SCIENCE AND TECHNOLOGY

Chapter 1: Cell

Cell

- Functional and fundamental unit of any living organism is cell
- According to cell theory (Proposed by Matthias Schleiden and Theodor Schwann):
  - All living organisms are composed of cells and products of cells.
  - All cells are able to reproduce themselves
- **Mycoplasma/ Pleuropneumonia like organisms [PPLO] is the smallest cell**
- **Ostrich egg is the largest cell**
- The Cerebellum's Granule Cell is the smallest cell in the human body
- Neurons/ Nerve cells are the longest cells in the human body

Cytoplasm

- A typical cell broadly consists of a matrix called cytoplasm, in which all other components are suspended.

Plasma Membrane

- Consists of lipid bilayer (phospholipids, glycolipids and sterols)
- Integral proteins are present which some of which serves a transporter of molecules and ions
- Fluid- mosaic model (Proposed by S.J. Singer and Garth L. Nicolson)

Cell Wall

- A cell wall is a structural layer surrounding some types of cells, just outside the cell membrane. It provides the cell with both structural support and protection, and also acts as a filtering mechanism
- Absent in animals, present in plant cells, fungi, algae
- Plant cell wall- Cellulose, hemicellulose and pectin
- Bacteria cell wall- Peptidoglycan
- Fungi cell wall - Chitin
- Algae cell wall - Agar and carrageenan

Mitochondria

- Membrane bound organelle
- The function of mitochondria is to produce energy for the cell from food
- Cells use a special molecule for energy called **adenosine triphosphate (ATP)** – The energy currency
- Mitochondria are called **the powerhouse of the cell.**

Ribosome

- Ribosomes also called Palade granules (after discoverer George Palade and due to their granular structure), are macromolecular machines, found within all cells, that **perform biological protein synthesis (mRNA translation)**

Endoplasmic Reticulum (ER)

- Performs general functions like transportation of proteins to the Golgi bodies
- 2 subunits- **Rough Endoplasmic Reticulum (RER)** which is **involved in protein synthesis due to the attachment of ribosomes in it** and **Smooth ER (SER) with no attached ribosomes** that **produce steroidal hormone and lipid synthesis**
- The SER is especially abundant in mammalian liver and gonad cells.
- Endoplasmic reticulum is absent in mature RBCs and Spermatozoa

Golgi Bodies

- Golgi bodies are the sites of packing and modification of the synthesized products (proteins to glycoproteins, lipids to glycolipids), which are to be transported to other parts of the cell
- It was identified in 1897 by the Italian scientist Camillo Golgi and was named after him in 1898

Vacuole

- Membrane bound organelle. Tonoplast is the membrane
- One single large vacuole is present in plant cells, but vacuoles are smaller and fewer or absent in animal cells

Lysosome

- Contain powerful hydrolytic enzymes that can break down many kinds of biomolecules thus destroy any foreign matter that enters the cell
- Lysosomes are known as the **suicidal bag** of the cell because it is capable of destroying its own cell in which it is present.

Plastids

- The plastids, present only in plants, contain pigments, either to trap light energy (chloroplasts), impart colour (chromoplasts) or to store starch (leucoplasts)
- They possess a double-stranded DNA molecule that is circular, like that of the circular chromosome of prokaryotic cells

Nucleus

- Nucleus stores all the hereditary information
- Nucleus has 4 parts:
- Nuclear membrane
- Nucleoplasm
- Nucleolus
- Chromatin

- Eukaryotes **usually have a single nucleus**, but a few cell types, such as **mammalian red blood cells, have no nucleus**, and a few others including osteoclasts (a type of bone cell) have many nuclei
- Chromatin is a complex of DNA and protein found in eukaryotic cells. Characteristic shapes of chromosomes visible during this stage are the result of DNA being coiled into highly condensed chromatin.
- DNA wraps around histone proteins, forming the so-called **beads on a string structure**

Prokaryotes and Eukaryotes

- **Prokaryotes-** which lack cells with membrane bound nucleus, e.g., bacteria, blue- green algae (Cyanobacteria), mycoplasma, etc
- **Eukaryotes-** which possess cells with membrane bound nucleus, e.g., protists, fungi and all other multicellular organisms

Location of DNA

- Most DNA is located in the cell nucleus (where it is called nuclear DNA).
- However, a small amount of DNA can also be found in the mitochondria (mitochondrial DNA). Majority of mitochondrial DNA is transferred from the mother
- Plastids in plants and algae also contain a significant amount of DNA

Central Dogma of Molecular Biology

- The central dogma of molecular biology is an explanation of the flow of genetic information within a biological system.
- **DNA can be copied to DNA (DNA replication), DNA information can be copied into mRNA (transcription), and proteins can be synthesized using the information in mRNA (translation)**
- DNA being synthesised using an RNA template (**reverse transcription**)

Chapter 2:Biomolecules

Carbohydrates/ Saccharides

- Macromolecules formed by units of sugar molecules
- **Glucose-** Simple sugar and most abundant monosaccharide. It is an universal and accessible source of energy
- **Fructose**- Fruit sugar found in many plants. It is often bonded to glucose to form the sucrose
- **Sucrose**- Found in sugarcane. Main constituent of white sugar
- **Lactose**- Milk sugar formed by glucose and galactose units
- **Ribose-** Pentose sugar found in nucleic acid
- Composed of Carbon, Hydrogen and Oxygen
- **Ratio of Hydrogen: Oxygen= 2:1**
- Polysaccharides serve as an energy store (e.g., starch and glycogen)
- **Glycogen is stored in muscle and liver cells of animals**
- **Starch is found in plants**
- **Cellulose** forms the cell wall of plant cell.
- **Chitin** forms the cell wall of fungi and is found in exoskeleton of insects

Proteins

- Macromolecules of amino acid residues
- Building blocks of tissues- Repair and maintenance
- Provides energy to the body
- Hormones- Chemical messenger. Except the sex hormones mostly hormones are proteins.
- Transportation –E.g., Hemoglobin (Hb) transports oxygen to each and every cell in the body. Hb binds to oxygen forming oxyhemoglobin. However, in the presence of carbon monoxide (CO), Hb has more affinity towards CO, thus causing toxicity to the organisms
- Antibodies- Army of proteins for protection against diseases
- **Enzymes are mostly proteins except ribozymes**
- Protein encodes for functionality

Enzymes

- Biological catalyst- Speeds up the rate of a reaction
- Contains an ‘active site’that acts as the major working sites
- Disadvantage- Thermostability- not stable at high temperature

Lipids/ Fats

- Macromolecules of fatty acids which are insoluble in water
- Main structural component of plasma membrane
- Energy storage in fats
- Chemical messenger/ Hormones -Steroidal Hormones (sex hormones)
- Maintenance of temperature- Presence of adipose tissue in animals
- Helps in cholesterol formation. Cholesterol also serves as a precursor for the biosynthesis of steroid hormones, bile acid and vitamin D
- **Fat soluble Vitamins (A, D, E, K)**

Nucleic Acid

- Biomolecules composed of nucleotides
- Two main classes of nuclei acid include: DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid
- Types of RNA- messenger RNA, transfer RNA and ribosomal RNA
- A nucleotide is composed of pentose sugar (5-Carbon) viz., ribose, a phosphate group and nitrogenous bases. DNA and RNA are negatively charged **because the nucleotides contain phosphate groups**
- The nitrogenous bases include: Adenine (A), Guanine (G), Cytosine (C), Thymine (T), Uracil (U)
- 'A' pair with 'T' or 'U' by 2 **hydrogen bonds**
- 'C' pairs with 'G' with 3 hydrogen bonds
- A, T, G and C are present in DNA. U is absent
- A, U, G and C are present in RNA. T is absent
- DNA is double stranded, whereas RNA is single stranded
- DNA is more stable than RNA because
- presence of T instead of U
- double stranded nature

Previous Year Questions

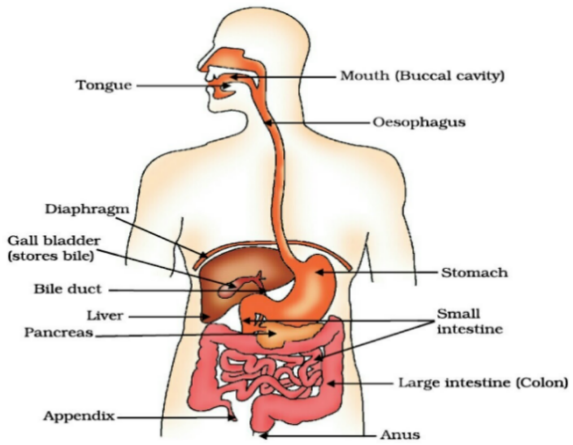
1) When a person is undergoing prolonged fasting, his/her urine will contain abnormal quantity of (2011)

a) Fat
b) Ketone
c) Amino acid
d) Glucose

Chapter 3:Human Life process

Facts about Digestion

- The food that we consume is broken by saliva that contains an enzyme called **salivary amylase (ptyalin)** that **breaks down starch (carbohydrate) only which is a complex molecule to give simple sugar**
- India food is masticated by chewing with teeth with the dental formula (**2,1,2,3- Incissor,Canines, Pre molar, Molar respectively**). Dental caries or tooth decay begins when bacteria acting on sugars produce acids that softens or demineralises the enamel.
- The gastric glands present in the wall of the stomach release **hydrochloric acid** and a protein digesting enzyme called pepsin. Stomach is the first site for protein digestion
- **Liver:** Produce bile, a dark green to yellowish fluid which helps to emulsify the lipids in food. Another function is detoxification
- **Gall bladder:** Stores and concentrates bile. **The two main pigments of bile are bilirubin, which is yellow, and its oxidised form biliverdin, which is green**. When mixed, they are responsible for the brown color of feces
- **Pancreas**: Acts as an **Exocrine gland during digestion**. Digestive enzymes are trypsin (Protein digestion), Amylase (Carbohydrate digestion, Lipase (lipid digestion). Bicarbonates are present to neutralise the stomach's acid
- The **small intestine is the site of the complete digestion** of carbohydrates, proteins and fats. It receives the secretions of the liver (bile juice) and pancreas (pancreatic enzymes) for this purpose.
- **Large intestine**: Extracts water and salt from solid wastes before they are eliminated from the body. It is the site in which the **fermentation of unabsorbed material by the gut microbiota** occurs.

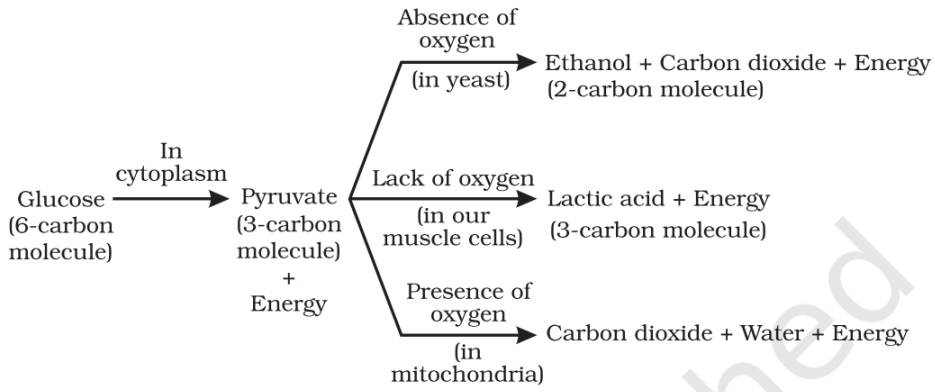


Respiration

- Within the lungs, the passage divides into smaller and smaller tubes which finally terminate in balloon-like structures which are called **alveoli (singular–alveolus**). The **alveoli provide a surface where the exchange of gases (CO_2 and O_2) can take place**

- Respiratory pigments take up oxygen from the air in the lungs and carry it to tissues which are deficient in oxygen before releasing it.
- In human beings, the r**espiratory pigment is haemoglobin which has a very high affinity for oxygen.** This pigment is present in the red blood corpuscles
- When food is swallowed, a flap called the **epiglottis** folds over the top of the windpipe and prevents food from entering into the larynx (voice box)
- The respiratory system in humans has the following important features:
- The energy is generated by the breakdown of glucose molecules in all living cells of the human body.
- Oxygen is inhaled and is transported to various parts and are used in the process of burning food particles (breaking down glucose molecules) at the cellular level in a series of chemical reactions.
- The obtained glucose molecules are used for discharging energy in the form of ATP- (adenosine triphosphate)
- The main difference between breathing and respiration in humans is that breathing is the physical process of inhaling oxygen and exhaling carbon dioxide in and out of our lungs. On the contrary, respiration is the chemical process where oxygen is utilized to break down glucose to generate energy to carry out different cellular processes.

Boost Your Knowledge:



Body fluids and Circulation

- Blood is the most commonly used body fluid by most of the higher organisms including humans for transportation of substances
- Another body fluid, lymph, also helps in the transport of certain substances.Lymph is a colourless fluid containing specialised lymphocytes which are responsible for the immune responses of the body
- **Erythrocytes or red blood cells (RBC) are the most abundant of all the cells in blood.**
- **RBCs are formed in the red bone marrow in the adults.**
- **RBCs are devoid of nucleus in most of the mammals and are biconcave in shape**.
- RBCs have an **average life span of 120 days** after which they are **destroyed in the spleen (graveyard of RBCs)**

- **Leucocytes are also known as white blood cells (WBC)** as they are colourless due to the lack of haemoglobin responsible for immunity
- Platelets also called thrombocytes, are cell fragments produced from megakaryocytes (special cells in the bone marrow). Platelets can release a variety of substances most of which are involved in the coagulation or clotting of blood. An injury or a trauma stimulates the platelets in the blood to release certain factors like **fibrinogen and thrombin** which activate the mechanism of coagulation. **Calcium ions** play a very important role in clotting
- Amphibians and the reptiles (except crocodiles) have a 3-chambered heart with two atria and a single ventricle
- Fishes, on the other hand, have only two chambers to their hearts

- Crocodiles, birds and mammals possess a 4-chambered heart with two atria and two ventricles

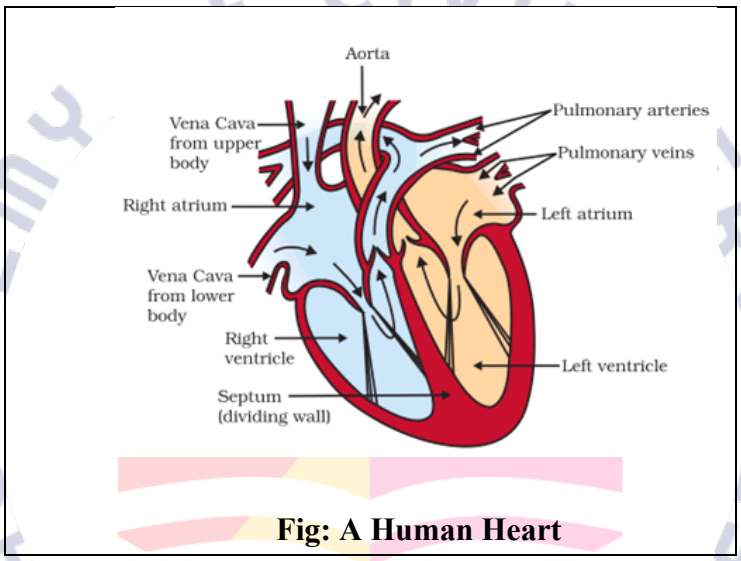
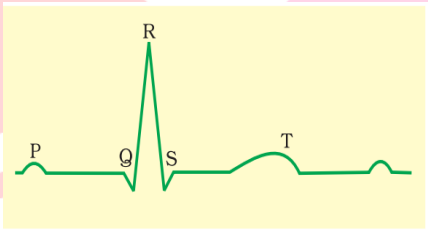


Fig: A Human Heart

- Blood goes only once through the heart in the fish during one cycle of passage through the body. On the other hand, it goes through the heart twice during each cycle in other vertebrates. This is known as **double circulation**
- Oxygen-rich blood from the lungs comes to the thin-walled upper chamber of the heart on the left (left atrium). De-oxygenated blood comes from the body to the upper chamber on the right (right atrium). Valves ensure that blood does not flow backwards when the atria or ventricles contract
- The opening between the right atrium and the right ventricle is guarded by a valve formed of three muscular flaps or cusps, **the tricuspid valve,** whereas a **bicuspid or mitral valve** guards the opening between the left atrium and the left ventricle.
- The openings of the right and the left ventricles into the pulmonary artery and the aorta respectively are provided with the **semilunar valves**
- A **patch of this tissue** is present in the right upper corner of the right atrium called the **sino-atrial node (SAN).** Another mass of this tissue is seen in the lower left corner of the right atrium close to the atrio-ventricular septum called the **atrio-ventricular node (AVN)**
- A bundle of nodal fibres, atrio- ventricular bundle (AV bundle) continues from the AVN which passes through the atrio-ventricular septa to emerge on the top of the inter-ventricular septum and

immediately divides into a right and left bundle. These branches give rise to minute fibres throughout the ventricular musculature of the respective sides and are called **purkinje fibres**

- The **SAN** can generate the maximum number of action potentials, i.e., 70-75 per min and is responsible for initiating and maintaining the rhythmic contractile activity of the heart. Therefore, it is called the **pacemaker**
- The **pressure of blood inside the artery during ventricular systole (contraction) is called systolic pressure and pressure in artery during ventricular diastole (relaxation) is called diastolic pressure**
- **The normal systolic pressure is about 120 mm of Hg and diastolic pressure is 80 mm of Hg**. Blood pressure is measured with an instrument called **sphygmomanometer**
- If repeated checks of blood pressure of an individual are 140/90 (140 over 90) or higher, it shows hypertension. High blood pressure leads to heart diseases and also affects vital organs like brain and kidney
- The sequential event in the heart which is cyclically repeated is called the **cardiac cycle** and it consists of systole and diastole of both the atria and ventricles. During each cardiac cycle two prominent sounds are produced which can be easily heard through a stethoscope. The **first heart sound (lub)** is associated with the **closure of the tricuspid** and **bicuspid valves** whereas the **second heart sound (dub)** is associated with the closure of the semi lunar **valves**
- **ECG (Electrocardiograph)** is a graphical representation of the electrical activity of the heart during a cardiac cycle
- Each peak in the ECG is identified with a letter from P to T that corresponds to a specific electrical activity of the heart



EXCRETORY PRODUCTS AND THEIR ELIMINATION

- **Ammonia, urea and uric acid** are the major forms of **nitrogenous wastes excreted by the animals**.
- **Ammonia is the most toxic form** and requires large amount of water for its elimination, whereas **uric acid, being the least toxic**, can be removed with a minimum loss of water
- Ammonia, as it is readily soluble, is generally excreted by diffusion across body surfaces or through gill surfaces (in fish) as ammonium ions
- **Mammals, many terrestrial amphibians and marine fishes mainly excrete urea**
- Reptiles, birds, land snails and insects excrete nitrogenous wastes as uric acid in the form of pellet or paste with a minimum loss of water

Boost Your Knowledge:

- **Protonephridia** or flame cells are the excretory structures in Platyhelminthes (Flatworms)
- **Nephridia** are the tubular excretory structures of earthworms and other annelids

- **Malpighian tubules** are the excretory structures of most of the insects including cockroaches
- **Antennal glands** or **green glands** perform the excretory function in crustaceans like prawns

- In humans, the excretory system consists of a pair of kidneys, one pair of ureters, a urinary bladder and a urethra. **Columns of Bertini** are associated with the kidney
- Each kidney has nearly one million complex tubular structures called **nephrons**
- **Loop of Henle**, **Bowman's capsule**, **Glomerulus**, proximal convoluted tubule (PCT), distal convoluted tubule (DCT), vasa recta, etc are some structures present in a nephron
- The amount of the filtrate formed by the kidneys per minute is called glomerular filtration rate (GFR**). GFR in a healthy individual is approximately 125 ml/minute, i.e., 180 litres per day**
- An excessive loss of fluid from the body can activate these receptors which stimulate the hypothalamus in the brain to release **antidiuretic hormone (ADH) or vasopressin**
- **Renin,** is a protease protein and enzyme secreted by the kidneys that participates in the body's renin–angiotensin–aldosterone system (RAAS)—also known as the renin–angiotensin–aldosterone axis—that mediates the volume of extracellular fluid (blood plasma, lymph and interstitial fluid) and arterial vasoconstriction. Thus, it regulates the body's mean arterial blood pressure.
- **Other than the kidneys, lungs, liver and skin also help in the elimination of excretory wastes. Sebaceous glands eliminate certain substances like sterols, hydrocarbons and waxes through sebum**
- Malfunctioning of kidneys can lead to accumulation of urea in blood, a condition called uremia, which is highly harmful and may lead to kidney failure. In such patients, urea can be removed by a process called hemodialysis.
- Renal calculi are the stones or insoluble mass of crystallised salts (oxalates, etc.) formed within the kidney

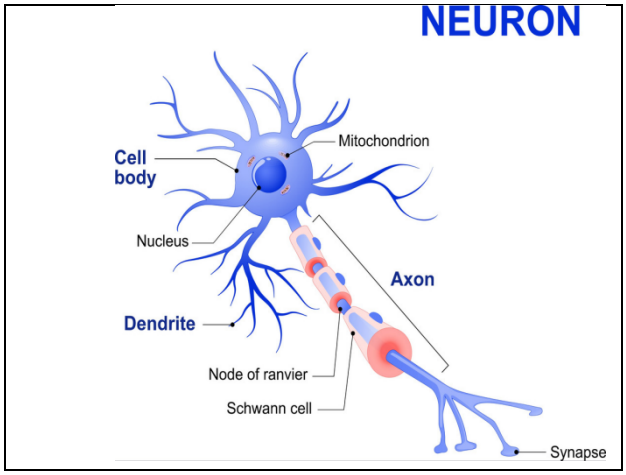
LOCOMOTION AND MOVEMENT

- A characteristic feature of the muscle fibre is the presence of a large number of parallelly arranged filaments in the sarcoplasm called **myofilaments or myofibrils**.
- Each myofibril has alternate dark and light bands on it. The light bands contain actin and is called I-band or Isotropic band, whereas the **dark band called 'A' or Anisotropic band contains myosin**
- **Calcium ions are important for muscle movement**
- Bone and cartilage are specialised connective tissues. Human beings consist of **206 bones** and a few cartilages. Ear contains three tiny bones – **Malleus, Incus and Stapes**, collectively called **Ear Ossicles**. There are 12 pairs of ribs
- **Femur**- thigh bone is the longest bone
- **Synovial joints** are characterised by the presence of a fluid filled synovial cavity between the articulating surfaces of the two bones.
- **Arthritis**: Inflammation of joints.

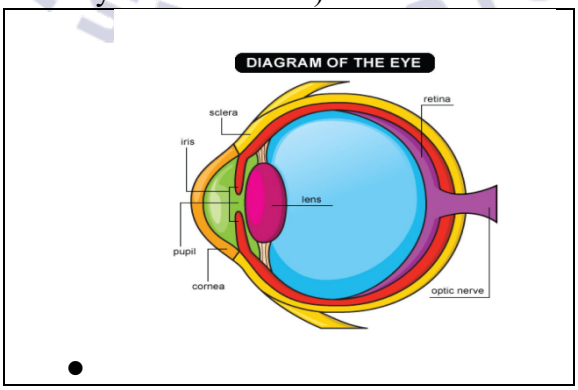
- **Osteoporosis**: Age-related disorder characterised by decreased bone mass and increased chances of fractures. Decreased levels of estrogen is a common cause.
- **Gout**: Inflammation of joints due to accumulation of uric acid crystals.

