Technology (DST) is a department within the Union Ministry of Science and Technology.
- It was established in May 1971 to promote new areas of science and technology and to play the role of a nodal department for organising, coordinating and promoting Scientific and Technological activities in the country.
- It gives funds to various approved scientific projects in India. It also supports various researchers in India to attend conferences abroad and to go for experimental works.
- The Department has major responsibilities towards formulation of policies relating to Science and Technology and matters relating to the Scientific Advisory Committee of the Cabinet (SACC).

Department of Scientific and Industrial Research (DSIR)

- The Department of Scientific and Industrial Research (DSIR) is a part of the Ministry of Science and Technology.
- DSIR has a mandate to carry out the activities relating to indigenous technology promotion, development, utilization and transfer.
- The primary endeavour of DSIR is to promote R&D by the industries, support a larger cross section of small and medium industrial units to develop state-of-the art globally competitive technologies of high commercial potential, catalyze faster commercialization of lab-scale R&D, enhance the share of technology intensive exports in overall exports, strengthen industrial consultancy & technology management capabilities and establish user friendly information network to facilitate scientific and industrial research in the country.
- It also provides a link between scientific laboratories and industrial establishments for transfer of technologies through National Research Development Corporation (NRDC) and facilitates investment in R&D through Central Electronics Limited (CEL).

Department of Atomic Energy (DAE)

- The Department of Atomic Energy (DAE) came into being in 1954 under the direct charge of the Prime Minister.
- According to the Resolution constituting the AEC, the Secretary to the Government of India in the Department of Atomic Energy is ex-officio Chairman of the Atomic Energy Commission.
- DAE has been engaged in the development of nuclear power technology, applications of radiation technologies in the fields of agriculture, medicine, industry and basic research.

Department of Biotechnology

- The Department of Biotechnology (DBT) was set up in 1986 and is under the control of the Ministry of Science and Technology.
- It is responsible for administrating development and commercialisation in the field of modern biology and biotechnology in India.
- The Department since its inception has been providing an enabling ecosystem to promote biotechnology research and improve capacity building across the country. The emphasis has been on fostering cutting edge-research and innovation, with strong emphasis on translational research.
- **Mission of DBT:**
  - Realising full potential of biotechnology
  - A well directed effort, significant investment for generation of products, processes and technologies.

Appendix - 6

Initiatives under Department of Science and Technology

National Supercomputing Mission

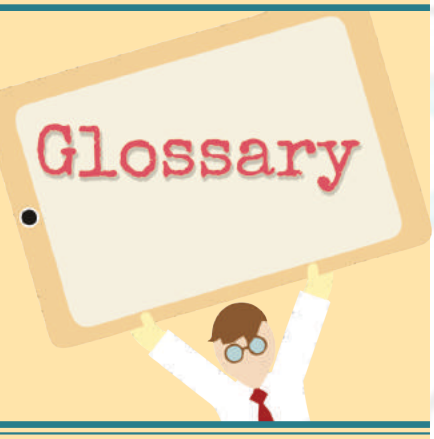
- The National Supercomputing Mission was announced in 2015, with an aim to connect national academic and R&D institutions with a grid of more than 70 high-performance computing facilities at an estimated cost of ₹4,500 crores over the period of seven years.
- It supports the government's vision of 'Digital India' and 'Make in India' initiatives.
- The mission is being implemented by the Department of Science and Technology (Ministry of Science and Technology) and Ministry of Electronics and Information Technology (MeitY), through the Centre for Development of Advanced Computing (C-DAC), Pune and Indian Institute of Science (IISc), Bengaluru.
- It is also an effort to improve the number of supercomputers owned by India.
  - These supercomputers will also be networked on the National Supercomputing grid over the National Knowledge Network (NKN). The NKN connects academic institutions and R&D labs over a high-speed network.
- Under NSM, the long-term plan is to build a strong base of 20,000 skilled persons who will be equipped to handle the complexities of supercomputers.
- **Progress of NSM:**
  - NSM's first supercomputer named Param Shivay has been installed in IIT-BHU, Varanasi, in 2019. It has 837 TeraFlop High-Performance Computing (HPC) capacity.
  - The second supercomputer with a capacity of 1.66 PetaFlop has been installed at IIT-Kharagpur.
  - The third system, Param Brahma, which has a capacity of 797 TeraFlop, has been installed at IISER-Pune.