NEURAL CONTROL AND COORDINATION

- The human neural system is divided into two parts:
    a. **The central neural system (CNS):** The CNS includes the **brain and the spinal cord** and is the site of information processing and control
    b. **The peripheral neural system (PNS):** The PNS comprises of all the nerves of the body associated with the CNS (brain and spinal cord. The nerve fibres of the PNS are of two types :
        i. afferent fibres
        ii. efferent fibres
- The afferent nerve fibres transmit impulses from tissues/organs to the CNS and the efferent fibres transmit regulatory impulses from the CNS to the concerned peripheral tissues/organs.
- **Brain:**
    - ✓ The brain consists of the **cerebrum, the brainstem and the cerebellum**
    - ✓ The brain is protected by the skull, suspended in cerebrospinal fluid, and isolated from the bloodstream by the blood–brain barrier.
    - The **cerebrum, the largest part of the human brain**, consists of two cerebral hemispheres. Each hemisphere has an inner core composed of white matter (myelinated axon), and an outer surface – the cerebral cortex – composed of grey matter (numerous cell bodies with very few myelinated axons). Its role is to **initiate and coordinates movement and regulates temperature. Other areas of the cerebrum enable speech, judgment, thinking and reasoning, problem-solving, emotions and learning. Other functions relate to vision, hearing, touch and other senses.**
    - The brainstem, resembling a stalk, attaches to and leaves the cerebrum at the start of the midbrain area. The brainstem **includes the midbrain, the pons, and the medulla oblongata.Brainstem sends messages to the rest of the body to regulate balance, breathing, heart rate and more**
    - Behind the brainstem is the cerebellum. Cerebellum consists of an inner medulla of white matter and an outer cortex of richly folded grey matter. The cerebellum appear to play a **role in the coordination and smoothing of complex motor movements, and the flocculonodular lobe in the maintenance of balance although debate exists as to its cognitive, behavioural and motor functions**
- A **neuron** is a microscopic structure composed of three major parts, namely, cell body, **dendrites** and **axon**. The cell body contains cytoplasm with typical cell organelles and certain granular bodies called **Nissl's granules**



- Each branch of neuron terminates as a bulb-like structure called synaptic knob which possess chemicals called **neurotransmitters (acetylcholine)**
- The myelinated nerve fibres are enveloped with **Schwann cells**, which form a myelin sheath around the axon. The gaps between two adjacent myelin sheaths are called **nodes of Ranvier**.
- Myelinated nerve fibres are found in spinal and cranial nerves.
- Sodium and Potassium ions are important for nerve impulse
- The nose contains mucus-coated receptors which are specialised for receiving the sense of smell and called **olfactory receptors**
- The tongue detects tastes through taste buds, containing **gustatory receptors**
- **Eyes:**
  - Our paired eyes are located in sockets of the skull called **orbits**
  - The inner layer is the retina and it contains three layers of neural cells – from inside to outside – ganglion cells, bipolar cells and photoreceptor cells. **There are two types of photoreceptor cells, namely, rods and cones.** The daylight (photopic) vision and colour vision are functions of cones and the twilight (scotopic) vision is the function of the rods.
  - The rods containa purplish-red protein called the **rhodopsin or visual purple**, which contains a derivative of Vitamin A. In the human eye, there are **three types of cones** which possess their own characteristic photopigments that respond to **red, green and blue lights**
  - Photoreceptor cells when absent is called the blind spot
- The photosensitive compounds (photopigments) in the human eyes is composed of **opsin** (a protein) and **retinal** (an aldehyde of vitamin A).



- The ear can be divided into the outer ear, the middle ear and the inner ear
- The **organ of corti** is a structure which contains hair cells that act as auditory receptors

- A **Eustachian tube** connects the middle ear cavity with the pharynx. The Eustachian tube helps in equalising the pressures on either side of the ear drum

Boost Your Knowledge:

- **Parkinson's disease**: **Deficiency of Dopamine** leading to symptoms like tremor, rigidity, slowness of movement, and difficulty with walking. Cognitive and behavioral problems may also occur with depression, anxiety, and apathy.Those with Parkinson's can also have problems with their sleep and sensory systems. It is a **Neurodegenerative Disorder**
- **Dementia**: Dementia is a disorder which manifests as a set of related symptoms, which usually surfaces when the brain is damaged by injury or disease. The symptoms involve progressive impairments in memory, thinking, and behavior, which negatively impact a person's ability to function and carry out everyday activities. Aside from memory impairment and a disruption in thought patterns, the most common symptoms include emotional problems, difficulties with language, and decreased motivation. Several diseases and injuries to the brain, such as a stroke, can give rise to dementia. However, the most common cause is Alzheimer's disease
- **Alzheimer's disease**: Alzheimer's disease (AD) is a neurodegenerative disease that usually starts slowly and progressively worsens. It is the cause of 60–70% of cases of dementia. The most common early symptom is difficulty in remembering recent events. As the disease advances, symptoms can include problems with language, disorientation (including easily getting lost), mood swings, loss of motivation, self-neglect, and behavioral issues. As a person's condition declines, they often withdraw from family and society. **Alzheimer's disease is caused by reduced synthesis of the neurotransmitter acetylcholine**
- **Schizophrenia**: Major symptoms include hallucinations (typically hearing voices), delusions, and disorganized thinking. Other symptoms include social withdrawal, decreased emotional expression, and apathy. Many people with schizophrenia have other mental disorders, especially substance use disorders, depressive disorders, anxiety disorders, and obsessive–compulsive disorder. The exact causes of schizophrenia are unknown. Research suggests a combination of physical, genetic, psychological and environmental factors can make a person more likely to develop the condition. Some people may be prone to schizophrenia, and a stressful or emotional life event might trigger a psychotic episode.
- **Myopia:** Myopia, also known as near-sightedness and short-sightedness, is an eye disorder where light focuses in front of, instead of on, the retina. As a result, distant objects appear blurry while close objects appear normal. Concave shaped lenes (minus power lenses) are used for correction
- **Hypermetropia**: Far-sightedness, also known as long-sightedness, hypermetropia, or hyperopia, is a condition of the eye where distant objects are seen clearly but near objects appear blurred. This blurred effect is due to incoming light being focused behind, instead of on, the retina wall due to insufficient accommodation by the lens. It then becomes more common again after the age of 40, known as **presbyopia**, affecting about half of people. Convex lens are used for hypermetropia.

CHEMICAL COORDINATION AND INTEGRATION

- Endocrine glands lack ducts and are hence, called ductless glands. Their secretions are called hormones.
- Hormones are chemical produced by endocrine glands in trace amount and released into the blood and transported to a distantly located target organ

- Pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus and gonads (testis in males and ovary in females) are the organised endocrine bodies in our body
- In addition to these, some other organs, e.g., gastrointestinal tract, liver, kidney, heart also produce hormones

Gland	Hormones	Functions	Common Diseases
Thyroid	Tetraiodothyronine or Thyroxine (T4) and triiodothyronine (T3)	Regulates metabolism	Simple Goitre, Exopthalmic goitre, Graves' disease.
	Calcitonin	Inhibits release of calcium from the bones	
Parathyroid's	Parathyroid hormone	Stimulate release of calcium from the bones	
Islet of Langerhans (in the Pancreas)	Insulin	**Decrease blood sugar by promoting uptake of glucose by cells**	**Diabetes mellitus**
	Glucagon	**Increase blood sugar by stimulating breakdown of glycogen in the liver**	
Testes	Testosterone	Regulates sperm production and secondary sexual characteristics	
Ovary	Estrogen	Stimulates egg maturation and secondary sexual characteristics	
Ovary	Progesterone	Prepares the uterus to receive a fertilised egg	
Adrenal cortex	Epinephrine or adrenaline	**Stimulates fright, fight or flight (Emergency Hormones)**	
Adrenal medulla	Glucocorticoids	Involved in carbohydrate metabolism	Addison's disease
	Aldosterone	Helps in the maintenance of electrolytes like	

		sodium and potassium, body fluid volume, osmotic pressure and blood pressure	
Pineal gland	Melatonin	Helps in maintaining the normal rhythms of sleep-wake cycle, body temperature	
Pituitary gland	Growth hormone (GH)	Growth of the body	
	Prolactin (PRL)	Regulates the growth of the mammary glands and formation of milk in them	
	Thyroid stimulating hormone (TSH),	Stimulates the synthesis and secretion of thyroid hormones from the thyroid gland	
	Adrenocorticotrophic hormone (ACTH)	Stimulates the synthesis and secretion of steroid hormones called glucocorticoids from the adrenal cortex	
	Luteinizing hormone (LH)	Stimulate gonadal activity and hence are called **gonadotrophins.**	
	Follicle stimulating hormone (FSH)		
	Oxytocin	Acts on the smooth muscles of our body and stimulates their contraction. In females, it stimulates a vigorous contraction of uterus at the time of child birth, and milk ejection from the mammary gland	

	ADH/ Vasopressin	• Acts mainly at the kidney and stimulates resorption of water and electrolytes by the distal tubules and thereby • reduces loss of water through urine (diuresis).	Diabetes insipidus
Hypothalamus	Thyrotropin-releasing hormone (TRH)	Master regulator of thyroid gland growth and function (including the secretion of the thyroid hormones thyroxine and triiodothyronine). These hormones control the body's metabolic rate, heat generation, neuromuscular function and heart rate, among other things.	
	Gonadotropin-releasing hormone (GnRH)	• It stimulates the production of two more hormones – follicle stimulating hormone and luteinising hormone. • GnRH are released into the general circulation and act on the testes and ovaries to initiate and maintain their reproductive functions.	

	Growth hormone-releasing hormone (GHRH)	Stimulates growth hormone (GH) secretion and GH synthesis and is also thought to cause somatotroph proliferation	
	Corticotropin-releasing hormone (CRH)	Corticotropin-releasing hormone (CRH; previously known as corticotropin-releasing factor) is the central regulator of the hypothalamic-pituitary-adrenal (HPA) axis, which is the main organizer of the body's response to stress. It is also present in diseases that cause inflammation.	
	Somatostatin	Somatostatin is a hormone that regulates a variety of bodily functions by hindering the release of other hormones, the activity of your gastrointestinal tract and the rapid reproduction of cells	
	Dopamine	Dopamine is a type of neurotransmitter and hormone. It plays a role in many important body functions, including movement, memory and pleasurable reward and motivation	Parkinson’s disease

- The atrial wall of our heart secretes a very important peptide hormone called atrial natriuretic factor (ANF), which decreases blood pressure. When blood pressure is increased, ANF is secreted which causes dilation of the blood vessels. This reduces the blood pressure
- The juxtaglomerular cells of kidney produce a peptide hormone called erythropoietin which stimulates erythropoiesis (formation of RBC).
- Endocrine cells present in different parts of the gastro-intestinal tract secrete four major peptide hormones, namely gastrin, secretin, cholecystokinin (CCK) and gastric inhibitory peptide (GIP). Gastrin acts on the gastric glands and stimulates the secretion of hydrochloric acid and pepsinogen. Secretin acts on the exocrine pancreas and stimulates secretion of water and bicarbonate ions. CCK acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice, respectively. **GIP inhibits gastric secretion and motility**

Nature of Hormones	**Names of Hormones**
peptide, polypeptide, protein hormones	insulin, glucagon, pituitary hormones, hypothalamic hormones
steroids	cortisol, testosterone, estradiol and progesterone
iodothyronines	thyroid hormones
amino-acid derivatives	epinephrine

Previous Year Questions

1. **Pacemaker is implanted in heart when one of the following is defective (2011)**
   - **a) SA node**
   - b) AV node
   - c) Purkinje fiber
   - d) Bundle of His
2. **A man suddenly encounters a tiger in the jungle and his heartbeat goes up, blood pressure increases and gets nervous. Which hormone is released more in his body at this point of time (2020)**
   - a) Thyroxine
   - b) Insulin
   - **c) Adrenaline**
   - d) Aldosterone

Chapter 4:Facts Related to Biology of Plants

Transport in Plants

- **Water and minerals absorbed by roots are transported byxylem** in a unidirectional manner and the **organic material synthesised in the leaves is transported to other parts of plant through phloem in** a bidirectional way
- Phloem sap is mainly water and sucrose, but other sugars, hormones and amino acids are also transported or translocated through phloem

- In **diffusion**, molecules move in a random fashion, the net result being
- substances moving from regions of higher concentration to regions of lower concentration. Diffusion is obvious in gases and liquids

- In **facilitated diffusion** special proteins help move substances across membranes without expenditure of ATP energy
- Osmosis is the special type of diffusion of water across a selectively permeable membrane which depends on pressure gradient and concentration gradient.
- The behaviour of the plant cells (or tissues) with regard to water movement depends on the surrounding solution. If the external solution balances the osmotic pressure of the cytoplasm, it is said to be **isotonic**. If the external solution is more dilute than the cytoplasm, it is **hypotonic** and if the external solution is more concentrated, it is **hypertonic**.
- **Cells swell in hypotonic solutions and shrink in hypertonic ones. Plasmolysis** occurs when water moves out of the cell and the cell membrane of a plant cell shrinks away from its cell wall
- When the cells are placed in a hypotonic solution (higher water potential or dilute solution as compared to the cytoplasm), water diffuses into the cell causing the cytoplasm to build up a pressure against the wall, that is called **turgor pressure**
- **Imbibition** is a special type of diffusion when water is absorbed by solids – colloids – causing them to increase in volume. The classical examples of imbibition are absorption of water by seeds and dry wood.
- Terrestrial plants take up huge amount water daily but most of it is lost to the air through evaporation from the leaves, i.e., **transpiration.** Water is transient in plants**.** Less than 1 per cent of the water reaching the leaves is used in photosynthesis and plant growth. Most of it is lost through the stomata in the leaves by transpiration
- Excess water collects in the form of droplets around special openings of veins near the tip of grass blades, and leaves of many herbaceous parts. Such water loss in its liquid phase is known as **guttation**

Key terms to Remember:

- **Cohesion** – mutual attraction between water molecules
- **Adhesion** – attraction of water molecules to polar surfaces (such as the surface of tracheary elements).
- **Surface Tension** – water molecules are attracted to each other in the liquid phase more than to water in the gas phase. It is responsible for the spherical shapes of rainfall as well

MINERAL NUTRITION

- Plants could be grown to maturity in a defined nutrient solution in complete absence of soil. This technique of growing plants in a nutrient solution is known as **hydroponics. Hydroponics has been successfully employed as a technique for the commercial production of vegetables such as tomato, seedless cucumber and lettuce**
- The macronutrients (generally present in plant tissues in large amounts) include **carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium and magnesium**. Of these, carbon, hydrogen and oxygen are mainly obtained from CO_2 and H_2O, while the others are absorbed from the soil as mineral nutrition.

- Micronutrients or trace elements, are needed in very small amounts These include **iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel.**
- Some **beneficial elements such as sodium, silicon, cobalt and selenium are required by higher plants**
- **Chlorosis** is the loss of chlorophyll leading to yellowing in leaves. This symptom is caused by the deficiency of elements Nitrogen, Potassium, Magnesium, Sulphur, Iron, Manganese, Zinc and Molybdenum
- **Necrosis**, or death of tissue, particularly leaf tissue, is due to the deficiency of Calcium, Magnesium, Copper, Potassium. Lack or low level of Nitrogen, Potassium, Sulphur, Molybdenum causes an inhibition of cell division.
- Some elements like Nitrogen, Sulphur, Molybdenum **delay flowering** if their concentration in plants is low.
- Only certain prokaryotic species are capable of fixing nitrogen. Reduction of nitrogen to ammonia by living organisms is called biological nitrogen fixation. The nitrogen-fixing microbes could be free-living or symbiotic. **Examples of free-living nitrogen-fixing aerobic microbes are *Azotobacter* and *Beijerinckia* while *Rhodospirillum* is anaerobic and free-living. In addition, a number of cyanobacteria such as *Anabaena* and *Nostoc* are also free- living nitrogen-fixer**
- Species of rod-shaped ***Rhizobium*** has a relationship with the roots of several legumes such as **alfalfa, sweet clover, sweet pea, lentils, garden pea, broad bean, clover beans**, etc. Both *Rhizobium* and *Frankia* are free living in soil, but as symbionts, can fix atmospheric nitrogen
- Nodules of legumes are pink in colour because of leguminous haemoglobin or **leg-haemoglobin**

PHOTOSYNTHESIS

- Green plants make their own food by photosynthesis. During this process carbon dioxide from the atmosphere is taken in by leaves through stomata and used for making carbohydrates, principally glucose and starch
- Within the leaves, the **mesophyll cells** have a large number of chloroplasts that are responsible for CO_2 fixation.
- **Calvin/ C_3 pathway**: The first CO_2 fixation product was a 3-carbon organic acid identified was **3-phosphoglyceric acid or in short PGA.** The Primary Acceptor of CO_2 is **ribulose bisphosphate (RuBP).** RuBP is converted to PGA by an enzyme called as RuBisCO
    - **RuB+ CO_2 $\xrightarrow{\text{RuBisCO}}$ PGA**
- **RuBisCO that is the most abundant enzyme in the world is characterised by the fact that its active site can bind to both CO2 and O2**
- C4 plants are a type of plant that has an adaptation that allows it to better fix carbon dioxide gas. This process is called C4 photosynthesis, and it enables the plant to convert carbon dioxide gas into organic matter more efficiently than other types of plants including C3 plants.
- **C_4 Pathway**: Plants that are adapted to dry tropical regions have the C_4 pathway. Though these plants have the C_4**oxaloacetic acid** as the first CO_2 fixation product they use the C_3 pathway or the Calvin cycle as the main biosynthetic pathway. C_4 plants are special. They have a special type of leaf anatomy, they tolerate higher temperatures, they show a response to high light intensities, they lack a process called photorespiration and have greater productivity of biomass.

Examples of C4 plants include corn, cactus, sugarcane, maize, bermuda grass, millet, sorghum

- All C4 plants share a common feature: they all have specialised cells that surround their leaf pores, called **bundle sheath cells**. These cells help the plant to better capture and use carbon dioxide gas for photosynthesis.

- **Photorespiration** is a process in plant metabolism where the enzyme RuBisCO oxygenates RuBP, wasting some of the energy in the form of ATP produced by photosynthesis. In the photorespiratory pathway, there is neither synthesis of sugars, nor of ATP. Rather it results in the release of CO_2 with the utilisation of ATP

RESPIRATION IN PLANTS

- **Stomata and lenticels allow gaseous exchange by diffusion**
- Under anaerobic conditions either lactic acid fermentation or alcohol fermentation occurs. In biochemistry, fermentation is narrowly defined as the extraction of energy from carbohydrates in the absence of oxygen. In food production, fermentation may more broadly refer to any process in which the activity of microorganisms brings about a desirable change to a foodstuff or beverage. The science of fermentation is known as **zymology**.
- For example, fermentation is used for preservation in a process that **produces lactic acid** found in such sour foods as **pickled cucumbers, kombucha, kimchi, and yogurt**, as well as for producing **alcoholic beverages such as wine and beer.**
- Industrial fermentation is the process of using microbes for the large-scale production of **chemicals, biofuels, enzymes, proteins and pharmaceuticals**. Fermentation also occurs within the gastrointestinal tracts of all animals, including humans
- **Mammalian muscle carries** out fermentation during periods of **intense exercise** where oxygen supply becomes limited, resulting in the creation of **lactic acid**
- Fermentative bacteria play an essential role in the production of methane in habitats ranging from the rumens of cattle to sewage digesters and freshwater sediments.
- Products of fermentation:
    - Ethanol
    - Lactic acid
    - Hydrogen gas
- The respiratory pathway is an amphibolic pathway as it involves both anabolism and catabolism.

PLANT GROWTH AND DEVELOPMENT

- Plants follow different pathways in response to environment or phases of life to form different kinds of structures. This ability is called **plasticity,** e.g., heterophylly in cotton, coriander and larkspur
- **Auxins** was first isolated from human urine. They are generally produced by the growing apices of the stems and roots, from where they migrate to the regions of their action. Auxins like IAA (indole-3-acetic acid) and indole butyric acid (IBA) have been isolated from plants. **NAA (naphthalene acetic acid) and 2, 4-D (2, 4-dichlorophenoxyacetic) are synthetic auxins**. In

most higher plants, the growing apical bud inhibits the growth of the lateral (axillary) buds, a phenomenon called **apical dominance**

- Auxins also induce **parthenocarpy**, e.g., in tomatoes. They are widely used as herbicides. 2, 4-D, widely used to kill dicotyledonous weeds, does not affect mature monocotyledonous plants.
- **Gibberellic acid (GA3)** was one of the first gibberellins to be discovered and remains the most intensively studied form. All GAs are acidic. They produce a wide range of physiological responses in the plants. Their ability to cause an increase in length of axis is used to increase the length of grapes stalks. Gibberellins, cause fruits like apple to elongate and improve its shape. They also delay senescence. Thus, the fruits can be left on the tree longer so as to extend the market period. GA3 is used to speed up the malting process in brewing industry. **Spraying sugarcane crop with gibberellins increases the length of the stem**
- **Cytokinins** have specific effects on **cytokinesis**. Natural cytokinins are synthesised in regions where rapid cell division occurs, for example, root apices, developing shoot buds, young fruits etc. It helps to produce new leaves, chloroplasts in leaves, lateral shoot growth and adventitious shoot formation. Cytokinins help overcome the apical dominance. They promote nutrient mobilisation which helps in the delay of leaf senescence.
- **Ethylene** is a simple gaseous PGR. It is synthesised in large amounts by tissues undergoing senescence and ripening fruits. Ethylene promotes senescence and abscission of plant organs especially of leaves and flowers. Ethylene is highly effective in fruit ripening. The most widely used compound as source of ethylene is ethephon. Ethephon in an aqueous solution is readily absorbed and transported within the plant and releases ethylene slowly. Ethephon hastens fruit ripening in tomatoes and apples and accelerates abscission in flowers and fruits (thinning of cotton, cherry, walnut). It promotes female flowers in cucumbers thereby increasing the yield. **Calcium carbide used to ripen fruits reacts with moisture to release ethylene**
- **Abscisic acid** acts as a general **plant growth inhibitor and an inhibitor of plant metabolism**. ABA inhibits seed germination. ABA stimulates the closure of stomata and increases the tolerance of plants to various kinds of stresses. Therefore, it is also called the stress hormone. **ABA acts as an antagonist to GAs.**
- Flowering in certain plants depends not only on a combination of light and dark exposures but also their relative durations. This response of plants to periods of day/night is termed **photoperiodism**. Based on that they are divided into short day plants, long day plants and day neutral plants
- There are plants for which flowering is either quantitatively or qualitatively dependent on exposure to low temperature. This phenomenon is termed **vernalisation**. Some important food plants include the winter variety of wheat, barley, rye. Another example of vernalisation is seen in biennial plants. Biennials are monocarpic plants that normally flower and die in the second season. Sugarbeet, cabbages, carrots are some of the common biennials.
- **Heliophytes** are sun loving plants, leaves are dark green and waxy
- **Sciophytes** are shade tolerant plants. They grow broader, thinner leaves to catch more sunlight relative to the cost of producing the leaf. Shade-tolerant plants are also usually adapted to make more use of soil nutrients than shade-intolerant plants. Ferns are a good example

Previous Year Questions

1) How does calcium carbide ripen mangoes? (2018)

a) It reacts with moisture and release ethylene

b) It reacts with moisture and release ethyne

c) It reacts with moisture and releases acetaldehyde which in turn releases ethylene.

d) It reacts with starch and releases acetylene.

2) Which one of the following is a biofertilizer? (2018)

a) Rhizobium

b) Azobacter

c) Blue-green Algae

d) All of the Above

3) Plants growing under direct sunlight are known as Heliophytes. What do we call the plants growing under shades? (2020)

a) Psammophytes

b) Sciophytes

c) Monocots

d) Dicots.

4) Wooden doors often swell up and get stuck during rainy season. This is due to the phenomenon of (2020)

a) Endosmosis

b) Imbibition

c) Endocytosis

d) Capillarity

Chapter 5:Biotechnology

Biotechnology

- Biotechnology deals with techniques of using live organisms or enzymes from organisms to produce products and processes useful to humans
- The scientifically erroneous and immoral theory of "racial improvement" and "planned breeding," which gained popularity during the early 20th century is called as **eugenics**. Eugenicists worldwide believed that they could perfect human beings and eliminate so-called social ills through genetics and heredity

Recombinant DNA technology

- Technique wherein a gene of interest is inserted into a vector to produce a recombinant DNA (rDNA) or products of the recombinant DNA
- An important tool is **Vectors**- A carrier or an agent. Eg., Virus, Bacterial Artificial Chromosome (BAC)/Yeast Artificial Chromosome (YAC)
- **Plasmid (A plasmid is a small, extra chromosomal DNA molecule within a cell that is physically separated from nuclear chromosomal DNA and can replicate independently. They are most commonly found as small circular, double-stranded DNA molecules in bacteria)**
- Enzymes- **Nuclease** (Restriction enzyme/ Molecular scissors) and Ligase for ligation

Steps in Recombinant DNA technology

- Isolation of genetic material- GoI is isolated using certain enzymes
- Restriction enzyme digestion- Nuclease will act as molecular scissors to extract the GoI
- Amplification using PCR (Polymerase Chain Reaction)- GoI is multiplied to for exact same copies called as **clones**
- Ligation of DNA molecules into vector using ligase
- Insertion of recombinant DNA into host
- Obtaining foreign gene/product
- Downstream processing – Purification and marketing

Genome sequencing

- Genome sequencing is figuring out the order of DNA nucleotides, or bases, in a genome—the order of Adenine, Cytosine, Guanines, and Thymine that make up an organism's DNA

Human genome project

- The Human Genome Project (HGP) is an international scientific research project with the goal of determining the sequence of nucleotide base pairs that make up human DNA, and of identifying and mapping all of the genes of the human genome.
- World's largest collaborative biological project
- The Project was coordinated by the National Institutes of Health (NIH) and the U.S. Department of Energy

- Planning started after the idea was picked up in 1984 by the US government, the project formally launched in 1990, and was declared complete on April 14, 2003. Level "complete genome" was achieved in May 2021

Goals of Human genome project

- Sequencing the entire genome.
- Identification of the complete human genome.
- Creating genome sequence databases to store the data.
- Optimization of the data analysis.
- Taking care of the legal, ethical, and social issues that the project may pose

Results of Human genome project

- Human Genome contains 3 billion nucleotides
- Proteins are coded by less than 2 percent of the genome
- On average, a gene is made up of 3000 nucleotides
- Most of the genome is made up of repetitive sequences which have no coding purposes

IndiGen Project

- IndiGen programme aims to undertake whole genome sequencing of thousands of individuals representing diverse ethnic groups from India.
- Objective is to enable genetic epidemiology and develop public health technologies applications using population genome data and open new vistas for advancing next-generation personalized medicine in the country

DNA fingerprinting

- DNA Fingerprinting is a technique that is used to determine the nucleotide sequences of repetitive areas of DNA which are unique to each individual.
- It is also called DNA profiling or DNA typing or DNA barcoding
- **Short nucleotide repeats** or **Short tandem repeats** that vary in number from person to person are called as **Variable number Tandem Repeats (VNTRs)** can characterize DNA profiling
- **Application of DNA Fingerprinting in Human:**
- Individuality: It helps to differentiate one human being from another with the exception of monozygotic/ identical twins
- Parental Disputes: Identification of original parents
- Human Lineage: Different races of human
- Hereditary Diseases
- Forensics: Investigation of criminal cases

INSACOG

- The Indian SARS-CoV-2 Genomics Consortium (INSACOG) is a multi-laboratory, multi-agency, Pan-India network to monitor genomic variations in the SARS-CoV-2 by a sentinel sequencing effort.
- Any changes to the genetic code, or mutations, can be observed in the samples and provide information to aid public health response
- INSACOG also aims to focus on sequencing of clinical samples to understand the disease dynamics and severity and for this a program on hospital network is also being considered.
- Till date ~~28~~ 38 genome sequencing labs under INSACOG has been established (as of Apr 2022)
- **In Assam, CSIR NEIST, Jorhat has the INSACOG lab**

Storing in database

- Scientists all over the world publish their genome sequencing results in a publicly available database, through which global awareness is given a direction by respective governments
- DNA Data Bank of Japan (National Institute of Genetics); EMBL (European Molecular Biology Laboratory); GenBank at (National Center for Biotechnology Information) are some examples
- **Global Initiative on Sharing Avian Influenza Data (GISAID):** Global science initiative and primary source established in 2008 that provides open-access to genomic data of influenza viruses and the coronavirus responsible for the COVID-19 pandemic.

Somatic cell nuclear transfer technology

- In this technique the nucleus of a somatic cell (body cell) is transferred to the cytoplasm of an anucleate egg
- The first animal that was developed by this technique was Dolly, the sheep, in 1996

Stem cell technology

- Stem cell is undifferentiated cell of multicellular organism which is capable of giving rise to indefinitely more cells (through mitosis) of same type, and from which certain other kinds of cell may be formed by the cellular differentiation
- Based on character:
- **Totipotent**: Stem cells which can give rise to a complete organism
- **Pluripotent**: Stem cells which can give rise to any type of cells
- **Multipotent**: Stem cells which can give rise to many type of cells
- Based on origin:
    - **Embryonic stem cell (ESC)**: Embryonic stem cells (ESCs) are pluripotent stem cells derived from the inner cell mass of the blastocyst, an early-stage embryo
    - **Adult stem cell**: Adult stem cells are undifferentiated cells, found throughout the body after development, that multiply by cell division to replenish dying cells and regenerate damaged tissues. Also known as somatic stem cells.
- **Induced Pluripotent stem cell (iPSC):** Induced pluripotent stem cells (iPS cells or iPSCs) are a type of pluripotent stem cell that can be generated from adult somatic cells such as by genetic reprograming or the 'forced' introduction of reprogramming genes called as Yamanaka factors
- Hematopoietic stem cell transplantation (HSCT) has been used to treat people with conditions such as leukemia and lymphoma

In vitro Fertilization

- Process of fertilization where an egg is combined with sperm in vitro (in the lab)
- IVF is a type of assisted reproductive technology used for infertility treatment and gestational surrogacy
- In July 1978, Louise Brown was the first child successfully born after her mother received IVF treatment

Genome editing

- Genome editing is a technique used to modify DNA precisely and efficiently within a cell.
- Genome editing can be used to add, remove, or alter DNA in the genome.
- It involves making cuts at specific DNA sequences with enzymes called 'engineered nucleases.
- Some examples of engineered nucleases are: Cas9, ZFNs (Zinc Finger Nucleases), TALENs (Transcriptor Activator Like Effector Nucleases) etc.
- By editing the genome, the characteristics of a cell or an organism can be changed.

Crispr-Cas9

- CRISPR: - Clustered Regularly Interspaced Short Palindromic Repeats. It is family of DNA sequences found in the genomes of prokaryotic organisms such as bacteria and archaea
- Cas9: - CRISPR-associated protein 9
- These sequences are derived from DNA fragments of bacteriophages that had previously infected the prokaryote.

Xenotransplantation

- Xenotransplantation or heterologous transplant, is the transplantation of living cells, tissues or organs from one species to another
- Such cells, tissues or organs are called xenografts or xenotransplants
- Example includes non-human heart, lungs, and kidneys to a human

Genetically Modified Organisms (GMO)

- Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called Genetically Modified Organisms (GMO)

Applications of GM Plants

- Made crops more tolerant to abiotic stresses (cold, drought, salt, heat,etc)
- Reduced reliance on chemical pesticides (pest-resistant crops)
- Helped to reduce post-harvest losses
- Increased efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil)
- Enhanced nutritional value of food, e.g., golden rice, i.e., Vitamin 'A' enriched rice

Bt Cotton

- ***Bacillus thuringiensis* (or Bt) is a Gram-positive, soil-dwelling bacterium, the most commonly used biological pesticide worldwide**.
- *B. thuringiensis* also occurs naturally in the gut of caterpillars of various types of moths and butterflies, as well on leaf surfaces, aquatic environments, animal feces, insect-rich environments, and flour mills and grain-storage facilities.
- Bt toxin gene code (**cry gene**) is inserted into cotton as a transgene, causing it to produce a natural insecticide in its tissues
- **Bollgard Bt cotton** (single-gene technology) is India's first biotech crop technology approved for commercialization in India in 2002. It introduced the gene Cry1Ac for protection against bollworms
- Bollgard II technology contains a superior double-gene technology – Cry1Ac and Cry 2Ab which provides protection against bollworms and Spodoptera caterpillar
- Bollgard III- Cry genes and vip3A (helps to control common cotton pests like black cutworm)

GM Mustard

- GM Mustard (Dhara Mustard Hybrid-11) is a genetically modified hybrid variety of the mustard
- Aim was to reduce India's demand for edible oil imports
- Developed by Professor Deepak Pental from the University of Delhi
- It uses a **system of genes from soil bacterium *Bacillus amyloliquefaciens*** that makes mustard — generally a self-pollinating plant — better suited to hybridization than current methods.
- It uses an East European mustard variety (EH-2) and the Indian mustard variety (Varuna) for the process.
- **Barnase gene of the bacteria induced Male sterility in Varuna and the barstar gene line is fertility restorer in EH-2. The Bar gene marks out GM crops from other non GM crops thus eliminating all non-sterile plants with a glufosinate spray in order to create pollen free sterile GM plants.**

Flavr Savr Tomato

- A genetically modified tomato, was the first commercially grown genetically engineered food to be granted a license for human consumption.
- The enzyme Beta polygalacturonase (PG) normally contributes to spoilage by degrading pectin in cell walls and results in the softening of fruit which makes them more susceptible to being damaged by fungal infections
- The Flavr Savr was made more resistant to rotting by the addition of an antisense gene (antisense RNA) which interferes with the production of the enzyme Beta polygalacturonase (PG). Antisense mRNA will make the RNA double stranded and invalid for protein formation, thus saving the flavor of tomato

Golden Rice (Biofortified rice)

- Golden rice is a variety of rice produced through genetic engineering to biosynthesize beta-carotene, a precursor of **vitamin A**, in the edible parts of rice

Disadvantage of GM Crops

- High cost- The entire process involves technology
- Resistance development- Certain group of organisms could develop resistance against the GM crops thus will not be beneficial further
- Terminator technology- **Genetic use restriction technology (GURT),** also known as terminator technology or suicide seeds, is the name given to proposed methods for restricting the use of genetically modified crops by activating (or deactivating) some genes only in response to certain stimuli, especially to cause second generation seeds to be infertile

RNA interference (RNAi)

- RNAi takes place in all eukaryotic organisms as a method of cellular defense
- Involves silencing of a specific mRNA due to a complementary dsRNA molecule (siRNA, shRNA, miRNA) that binds to and prevents translation of the mRNA thus preventing the protein formation
- The complex formed is called as **RISC (RNA Induced Silencing Complex)**
- The source of this complementary RNA could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons)that replicate via an RNA intermediate
- **Application of RNAi:**
    - Insecticide/ Pesticide
    - Cancer treatment
    - Treatment of neurogenerative diseases
    - Viral infection suppression

Mycorrhizal Biotechnology

- A mycorrhiza is a mutual symbiotic association between a fungus and a plant. The term mycorrhiza refers to the role of the fungus in the plant's rhizosphere, its root system. Mycorrhizae play important roles in plant nutrition, soil biology, and soil chemistry.
- Mycorrhiza fungi act as biofertilizer and helps in maintaining the soil resulting in higher organic content
- It has ability to tolerate extremes of pH, high temperature and heavy metal toxicity
- Provides nutrients to plants
- Helps in resisting drought and salinity
- Fungi can reduce disease occurrence
- Absorb phosphorous
- Decrease soil erosion

Genetically Engineered Insulin- Humulin

- In ancient times the insulin that is required was extracted from the slaughtered cattle or pigs. The extraction process was difficult and even the production quantity was low.
- The insulin made from slaughtered animals affected some patients with allergies and other side effects due to foreign particles. Hence humulin was introduced to avoid all these disadvantages caused by animal insulin.

- In 1983, Eli Lilly an American company prepared two DNA sequences corresponding to A and B, chains of human insulin and introduced them in plasmids of E. coli to produce insulin chains.
- Insulin has two peptide chains referred to as A chain and B chain. These two chains are linked together by two disulfide bonds.
- In most of the species, A chain has 21 amino acids and B chain has 30 amino acids

Gene Therapy

- Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo.
- A mutation in a certain gene causes the production of a dysfunctional protein resulting (usually recessively) in an inherited disease, gene therapy could be used to deliver a copy of this gene that does not contain the deleterious mutation and thereby produces a functional protein
- **The first clinical gene therapy was given in 1990 to a 4-year-old girl with adenosine deaminase (ADA) deficiency**
- Gene therapy can treat SCID (severe combined immunodeficiency), cystic fibrosis, muscular dystrophy

Molecular Diagnosis

- **PCR**- Polymerase chain reaction (PCR) is a method widely used to rapidly make millions to billions of copies (complete or partial) of a specific DNA sample, allowing scientists to take a very small sample of DNA and amplify it (or a part of it) to a large enough amount to study in detail. PCR was invented in 1983 by the American biochemist Kary Mullis. Taq polymerase is an enzyme used in PCR and is isolated from the thermophilic bacterium *Thermus aquaticus*.
- **ELISA**- The enzyme-linked immunosorbent assay (ELISA) is a commonly used analytical biochemistry assay. ELISA has been used as a diagnostic tool in medicine, pathology, and biotechnology, as well as a quality control check in various industries. **Used for HIV test or West Nile virus**.

Transgenic Animals

- Transgenic animal is one whose genome has been altered by the transfer of a gene or genes from another organism
- Over 95 per cent of all existing transgenic animals are mice
- Human protein (**α-1-antitrypsin) used to treat emphysema**.
- In 1997, the first transgenic cow, Rosie, produced human protein-enriched milk (2.4 grams per litre). The milk contained the **human alpha-lactalbumin** and was nutritionally a more balanced product for human babies than natural cow-milk

Biopiracy

- The practice of commercially exploiting naturally occurring biochemical or genetic material, especially by obtaining patents that restrict its future use, while failing to pay fair compensation to the community from which it originates
- Traditional knowledge is exploited

- The Traditional Knowledge Digital Library (TKDL) was established in 2001. Vinod Kumar Gupta is the founder of TKDL
- **Biopiracy in India**
    - Neem
    - Basmati Rice
    - Indian Wheat
    - Turmeric

Bioinformatics

- Bioinformatics is an interdisciplinary field that develops methods and software tools for understanding biological data, in particular when the data sets are large and complex
- It helps in prediction of structure of several molecules thus helping in predicting a target based drug delivery

ART Act, 2021

- The ART Regulation Act aims to regulate and supervise assisted reproductive technology clinics and banks, prevent misuse of the technology and promote the ethical practice of the services.
- **Features of ART Act, 2021:**
    - Setting up of ART Banks
    - Regulation of ART Clinics
    - National and State Boards for Surrogacy for the regulation of ART services
    - Pre-implantation genetic testing shall be used to screen the embryo for known, pre-existing, heritable, or genetic disease
    - Offences under the act include clinics offering sex selection, abandoning or exploiting children born through ART, the selling, buying, or importing of human embryos and exploiting the couple or donors concerned in any form.

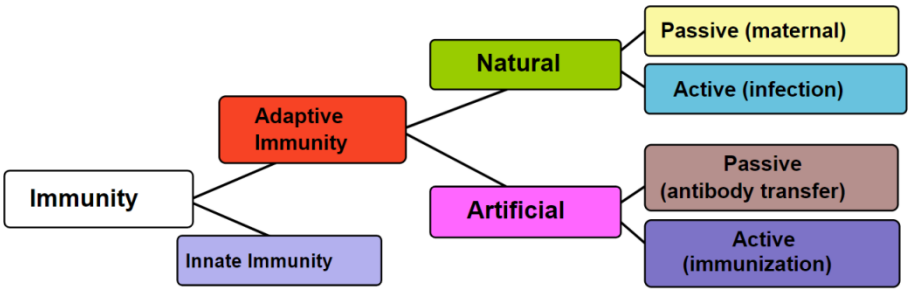
Previous Year Questions

1. **Science of improving human race is (2011)**
    a) **Eugenics**
    b) Epigenesis
    c) Epistasis
    d) Euthenics

Chapter 6:Health and Diseases

Immunity

- Immunity is the capability of multicellular organisms to resist harmful microorganisms
- **Immunity present since birth is called innate immunity**
- **Adaptive immunity can be acquired either 'naturally' (by infection) or 'artificially' (through deliberate actions such as vaccination). Adaptive immunity can also be classified as 'active' or 'passive'.**
- **Active immunity is acquired through the exposure to a pathogen, which triggers the production of antibodies by the immune system. Passive immunity is acquired through the transfer of antibodies or activated T-cells derived from an immune host either artificially or through the placenta; it is short-lived, requiring booster doses for continued immunity.**
- The primary and secondary immune responses are carried out with the help of two special types of lymphocytes present in our blood, i.e., B-lymphocytes and T-lymphocytes
- B-lymphocytes produce an army of proteins in response to pathogens into our blood to fight with them. These proteins are called antibodies
- T-cells themselves do not secrete antibodies but help B cells to produce them.



Types of Antibodies

Antibody/ Immunoglobulin	Secretion
IgA	Tears, saliva, respiratory and intestinal secretions, and colostrum (the first milk produced by lactating mothers). IgA is produced by B cells located in the mucous membranes of the body.

IgD	Expressed in the plasma membranes of immature B-lymphocytes. IgD is also produced in a secreted form that is found in small amounts in blood serum
IgE	Allergy and worm infections
IgG	Maternal IgG is transported across the placenta directly into the bloodstream of the fetus during intrauterine life
IgM	IgM is the first antibody secreted by the adaptive immune system in response to a foreign antigen

Deficiency Disease

S. No.	Vitamin	Deficiency diseases
1)	Thiamine (B_1)	Beriberi
2)	Riboflavin (B_2)	Glossitis
3)	Niacin (B_3)	Pellagra
4)	Pyridoxine (B_6)	Anaemia
5)	Cyanocobalamine (B_{12})	Pernicious anaemia
6)	Folic acid (B_9)	Anaemia
7)	Pantothenic acid	Burning feet
8)	Biotin	Nerves disorders
9)	Ascorbic acid (Vitamin C)	Scurvy
10)	Retinol (Vit. A)	Eye and Skin diseases – Night blindness, Xerophthalmia, Rupture of cornea, Scale formation on skin
11)	Calciferol (Vit. D)	Rickets, fragile bones
12)	Tocoferol (Vit. E)	Fertility disorders – Sterility in males, Abortions in females
13)	Phylloquinone (Vit. K)	Blood clotting

Common Infectious Diseases

Disease	Causative Organism
Typhoid	*Salmonella typhi* (Can be detected by Widal test)
Cholera	*Vibrio cholerae*
Yaws	*Treponema pallidum*
Diptheria	*Corynebacterium diphtheriae*
Leprosy	*Mycobacterium leprae*
Pneumonia	*Streptococcus pneumoniae* and *Haemophilus influenzae*

Tuberculosis	*Mycobacterium tuberculosis*
Common cold	Rhino virus, Adenovirus
Smallpox	Variola virus
Hepatitis	Hepatitis A virus, Hepatitis B virus, Hepatitis C virus
Influenza	Influenza virus
Smallpox	Variola virus
Encephalitis	Herpes Simplex Virus
Mumps	Paramyxovirus
Genital warts	HPV
Syphilis	*Treponema pallidum*
Diarrhoea	Rotavirus
Malaria	Plasmodium spp
Amoebiasis	*Entamoeba histolytica*
Ascariasis	Ascaris
Elephantiasis or filariasis	Wuchereria
Ringworm	Microsporum, Trichophyton and Epidermophyton
Warts	Papiloma virus
AIDS	HIV- Sexually transmitted disease (STD)
Syphilis	*Treponema pallidum* (STD)
Gonorrhea	*Neisseria trachomatis* (STD)
Chickenpox	Varicella-zoster virus
Monkeypox	Monkeypox virus

DNA virus

Virus	**Disease**
Herpesviruses	Herpes simplex and shingles- blisters around the mouth and blisters around the genitals
Human Papiloma virus (HPV)	Warts or Cancer of the cervix, vulva, vagina, penis, anus, mouth, tonsils, or throat (STD)
Hepadnavirus	Hepatitis B- Liver is affected
Monkeypox virus	Monkeypox disease

Common Mosquito borne disease

Disease	Mosquito (As a Vector)	Causative Organism
Malaria	Female Anopheles	*Plasmodium spp (*Protozoa)
Dengue	Female *Aedes aegypti*	Dengue virus
West Nile virus	Culex	Flavivirus
Chikungunya	*Aedes albopictus* and *Aedes aegypti*	Chikungunya virus (CHIKV)
Yellow fever	*Aedes aegypti*	Flavivirus
Filariasis	*Culex pipiens*	Roundworms (*Wuchereria bancrofti*)
Japanese encephalitis	*Culex*	Japanese encephalitis virus
Zika fever	*Aedes*	Zika virus

AIDS

- HIV (Human Immunodeficiency Virus), a **retrovirus** enters into helper T-lymphocytes (TH), replicates and produce progeny viruses
- A widely used diagnostic test for AIDS is enzyme linked immuno-sorbent assay (ELISA) and Western Blot
- Zidovudine (ZDV), also known as azidothymidine (AZT), is an **antiretroviral medication** used to prevent and treat HIV/AIDS.

Malaria

- The parasites **initially multiply within the liver cells and then attack the red blood cells (RBCs) resulting in their rupture**
- The rupture of RBCs is associated with release of a toxic substance, **hemozoin**, which is responsible for the chill and high fever recurring every three to four days

Swine flu

- Swine influenza is an infection caused by any of several types of swine influenza viruses.
- Direct transmission of a swine flu virus from pigs to humans is occasionally possible
- Severe respiratory infection caused by the virus **H1N1 strains**

Bird Flu

- Avian influenza, known informally as avian flu or bird flu, is a variety of influenza caused by viruses adapted to birds
- The type with the greatest risk is highly pathogenic avian influenza (HPAI). The most well-known HPAI strain, H5N1

Corona virus Diseases

- 2002-2003: Severe Acute respiratory Syndrome (SARS)
- 2012- Middle East Respiratory Syndrome (MERS)
- 2019-20: COVID-19
- **The World Health Organization (WHO) on March 11, 2020, has declared the novel coronavirus (COVID-19) outbreak a global pandemic**
- **Spike (S) proteins** of the virus are responsible to cause disease in human beings as the S protein can bind to a receptor in human called as **Angiotensin Converting Enzyme (ACE-2) receptor**
- **XE is a recombinant variant that has characteristics of both the BA.1 and BA.2 strains of the Omicron variant**.

Monkeypox

- An ongoing outbreak of Monkeypox, a viral disease, was confirmed in May 2022.[17] The initial cluster of cases was found in the United Kingdom, where the first case was detected on 6 May 2022 in an individual with travel links to Nigeria (where the disease is endemic)
- On 23 July, the Director-General of the World Health Organization (WHO), Tedros Adhanom Ghebreyesus, declared the outbreak a public health emergency of international concern (PHEIC)
- Monkeypox is a viral infection that manifests a week or two after exposure with fever and other non-specific symptoms, and then produces a rash with lesions that usually last for 2–4 weeks before drying up, crusting and falling off
- While Monkeypox can cause large numbers of lesions, in the current outbreak, some patients experience only a single lesion in the mouth or on the genitals, making it more difficult to differentiate from other infections
- Monkeypox **spreads through close, personal, often skin-to-skin contact**. The disease **can spread through direct contact with rashes, or body fluids from an infected person, by touching objects and fabrics that have been used by someone with Monkeypox or through respiratory secretions.**

National Tuberculosis Elimination Programme (NTEP)

- The commitment is emphasized of the Union government achieving the sustainable development **goal of ending TB by 2025**, five years ahead of the global targets

Cancer

- Normal cells show a property called contact inhibition by virtue of which contact with other cells inhibits their uncontrolled growth
- Cancer cells appears to have lost this property
- **Tumors**- Benign and Malignant
- Malignant tumors when spreads from one part to another part is called metastasis
- World cancer day- 4th February
- National cancer awareness day- 7th November

Autoimmuned disorders

- Autoimmune disorders are those diseases that occur as a result of the body's immune system attacking different cells, tissues, organs or the entire body
- Some common autoimmune diseases include: Rheumatoid arthritis (RA), Graves' disease, Hashimoto's thyroiditis, Addison's disease, Guillain-Barre syndrome, Multiple sclerosis (MS), Myasthenia gravis, Autoimmune vasculitis, Type 1 diabetes, Pernicious anemia.

Diabetes

- **Type 1 diabetes**: Body attacks the cells in the pancreas which means it cannot make any insulin. Found in children
- **Type 2 diabetes**: Body is unable to make enough insulin or the insulin you do make doesn't work properly
- **Gestational diabetes**: Diabetes seen among women during pregnancy

Allergy

- Number of conditions caused by hypersensitivity of the immune system to typically harmless substances in the environment. The underlying mechanism involves immunoglobulin E antibodies (IgE), that release inflammatory chemicals such as histamine

Hereditary Diseases

Disease	Cause
Downs syndrome	Trisomy of 21st Chromosome
Klinefelter's syndrome	44+ XXY chromosomes
Turner's syndrome	44+ X0 chromosomes
Erythroblastosis foetalis	Rh incompatibity
Hemophilia	Haemophilia is an inherited genetic condition, caused by a defect in the gene that determines how the body makes clotting factors
Colour-blindness	Genetic (inherited usually X-linked)
Thalassemia	Thalassemia is inherited blood disorders characterized by decreased hemoglobin production
Sickle cell anemia	Mutation of RBC resulting into defect. β-globin gene, which results in glutamate being substituted by valine at position 6

Mitochondrial inheritance

- Caused because of defective mitochondria of the mother
- As of 2016 there were three Mitochondrial Replacement Therapy (MST) techniques in use:
    - maternal spindle transfer (MST)
    - pronuclear transfer (PNT)
    - polar body transfer (PBT)

PLANT DISEASE

Crop	Disease	Causative Organism
Wheat	Rust (Black, Brown, Yellow)	*Puccinia (Fungi)*
Wheat	Smut	*Tilletia (Fungi)*
Wheat	Loose smut	*Ustaligo nuda (Fungi)*
Wheat	Powdery mildew	*Blumeria graminis (Fungus)*
Rice	Brown spot	*Bipolaris oryzae (Fungi)*
Rice	False smut	*Ustilaginoidea virens (Fungi)*
Rice	Tungro	Rice tungro spherical virus (RTSV)
Maize	Banded leaf and sheath blight	*Rhizoctonia solani (Fungus)*
Bajra	Ergot	*Claviceps fusiformis (Fungi)*
Tobacco	Mosaic of tobacco	TM
Potato	Late blight	*Phytopthora infestons (Fungi)*
Potato	Early blight	*Alternaria solani(Fungi)*
Tea	Blister blight	*Exobasidium vexans (Fungi)*
Coffee	Coffee rust	*Hemileila vastatrix*
Banana	Panama disease	*Fusarium oxysporum*
	Bunchy top	*Banana bunchy top virus (BBTV).*
Mango	Bunchy top	*Fusarium*
Mango	Black tip	*Brick kilns release SO2, CO, ethylene*
Mango	Spongy tissue	*Internal physiological disorder*
Apple	Scab	*Venturia inaequalis*
Sugarcane	Red rot	*Colletotrichum falcatum*

- **Brown spot- Bengal famine 1943**
- **Great famine in Ireland- 1845-52: Blight of potato**

Previous Year Questions

1. Swine flu is caused by (2011)

a) Bacteria
b) Virus
c) Protozoa
d) Fungi

2. Which of the following diseases is not caused by virus? (2020)

a) Influenza
b) Anthrax
c) AIDS
d) Denguefever

Chapter 7: Vaccination and Treatment

Vaccine

- A vaccine is a biological preparation that provides active acquired immunity to a particular infectious disease
- **Edward Jenner** (17 May 1749 – 26 January 1823) was a British physician and scientist who pioneered the concept of vaccines including creating the smallpox vaccine, the world's first vaccine. In the West, Jenner is often called "**the father of immunology**"
- The terms vaccine and vaccination are derived from *Variolae vaccinae* ('smallpox of the cow'), the term devised by Jenner to denote cowpox
- **Serum Institute of India (SII), Pune is the world's largest manufacturer of vaccines**

Mission Indradhanush

- Mission Indradhanush is a health mission of the Government of India. It was launched by Union Health Minister J. P. Nadda on **25 December 2014.**
- **The scheme seeks to drive towards 90% full immunisation coverage of India and sustain the same by year 2022**.
- The ultimate goal of Mission Indradhanush is to ensure full immunisation with all available vaccines for children up to two years of age and pregnant women.