IMPacting Research, INnovation and Technology (IMPRINT) India

- IMPRINT (IMPacting Research INnovation and Technology) is a first-of-its-kind Pan-IIT and IISc joint initiative to develop a new education policy and a roadmap for research to solve major engineering and technology challenges that India must address and champion to enable, empower and embolden the nation for inclusive growth and self-reliance.
- The ten domains that represent the most important areas for the country along with their coordinating institutes are:
  - Healthcare Technology
  - Computer Technology
  - Advance Materials
  - Water Resources
  - Sustainable Habitat
  - Security and Defence
  - Manufacturing Technology
  - Nano-technology Hardware
  - Environment and Climate
  - Energy Security
- IMPRINT provides overarching vision that guide research into areas that are predominantly socially relevant.
- The scheme was released in 2015 by the Ministry of Human Resource Development.

Technology Mission for Indian Railways (TMIR)

- In 2018, the three Ministries of the Union Government, the Ministry of Railways, Ministry of Human Resource



- **Absolute Refractive Index:** It is the ratio of velocity of a light ray in vacuum to the velocity of the light ray in a given medium.
- **Acids:** Chemical agents that donate protons, accept electrons and/or release hydrogen (H^+) ions when dissolved in water.
- **Adipose:** Adipose tissue or fat is a type of loose connective tissue located mainly beneath the skin. Its main role is to store energy in the form of fat, although it also acts as a cushion and insulates the body.
- **Algae:** These are green undifferentiated plants possessing chlorophyll. They prefer moist conditions and can make their own food.
- **Amphibians:** Animals which are found both in land and water are known as amphibians. They lay eggs, and are cold blooded. Examples, frogs, toads and salamanders.
- **Analog signals:** These are continuous electromagnetic waves that vary in strength.
- **Antigens:** They are any substance that stimulates the immune system to produce antibodies. Antigens can be bacteria, viruses, or fungi that cause infection and disease.
- **Aphelion:** It is the position of a planet in an elliptical orbit around the sun where the planet is furthest away from the Sun.
- **Appendicitis:** It is inflammation of the vermiform appendix located at the cecum in large-intestine and is potentially fatal disease, if left untreated.
- **Application Programming Interfaces (API):** They are portable packages of code that make it possible to add new functionality to existing products and software packages.
- **Astigmatism:** It is a common vision problem caused by an error in the shape of the cornea.
- **Asteroids:** These are small rocky, airless remains left over from the early formation of our solar system about 4.6 billion years ago.
- **Atomic Number:** Atomic number is the total number of protons existing in the nucleus of an atom. It is represented by Z.
- **Barak:** It is a surface to air missile jointly developed by India and Israel.
- **Bases:** Bases donate electrons, accept protons, or release hydroxide (OH^-) ions when dissolved in water.
- **Biofortification:** Biofortification is the process by which the nutritional value of food crops is improved through agronomic practices, conventional selective breeding, or modern biotechnology.
- **Bioinformatics:** It is the interplay between biology and information technology, encompassing data creation and assembling, data analysis and interpretation, and modelling of various biological phenomena through the use of algorithms and software tools.
- **Biomarker:** It is a naturally occurring molecule, gene, or characteristic through which a particular process, disease, etc., can be identified.
- **Biomethanation:** The process of converting organic waste materials into biogas and manure.
- **Bioremediation:** The process that uses mainly microorganisms, plants, or microbial or plant enzymes to detoxify contaminants in the soil and other environments.
- **Biosensors:** Biosensors are biophysical devices that can identify and determine the quantities of specific substances in different environments.
- **Bleaching Powder [$Ca(ClO)_2$]:** It is produced by the action of chlorine on dry slaked lime [$Ca(OH)_2$]. It is used for bleaching cotton and linen in the textile industry.
- **Blood:** It is the only fluid connective tissue that helps in the transport of various substances. It contains plasma, red blood cells (RBC), white blood cells (WBC) and platelets.

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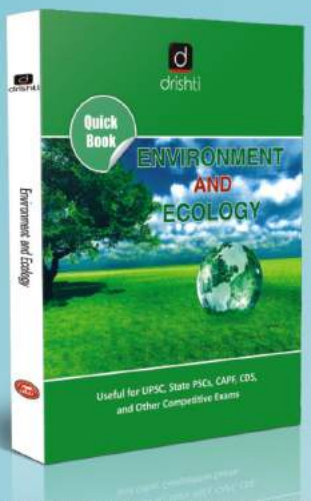

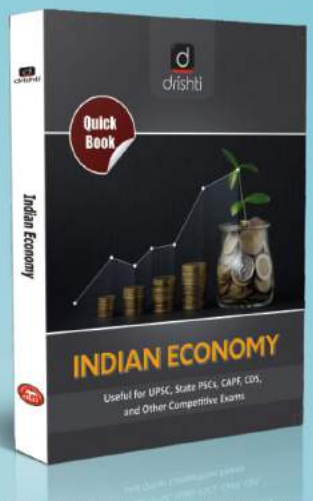

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