Universal Immunisation Programme

- Universal Immunisation Programme (UIP) is a vaccination programme **launched by the Government of India in 1985.**
- It became a part of Child Survival and Safe Motherhood Programme in 1992 and is currently one of the key areas **under National Rural Health Mission since 2005**.
- The programme now consists of **vaccination for 12 diseases**- tuberculosis, diphtheria, pertussis (whooping cough), tetanus, poliomyelitis, measles, hepatitis B, diarrhoea, Japanese encephalitis, rubella, pneumonia (haemophilus influenzae type B) and Pneumococcal diseases (pneumococcal pneumonia and meningitis).
- Hepatitis B and Pneumococcal diseaseswere added to the UIP in 2007 and 2017 respectively.
- The other additions in UIP through the way are inactivated polio vaccine (IPV), rotavirus vaccine (RVV), Measles-Rubella vaccine (MR). Four new vaccines have been introduced into the country's Universal Immunisation Programme (UIP), including injectable polio vaccine, an adult vaccine against Japanese Encephalitis and Pneumococcal Conjugate Vaccine
- From February 2017, Union ministry of health and family welfare has rolled out Measles-Rubella vaccine from UIP

Major Vaccine Types

Attenuated Vaccine:

- Most attenuated vaccines are viral; some are bacterial in nature. Many of these are active viruses that have been cultivated under conditions that disable their virulent properties, or that use closely related but less dangerous organisms to produce a broad immune response.

- Examples include the vaccines for viral diseases **yellow fever, measles, mumps, Oral polio vaccine (OPV) and rubella, and the bacterial disease typhoid**.
- The live **Mycobacterium tuberculosis vaccine developed by Calmette and Guérin is not made of a contagious strain but contains a virulently modified strain called "BCG"**used to elicit an immune response to the vaccine.
- The live attenuated vaccine containing strain **Yersinia pestis is used for plague immunization**
- **NOTE**: When a virus in oral polio vaccine (OPV) de-attenuates by mutations, acquiring transmission efficiency and neuro-virulence, it is called cVDPV (Circulating vaccine-derived poliovirus)

Inactivated Vaccine:

- Some vaccines contain inactivated, but previously virulent, micro-organisms that have been destroyed with chemicals, heat, or radiation.
- Examples include **polio vaccine (IPV), hepatitis A vaccine, rabies vaccine and most influenza vaccines including Covaxin**
- **Covaxin:**Covaxin (codenamed as BBV152) is a whole inactivated virus-based COVID-19 vaccine developed by Bharat Biotech in collaboration with the Indian Council of Medical Research - National Institute of Virology. On 3 November 2021, the World Health Organization (WHO) validated the vaccine for emergency use.As of 31 January 2022, Covaxin has been granted emergency use approval in 13 countries
- **Toxoid:** Toxoid vaccines are made from inactivated toxic compounds that cause illness rather than the micro-organism. Examples of toxoid-based vaccines include **tetanus** and **diphtheria**

Subunit Vaccine:

- A subunit vaccine uses a fragment of it to create an immune response.
- Examples are subunit vaccine against hepatitis B, plague, Corbevax etc
- **Corbevax**: Biological-E in collaboration with US-based Dynavax and Baylor College of Medicine is the manufacturer. Recombinant Protein Sub-Unit Vaccine (India's 1st indigenously developed). It's made up of "spike protein", combined with adjuvant (Al $(OH)_3$ gel) which the virus uses to latch on and enter human cells. It is synthesized in Yeast (*Pichia pastoris*). **India starts vaccinating children in 12-14 age group with Corbevax from 16th March 2022**
- **Covovax:** The Novavax candidate, which is also known as NVX-CoV2373, is a "recombinant nanoparticle" vaccine with the company saying it is the "first protein-based option" that has sought a green light for launch from any regulatory agency. Novavax scientists first isolated the spike gene and then used another virus to carry the gene into moth cells, where it went ahead and formed the spikes of the kind that stud the novel coronavirus's surface. These spikes were then harvested and arranged as nanoparticles that are injected into the arm muscle. Covovax, the Indian Novavax candidate is manufactured by SII

Conjugate Vaccine:

- Conjugate vaccines **combine weak antigen with strong antigen as a carrier**.
- Examples include *Haemophilus influenzae* type B vaccine,Soberana 2 (Cuba developed the world's first conjugate vaccine for COVID-19. It is the only conjugate vaccine that combines the

virus' **S-protein with a deactivated form of tetanus** to boost the immune response), Pneumococcal conjugate vaccine etc.

- **Pneumococcal conjugate vaccine**: It's effective against pneumonia, meningitis, sepsis. Different serotypes are **conjugated with nontoxic diptheria toxin.** India's first pneumococcal conjugate vaccine is "Pneumosil" which is developed by the Serum Institute of India Private Limited (SIIPL) in collaboration with various other partners like the Bill and Melinda Gates Foundation

Viral Vector Vaccine:

- A viral vector vaccine is a vaccine that uses a viral vector to deliver genetic material coding for a desired antigen into the recipient's host cells.
- As of April 2021, six viral vector vaccines have been authorized for use in humans in at least one country: four COVID-19 vaccines and two Ebola vaccines.
- Vector virus- Adenovirus, Ebola virus, adeno-associated virus, retrovirus (including lentivirus), cytomegalovirus, and Sendai virus, as well as influenza virus and measles virus.
- **Oxford–AstraZeneca COVID-19 vaccine**: The Oxford–AstraZeneca COVID-19 vaccine, codenamed AZD1222, and sold under the brand names Covishield and Vaxzevria among others, is a viral vector vaccine for prevention of COVID-19. Developed in the United Kingdom by the Oxford University and British-Swedish company AstraZeneca, using as a vector the modified chimpanzee adenovirus ChAdOx1. The vaccine is given by intramuscular injection. In India, the manufacturer of covishield isSerum Institute Of India Ltd

mRNA Vaccine:

- An mRNA vaccine is a type of vaccine that uses a copy of a molecule called messenger RNA (mRNA) to produce an immune response.
- The mRNA is delivered by a co-formulation of the RNA encapsulated in lipid nanoparticles that protect the RNA strands and help their absorption into the cells.
- **Examples include Pfizer–BioNTech COVID-19 vaccine, Moderna, CureVac, and Walvax, Sputnik V etc**.

DNA vaccine:

- DNA vaccines work by injecting genetically engineered plasmid containing the DNA sequence encoding the antigen(s) against which an immune response is sought, so the cells directly produce the antigen, thus causing a protective immunological response.
- **In August 2021, Indian authorities gave emergency approval to ZyCoV-D. Developed by Cadila Healthcare, it is the first DNA vaccine approved for humans**.

National Technical Advisory Group on Immunization (NTAGI)

- A body whose express mandate is to study various facets of the vaccine before clearing it for the national immunization programme

COVAX

- COVID-19 Vaccines Global Access, abbreviated as COVAX, is a worldwide initiative aimed at equitable access to COVID-19 vaccines
- Directed by the GAVI vaccine alliance, the Coalition for Epidemic Preparedness Innovations (CEPI), and the World Health Organization (WHO), alongside key delivery partner UNICEF
- COVAX began distributing vaccines in February 2021.

GAVI

- Global Alliance for Vaccines and Immunisation (GAVI) is public-private international health cooperation that aims to improve vaccination access in low-income nations
- Gavi Vaccine Alliance advocates for the vaccination of over half of the world's children.
- **A total of 16.29 crore COVID-19 vaccine doses had been supplied by India to 98 countries. These vaccines were supplied in the form of grants-in-aid, commercial sales by Indian manufacturers, and through vaccine alliance GAVI's COVAX (COVID-19 Vaccines Global Access) facility**

Vaccine Maitri

- Vaccine Maitri is a humanitarian initiative undertaken by the Indian government to provide COVID-19 vaccines to countries around the world
- **The government started providing vaccines from 20 January 2021**
- **Bhutan and Maldives were the first countries to receive vaccines as a grant by India**. This was quickly followed by shipments to Nepal, Bangladesh, Myanmar and Seychelles. By mid-March 2021, India was also supplying vaccines on a commercial basis to countries including Canada, the UK, and Saudi Arabia

Immunotherapy

- Immunotherapy or biological therapy is the treatment of disease by **activating or suppressing the immune system.**
- Immunotherapies designed to elicit or amplify an immune response are classified as activation immunotherapies, used for cancer treatment while immunotherapies that reduce or suppress are classified as suppression immunotherapies used for organ transplantation and allergies

Drug

- Drugs are chemicals of low molecular masses (~100 – 500u)
- When the biological response is therapeutic and useful, these chemicals are called medicines and are used in diagnosis, prevention and treatment of diseases.
- **Use of chemicals for therapeutic effect is called chemotherapy**
- **A generic drug is a pharmaceutical drug that contains the same chemical substance as a drug that was originally protected by chemical patents.** Generic drugs are allowed for sale after the patents on the original drugs expire. Because the active chemical substance is the same, the medical profile of generics is believed to be equivalent in performance. A generic drug has the same active pharmaceutical ingredient (API) as the original, but it may differ in some characteristics such as the manufacturing process, formulation, excipients, color, taste, and packaging
- **Over-the-counter (OTC) drugs** are medicines sold directly to a consumer without a requirement for a prescription from a healthcare professional, as opposed to prescription drugs, which may be supplied only to consumers possessing a valid prescription. **Examples includes antacid, antihistamine, aspirin, etc**

Antibiotics

- An antibiotic refers to a substance produced wholly or partly by chemical synthesis, which in low concentrations inhibits the growth or destroys microorganisms by intervening in their metabolic processes.
- Sir Alexander Fleming was a Scottish physician and microbiologist, best known for discovering the world's first broadly effective antibiotic substance, which he named **penicillin**. For this discovery, he shared the Nobel Prize in Physiology or Medicine in 1945 with Howard Florey and Ernst Boris Chain
- Antimicrobial resistance (AMR) is the ability of a microorganism (like bacteria, viruses, and some parasites) to stop an antimicrobial drug from working against it. As a result, standard treatments become ineffective, infections persist and may spread to others. Microorganisms that develop antimicrobial resistance are sometimes referred to as "superbugs"
- Multidrug-Resistant Mycobacterium Tuberculosis (MDR-TB), which is resistant to two tuberculosis drugs, isoniazid, and rifampicin. To combat MDR-TB scientists have developed a new drug named 'Bedaquiline'.
- **'Superbug gene' on the move: First found in Delhi, has now reached the Arctic**.

Probiotics

- Probiotics are live microorganisms promoted with claims that they provide health benefits when consumed, generally by improving or restoring the gut flora
- The **first discovered probiotic was a certain strain of bacillus in Bulgarian yoghurt**, called *Lactobacillus bulgaricus*. The discovery was made in 1905 by Bulgarian physician and microbiologist Stamen Grigorov

Antiseptics

- Antiseptics are applied to the living tissues such as wounds, cuts, ulcers and diseased skin surfaces
- Commonly used antiseptic, **dettol is a mixture of chloroxylenol and terpineol**

Drugs Controller General of India

- Drugs Controller General of India (DCGI) is the head of department of the Central Drugs Standard Control Organization of the Government of India responsible for approval of licences of specified categories of drugs such as blood and blood products, IV fluids, vaccines, and sera in India.
- Drugs Controller General of India, comes under the Ministry of Health & Family Welfare.
- DCGI also sets standards for manufacturing, sales, import, and distribution of drugs in India.

Diseases eradicated from India

- **Polio**: Polio has long been eradicated from India, and the entire South-East Asian region was declared polio-free **in 2014**
- **Rinderpest**: Rinderpest was not a disease that affected humans but caused disease and death to livestock including cattle. It was the second disease to be eradicated in India, and the only livestock disease to be eradicated through human efforts globally. The United Nations' Food and

Agriculture Organization declared the eradication of rinderpest **in 2010**, after 9 years of no diagnoses.

- **Smallpox**: Smallpox saw a global campaign aimed at its eradication, which finally came about in 1980.
- **Maternal and Neonatal Tetanus**: Maternal and Neonatal Tetanus (MNT) is one of the most recently eliminated diseases, with its **elimination in India being announced in August 2015**
- **Yaws:** India received citations from global bodies such as the WHO and UNICEF for eradicating yaws, in **July 2016**. This is especially remarkable in light of the fact that the WHO has set a global target for eradicating the disease by 2020. Yaws is a chronic bacterial infection that targets mainly the skin, bones and joints. It was especially prevalent among tribal populations living in remote, hilly and forest areas. Through strenuous efforts, it was eliminated in India in 2006.

Previous Year Questions

1) The prime minister of India started the largest vaccination drive in Indian history against the COVID-19 virus on (2020)

a) 14thJanuary,2021
b) 16thJanuary,2021
c) 18thJanuary,2021
d) 20thJanuary,2021

2) The biggest vaccine manufacturer, by volume ,in the world is (2020)

a) Codagenix
b) SpyBiotech
c) **SerumInstituteofIndia**
d) Novavax

3) Name the clinical procedure in which blood is transfused from recovered COVID-19 patients to a COVID-19 affected patient in critical condition. (2020)

a) Dialysistherapy
b) **Plasmatherapy**
c) Solidaritytechnique
d) Hydroxychloroquineadministration

4) What major success our country has achieved in the field of health in March this year as declared by the World Health Organisations? (2014)

a) Zero level femal mortality at childbirth
b) Total stop to open defection
c) We are declared a polio free country
d) None of the above

Chapter 8: Facts in Chemistry

Important facts

- Densest Metal: Osmium
- Heaviest Metal: Francium
- Densest Non-Metal: Iodine
- Least Dense Metal: Lithium
- Least Dense nonmetal solid: Hydrogen
- Highest Melting point: Tungsten (3410 degree Celsius): Therefore, used in bulb filaments
- Lowest melting point: Helium (-272 degree Celsius)
- Best Conductors: 1. Silver 2. Copper
- Most Corrosion Resistant: Iridium
- Hardest Substance: Diamond
- Elements most common in Universe: Hydrogen
- Most common solid elements in Earth crust: Silicon
- Most Abundant element in the earth crust: Oxygen (45%) followed by silicon, aluminium and iron
- Most abundant metallic element in Earth Crust: Aluminum
- Most abundant in earth atmosphere: Nitrogen (78%) followed by oxygen (21%) and Argon (0.93%) and CO_2 (0.04%)
- Rarest in Earth Crust: Astatine
- Highest gas at standard Temperature and Pressure (STP): Hydrogen
- Heaviest gas at STP: Radon
- Lowest melting point for a metallic element: Mercury (Liquid at room temperature, hence used in thermometer. Mercury is also used in Liquid mirror telescope)
- At room temperature, there are only two liquid elements. These are bromine and mercury.
- Gold is lustrous and ductile with purest form being the 24 carats
- **Methyl Mercaptan**: which has the worst smell in the world. The bad smell of unwashed socks and unventilataed shoes is due to methyl Mercaptan
- The characteristics odour of garlic is due to: Di propenyl di sulphide
- Metal of the future: Titanium (strong as steel but with half weight)
- **Methyl Isocyanate**: The Bhopal Killer manufactured by Union Carbide's Factory- Bhopal Gas Tragedy 1984
- The Main Ozone Depleting Substance: Chloro Fluoro Carbons (CFC)
- Acid used in storage batteries- Sulphuric acid
- Ajinomoto is Mono Sodium Glutamate mostly used in Chinese cuisine
- Royal liquid- Aqua regia: It is a mixture of hydrochloric acid (HCl) and nitric acid (HNO3) at a ratio of either 3:1 or 4:1. It is commonly used to remove noble metals such as gold, platinum and palladium from substrates, particularly in microfabrications and microelectronics labs.
- White vinegar- Acetic acid
- Nail Polish Remover- Acetone

- Aspirin- Acetylsalicylic acid used as pain releiver
- Photography store/Darkroom; "bleach bath" for photograph development- Ammonium bromide
- radiocontrast agent for x-rays and CAT scans- barium sulfate
- Chunks: Marble, limestone. Powder: Precipitated chalk- calcium carbonate
- Bleaching powder and some swimming pool disinfectants- calcium hypochlorite
- Dry ice and ice cream. Used in air guns and in paintball - carbon dioxide
- Hand sanitizer- Ethanol
- **Packet of chips contains Nitrogen** to prevent oxidation of food
- Chemical compound RDX is used- As an explosive
- vegetable preservative- polyUrethanes foam
- Soap is made up of Sodium and Potassium salt with fatty acids
- Vulcanization- Sample of rubber mixed with sulphur and litharge
- Hydrogen peroxide is used as clean oxidation
- Leviatiae is known as the father of Modern Chemistry
- Same atomic number, but different mass number- Isotopes
- Protium, Deuterium and Tritium are isotopes of hydrogen
- The higher boiling point of the water occurs due to its more value of the dielectric constant
- The rusting of the iron is the example of Oxidation
- Mohr salt is double salt
- German silver is a white alloy of nickel, zinc, and copper. Silver is absent
- The average pH value of the human blood is 7.4
- Philosopher's wool- Zinc oxide
- The iron container or vessel is galvanized by zinc
- The employed catalyst in the production of ammonia through the Haber's process is molybdenum
- The gaseous mixture of carbon monoxide and nitrogen is called Producer gas
- The main component of the natural gas is Methane
- In **L.P.G**. the main component is Butane
- **Compressed natural gas (CNG)** is a fuel gas **mainly composed of methane** (CH_4), compressed to less than 1% of the volume it occupies at standard atmospheric pressure.
- The anti-knocking properties of any fuel exhibit **octane number**
- Lignite is the brown coal
- **Anthracite coal contains the highest percentage amount of carbon**
- Galena is the ore of the metal lead
- **Graphite, Charcoal and Diamond are allotropes of carbon** (Allotrope: Each of two or more different physical forms in which an element can exist.)
- **Buckminsterfullerene** is a type of fullerene with the formula C_{60}. It has a cage-like fused-ring structure (truncated icosahedron) and resembles a soccer ball. Each of its 60 carbon atoms is bonded to its three neighbors. It is another allotrope of carbon

Phase Change Process

- A phase change, or transition, occurs when a substance undergoes a change in state on a molecular level. In most substances, changes in temperature or pressure result in a substance phase change
- **Fusion**: It occurs when a **substance changes from a solid to a liquid**. Prior to melting, strong intermolecular bonds or attractions hold the atoms, molecules or ions that comprise a solid substance tightly together in the solid form. Upon heating, the particles gain enough kinetic energy to overcome the bonds that are holding them together and become mobile.
- **Solidification**: It occurs when a **substance changes from a liquid to a solid.** While in the liquid state, the particles in a substance possess enough kinetic energy to move around in close proximity to each other. When a drop in temperature occurs, the particles lose their kinetic energy and band together. Gradually, the particles settle into a fixed position, causing the substance to take shape and become a solid
- **Vaporization**: It occurs when a **substance changes from a liquid to a gas**. The molecules in a liquid are in constant motion while staying relatively close together due to intermolecular forces. When an increase in temperature occurs, the molecules' kinetic energy also increases. This increase in temperature allows the molecules to gain kinetic energy and overcome the intermolecular forces, resulting in the vaporization of the substance.
- **Condensation**: It occurs when a **substance changes from a vapor to a liquid**. In a vapor, there are molecules with high and low kinetic energy that often collide with surfaces and each other. When molecules with low kinetic energy collide, intermolecular forces cause them to stick together. As temperature decreases, the kinetic energy of the molecules also decreases causing the molecules to stick together and resulting in condensation.
- **Sublimation:** It occurs when a **substance changes from a solid into a gas**. Increases in temperature causes the kinetic energy of particles to also increase. This allows the particles to overcome the intermolecular forces and become mobile. Low pressure also increases the particles' kinetic energy. As the particles escape the solid and disperse as a gas, sublimation occurs.
- **Physical Vapor Deposition**: It occurs when a **substance changes from a gas into a solid**. In low-pressure situations, thin films of vaporized materials develop on various surfaces due to plasma sputter bombardment or high-temperature vacuum evaporation.

Calorific value

- It is the energy contained in a fuel or food, determined by measuring the **heat produced by the complete combustion of a specified quantity of it**. This is now usually expressed in joules per kilogram.
- Amount of calories generated when a unit amount of substance is completely oxidized and is **determined using the bomb calorimeter**

Fact File:

- An **element** consists of only one kind of atom, cannot be broken down into a simpler type of matter by either physical or chemical means, and can exist as either atoms (e.g. argon) or molecules (e.g., nitrogen).
- A **molecule** consists of two or more atoms of the same element, or different elements, that are chemically bound together
- A **compound** consists of atoms of two or more different elements bound together, can be broken down into a simpler type of matter (elements) by chemical means (but not by physical means), has properties that are different from its component elements, and always contains the same ratio of its component atoms
- A mixture consists of two or more different elements and/or compounds physically intermingled, can be separated into its components by physical means, and often retains many of the properties of its components.
- In **homogeneous mixture**, components mixed are uniformly distributed throughout the mixture. In other words, "they are uniform throughout".
- In **heterogeneous mixture**, all the components are completely mixed but non-uniform in nature. All the particles can be seen under a microscope. We can easily identify the components and more than one phase can be seen by naked eyes.
- **Ernest Rutherford discovered protons**
- **Sir James Chadwick, the British Physicist discovered neutrons**
- **J.J Thomson discovered electrons**
- The mass of the electron is $9.1093837015 \times 10^{-31}$ kg
- A mass of proton which is about 1.67×10^{-27} kilograms
- **Atomic Number (Z):** The number of protons or electrons in a neutral atom
- **Mass Number (A):** Sum of protons and neutrons in an atom
- **Isotopes:** Elements having same atomic number, but different mass number are called isotopes
- **Isobars:** Atoms of different chemical elements having equal values for atomic mass.
- **Isotones:** Atoms of different elements having an equal number of neutrons in the atomic nucleus.

The hydrogen colour spectrum

- **Green hydrogen** is the one produced with no harmful greenhouse gas emissions. Green hydrogen is made by using clean electricity from surplus renewable energy sources, such as solar or wind power, to electrolyse water
- **Blue hydrogen** is produced mainly from natural gas, using a process called steam reforming, which brings together natural gas and heated water in the form of steam. The output is hydrogen – but also carbon dioxide as a by-product. That means carbon capture and storage (CCS) is essential to trap and store this carbon.
- **Grey hydrogen** is created from natural gas, or methane, using steam methane reformation but without capturing the greenhouse gases made in the process.
- Any hydrogen made from fossil fuels through the process of 'gasification' is sometimes called **black or brown hydrogen** interchangeably.
- **Pink hydrogen** is generated through electrolysis powered by nuclear energy. Nuclear-produced hydrogen can also be referred to as purple hydrogen or red hydrogen.
- **Turquoise hydrogen** is made using a process called methane pyrolysis to produce hydrogen and solid carbon. In the future, turquoise hydrogen may be valued as a low-emission hydrogen, dependent on the thermal process being powered with renewable energy and the carbon being permanently stored or used.
- **Yellow hydrogen** is a relatively new phrase for hydrogen made through electrolysis using solar power.
- **White hydrogen** is a naturally-occurring geological hydrogen found in underground deposits and created through fracking. There are no strategies to exploit this hydrogen at present.

The Carbon colour spectrum

- **Black carbon** is the soot emitted during incomplete combustion of fossil fuels in coal-fired power plants, cars and other equipment
- **Brown carbon** which originates primarily during the combustion of organic biomass and is a close cousin of black carbon
- **Blue carbon** is the carbon stored in coastal and marine ecosystems.
- **Green carbon** is the carbon stored in the biosphere.

Previous Year Questions

1. The purest form of gold is (2011)

a) 18 carat
b) 22 carat
c) 24 carat
d) 28 carat

2. What is the percentage of oxygen in the earth's crust? (2011)

a) 92
b) 50
c) 61
d) 45

3. Liquified petroleum gas (LPG) is mainly a mixture of (2011)

a) Propane and butane
b) Butane and isobutane
c) Propane and isobutane
d) Propane and tetralin

4.The third most abundant gas in the atmosphere is (2011)

a) Argon
b) Carbon dioxide
c) Helium
d) Hydrogen

5) The filament string of an electric bulb is made of (2020)

a) Copper
b) Silver
c) Platinum
d) Tungsten

6) The mass of an iron piece when gets rusted (2011)

a) May increase or decrease depending upon temperature
b) Decreases
c) Increases
d) Remains same

7) Which of the types of coal has the highest heating capacity? (2001)

a) Bituminous
b) Lignite
c) Anthracite
d) Peat

Chapter 9:Energy

Introduction

- **Conventional**: The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time. The **coal, petroleum, natural gas and electricity are conventional sources of energy.**

Boost Your Knowledge:

- Till 1960s, Assam was the only oil producing state in India. Currently there are more than 100 oil fields in Assam. **Some major oil fields of Assam: Digboi, Nahorkatiya, Moran, Rudrasagar, Lakwa, Rudrasagar, Sonari, Amguri, Geleki, Dikom, Kathaloni, Baghjan, Charali, Laplingaon, Panidihing, Hugrijan, Tengakhat, Borhola etc**. Oil India Private Limited (OIL) and Oil and Natural Gas Commission (ONGC) are the two main players involved in oil exploration and extraction in Assam. **There are four oil refineries in Assam – Digboi Refinery, Guwahati Refinery, Bongaigaon Refinery and Numaligarh Refinery**.

- **Non-Conventional**: Also referred to as the **renewable sources** of energy, the non-conventional sources of energy refer to those energy sources, which are replenished by natural processes, that too continuously. The non-conventional sources of energy can't be exhausted easily and can be generated at a constant rate for their use over and over again. Furthermore, these energy sources do not pollute the environment and natural surroundings and require less expenditure. A few examples of non-conventional sources of energy include **wind energy, tidal energy, solar energy, geothermal energy, and biomass energy.**

Photovoltaic electricity

- Photovoltaics (PV) is the conversion of light into electricity using semiconducting materials
- Photovoltaic cells **generate direct current (DC) electricity**. This DC electricity can be used to charge batteries that, in turn, power devices that use direct current electricity

Solar Thermal technology

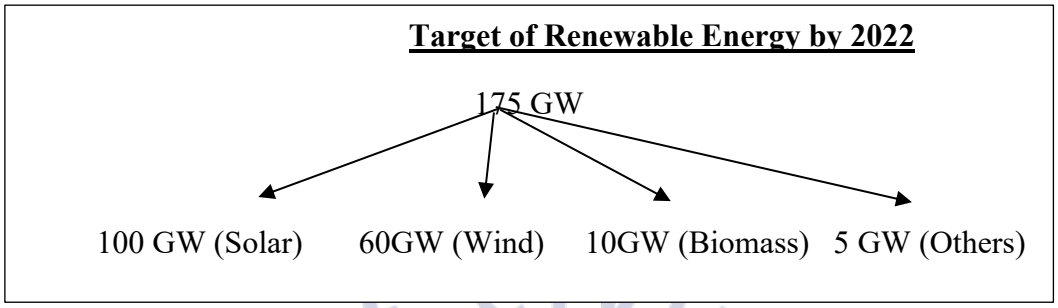
- Utilises focused sunlight and convert it into high temperature heat
- Heat is channelled through a conventional generator to produce electricity
- A **parabolic trough** is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two, lined with a polished metal mirror.

Luminescent solar concentrator

- Luminescent solar concentrators operate on the principle of collecting radiation over a large area, converting it by luminescence (specifically by fluorescence) and directing the generated radiation into a relatively small output target.
- The thin sheet of material typically consists of a polymer such as **polymethylmethacrylate (PMMA)** doped with luminescent species such as organic dyes, quantum dots or rare earth complexes

National Solar Mission

- **Jawaharlal Nehru National Solar Mission** is also known as the National Solar Mission. The mission was launched in January 2010
- It has a set a target of **1,00,000 MW or 100 GW by 2022**



SARAL INDEX

- State Rooftop Solar Attractiveness Index
- The SARAL index has been jointly designed by the Ministry of New and Renewable Energy (MNRE), Shakti Sustainable Energy Foundation (SSEF), ASSOCHAM and Ernst & Young (EY)
- States are given ranks based on their performance. As per the index, Karnataka ranks first followed by Telangana, and Gujarat (as per 2019)

SOLAR ENERGY CORPORATION OF INDIA Ltd (SECI)

- Company of the MNRE, Government of India, established to facilitate the implementation of the National Solar Mission (NSM).

PM KUSUM

- Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM)
- Launched in 2019
- Promoting solar power in Agriculture

AJAY

- **The Ministry of New and Renewable Energy (MNRE) launched the Atal Jyoti Yojana (AJAY) to illuminate dark regions through installation of 3,04,500 solar street lights.**
- **Phase I:** The rural, semi-urban and urban areas that face less than 50% grid connectivity in Uttar Pradesh, Assam, Bihar, Jharkhand, and Odisha will be illuminated with 7 W solar LED street lights
- **Phase II**: States covered during Phase I - Uttar Pradesh, Assam, Bihar, Jharkhand, and Odisha. Hilly states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand; North-eastern states including Sikkim; islands of Andaman Nicobar and Lakshadweep; and Parliamentary constituencies covering 48 Aspirational districts of states other than those covered above.

Assam Solar Policy, 2017

- The State Government of Assam aims to fulfill its commitments under Sustainable Development Goals by promoting clean, accessible, affordable, and equitable solar energy availability to ensure energy security for its citizens, as well as facilitate meeting of renewable energy obligations placed by MNRE
- Ministry of New & Renewable Energy (MNRE) has allocated 250 MW Grid Connected Solar Rooftop projects in the state of Assam by the year 2022.

State budget for 2022-23

- Rs 4,000 crore has been earmarked for solar power project to increase the generation of clean energy by installing solar power generation plants with aggregated installed capacity of 1000 MW.

File Fact:

- The Thanagarha village under Bhurbandha Gaon Panchayat in the Morigaon district, located less than 200 kilometers from Guwahati has started to receive electricity from a 10.5 KW solar project which has been recently set up in the village.
- 80 kWp Grid Connected Rooftop Solar Power Plant at Sri Sankaradeva Nethralaya, Beltola under 14 MW Grid Connected Rooftop Solar Programme

Facts about Solar Plants in India (Till August 2022)

- **Bhadla Solar Park is the world's largest solar park located in India** which is spread over a total area of 14,000 acres in Bhadla, Phalodi tehsil, Jodhpur district, Rajasthan, India. The park has a total capacity of 2245 MW.
- Karnataka, the southwestern state heads India's list of states producing solar energy. With a total installed solar power capacity of about 7,100MW
- **India's largest floating solar power project with 92 MW capacity has become fully functional at Ramagundam in Telangana. It was launched by PM virtually on 30th July 2022.** However, a floating solar power plant is going to be built in Madhya Pradesh's Khandwa. Said to be the world's largest floating solar plant, it will generate 600-Megawatt power by 2022-23.
- CSIR-CMERI has developed the **World's Largest Solar Tree**, which is installed at **CSIR-CMERI Residential Colony, Durgapur** with annual capacity to generate 12,000-14,000 units of Clean and Green Power
- **Tata Power Solar is India's Largest Solar Power Company**.

Fact File:

- A solar tree is a structure incorporating solar energy technology on a single pillar, like a tree trunk
- Save 10-12 tons of CO2 emissions
- Surplus generated power can be fed into an Energy Grid
- Substituting price-volatile fossil fuels

Boost Your Knowledge- 'Ujjwal Bharat Ujjwal Bhavishya – Power @2047'

- It has **taken place from 25th to 30th July**, **as part of 'Azadi Ka Amrit Mahotsav'**.
- Organized across the country, it showcases the transformation in the power sector achieved in the last eight years.
- It aims to empower citizens by improving their awareness and participation in various power-related initiatives, schemes, and programs of government.

WIND ENERGY

- It is the kinetic energy associated with the movement of atmospheric air
- Transform wind energy into mechanical energy, further converting it into electrical energy
- Germany, USA, Denmark, Spain and India accounts for 80% of the world's installed capacity
- India is the 4th largest wind power producer in the world as of May 2022 (Updating is required)

WIND FARM

- Group of wind turbines in the same location used for the production of electricity is called as wind farm
- **ONSHORE WIND FARMS:**
- Operates on land where wind tends to be the strongest
- **OFFSHORE WIND FARMS:**
- Construction of wind farms in large water bodies to generate electricity

NATIONAL OFF SHORE WIND ENERGY POLICY

- The National Offshore Wind Energy Policy was promulgated by the Indian Government in 2015.
- Exploring and promoting the deployment of offshore wind farms in **India's Exclusive Economic Zone (EEZ)**
- **Exclusive Economic Zone (EEZ):**
    - **The 1982 United Nations Convention on the Law of the Sea (UNCLOS) defined the EEZ as a zone in the sea over which a sovereign nation has certain special rights with respect to the exploration and usage of marine resources, which includes the generation of energy from wind and water, and also oil and natural gas extraction**
    - It **stretches from the outer limit of the territorial sea (12 nautical miles from the baseline) out to 200 nautical miles (nmi) from the coast of the state in question**. It is also referred to as a maritime continental margin

Green Energy Corridor

- Launched by MNRE in 2013
- Aims at synchronizing electricity produced from renewable sources, such as solar and wind, with conventional power stations in the grid.
- The second phase of the Green Energy Corridor implemented during 2021-22 to 2025-26 fiscal years. Green Energy Corridor Scheme will facilitate the grid integration and the power evacuation

of about 20 GW of renewable energy (RE) projects in **7 states- Himachal Pradesh, Gujarat, Rajasthan, Kerala, Karnataka, Uttar Pradesh, and Tamil Nadu**

Biomass

- Biomass is plant-based material used as fuel to produce heat or electricity.
- Examples are wood and wood residues, energy crops, agricultural residues, and waste from industry, farms and households.
- Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes- **Cogeneration**

Biogas

- Biogas is a mixture of gases, **primarily consisting of methane, carbon dioxide and hydrogen sulphide**, produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste and food waste.
- Dung/ Biomass is mixed with water to form slurry in a Biogas Plant
- Biogas is produced by **anaerobic digestion** with anaerobic organisms or methanogen inside an anaerobic digester, biodigester or a bioreactor
- **Biogas is primarily methane (CH_4) with 55-75% and carbon dioxide (CO_2) and may have small amounts of hydrogen sulfide (H_2S), moisture and siloxanes.**
- **Biomethane can also be compressed and bottled into cylinders and it is called Bio-Compressed Natural Gas (Bio-CNG) or simply Compressed Bio-Gas (CBG).**
- Bio CNG is a more purified form of biogas as it contains about 92 - 98% methane and 2-3% carbon dioxide

Fact File:

- Compressed natural gas (CNG) is a fuel gas made of petrol which is mainly composed of methane (CH4), compressed to less than 1% of the volume it occupies at standard atmospheric pressure.

Gasification

- Gasification is a process that **converts biomass- or fossil fuel-based carbonaceous materials into gases**
- This is achieved by reacting the feedstock material at high temperatures (typically >700 °C), without combustion, via controlling the amount of oxygen and/or steam present in the reaction.
- The resulting gas mixture is called **syngas (from synthesis gas) or producer gas** and is itself a fuel due to the flammability of the H_2 and CO of which the gas is largely composed

Biofuel

- Biofuel is a fuel that is produced over a short time span from biomass, rather than by the very slow natural processes involved in the formation of fossil fuels, such as oil.
- The two most common types of biofuels are **bioethanol and biodiesel**.

- **USA is the largest producer of bioethanol, while EU is the largest producer of biodiesel**
- **1st Generation**: These are usually **made from food sources** containing sugar, starch, vegetable oil, or animal fats
- **2nd Generation Biofuels**: These biofuels **utilize inedible parts** (ligno-cellulosic part) of the plant such as stems and husk to produce biofuel. Use of Jatropha, Mahua, Castor, Pongamia (Karanj), Sweet sorghum. eg. Biodiesel
- **3rd Generation Biofuels**: These biofuels are **produced using microorganisms** such as algae. Micro-organisms like algae can be grown on land and water unsuitable for food production. This in return, reduces the strain on depleted water resources. E.g. Butanol
- **4th Generation Biofuels**: Plants used for the production of the fourth-generation biofuel, are **genetically modified** to absorb and store higher amounts of carbon which can be harvested as biomass.

National Policy on Biofuel

- A National Policy on biofuels was made by the Ministry of New and Renewable Energy during the year 2009.
- The objective of the National Policy on Biofuels 2018: The policy is aimed at taking forward the indicative target of achieving **20% blending of ethanol with fossil-based fuels by 2025-26** (Amendments to NPB,2018)
- The policy expands the scope of raw materials to be used for ethanol production by allowing the use of Sugarcane Juice, sugar-containing materials like Sugar Beet, starch containing materials like Cassava, damaged food grains like broken rice, and rotten potatoes which are unfit for human consumption

Waste to energy

- Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste, or the processing of waste into a fuel source.
- WtE is a form of energy recovery.
- Processes include:
  - **Incineration**,
  - **Pyrolysis**:
  - **Gasification**:
  - **Refuse Derived Fuel (RDF)**
- **Microbial Fuel Cell**: It is a bioelectrochemical process that aims to produce electricity by using the electrons derived from biochemical reactions catalyzed by bacteria

Hydroelectric Power

- Hydraulic power can be captured when water flows downward from a higher level to a lower level which is then used to turn the turbine, thereby converting the kinetic of water into mechanical energy to drive the generator.

- Hydropower is among the cheapest and cleanest source of energy but there are many environmental and social issues associated with big dams
- **Impoundment**: The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir.
- **Diversion**: A diversion, sometimes called a run-of-river facility, channels a portion of a river through a canal or penstock and then flows through a turbine, spinning it, which in turn activates a generator to produce electricity.
- **Pumped storage**: It works like a battery, storing the electricity generated by other power sources. When the demand for electricity is low, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir and turns into a turbine, generating electricity.
- Micro: upto 100 KW; Mini: 101KW to 2 MW; Small: 2 MW to 25 MW; Mega: Hydro projects with installed capacity >= 500 MW
- In India, hydro projects up to 25 MW station capacities have been categorized as Small Hydro Power (SHP) projects.
- While Ministry of Power, Government of India is responsible for large hydro projects, the mandate for the subject small hydro power (up to 25 MW) is given to Ministry of New and Renewable Energy.
- India is 5th globally for installed hydroelectric power capacity

GEOTHERMAL ENERGY

- Geothermal energy is the thermal energy in the Earth's crust which originates from the formation of the planet and from radioactive decay of materials in currently uncertain but possibly roughly equal proportions.
- The high temperature and pressure in Earth's interior cause some rock to melt and solid mantle to behave plastically. This results in parts of the mantle convecting upward since it is lighter than the surrounding rock.
- More recently geothermal power, the term used for generation of electricity from geothermal energy, has gained in importance.
- **India's first-ever geothermal field development project in Puga valley Leh has been signed**
- Developed by ONGC Energy, Ladakh Autonomous Hill Development Council, and Power Department of UT Ladakh

Previous Year Questions

1. **The largest source of power supply in India is (2014)**

   a) Hydroelectric Power
   b) Thermal Power
   c) Renewable Source
   d) Nuclear Power

2. **Which among the following is the chief constituent of biogas? (2020)**

   a) Carbondioxide
   b) Hydrogen
   c) Ethane
   d) **Methane**

3. **Which of the following numericals stands as the extent of seawater/ocean water distance from the baseline in case of Exclusive Economic Zone (EEZ)? (2018)**

   a) 200 nautical miles
   b) 250 nautical miles
   c) 300 nautical miles
   d) 500 nautical miles

4. **Recently India's largest solar power plant has been launched in which of the following States? (2014)**

   a) Rajasthan
   b) Madhya Pradesh
   c) Tamil Nadu
   d) Gujarat

   (Note: By 2022 datas have change. Read the ~~context~~ content)

Chapter 10: Fundamentals in Physics

Kinetic and Potential Energy

- The capacity to do work is called Energy.
- This energy can be stored in different forms.
- When an object is at rest, the body is said to possess **potential energy**.
- In another case, when the object is in motion, then it is said to possess **kinetic energy.**
- **Potential energy tends to affect the object within the environment if and only when it gets transformed to other kinds of energy.**
- **A rock which rests at the top of the cliff is said to be an example of the body possessing potential energy. When an object falls freely, its potential energy gets converted into kinetic energy. Thus, when the rock falls, it possesses kinetic energy.**
- **The energy which is stored in a body because of the elevation is called gravitational potential energy. Some bodies like waterfalls contain both kinetic and potential energy. The height of the waterfall is one of the bases for potential energy, while the movement of water is a base for kinetic energy.**

Dispersion

- Spreading of white light into a full spectrum of wavelengths

Reflection

- When a ray of light approaches a smooth polished surface and the light ray bounces back, it is called the reflection of light
- The laws of reflection determine the reflection of incident light rays on reflecting surfaces, like mirrors, smooth metal surfaces and clear water. The law of reflection states that:
- The incident ray, the reflected ray and the normal all lie in the same plane
- The angle of incidence = Angle of reflection

Refraction

- In physics, refraction is the redirection of a wave as it passes from one medium to another.
- The redirection can be caused by the wave's change in speed or by a change in the medium.
- Refraction of light is the most commonly observed phenomenon, but other waves such as sound waves and water waves also experience refraction

Total Internal Reflection

- The optical phenomenon of total internal reflection occurs when light is entirely reflected at the interface between two media.
- The effect happens when the incidence angle exceeds a predetermined limiting angle, referred to as the critical angle.
- Practical Applications of Total Internal Reflection:

- **Optical Fibre**: Total internal reflection method is used in optical fibre. The inner part of the fibre lies inside the core of the higher refractive index. All of these fibres are surrounded by another layer of glass. They lie just beneath the lower refractive index. A plastic jacket is there to surround the fibres. Back to back total internal reflection occurs when the light from one end of the core travels toward cladding, and the light propagates through it. Optical fibres usage is quite popular among decorative table labs. They have huge applications in the medical field for endoscopy and for internet connections
- **Mirage**: Mirage is also known as another name called optical illusion of water. The appearance of mirages is quite higher in the deserts on a hot summer day. Mirage occurs when a ray of light falls on earth by travelling from the top of a tree or sky; it gradually deviates away from the normal. We know that total internal reflection exists when the angle of incidence becomes greater than the critical angle. So this generates mirage in hot deserts or any open spaces during the hot summer.
- **Prisms**: A few examples of optical equipment that use right-angled prisms to reflect a light beam through 90° or 180° are as below:

Pink noise

- Pink noise, also known as 1/f noise (where f is frequency), is a sound that has equal energy in all octaves.
- It primarily consists of low frequency sounds.
- Due to practical constraints, pink noise can be produced only over a certain range of frequencies and occurs naturally.
- Astronauts listening to electromagnetic radiation in outer space have noted it being emitted from certain stars.
- In biology, it is produced by the heartbeat and has shown up in DNA sequence statistics.

Plasma

- The fourth state of matter is called as Plasma.
- In Plasma, the medium is in the form of positive and negative ions.
- Plasma occurs in the atmosphere of stars (including the sun) and in discharge tubes.

Photoelectric Effect

- The photoelectric effect is the emission of electrons when electromagnetic radiation, such as light, hits a material. Electrons emitted in this manner are called photoelectrons
- Albert Einstein proposed that a beam of light is not a wave propagating through space, but a swarm of discrete energy packets, known as photons.
- It is expressed as

    a) $E= hf$ or $E=h (c/ \lambda)$ where E is energy, **h is Plank's constant whose value is $6.62607015 \times 10^{-34}$**,

    b) C is the **speed of light in vacuum whose value is 3×10^8 m/s, f is frequency and λ is wavelength**

Instruments

- Device to record relative humidity is called **hygrometer**
- Device to record air humidity is called **psychrometer**
- Device to record temperature is called **thermometer**
- Device to record pressure is called **barometer**

Previous Year Questions

1. A photon will have less energy, if its (2011)

a) Amplitude is higher
b) Frequency is higher
c) Wavelength is longer
d) Wavelength is shorter

2. Which of the following devices is used to record humidity? (2016)

a) Hygrometer
b) Psychrometer
c) Thermo-hygrograph
d) All of the above

3. Who won the Nobel Prize in Physics for the discovery of the 'law of photoelectric effect? (2020)

a) WilhelmRoentgen
b) AlbertEinstein
c) IsaacNewton
d) ErnestRutherford

4. **As an object falls freely through air, the kinetic energy of the object**

a) Decreases
b) Increases
c) Doesn't change
d) Becomes 0

5. Which of the following devices is used to record humidity? (2016)

a) Hygrometer
b) Psychrometer
c) Thermo-hygrograph
d) All of the above

Chapter 11:Semiconductors

SEMICONDUCTOR

- A semiconductor material has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass
- **Gallium arsenide, germanium, and silicon** are some of the most commonly used semiconductors. Silicon is used in electronic circuit fabrication and gallium arsenide is used in solar cells, laser diodes, etc.
- Semiconductor acts like an insulator at Zero Kelvin. On increasing the temperature, it works as a conductor.
- **Holes and electrons are the types of charge carriers accountable for the flow of current in semiconductors**.
- **Holes are the positively charged** electric charge carrier whereas **electrons are the negatively charged particles.**

Intrinsic Semiconductor

- An intrinsic type of semiconductor material is made to be very pure chemically. It is made up of only a single type of element
- Germanium (Ge) and Silicon (Si) are the most common type of intrinsic semiconductor elements. They have four valence electrons (tetravalent).

Extrinsic Semiconductor

- The conductivity of semiconductors can be greatly improved by introducing a small number of suitable replacement atoms called impurities.
- The **process of adding impurity atoms to the pure semiconductor is called doping**.
- An extrinsic semiconductor can be further classified into:

- **N-type Semiconductor**: When a pure semiconductor (Silicon or Germanium) is doped by **pentavalent** impurity (5 electrons in the outermost shell) like P, As, Sb, Bi then, four electrons out of five valence electrons bonds with the four electrons of Ge or Si.
- **P-type Semiconductor**: When a pure semiconductor is doped with a trivalent impurity (5 electrons in the outermost shell) like B, Al, In, Ga then, the three valence electrons of the impurity bonds with three of the four valence electrons of the semiconductor.

Applications of Semiconductors

- Semiconductors are used in almost all electronic devices
- Transistors, diodes, photosensors, microcontrollers, integrated chips and much more are made up of semiconductors.
- Transistor and MOSFET used as a switch in Electrical Circuits are manufactured using the semiconductors.
- The physical and chemical properties of semiconductors make them capable of designing technological wonders like microchips, transistors, LEDs, solar cells, etc.
- The microprocessor used for controlling the operation of space vehicles, trains, robots, etc is made up of transistors and other controlling devices which are manufactured by semiconductor materials

LED

- Light-emitting diode (LED) is a widely used standard source of light in electrical equipment.
- It has a wide range of applications ranging from your mobile phone to large advertising billboards.
- They mostly find applications in devices that show the time and display different types of data
- When current passes through an LED, the electrons recombine with holes emitting light in the process.
- The colour of an LED is determined by the material used in the semiconducting element. The two primary materials used in LEDs are aluminium gallium indium phosphide alloys and indium gallium nitride alloys. Aluminium alloys are used to obtain red, orange and yellow light, and indium alloys are used to get green, blue and white light. Slight changes in the composition of these alloys change the colour of the emitted light.

Moore's Law

- Moore's Law is the prediction that the number of transistors in a dense integrated circuit doubles every two years as technological progress advances.
- The observation was made by **Gordon Moore, co-founder of Intel**, who saw that the size of transistors was shrinking rapidly due to continuous innovation.

India semiconductor mission

- India Semiconductor Mission is a specialised business division that has been created within the Digital India Corporation.
- The mission aims to build a vibrant semiconductor and display ecosystem to enable India's emergence as a global hub for electronics manufacturing and design
- Union Information Technology Minister Ashwini Vaishnaw launched the India Semiconductor Mission on **December 29, 2021**

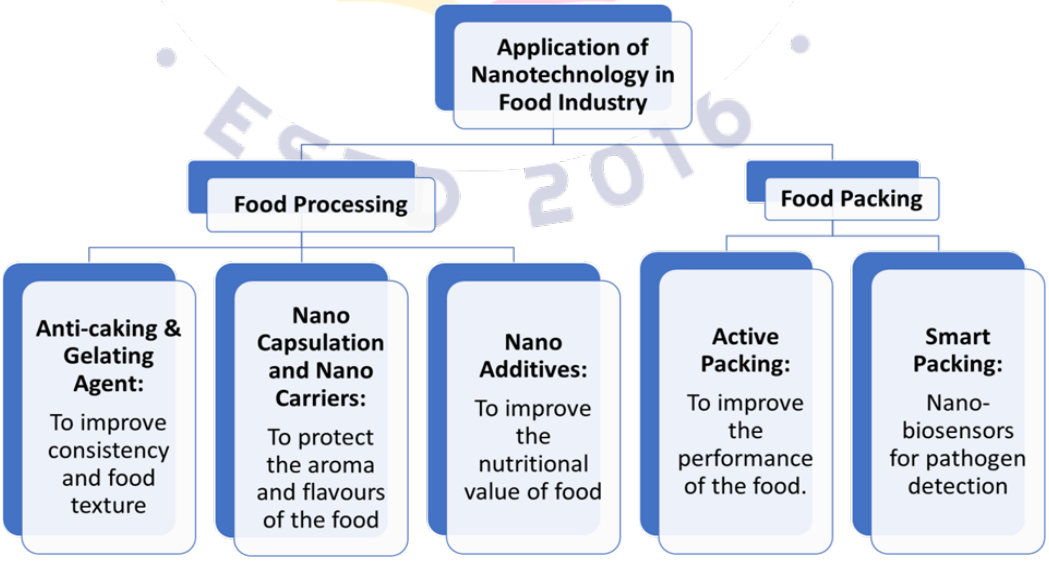
Chapter 12:Nanotechnology

Introduction

- 1959- "There is plenty of room at the bottom": **Richard Feynman- Father of Nanotechnology**
- 1974- The Japanese scientist called **Norio Taniguchi of Tokyo University of Science was first to use the term "nano-technology" in a conference**
- 1981- Scanning Tunneling Microscopy (STM) was invented and was developed by Gerd Binnig and Heinrich Rohrer.
- 1986- The term "nanotechnology" (which paralleled Taniguchi's "nano-technology") was independently applied by Drexler in his 1986 book "Engines of Creation: The Coming Era of Nanotechnology"
- 1991- **Discovery of carbon nanotubes (CNTs) by Sumio Iijima**
- 1996- Nobel prize in Chemistry to Robert F. Curl, Harold W. Kroto and Richard E. Smalley for discovery of fullerenes which led to research in carbon nanotubes, the cylindrical cousins of buckyballs, and the development of new fields of advanced materials
- Research and work on nanotechnology in India started in 2001 with the formation of the Nanoscience and Technology Initiative with initial funding of Rs. 60 crores. In 2007, the GOI launched a **5-year program called Nano Mission**
- **Nanotechnology is science and engineering at the scale of atoms and molecules. It is the manipulation and use of materials and devices so tiny that nothing can be built any smaller.**
- **Nanomaterials are typically between 1 and 100 nanometres (nm) in size**

Applications of Nanotech

- **Healthcare & Medicine:**
  - Drug Delivery: employing nanoparticles to deliver drugs to specific types of cells.
  - Surgery: development of minute surgical instruments and nanobots to perform microsurgeries.
  - Therapy Techniques: using nano sponges to absorb toxins and remove them from the bloodstream
  - Gene Therapy: Polymer nanoparticles can deliver genes or therapeutic proteins to specific sections of the DNA



- **Energy:**
  - **a)** Solar paints or photovoltaic paints: multi-layered nanoparticles which is capable to capture

energy from the sun and transform it into electricity.

b) The process of manufacturing solar panels can be made cheaper and more efficient with nanotechnology.

c) Nanobatteries: used to help rechargeable lithium-ion batteries last longer. It also increases its power density.

d) Nanocomposites can be used in turbines of windmills. The blades will be lighter and sturdier, thus increasing efficiency.

- **Environment:**
  - Nanofiltration is a new method for water treatment. It has the capacity to filter out even multivalent ions, pesticides, and heavy metals.
  - Air Purification by absorption of toxic gases: carbon nanotubes are used for adsorption of nitrous oxide from the air.
- **Agriculture**
  - Smart Field System: Bio-nanotechnology has designed sensors that increases the sensitivity to environmental changes. Thus, monitoring of crop growth and soil conditions can be increased

Graphene

- Single layer of graphite
- 2D network of Carbon
- One of the strongest and thinnest material
- Harder than diamond and 300 times stronger than steel
- Good conductor of electricity
- **Applications of Graphene**:
  - **Cancer treatment**: Graphene oxide (GO) targets and neutralizes these particularly hardy cancer cells.
  - Solar cell
  - Graphene-enhanced composite materials can find uses in aerospace, building materials, mobile devices, and many other applications

Carbon Nanotubes

- Carbon nanotubes (CNTs) are cylindrical molecules that consist of rolled-up sheets of single-layer carbon atoms (graphene).
- They can be single-walled (SWCNT) with a diameter of less than 1 nanometer (nm) or multi-walled (MWCNT), consisting of several concentrically interlinked nanotubes, with diameters reaching more than 100 nm
- Carbon nanotubes can exhibit remarkable electrical conductivity, they also have exceptional strength and thermal conductivity

Applications:

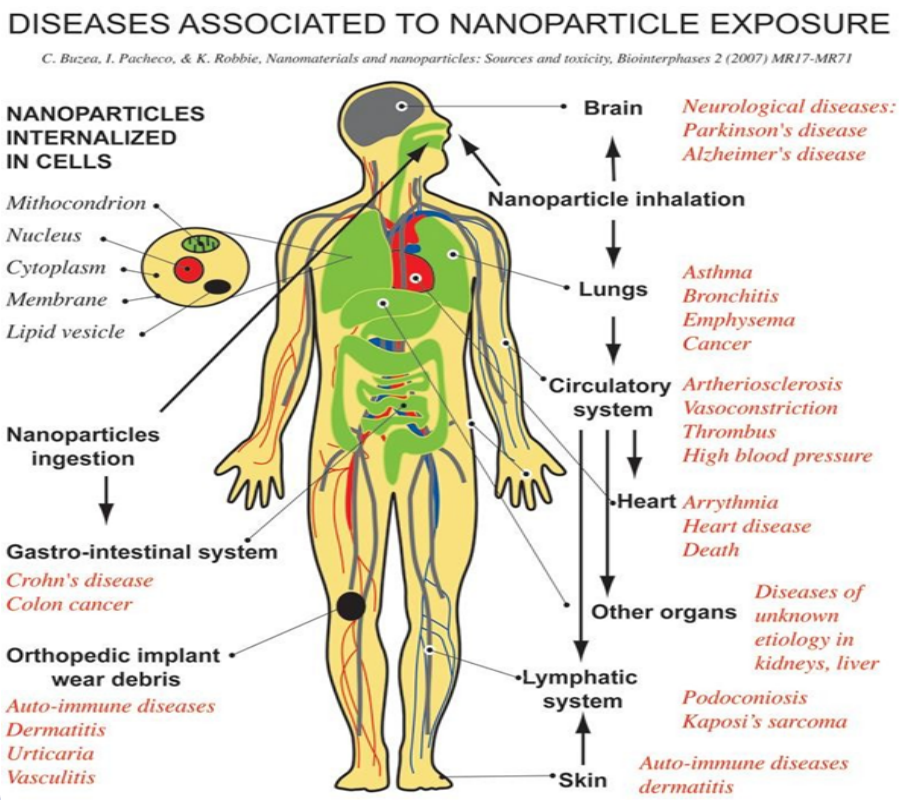
- CNT based air and water filtration devices. It has been reported that these filters can not only block the smallest particles but also kill most bacteria.
- Cells have been shown to grow on CNTs
- CNTs are used to make textiles stain resistant
- Energy storage, thermal materials, etc
- Use of carbon nanotubes increases the germination through better penetration of moisture.

Fullerene

- World's most efficient radical scavengers' or 'radical sponge'- Antioxidants
- Effective cytoprotectors against the ultraviolet A irradiation. These bind to the Reactive Oxygen Species (ROS) and prevent damage to cells
- Antiviral agent- Dendrofullerene is effective against HIV
- Delivery of hydrophobic drugs
- Fullerenes get excited upon irradiation, when these molecules return to ground state, they give off energy that splits the oxygen present to generate singlet oxygen, which can be cytotoxic in nature
- Solar cells

Potential risk of Nanotechnology

- Nanomaterials show properties dominated by quantum effects; some nanoparticles are considered toxic. This can be harmful for the human body as well as the environment in general.
- **Nanotoxicology** is the study of potential health risks of nanomaterials.
- Nanoparticles can get into the body through the skin, lungs and digestive system since they are very small in size. Macrophages can engulf them thus creating free radicals that can cause cell damage. This is a serious concern for the cosmetic industry that heavily uses titanium dioxide nanoparticles.
- Nano pollution is the generic term that is used to describe the waste generated by the nanodevices or nanomaterials during the manufacturing process.
- Nano wastes may be of risk due to their size and different properties and interactions. Since the man-made nanoparticles are not naturally made, living organisms may not have the appropriate means to deal with them. Nanotechnology can be used to create powerful weapons, both lethal and non-lethal. This raises a question on the ethical implications of nanotechnology.



Nano Mission

- Nano Mission is an umbrella programme for capacity building which envisages the overall development of nanotechnology in the country.
- **Aim:** Create the background and infrastructure for R&D in nanotechnology
- 2001-2006 – Nanoscience & Technology Initiative (NSTI) by Department of Science and Technology (DST). 2007 – Nanoscience & Technology Mission (NSTM) aka Nano Mission.

Objectives of Nano Mission:

- Basic Research Promotion
- Infrastructure Development for Nano Science & Technology Research
- Human Resource Development
- International Collaboration

Chapter 13:Nuclear Science

Radioactivity

- **Radioactivity**: Spontaneous decomposition of unstable atomic nuclei to form nuclei with a higher stability. The decomposition process is called radioactivity
- Energy and particles released during the decomposition process are called radiation.
- **A. H. Becquerel discovered radioactivity in 1896 purely by accident**
- **G. M. Counter measures radioactivity**
- SI unit is Becquerel (Bq). Other units are Curie, Rutherford
- Radioactive decay emits: alpha, beta and gamma particles
- **Alpha decay** or α-decay is a type of radioactive decay in which an atomic nucleus emits an **alpha particle (helium nucleus)** and thereby transforms or 'decays' into a different atomic nucleus, with a mass number that is reduced by four and an atomic number that is reduced by two. An alpha particle is identical to the nucleus of a helium-4 atom, which consists of two protons and two neutrons
- In nuclear physics, **beta decay (β-decay)** is a type of radioactive decay in which a **beta particle (fast energetic electron or positron)** is emitted from an atomic nucleus. **Positron** is a subatomic particle with the same mass as an electron and a numerically equal but positive charge.
- A **gamma ray**, also known as gamma radiation (symbol γ), is a penetrating form of electromagnetic radiation arising from the radioactive decay of atomic nuclei. It consists of the shortest wavelength electromagnetic waves, typically shorter than those of X-rays

Uses of Radioactive Isotopes

- Radioisotopes used in medicine have **short half-lives, which means they decay quickly and are suitable for diagnostic purposes**; others with **longer half-lives take more time to decay, which makes them suitable for therapeutic purposes**.
- Half-life (symbol $t_{1/2}$) is the time required for a quantity to reduce to half of its initial value
- **Cobalt-60** emits large amounts of gamma radiation as it decays and is extensively used as a radiation source to **arrest the development of cancer**.
- When **Tc-99** is given to patients with cancerous tumors, it accumulates in the tumor and can easily be detected by a scan.
- **Carbon-14** is perhaps best known for its use in dating previously living materials. There is an extremely small amount of C-14 in the atmosphere. When an organism is alive, it uses this radioactive carbon in the same way as it uses stable C-12. When the organism dies, it no longer takes in any carbon. Each gram of carbon in a living organism emits about 15 disintegrations per minute (dpm). After the organism dies and time passes, the radioactive carbon-14 continues to decay, but it is NOT replaced. Therefore, the dpm decreases with time. Because the **half-life of C-14 is 5730 years**, after that time period there will only be about 7 dpm (almost half of 15) for each gram of carbon in the organism. Therefore, **a reading of 7 dpm/g carbon indicates the remains are about 5700 years old, while a reading of 3.5 dpm would show a material to be about twice as old, about 11,000 years**. After about four half-lives, C-14 becomes ineffective as a method for dating materials because too little C-14 remains to be accurately measured

- U-238 is a radioactive material that spontaneously decays through a series of steps until it forms stable Pb-206. As time passes, the amount of lead in the sample will increase as the amount of uranium decreases**. Scientists can use the ratio of U-238: Pb-206 to date rocks and other geological formations**
- **As Tracer:** Any radioisotope used to follow the path of a material in a system is called a tracer. If radioactive **P-31** is present in fertilizer administered to a plant, the uptake of the phosphorus can be traced by detectors. Scientists can then determine the proper amounts and timing of fertilizer applications. **C-14** is another tracer used to map the path of carbon in metabolic processes
- **Americium-241** an alpha emitter is used in domestic smoke detectors in the United States.
- **Iodine-131** is found effective in **treating hyperthyroidism**. I-131 can be given in large enough doses to destroy some of the thyroid and reduce its production of thyroxin.
- Another important radioactive isotope is **carbon-14**, which is used in a **breath test** to **detect the ulcer-causing bacteria *Heliobacter pylori*.**
- **Co-60 and Cs-137 are two of the sources of gamma radiation currently being used to destroy Anthrax bacilli.**
- Radioactive isotopes are also used to measure the thickness of metal or plastic sheets, the precision of thickness is indicated by the strength of the radiations that penetrate the material being inspected
- Other significant applications include the use of radioactive isotopes as compact sources of electrical power—e.g**., plutonium-238 in spacecraft**. In such cases, the heat produced in the decay of the radioactive isotope is converted into electricity by means of thermoelectric junction circuits or related devices

Some Facts

- **Kudankulam Nuclear Power Plant In Tamil Nadu Is the Highest Capacity Nuclear Plant in India with an installed capacity Of 2000 MW.**
- **Apsara Research Reactor in Mumbai Is Asia's First Nuclear Reactor**
- **Tarapur Atomic Power Plant-1 (TAPS-1) Is the First Nuclear Power Plant in India**. It is operational since October 1969 and is **situated in Boisar, Maharastra**.
- Under Prime Minister Indira Gandhi, **India first tested a nuclear weapon in 1974 (code-named "Smiling Buddha"),** which is described as a "peaceful nuclear explosion."

INDIA'S NUCLEAR POWER PLANT

- At Present, India Has 22 Operating Nuclear Reactors in 7 Nuclear Power Plants

Power Plant	Kaiga	Kakrapar	Kudankulam	Madras (Kalpakkam)	Narora	Rajasthan	Tarapur
Location	Karnataka	Gujarat	Tamil Nadu	Tamil Nadu	Uttar Pradesh	Rajasthan	Maharashtra

Nuclear Force

- Force that acts between the protons and neutrons of atoms (nucleons)
- Nuclear force plays an essential role in storing energy used in nuclear power and weapon

Nuclear Reaction

- Nucleus is bombarded with a high energy particle
- Bombarding particle may be: alpha, beta gamma rays, neutrons, protons etc
- **Nuclear Fission**: Splitting of a heavy unstable nucleus into two smaller nuclei.
- **Nuclear Fusion**: combination of two light nuclei to form a single heavier nucleus

URANIUM

- The most common isotopes in natural uranium are **uranium-238** (accounts for over **99.3%** of uranium on Earth) and **uranium-235** (accounts for **0.7%**). Uranium has the highest atomic weight of the primordially occurring elements
- Uranium is **weakly radioactive**
- **Uranium-238** is **fertile**, meaning it can be transmuted to fissile plutonium-239 in a nuclear reactor
- **Uranium-235** is the only naturally occurring **fissile** isotope, which makes it widely used in nuclear power plants and nuclear weapons.
- Another fissile isotope, **uranium-233**, can be produced from natural thorium and is studied for future industrial use in nuclear technology.
- To increase the concentration of U-235, "**Uranium Enrichment**" is done- Isotope separation
- **Low-enriched uranium (LEU)** has a lower than 20% concentration of U-235.It can be given to other countries for civil purpose. Used as a fuel in nuclear reactor
- **Highly enriched uranium (HEU)** has a 20% or higher concentration of U-235. The fissile uranium in nuclear weapon primaries usually contains 85% or more of 235U known as weapons-grade.
- The very **first uranium bomb, Little Boy**, dropped by the **United States on Hiroshima** in 1945, used 64 kilograms of 80% enriched uranium
- **Reprocessed uranium (RepU)** is a product of nuclear fuel cycles **involving nuclear reprocessing of spent fuel**. RepU recovered from light water reactor (LWR) spent fuel typically contains slightly more U-235 than natural uranium, and therefore could be used to fuel reactors that customarily use natural uranium as fuel, such as CANDU reactors.

THORIUM

- It is a weakly radioactive metal.
- One of only two significantly radioactive elements that still occur naturally in large quantities
- Th-232 is not fissile by itself, but it can be converted to Uranium-233 which is fissile by transmutation
- Estimated to be about 3-4 times more abundant than uranium in the earth's crust, chiefly refined from **monazite sands**.
- **India has one of the largest reserves of thorium in the world (~25%)**

Boost Your Knowledge Monazite

- Monazite is a primarily reddish-brown phosphate mineral that contains rare-earth elements. The most common species of the group is monazite-(Ce), that is, the cerium-dominant member of the group. Monazite is an important ore for thorium, lanthanum, and cerium. It is often found in placer deposits. India, Madagascar, and South Africa have large deposits of monazite sands. **The deposits in India are particularly rich in monazite. The most extensive offshore monazite deposits are found in southern India and Sri Lanka.** Monazite is radioactive due to the presence of thorium and, less commonly, uranium.

PLUTONIUM

- Not a naturally occurring element.
- Produced as a **by-product** in a nuclear reactor (through the absorption of neutrons by Uranium-238)
- Plutonium was used to create the atom bomb "Fat Man", which was dropped on Nagasaki in World War II

RADIUM

- In nature, radium is found in uranium and (to a lesser extent) thorium ores in trace amounts
- **Radium, in the form of radium chloride, was discovered by Marie and Pierre Curie in 1898**
- Pure radium is silvery-white, but it readily reacts with nitrogen (rather than oxygen) on exposure to air, forming a black surface layer of radium nitride (Ra_3N_2).
- All isotopes of radium are highly radioactive, with the most stable isotope being radium-226

NUCLEAR FUSION

- For fusion to take place, the two nuclei must come close enough
- When fusion is achieved by raising the temperature of the system so that particles have enough kinetic energy to overcome the coulomb repulsive behaviour, it is called thermonuclear fusion

- Thermonuclear fusion is the source of energy output in the interior of stars
- Fusion generates 9-13 times more energy generation than fission

INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)

- Harnessing fusion's power is the goal of ITER, which has been designed as the key experimental step between today's fusion research machines and tomorrow's fusion power plants
- ITER is funded and run by seven member parties: China, the European Union, India, Japan, Russia, South Korea and the United States

NUCLEAR REACTOR AND ITS COMPONENTS

- Device used to initiate and control a self-sustained nuclear chain reaction
- Used at nuclear power plants for electricity generation and in nuclear marine propulsion
- **Fuel**: Pellets of Uranium Oxide (UO_2) (U-235)
- **Control Rods**: Neutron absorbing material like Cadmium, Hafnium or Boron. Used to control the rate of the reaction. Control Rods can also be used to stop the nuclear reaction.
- **Moderator**: To slow down fast-moving neutrons
- **Coolant:** A liquid circulating through the core of the reactor to transfer heat from core to the heat exchanger. Water, liquid metal (sodium or lead) or gas (CO_2, He) are used as coolant
- **Heat Exchanger/ Steam Generator**: Part of the system wherein the heat from the reactor core is used to generate steam to spin the turbines.
- **Containment System**: A thick structure around the core to protect it from outside disturbances and to protect the outside region from any radiation in case of any malfunction

INDIA'S ATOMIC ENERGY PROGRAMME

- An early historic achievement was the design and construction of **the first nuclear reactor in India (named Apsara)** which went into operation on August 4, 1956.
- It used enriched uranium as fuel and water as moderator
- **India's three-stage nuclear power programme was formulated by Homi Bhabha**
- The ultimate focus of the programme is on enabling the thorium reserves of India to be utilised in meeting the country's energy requirements

Stage 1: Pressurized Heavy Water Reactor (PHWR):

- Fuel: Natural Uranium
- Moderator: Heavy water
- By product: Pu-239

Stage 2: Fast Breeder Reactor (FBR):

- Fuel: Pu-239 (By product of Stage1)
- Moderator: Not required
- By-product: Mixed oxide fuel
- Pu239 undergoes fission to produce energy and U238 and finally gets converted into Pu 239

- After surplus Pu-239 is obtained the second stage will be blanketed with Thorium-232 (Th-232) to produce Uranium-233 (U-233) in the 3rd stage

Stage 3: Advanced Heavy Water Reactor (AHWR):

- A Stage III reactor or an Advanced nuclear power system involves a self-sustaining series of thorium-232–uranium-233 fuelled reactors.
- This would be a thermal breeder reactor, which in principle can be refuelled – after its initial fuel charge – using only naturally occurring thorium

INDIA'S RESEARCH ATOMIC REACTOR

- Apsara and CIRUS (Canada India Research U.S.) spurred research in a wide range of areas of basic and applied nuclear science.
- Research reactors that have been subsequently commissioned include ZERLINA, PURNIMA (I, II and III), DHRUVA and KAMINI
- KAMINI is the country's first large research reactor that uses U-233 as fuel.

INDIA'S NUCLEAR POLICY

- India's Nuclear Policy, otherwise called the nuclear doctrine refers to how a government with a nuclear weapon uses the weapon in both peace and conflict.
- The three pillars of India's nuclear doctrine are:
- **No first use**
- **Credible minimum deterrent**: It underlines no first use (NFU) with an assured second strike capability and falls under minimal deterrence, as opposed to mutually assured destruction.
- **Civilian control (Nuclear command authority (NCA)):** On 4th January 2003, India unveiled a 3-tier Nuclear Command Authority (NCA) to manage its nuclear weapons. This board framework was approved on the nuclear doctrine prepared by the National Security Board. **The political council is headed by the Prime Minister**
- **India became the first country to achieve nuclear power without signing the Non-Proliferation Treaty.**

NON-PROLIFERATION TREATY

- Non-proliferation, disarmament, and the right to peacefully use nuclear technology are the three fundamental goals of the pact.
- **India is one of only five countries that either did not sign the NPT or signed but later withdrew, joining Pakistan, Israel, North Korea, and South Sudan on the list.**

COMPREHENSIVE TEST BAN TREATY (CTBT)

- The Comprehensive Nuclear-Test-Ban Treaty (CTBT) is a multilateral treaty that bans nuclear weapons test explosions and any other nuclear explosions, for both civilian and military purposes, in all environments.
- It was adopted by the United Nations General Assembly on 10 September 1996, but has not entered into force, as eight specific nations have not ratified the treaty.

NUCLEAR SUPPLIERS GROUP (NSG)

- NSG is a group of nuclear supplier countries that seeks to contribute to the non-proliferation of nuclear weapons through the implementation of guidelines for nuclear exports and nuclear-related exports.
- The aim of the NSG is to ensure that nuclear trade for peaceful purposes does not contribute to the proliferation of nuclear weapons.

INDIA–UNITED STATES CIVIL NUCLEAR AGREEMENT

- The Indo-US nuclear agreement was initiated in July 2005, when the then Indian Prime Minister Manmohan Singh visited the US.
- This was a landmark occasion also because this was the first time that India was being recognized as a nuclear weapons state.
- The Agreement is between two States possessing advanced nuclear technology, both parties having the same benefits and advantages.

Previous Year Question

1. **Which radioactive isotope is most useful for nuclear power generation? (2011)**
   - **a)** Uranium-238
   - **b)** **Uranium-235**
   - **c)** Carbon-14
   - **d)** Rubidium-87
2. **Indira Gandhi Centre for Atomic Research is located at (2011)**
   - **a)** Trombay
   - **b)** **Kalpakkam**
   - **c)** Tarapore
   - **d)** Jaduguda
3. **Which radioactive isotope is used in geological dating? (2018)**
   - **a)Uranium 238**
   - b) Iodine 131
   - c) Cobalt 60
   - d) d)Technetium 99

- **The most important condition laid down by India for signing the CTBT has been stated as (1998)**
  - a) India should be recognised as nuclear power
  - b) India should be admitted as a permanent member of the UN security council
  - **c) India should be free to develop capacity for a minimum nuclear deterrence in the interests of her own national security**
  - d) Pakistan should be declared as a terrorist state
- **Nuclear energy is a result of conversion of (1998)**
  - **a)** Neutron into proton
  - **b)** Light into heat
  - **c)** Helium into hydrogen
  - **d)** **Mass into energy**

Chapter 15:Space Science

ISRO

- Headquarters: Bengaluru
- Chairman: S. Somnath (Present)
- Established on 15th Aug, 1969
- Founder: Vikram Sarabhai
- ISRO has the world's largest constellation of remote-sensing satellites and operates the GAGAN and NAVIC satellite navigation systems
- **Achievements:**
- **Aryabhata was the first satellite** which was launched by ISRO on April 19, 1975 This was **launched by the Russian rocket launcher (C-1 Intercosmos)**
- ISRO's Mangalyaan mission made India the first country in the world to reach Mars in its first attempt.
- ISRO launched GSLV MkIII-D1, the heaviest rocket ever made by India, giving India the capability of sending astronauts into space.
- ISRO created history in February 2017, by launching 104 satellites in a single mission of PSLV.
- ISRO launched **AstroSat, India's own space observatory by PSLV-XL on 28 September 2015**: AstroSat, India's first dedicated space observatory launched in 2015 may be 10 times smaller than Hubble Telescope but is the **first space telescope launched by a developing country**.
- The Balloon Experiment of ISRO which lead to the discovery of the three new bacteria's which cannot be found on earth. They are highly resistant to ultraviolet radiation and are found in the upper stratosphere.

Vikram Sarabhai Space Centre (VSSC)

- Lead centre of ISRO responsible for the design and development of launch vehicle technology.
- Situated in Thiruvananthapuram
- Major programmes include: PSLV, GSLV, GSLV Mk III etc

Liquid Propulsion Systems Centre

- Design, development and realisation of liquid propulsion stages for ISRO’s launch vehicles

Satish Dhawan Space Centre (SDSC)

- **Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota, theSpaceport of India**, is responsible for providing Launch Base Infrastructure for the Indian Space Programme.

U R Rao Satellite Centre

- The U R Rao Satellite Centre (URSC), formerly ISRO Satellite Centre (ISAC) is an Indian Space Research Organisation centre for the design, development, and construction of Indian satellites

Space application centre

- The Space Applications Centre (SAC) is an institution of research in Ahmedabad under the aegis of the Indian Space Research Organisation (ISRO).
- It is one of the major centres of ISRO that is engaged in the research, development and demonstration of applications of space technology in the field of telecommunications, remote sensing, meteorology and satellite navigation (Sat Nav).

National Remote Sensing Centre

- National Remote Sensing Centre or NRSC, located in Hyderabad, Telangana is one of the centres of the Indian Space Research Organisation (ISRO).
- NRSC manages data from aerial and satellite sources.

Antrix Corporation Limited (Commercial Wing)

- Set up as the marketing arm of ISRO, Antrix's job is to promote products, services and technology developed by ISRO

NewSpace India Limited (Commercial Wing)

- Set up for marketing spin-off technologies, tech transfers through industry interface and scale up industry participation in the space programmes.
- It is a Public Sector Undertaking (PSU) of Government of India and commercial arm of Indian Space Research Organisation (ISRO).

Orbit

- Curved path of a celestial object or spacecraft round a star, planet, or moon
- Dynamic balance of the attractive gravitational force and the repulsive centrifugal force keeps a body in an orbit

Types of orbits

- Polar orbit
- Equatorial orbit
- Based on altitude:
  - LEO (Low Earth Orbit)
  - MEO (Middle Earth Orbit)
  - GEO (Geostationary Earth Orbit)
  - HEO (High Earth Orbit)
- Sun Synchronous Orbit
- Halo Orbit

Low Earth Orbit

- Very low altitude (**160-2000km**)
- Satellites move at very high speed to overcome the gravitational force
- International Space Station, Remote sensing satellite, Human spaceflight, Iridium phone system.

Boost Your Knowledge: International Space Station

- The International Space Station (ISS) is the largest modular space station currently in low Earth orbit.
- It is a multinational collaborative project involving five participating space agencies: NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada).
- The first segment of the ISS launched The Zarya Control Module launched aboard a Russian Proton rocket from Baikonur Cosmodrome, Kazakhstan on 20th November 1998

- The ISS is made up of 17 pressurized modules: six Russian modules (Zarya, Zvezda, Poisk, Rassvet, Nauka, and Prichal), eight US modules (BEAM, Leonardo, Harmony, Quest, Tranquility, Unity, Cupola, and Destiny), two Japanese modules (the JEM-ELM-PS and JEM-PM) and one European module (Columbus).
- The International Space Station location is in orbit around the Earth, at an average altitude of 248 miles (400 kilometers).
- The station serves as a microgravity and space environment research laboratory in which scientific research is conducted in astrobiology, astronomy, meteorology, physics, and other fields
- The station is divided into two sections: the Russian Orbital Segment (ROS) is operated by Russia, while the United States Orbital Segment (USOS) is run by the United States as well as by the other states
- In January 2022, NASA announced a planned date of January 2031 to de-orbit the ISS using a deorbit module and direct any remnants into a remote area of the South Pacific Ocean

Medium Earth Orbit

- A medium Earth orbit (MEO) is an Earth-centred orbit with an altitude above a low Earth orbit (LEO) and below a high Earth orbit (HEO) – **between 2,000 and 35,786 km above sea level**
- A medium Earth orbit is sometimes called mid Earth orbit or intermediate circular orbit (ICO)
- Used for navigation satellites like Global Positioning System (GPS) constellation (20,200km). Other navigation satellite systems use similar medium Earth orbits including GLONASS (with an altitude of 19,100 kilometres, Galileo (with an altitude of 23,222 kilometres) and BeiDou (with an altitude of 21,528 kilometres)

Geosynchronous orbit

- A geosynchronous orbit (sometimes abbreviated GSO) is an Earth-centered orbit with an orbital period that matches Earth's rotation on its axis, 23 hours, 56 minutes, and 4 seconds
- A circular geosynchronous orbit has a constant altitude of **35,786 km**
- A special case of geosynchronous orbit is the **geostationary orbit**, which is a circular geosynchronous orbit in Earth's equatorial plane with both inclination and eccentricity equal to 0. A satellite in a geostationary orbit remains in the same position in the sky to observers on the surface.
- **Geostationary Transfer Orbit(GTO)** is a special case of geocentric orbits which serve as an intermediate orbit for satellites that are destined for Geostationary orbit. It is an elliptical orbit with the perigee as low as the Low earth orbit and apogee as high as the geostationary orbit

High Earth Orbit

- A high Earth orbit is a geocentric orbit with an altitude entirely above that of a geosynchronous orbit (35,786 kilometres).
- The orbital periods of such orbits are greater than 24 hours
- Their orbital velocity is lower than Earth's rotational speed

Sun-synchronous orbit

- A Sun-synchronous orbit (SSO), also called a heliosynchronous orbit, is a nearly polar orbit around a planet, in which the satellite passes over any given point of the planet's surface at the same local mean solar time

Halo Orbit

- A halo orbit is a periodic, three-dimensional orbit near one of the L1, L2 or L3 Lagrange points
- A Lagrange point is a location in space where the combined gravitational forces of two large bodies is equal the centrifugal force felt by a much smaller third body
- **The earth-sun system has 5 Lagrange points – L1, L2, L3, L4 and L5**
- The major advantage of placing the satellite at Lagrange point L1 is that it will have continuous view of the sun without any occultation/eclipse

Satellite

- Any object that orbits another celestial body (sun, planet, moon, etc).
- **Escape velocity**: The minimum speed required for an object to reach infinity. The **escape velocity of the earth is 11.2 km/s**

Spacecraft

- A spacecraft is a vehicle or machine designed to fly in outer space.
- A type of artificial satellite, spacecraft are used for a variety of purposes, including communications, Earth observation, meteorology, navigation, space colonization, planetary exploration, and transportation of humans and cargo

Types:

- **Orbiter**: A spacecraft designed to go into orbit, especially one that does not subsequently land. Observations of atmosphere, weather, communication. **Mars Orbiter Mission, Chandrayaan-1, etc.**
- **Lander**: A spacecraft designed to land on the surface of a planet or moon. For bodies with atmospheres, the landing occurs after atmospheric entry. In these cases, landers may employ parachutes to slow them down enough to maintain a low terminal velocity. In some cases, small landing rockets will be fired just before impact in order to reduce the lander's velocity
- **Rover**: A rover (or sometimes planetary rover) is a planetary surface exploration device designed to move across the solid surface on a planet or other planetary mass celestial bodies. Some rovers have been designed as land vehicles to transport members of a human spaceflight crew; others have been partially or fully autonomous robots
- **Flyby**: A flyby is a path a spacecraft follows past a planet or other body in space to get information about it. In a flyby, the spacecraft passes close, but isn't "captured" into an orbit by gravity. During a flyby, a spacecraft must use its instruments to observe the target as it passes, changing the aim of the instruments as it passes. A spacecraft in a flyby has a limited opportunity to gather information. Once it has flown by its target, it cannot return.

- **Space probe**: A probe is a spacecraft that travels through space to collect science information. Probes do not have astronauts. Probes send data back to Earth for scientists to study. Sputnik 1 was the first probe to go into space. It was launched on Oct. 4, 1957, by the former Soviet Union.
- **Impactor**: An impactor is set to hit a body and usually an accompanying probe will analyse the effect of its impact.

Boost Your Knowledge:

- Orbiter Spacecraft's main goal is to orbit and observe one planet whereas the Flyby has the ability to observe many
- Satellites are spacecrafts intended to be placed in planet's orbit. Spaceships applied to piloted spacecrafts and probes are spacecrafts destined to explore the Solar System.

Remote Sensing Satellite

- Remote sensing is the method of detecting and monitoring the physical characteristics of a region by measuring its reflected and emitted radiation at a distance from a satellite.
- Remote sensing satellites are also called **Earth observation satellites** or Earth remote sensing satellites. They're used as **spy satellites or for environmental monitoring, meteorology, and cartography.**
- **The first occurrence of remote sensing satellites on October 4, 1957, with the launch of the first artificial satellite, Sputnik 1**.

Indian Remote Sensing Programme

- India's remote sensing programme under the Indian Space Research Organization (ISRO) started off in 1988 with the **IRS-1A, the first of the series of indigenous state-of-art operating remote sensing satellites, which was successfully launched into a polar sun-synchronous orbit on March 17, 1988 from the Soviet Cosmodrome at Baikonur**.
- The IRS system is the **largest constellation of remote sensing satellites for civilian use in operation today in the world**, with 11 operational satellites

Boost your knowledge: SAR

- Synthetic-aperture radar (SAR) is a form of radar that is used to create two-dimensional images or three-dimensional reconstructions of objects, such as landscapes. SAR uses the motion of the radar antenna over a target region to provide finer spatial resolution than conventional stationary beam-scanning radars. SAR is typically mounted on a moving platform, such as an aircraft or spacecraft, and has its origins in an advanced form of side looking airborne radar (SLAR).

RISAT

- Radar Imaging Satellite or RISAT is a series of Indian radar imaging reconnaissance satellites
- They provide all-weather surveillance
- The RISAT series consist of RISAT 2, 1, 2B, 2BR1

EOS-04

- EOS-04 or Earth Observation Satellite - 04 (formerly known as RISAT-1A) is an Indian Space Research Organisation Radar Imaging Satellite designed to provide high quality images under all weather conditions for applications such as Agriculture, Forestry & Plantations, Soil Moisture & Hydrology and Flood mapping.
- PSLV-C52 launched EOS-04 and two small satellites onboard. The small satellites include a student satellite (**INSPIREsat-1**) and the other satellite is a technology demonstrator satellite (**INS-2TD**) from ISRO

NISAR

- NASA ISRO Synthetic Aperture Radar
- NISAR's data can help people worldwide better manage natural resources and hazards, as well as providing information for scientists to better understand the effects and pace of climate change. It will also add to our understanding of our planet's hard outer layer, called its crust.

Indian National Satellite (INSAT) System

- Series of multipurpose geo-stationary satellites launched by ISRO.
- The GSAT (Geosynchronous Satellite) satellites are India's indigenously developed communications satellites, used for digital audio, data and video broadcasting
- **GSAT-11 – India's heaviest satellite (5854 kg), launched by Ariane-5 rocket**
- **GSAT-7 or INSAT-4F** is a multi-band military communications satellite developed by the Indian Space Research Organisation.

Global Navigation Satellite Systems

- A global navigation satellite system (GNSS) is a network of satellites broadcasting timing and orbital information used for navigation and positioning measurements.
- There are four main constellations in orbit – **GPS (USA), GLONASS (Russia), Galileo (EU) and BeiDou (China) as well as two regional systems Quasi-Zenith Satellite System or QZSS (Japan) and IRNSS (India)**
- GPS satellites broadcast signals from space, and each GPS receiver uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time
- As of May 2021, 16 GPS satellites are broadcasting signals, and the signals are considered pre-operational, scheduled to reach 24 satellites by approximately 2027.

NAVIC

- Navic (Navigation with Indian Constellation) is the operational name of the Indian Regional Navigation Satellite System (IRNSS) developed by ISRO.

- Unlike GPS which is a Global tracking constellation, Navic has been designed to focus especially on India and adjoining regions (**1500 Kms around India**) and is a very significant achievement for the country.
- Total launches = 9; Total satellites = 8; Satellites in orbit = 7; 3 in GEO and 4 in GSO the 8th satellite if it reaches the orbit will be placed into GSO

GAGAN

- The GPS-aided GEO augmented navigation (GAGAN) is an implementation of a regional satellite-based augmentation system (SBAS) by the Government of India.
- The Airports Authority of India (AAI)'s efforts towards implementation of operational SBAS can be viewed as the first step towards introduction of modern communication, navigation and surveillance / air traffic management system over the Indian airspace
- Satellite included for GAGAN system is GSAT-8, 10 and 15

Boost Your Knowledge:

- Solar sails (also known as light sails and photon sails) are a method of spacecraft propulsion using radiation pressure exerted by sunlight on large mirrors.
- A number of spaceflight missions to test solar propulsion and navigation have been proposed since the 1980s.
- **The first spacecraft to make use of the technology was IKAROS, launched in 2010.**
- **Dubbed Sunjammer**, the giant solar sail measures about 124 feet (38 meters) on a side and boasts a total surface area of nearly 13,000 square feet (1,208 square m, or one-third of an acre). The project is under the wing of **NASA's Space Technology Program**
- The Diffractive Solar Sailing project was selected for Phase III study under the NASA Innovative Advanced Concepts (NIAC) program. Phase III aims to strategically transition NIAC concepts with the highest potential impact for NASA, other government agencies, or commercial partners.

LAUNCHERS

- Launch Vehicle or Launcher or Rocket
- A rocket engine differs from other engines – uses **propellant** which isa **mix of fuel and oxidiser**
- **Solid propellant rockets:**
- Solid propellants are useful for providing the initial thrust. **Nitrocellulose, ammonium nitrate, ammonium perchlorate** is some of the solid propellants used in rockets.
- **Liquid Propellant Rockets:**
- **Liquid hydrogen, kerosene, liquid methane, hydrazine**, etc are used as liquid propellants
- **Cryogenic propellants**: Liquefied gases stored at very low temperatures. Liquid hydrogen is the fuel and liquid oxygen (LO_2 or LO_x) is the oxidizer. LH_2 at -253 degree C and LO_2 at -183-degree C.

- **Semi- Cryogenic propellants**: Developed by ISRO. Uses kerosene as the propellant and liquid oxygen as the oxidiser – **ISROSENE**.
- **Hypergolic propellants**: Fuels and oxidizers that ignite spontaneously on contact with each other. The most common such propellant combination, **dinitrogen tetroxide plus hydrazine and/or its relatives monomethylhydrazine (MMH) and unsymmetrical dimethylhydrazine (UDMH).**
- **Hybrid Propellants:** One of the substances is solid, (usually fuel), while the other is liquid (usually oxidizer). **Common fuels for a typical hybrid rocket engine include polymers such as acrylics, polyethylene (PE), cross-linked rubber, such as HTPB (Hydroxyl-terminated polybutadiene), or liquefying fuels such as paraffin wax**

Boost Your Knowledge: Vikas Engine

- The Vikas (a portmanteau from initials of **VIK**ram **A**mbalal **S**arabhai) is a family of liquid fuelled rocket engines conceptualized and designed by the Liquid Propulsion Systems Centre in the 1970s
- The engine uses up about 40 metric tons of **Unsymmetrical Dimethyl Hydrazine (UDMH) as fuel and Nitrogen tetroxide (N_2O_4) as oxidizer**
- Vikas engine is used to power the second stage of PSLV, boosters and second stage of GSLV

India and Cryogenics

- In 1994, India formally launched the **Cryogenic Upper Stage Project (CUSP)** of ISRO.
- Indian scientists conducted the **first successful cryogenic engine test in the year 2003 and the first successful flight was conducted in 2014**.
- **US, Russia, Japan, India, France and China are the only countries to have operational cryogenic rockets**

PSLV

- The Polar Satellite Launch Vehicle (PSLV) is an expendable medium-lift 4 staged launch vehicle designed and operated by the Indian Space Research Organisation (ISRO).
- It was developed to allow India to launch its Indian Remote Sensing (IRS) satellites into sun-synchronous orbits
- PSLV can also launch small size satellites into Geostationary Transfer Orbit (GTO).
- Some notable payloads launched by PSLV include India's first lunar probe **Chandrayaan-1,** India's first interplanetary mission, **Mars Orbiter Mission (Mangalyaan)** and India's first space observatory, **Astrosat**
- **PSLV-C37 successfully carried and deployed a record 104 satellites in sun-synchronous orbits. Launched on 15 February 2017 by the Indian Space Research Organisation (ISRO) from the Satish Dhawan Space Centre at Sriharikota, Andhra Pradesh.**
- **SpaceX broke ISRO record of most satellites on a single rocket. SpaceX created yet another** record on 24th January 2021— launch of most number of satellites on a single rocket — when its first small sat ride share mission called **Transporter-1** successfully **launched 143 spacecraft** into orbit

GSLV

- Geosynchronous Satellite Launch Vehicle (GSLV) is an expendable 3 staged launch system operated by the Indian Space Research Organisation (ISRO).
- GSLV was used in fourteen launches from 2001 to 2021, with more launches planned
- The 3rd stage used cryogenic fuel
- GSLV Mark III was used in Chandrayaan-II

Reusable Launch Vehicle

- RLV-TD is India's first uncrewed flying test bed developed for the Indian Space Research Organisation (ISRO)'s Reusable Launch Vehicle Technology Demonstration Programme
- 2 staged LV: 1st stage uses semi cryogenics; 2nd stage uses cryogenics which can be useful for men in space mission

Boost Your Knowledge: SSLV-D1/EOS-2 Mission (7th August, 2022)

- Purpose of the mission was to place the two satellites in circular low-Earth orbits at a height of about 350 km above the Equator (LEO)
- The two satellites are EOS-2 by ISRO and AzadiSAT (with 75 payloads, developed by 750 girl students from across India,)
- Launched by Small Satellite Launch Vehicle (SSLV)
- The advantage of using SSLV over PSLV or GSLV is that SSLV can easily carry small-to-medium loads from 10 kg to 500 kg. It is less expensive. The three stages being powered by solid fuel is another advantage

Important missions of ISRO

- **GAGANYAAN**: This will be the first indigenous human mission developed by ISRO. It is an Indian crewed orbital spacecraft mission (jointly made by ISRO and HAL) that is expected to carry three people seven days into space and intended to be the basis of the Indian Human Spaceflight Programme. **Vyomamitra** is an artificial intelligence-based robotic system to mimic crew activity inside the crew module of Gaganyaan.
- **CHANDRAYAAN 1**: It was launched in October 2008. It was the first lunar probe of India. The mission had a lunar orbiter and an impactor. The most significant result from Chandrayaan-1 is the discovery of the presence of vapour water molecules in trace amount on the lunar surface
- **CHANDRAYAAN 2**: ISRO launched the Chandrayaan-2 mission to the Moon in July 2019, but its lander did not touch the lunar surface. It is a completely indigenous mission comprising of an Orbiter, Lander (called Vikram) and Rover (called Pragyan). Vikram, the lander failed in the mission. Its main objective was to explore the South Pole of the moon

- **CHANDRAYAAN 3**: Chandrayaan-3 will be a mission repeat of Chandrayaan-2 but will only include a lander and rover similar to that of Chandrayaan-2
- **MANGALYAAN**: Mars Orbiter Mission is India's first interplanetary mission to Mars. It is primarily a technology demonstrator mission launched in 2014. Orbiter completed its energy in 3 phases- Geocentric, heliocentric and Martian. Its main objectives includes the study of Morphology, mineralogy and Martian atmosphere along with Methane source exploration

- **G.E.M.I.N.I**.: The Gagan Powered Mariner's Instrument for Navigation and Information (G.E.M.I.N.I.) system, a satellite-based advice service for deep-sea fishermen, has been launched by the Government of India. G.E.M.I.N.I. has been developed by the Indian National Centre for Ocean Information Services and Airport Authority of India
- **Aditya-L1 Mission**: Aditya-L1 is a first Indian based project to research the solar Corona. It will be placed in a halo orbit around the Lagrangian Sun-Earth point (L1), about 1,5 million km from the Earth.
- **XPoSat**: X-ray polarimeter satellite is a dedicated polarization study mission planned. It will study black holes around neutron stars, supernova remnants, pulsars, and regions.
- **Shukrayaan 1:** The Venusian mission Shukrayaan 1, is a planned orbiter to Venus to study the surface and atmosphere of the Venus

Other important Missions

Mission	Agency	Launch Year	Objectives
PARKER SOLAR PROBE	NASA	2018	The mission's central aim is to trace how energy and heat move through the Sun's corona and to study the source of the solar wind's acceleration. It was found that Venus sports an electrically charged layer of gas at the upper edge of its atmosphere, called the ionosphere. This sea of charged gases, or plasma, naturally emits radio waves.
ARTEMIS (Space Launch System rocket)	NASA (Kennedy Space Center)	2022	Lunar exploration programme. With Artemis missions, NASA will land the first woman and first person of color on the Moon, using innovative technologies to explore more of the lunar surface than ever before

Boost Your Knowledge: SpaceX and Starlink

- Starlink is a satellite internet constellation operated by SpaceX, providing satellite Internet access coverage to 40 countries.
- It also aims for global coverage with satellite personal communications service after 2023.
- SpaceX started launching Starlink satellites in 2019.
- As of September 2022, Starlink consists of over 3,000 mass-produced small satellites in low Earth orbit (LEO), which communicate with designated ground transceivers.
- Starlink provides internet access to over 500,000 subscribers as of June 2022

Boost Your Knowledge: Space Debris and Kessler's Syndrome

- Space debris, also called space junk, artificial material that is orbiting Earth but is no longer functional. This material can be as large as a discarded rocket stage or as small as a microscopic chip of paint
- The Kessler syndrome (also called the Kessler effect, collisional cascading, or ablation cascade), proposed by NASA scientist Donald J. Kessler in 1978, is a scenario in which the density of objects in low Earth orbit (LEO) due to space pollution is high enough that collisions between objects could cause a cascade in which each collision generates space debris that increases the likelihood of further collisions.

Previous Year Questions

1. Minimum velocity required by a body to escape earth's gravitation (escape velocity) is (2011)

a) 9.5 km/s
b) **11.2 km/s**
c) 13 km/s
d) 24.25 km/s

2. GSAT-7, the first Indian satellite for defense purpose, was launched from (2013)

a) Sriharikota
b) **Kourou**
c) Baikanour
d) Cape Canaveral

3. India's first remote sensing satellite (IRS-IA) was launched from (2014 & 2015)

a) Sriharikota
b) **Baikonur**
c) Cape Kennedy

d) French Guiana

4. **Which was the first Indian satellite that was launched from Soviet Cosmodrome in 1975? (2014)**

a) **Aryabhatta**
b) Bhaskara-I
c) Bhaskara-II
d) INSAT-JA

5. **Which of the following satellites helps to telecast TV Network programmes all over the country? (2014)**

a) Aryabhatta
b) APPLE
c) Rohini
d) **INSAT-18**

6. **How many satellited were launched by Indian Space Research Organization (ISRO) to create history on February 15, 2017? (2016)**

a) 84
b) 93
c) 102
d) **104**

7. **Which country on 19th July, 2020 Launched its first mission to the Mars? (2020)**

a) India
b) Malaysia
c) **United Arab Emirates**
d) Iran

8. **Which of the following statements is not correct about the International Space Station? (1998)**

a) It came into reality in December, 1998.
b) The Russian-built Zarya Module and the USA-built Unity Module fitted together for the first time.
c) **It revolves around the earth at a height of about 1000 km.**
d) The Project seeks to join more than 100 space station components

9. **What is the name of the spacecraft launched in the year 2004 which would fly by Earth, Venus and Mercury several times and circle the Sun 15 times? (2006)**

a) Rover
b) Ranger
c) **Messenger**
d) Marker

10. **Which of the following has announced its plan to launch the world's largest solar sail in 2014? (2013)**

a) **NASA**
b) ISRO
c) European Space Agency
d) Japanese Space Agency

11. PSLV-C14 in its latest space quest had carried Oceanset-2 with how many foreign nano satellites? (2014)

a) 5
b) **6**
c) 7
d) 9

Chapter 15: Space, Matter and Science

Elementary/ Fundamental Particles

- Elementary Particles in physics deals with the fundamental constituents of matter and their interactions
- They are **Fermions** and **Bosons**
- There are 12 Fermions: 6 **quarks** and 6 **leptons**
- In particle physics, a lepton is an elementary particle that does not undergo strong interactions.
- Electron, muon, Tau, neutrinos etc. comprises of leptons. **Neutrinos** are second most abundant particles in the universe and are known as ghost particles as they hardly interact with matter
- Neutrinos are hard to detect. In body they are produced by radioactive decay of potassium, nuclear reactions inside sun, cosmic reaction produces neutrinos in the earth
- **Higgs Boson** is known as God's Particle. Named after physicist Peter Higgs, who in 1964 along with five other scientists in three teams, proposed a way that some particles can acquire mass

Fundamental Forces

- The Standard Model of particle physics is the theory describing three of the four known fundamental forces in the universe and classifying all known elementary particles
- There are four fundamental forces: **Gravitational force, Electromagnetic force, Weak nuclear force and Strong nuclear force**. Gravity is not considered in Standard Model of Physics

Experiments to detect Neutrinoes

- ANtarctic Impulsive Transient Antenna (ANITA)
- IceCube Neutrino Observatory at Antartica
- Astronomy with a Neutrino Telescope and Abyss environmental RESearch (ANTARES) - The first undersea neutrino telescope. Located in the Mediterranean Sea
- Baikal-GVD (Gigaton Volume Detector)
- India-based Neutrino Observatory- Construction of an underground laboratory and associated surface facilities at Pottipuram in Bodi West hills of Theni District of Tamil Nadu.

Dark Energy

- In physical cosmology and astronomy, dark energy is an unknown form of energy that affects the universe on the largest scales.
- The first observational evidence for its existence came from measurements of supernovae, which showed that the universe does not expand at a constant rate; rather, the universe's expansion is accelerating
- Dark Energy Spectroscopic Instrument (DESI)- By the end of its run in 2026, DESI is expected to have over 35 million galaxies in its 3D catalog, enabling an enormous variety of cosmology and astrophysics research

Black hole

- A black hole is a place in space where gravity pulls so much that even light can not get out.
- The gravity is so strong because matter has been squeezed into a tiny space
- Consists of Event Horizon and point of Singularity (infinite gravity)

LIGO

- **L**aser **I**nterferometer **G**ravitational-Wave **O**bservatory
- Colliding black holes send ripples through spacetime that can be detected on Earth.
- The gravitational wave observatories LIGO, Virgo, and KAGRA are coordinating to continue observations
- As of January 2022, LIGO has made 3 runs (with one of the runs divided into 2 "subruns"), and made 90 detections of gravitational waves.
- The Laser Interferometer Gravitational-Wave Observatory (LIGO) consists of two widely separated installations within the United States -- one in Hanford Washington and the other in Livingston, Louisiana -- operated in unison as a single observatory

LISA

- Laser Interferometer Space Antenna (LISA) is a proposed space probe to detect and accurately measure gravitational waves
- The evolved LISA (eLISA) concept has a constellation of three spacecraft arranged in an equilateral triangle with sides 2.5 million km long, flying along an Earth-like heliocentric orbit. The distance between the satellites is precisely monitored to detect a passing gravitational wave.

Hubble Space Telescope

- The Hubble Space Telescope (often referred to as HST or Hubble) is the **only space telescope** that was launched into low Earth orbit in 1990 and remains in operation.
- It was not the first space telescope, but it is one of the largest and most versatile
- Uses the visible light and UV

James Webb Space Telescope - Successor of the Hubble

- The James Webb Space Telescope (JWST) is a space telescope designed primarily to conduct **infrared astronomy**.
- As the **largest optical telescope in space**, its greatly improved infrared resolution and sensitivity allows it to view objects too old, distant, or faint for the Hubble Space Telescope
- The James Webb Space Telescope was **launched on 25 December 2021 on an Ariane 5 rocket from Kourou, French Guiana**

International Liquid Mirror Telescope

- India's first liquid-mirror telescope will observe asteroids, supernovae, space debris and all other celestial objects from an altitude of 2,450 metres in the Himalayas
- Established on the campus of the Devasthal Observatory of the Aryabhatta Research Institute of Observational Sciences (ARIES) in **Nainital**
- Only liquid-mirror telescope operational anywhere in the world
- The **most common liquid used is mercury**, but other liquids will work as well (for example, low-melting alloys of gallium).

Previous Year Question

Black hole is an object to be found (2011)

a) At the bottom of oceans
b) **In the sky**
c) Inside a current-carrying conductor
d) None of the above

Chapter16:Defense Technology

DRDO

- Defence Research and Development Organisation
- It was established in 1958 by the Government of India, under the Ministry of Defence
- **Project Indigo was the DRDO's first major defence project**
- R&D of DRDO:
- Development of Bio-Toilets by DRDO in Indian Railway coaches
- **Leuskin Herbal to treat leukoderma**
- **Anti-Covid-19 drug, 2-deoxy-D-glucose (2DG)**
- Sindhu Netra' satellite developed by Defence Research and Development Organisation (DRDO) was successfully deployed in space on February 28th, 2021. The satellite aims to boost the country's surveillance capabilities to monitor the activities of both military warships and merchant shipping in the Indian Ocean Region (IOR). The satellite was launched using the Indian Space Research Organisation's PSLV-C51
- The Pune-based R&DE Lab of DRDO has developed a smart robust robot to handle land mines and Inert Explosive Devices (IEDs) which will help the Indian Armed Forces to disarm them from far distances despite hostile surroundings. This robot, named Mobile Autonomous Robot System (MARS), was developed by the Electro-Mechanical Systems Group of the R&DE Lab.
- **DRDO's centre in Ladakh is at 17,600 feet above sea level at Changla near Pangong lake. (world's highest terrestrial centre).** It is intended to serve as a natural cold storage unit for the preservation of natural and medicinal plants.

The centre will also act as a research unit for food, agriculture and bio-medical sciences that will benefit the soldiers deployed at high altitude.

- Air Defence Fire Control Radar (ADFCR) **'Atulya'** main purpose is effective point defence against all air threats at short and very short ranges during day and night under all weather conditions and also in the presence of enemy jamming.
- DRDO developed a self-ejectable black box named BSAT for airplanes that can help rescuers easily locate the debris in the event of a crash in water.
- Radiation Countermeasures & Biodosimetry Research (Rakshak Project)
- Mobile Whole-Body Counter (DivyaDrishti)
- Sanjay Netra-NETRA is a completely autonomous, hovering Unmanned Aerial Vehicle (UAV).

CDS

- The Chief of Defence Staff of the Indian Armed Forces (CDS) is the military head and permanent Chairman of the Chiefs of Staff Committee (CoSC) of the Indian Armed Forces.
- The Chief of Defence Staff is the highest-ranking uniformed officer on active duty in the Indian military and chief military adviser to the Minister of Defence.
- The first Chief of Defence Staff took office on 1 January 2020.
- **General Bipin Rawat served as the first Chief of Defence Staff (CDS) of the Indian Armed Forces from January 2020 until his death in a helicopter crash on 8 December 2021, a Mil**

Mi-17V-5 transport helicopter operated by the Indian Air Force (IAF) crashed between Coimbatore and Wellington in Tamil Nadu, after departing from Sulur Air Force Station.

- The position was created with the aim of improving coordination, tri-service effectiveness and overall integration of the combat capabilities of the Indian armed forces
- "The Central Government may, if considered necessary, in public interest, appoint as CDS, an officer who is serving as Lieutenant General or General or an officer who has retired in the rank of Lieutenant General or General but has not attained the age of 62 on the date of appointment," the **amendment in the Service Rules of the Army says in the gazette dated June 6, 2022**. Similar amendment was made in the service rules of Navy and Air Force as well

Classification of Missiles

Based on Trajectory: Ballistic and Cruise

- **Ballistic Missile**: Follows a Parabolic Pathway. It is also called as re-entry missile system as it makes its entry back to the endo atmosphere from the exo atmosphere
- **Cruise missile**: It uses jet technology. Remains in the endo atmosphere, remains closer and parallel to surface. It is a guided missile

Based on range:

- Tactical Missiles (less than 300km)
- Short range ballistic missiles (300- 1000km)
- Medium range ballistic missiles (1000-3000km)
- Intermediate/ Long range ballistic missiles (3000-5500km)
- Intercontinental ballistic missiles (more than 5500km)

Based on Nature:

- Surface to surface- Prithvi and Agni
- Surface to air- Trishul and Akash
- Air to air- Ashtra
- Anti-tank - Nag, HeliNa
- Submarines- K series

Based on speed

- Hypersonic (Mach more than 5)
- Supersonic (Mach more than 1)
- Subsonic (Mach less than 1)
- **By definition, at Mach 1, the local flow velocity is equal to the speed of sound**

Integrated Guided Missile Development Programme

- IGMDP was launched in 1982-83 by the Indian Government and was completed in 2008
- Prithvi (Short range surface to surface missile)

- Trishul (short range surface to air missile)
- Aakash (Medium range surface to air supersonic missile)
- Nag (Third generation anti-tank missile)
- Agni-I (Agni missile was later separated from the IGMDP due to its strategic importance)

Agni Missile Development Programme

- Agni-I was developed under the Integrated Guided Missile Development Program (IGMDP) and tested in 1989. After its success, Agni missile program was separated from the IGMDP upon realizing its strategic importance.
- As of November 2019, the missiles in the Agni series are being inducted into service

Prithvi

- Prithvi-I is an Indian short-range ballistic missile with a range of 150 km
- Prithvi II class is also a single-stage liquid-fueled missile having a maximum warhead mounting capability of 500 kg, but with an extended range of 250 km (Dhanush in airforce version)
- Prithvi III class is a two-stage SURFACE-to-SURFACE missile. The first stage is solid fueled. The second stage is liquid-fueled. The missile can carry a 1,000 kg warhead to a distance of 350 km and a 500 kg warhead to a distance of 600 km and a 250 kg warhead up to a distance of 750 km (Navy version)

Akash

- Akash is a surface-to-air missile with an intercept range of 30 km
- 1st indegenous supersonic air defense missile (Mach 2.5)
- Made for airforce and Indian army

Trishul

- Trishul is the name of a short range surface-to-air missile developed by India as a part of the Integrated Guided Missile Development Program.
- It has a range of 12 km and is fitted with a 5.5 kg warhead.
- Designed to be used against low-level (sea skimming) targets at short range, the system has been developed to defend naval vessels against missiles and also as a short-range surface-to-air missile on land

Agni

- Agni-I: 1,000kg payload; 700–1200 km range (medium range ballistic missile)
- Agni-II: 820–2,000 kg payload; 2,000–3,500 km range (intermediate range ballistic missile)
- Agni-III: 2,500 kg payload; 3,000–5,000 km range (intermediate range ballistic missile)
- Agni-IV: 800–1,000 kg payload; 3,500–4,000 km range (medium range ballistic missile)
- Agni-V: 1,500 kg payload; 5,000+ km range (intercontinental range ballistic missile)
- Agni-VI: 3,000 kg payload; 11,000-12,000 km range (intercontinental range ballistic missile)-under development

Fuel used are solid for all stages

- Agni 1 - single staged solid fuel
- Agni 2, 3 and 4- double staged solid fuel
- Agni 5- Triple staged solid fuel

Nag

- Third generation anti-tank missile
- It is a Fire and Forget missile
- 4-8km range
- **Prospina**- land version of the missile,
- **HeliNa/Dhruvastra**- helicopter-launched version of NAG,
- **Man, Portable Anti-Tank Guided Missile (MPATGM)**- This version is lighter in comparison to other variants

QRSAM

- Quick Reaction Surface-to-Air Missile (QRSAM) is a missile developed by the Defence Research and Development Organisation (DRDO), Bharat Electronics Limited and Bharat Dynamics Limited for the Indian Army, meant for protecting moving armoured columns from aerial attacks
- The missile system possesses two four-walled radars both of which encompass a 360-degree coverage, namely, the Active Array Battery Surveillance Radar and the Active Array Battery Multifunction Radar, apart from the launcher while Laser proximity fuze ensures that missile can't be jammed.

VL-SRSAM

- Vertical Launch Short Range Surface-to-Air Missile (VL-SRSAM)
- Meant for neutralising various aerial threats at close ranges, including sea-skimming targets
- Range of 40 to 50 km and at an altitude of around 15 km
- Two key features of the VL-SRSAM are cruciform wings and thrust vectoring

BrahMos

- Medium-range ramjet supersonic cruise missile that can be launched from submarine, ships, aircraft or land
- It is the world's fastest anti-ship cruise missile currently in operation
- **Named after two rivers Brahmaputra of India and Moskva of Russia**
- Joint venture between the Russian Federation's NPO Mashinostroyeniya and India's Defence Research and Development Organisation (DRDO), who together have formed BrahMos Aerospace
- Initial BrahMos flight range was 290km and 500kg payload
- In 2016, as India became a member of the Missile Technology Control Regime (MTCR), India and Russia planned to jointly develop a new generation of Brahmos missiles with 800 km range and an ability to hit protected targets with pinpoint accuracy. Plans are to eventually upgrade all missiles to a range of 1500 km

K Missile family

- Family of submarine-launched ballistic missiles (SLBM) developed by India to boost its second-strike capabilities and thus augment its nuclear deterrence
- 'K missiles' are faster, lighter and stealthier than their Agni missile counterparts.
- K-15 or Sagarika missile (750-1500 km) is India's first submarine launched ballistic missile. K-15 (now renamed the B-05) is a 10-metre long two-stage solid-fuelled manoeuvering ballistic missile with a range of 750 km.
- **NOTE**: A hypersonic land-based and nuclear-armed variant of the K-15 is the **Shaurya missile**
- K-4 (3500km) , K-5 (5000km), K-6 (6000km)

S-400 Triumf

- Mobile, surface-to-air missile (SAM) system developed in the 1990s by Russia's Almaz Central Design Bureau for Marine Engineering
- 400 km range
- Visualize 80 targets at a time
- Radar system is present

Pinaka

- Pinaka is a multiple rocket launcher produced in India and developed by the Defence Research and Development Organisation (DRDO) for the Indian Army.
- It can fire a salvo of 12 HE rockets in 44 seconds.
- Upgraded version has range of 90km
- Pinaka saw service during the Kargil War

Anti – Ballistic Missile System of India

- The **Prithvi Air Defence (PAD)/ Pradyumna and Prithvi Defence Vehicle** is a double staged solid and liquid fueled anti-ballistic missile developed to intercept incoming ballistic missiles.
- Single staged solid rocket propelled **Advanced air Defence (AAD) missiles/ Ashwin** for endo altitude regions of 15-40km: 2nd Layer

Airborne Early Warning and Control System

- Currently two AEW&C systems named Netra, are being used extensively by the Indian Air Force for various operations
- Active Electronically Scanned Antenna based Primary Radar (PR), Identification Friend or Foe (IFF) etc all hosted on an executive jet platform namely the Embraer-145
- AWACS, abbreviation of Airborne Warning And Control System, a mobile, long-range radar surveillance and control centre for air defence

Iron Dome

- Mobile all-weather air defense system developed by Rafael Advanced Defense Systems and Israel Aerospace Industries
- Short range ground to air defence system that includes a radar and Tamir interceptor missiles

MUNTRA

- DRDO has rolled out Muntra, India's first unmanned, remotely operated tank at its Chennai lab.
- It has been launched in three variants. All the variants are tele-operated by Muntra B
- Muntra-S: surveillance
- Muntra-M: Mine detection by Ground Penetrating Radar (GPR) and Vapour Detection System (VDS)
- Muntra-N: Reconnaissance in areas with nuclear and biological threats.

Tejas

- HAL Tejas is an Indian multirole light fighter for the Indian Air Force and Indian Navy
- It is a Light Combat Aircraft (LCA) and is the smallest and lightest in its class of contemporary supersonic combat aircraft.
- Tejas has a night vision goggles compatible glass cockpit
- Air Force Refueling Aircraft

Sukhoi-30 MKI

- Sukhoi-30 MKI is the backbone of the Indian Air Force
- A twin engine-Heavy- Long Range- Air Superiority fighter jet of Russian Origin made in India under license by HAL
- A variant of the Sukhoi Su-30, it is a heavy, all-weather, long-range fighter.

Dassault Rafale

- The Dassault Rafale " in a more military sense is a French twin-engine, supersonic (Mach 1.8) multirole fighter aircraft (4.5 G) designed and built by Dassault Aviation.
- India has 36 aircraft contracts with France
- The last Rafale fighter will arrive in India in April 2022

Kh-47M2 Kinzhal

- Russia said that it had unleashed hypersonic missiles against an arms depot in Ukraine, the first use of the next-generation weapons in combat
- The Kh-47M2 Kinzhal ("dagger") is a Russian nuclear-capable hypersonic aero-ballistic air-to-surface missile
- It has a claimed range of more than 2,000 km, Mach 12 speed
- It can carry both conventional and nuclear warheads and can be launched from Tu-22M3 bombers or MiG-31K interceptors

Aircraft Carriers of India

- **INS Vikrant (1957**)- The first-ever aircraft carrier warship of India commissioned in and was decommissioned in 1997. India purchased the incomplete carrier in 1957, and construction was completed in 1961
- **INS Virat**: Bought from the UK, this carrier served the country for 30 years before it was officially decommissioned in 2017
- **INS Vikramaditya**: Current serving aircraft carrier of India. It was made by USSR. It operates on the STOBAR (Short Take-Off But Arrested Recovery) system of launch and recovery of the aircraft.
- **INS Vikrant (2013):** Indigenous Aircraft Carrier 1 (IAC-1), informally called INS Vikrant 2. It is the first aircraft carrier warship to be made in India. It has STOBAR and EMALS (Electro-Magnetic Aircraft Launch System) system. **It was commissioned in 2nd September 2022**
- **INS Vishal**: Chief Naval Admiral has been strongly demanding for a second Indigenous Aircraft Carrier (IAC-2). Though it has been planned the Defence Minister Of India has still not cleared its project, mainly due to lack of funds. However, it is expected to be made and commissioned by the 2030s

Attack Submarines

Diesel Attack and Nuclear attack submarines based on its operation

- Diesel attack submarines comes out after every 24-48 hrs to release CO_2. It is not suitable for long range. Nuclear attack submarines can remain under sea for months and cannot be detected by enemies easily
- For most countries a submarine is predominantly a defensive weapon on short patrols. In these cases, a diesel is a very effective weapon. There is an added benefit of not having to spend time and money training nuclear operators
- Currently, India has 15 conventional diesel-electric submarines, classified as SSKs, and one nuclear ballistic submarine, classified as SSBN.

Diesel attack submarines:

- **Sindhughosh:** Sindhughosh class submarines are the Kilo class diesel-electric submarines. They are designated 877EKM, and were built under a contract between Rosvooruzhenie and the Ministry of Defence (India).
- **Sishumar:** The Shishumar class vessels (Type 1500) are diesel-electric submarines..These submarines are developed by the German yard Howaldtswerke-Deutsche Werft (HDW)
- **Kalvari:** INS Kalvari is the first of the six Scorpene class submarines built under Project 75. The Submarine was commissioned on 14 December 2017
- **Project 75:** Under Project 75, the Navy will build six conventional diesel-electric stealth submarines that would be bigger than the under-construction Scorpene-class submarines being built at the Mazagon Dockyards Limited in Mumbai. INS Kalvari, INS Khanderi and INS Kharanj are comissioned. Recently comissioned is INS Vela(Nov 2021). INS Vagir is underway while the construction of the 6th Vagsheer is underway.

- **Project-75 (I)** envisages indigenous construction of six modern conventional submarines with contemporary equipment, weapons & sensors including Fuel-Cell based AIP (Air Independent Propulsion Plant). Conventional diesel-electric submarines have to surface every few days to get oxygen to recharge their batteries. With AIP systems, they can stay submerged for much longer periods. Project 75-I will have both vertical launched BrahMos for the sea & land targets and tube-launched torpedoes for anti-submarine warfare

Nuclear attack submarines:

- Arihant
- Arighat
- Chakra

Destroyer class submarines:

- Kolkata
- Delhi
- Vishakapatnam
- The Kolkata class is a class of guided missile destroyers with stealth technology- (Project 15A)
- The Visakhapatnam class is a class of stealth guided missile destroyers under construction- (Project 15B)

Torpedo

- A modern torpedo is an underwater ranged weapon launched above or below the water surface, self-propelled towards a target, and with an explosive warhead designed to detonate either on contact with or in proximity to the target
- **Varunashtra**: Indian advanced heavyweight anti-submarine torpedo, developed by Naval Science and Technological Laboratory (NSTL) of the Defence Research and Development Organisation (DRDO) for the Indian Navy. It is manufactured by Bharat Dynamics Limited. It is powered by an electric propulsion system with multiple 250 KWs silver oxide zinc (AgOZn) batteries

Maareech

- Advanced anti-torpedo decoy system with the help of SONAR
- DRDO (Defence Research and Development Organization) has designed and developed Maareech.
- Detect, locate, divert and neutralize incoming torpedo

Fractional Orbital Bombardment System

- The Fractional Orbital Bombardment System (FOBS) is a program that after launch would go into a low Earth orbit and would then de-orbit for an attack.
- It had no range limit and the orbital flight path would not reveal the target location.

Outer Space Treaty

- The Outer Space Treaty, formally the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, is a multilateral treaty that forms the basis of international space law.
- The Outer Space Treaty was spurred by the development of intercontinental ballistic missiles (ICBMs) in the 1950s, which could reach targets through outer space

Missile Technology Control Regime (MTCR)

- The Missile Technology Control Regime (MTCR) is a multilateral export control regime whose members have an informal political understanding to limit the proliferation of missiles and missile technology

Previous Year Question

1.The Defense Research Development Organization (DRDO) has developed a drug named 'Lukosin' for the treatment of (2015)

a) Leukemia
b) **Leukoderma**
c) Lung cancer
d) Brain Tumor

1. Which one of the following is an air-to-air missile? (2016)

a) **Astra**
b) Akash
c) Becquerel
d) Prithvi

2. What does India's first all-weather tracked-chassis QR-SAM stand for? (2018)

a) **Quick Reaction Surface-to-air Missile**
b) Quotient reaction Surface-to-air Missile
c) Quicker Reaction Surface-to-air Missile
d) None of the above

3. For the first time in India, a senior defence personnel in a newly created position of'Chief of Defence Staff' was installed on 1st January, 2020, who will be above all the three chiefs of the three wings, viz., Army, Navy and Air force. Who is the first incumbent in this position? (2020)

a) **General Bipin Rawat**
b) General Bikram Singh
c) General Manoj Naravane
d) Admiral Karambir Singh

4. Name of the Submarine which was destroyed in a major accident in 2013 is (2013)

a) **INS Sindhurakshak**
b) INS Shalki
c) INS Godavari
d) INS Yamuna

Chapter 16: Emerging and Digital tech

IP

- Internet Protocol (IP) are the fundamental protocol for communications on the Internet.

- It specifies the way information is packetized, addressed, transferred, routed, and received by networked devices.
- An IP address is a number identifying of a computer or another device on the Internet.

Cookie

- A packet of information that travels between a browser and the web server.

IoT

- The Internet of Things is the extension of Internet connectivity into physical devices and everyday objects
- Embedded with electronics, internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the internet, and they can be remotely monitored and controlled
- Examples include smart devices

WiFi

- Wi-Fi or Wireless Fidelity is any "wireless local area network (WLAN) products
- Wi-Fi networks have no physical wired connection between sender and receiver.
- They function by using radio frequency (RF) technology a frequency within the electromagnetic spectrum associated with radio wave propagation.

Visible light communication (VLC)

- Visible light communication (VLC) is a wireless method that enables high-speed transmission of data with visible light.
- Also known as Li-Fi
- Data can be transmitted at higher speed (224GB/s). It's up to 100 times faster than standard WiFi.
- Nav Wireless Technologies is the only registered company in the LiFi sector in Asia
- The Students' Educational and Cultural Movement of Ladakh (SECMOL) has become the first-of-its-kind institute in the Union Territory to have an internet connection using Light Fidelity (LiFi) technology.

VoIP

- Voice Over Internet Protocol
- Making phone calls using internet connections
- The audio is converted into digital packets handled by codecs and transmitted via IP

ROIP System

- In view of a much-needed solution for providing effective long range Marine communication, the Radio over Internet Protocol (ROIP) System at Syama Prasad Mookerjee Port, Kolkata (SMP, Kolkata), was inaugurated

Bharat Net Project

- World's largest rural broadband connectivity programme using Optical fibre.
- It is implemented by Bharat Broadband Network Limited (BBNL)

Supercomputer

- A computer with a high level of performance compared to a general-purpose computer
- Its performance is measured in floating point operations per second (FLOPS)
- Used in scientific simulations and research such as weather forecasting, meteorology, testing military machines like jets, ships and tanks, physics, and chemistry- Dual use Tech
- India has setup Centre for Development of Advanced Computing (C-DAC) in 1988.
- Aim of C-DAC: Development of indigenous supercomputers.
- **India's first supercomputer called PARAM 8000 was launched in 1991 was built by CDAC**.
- Param Shivay the first super computer designed & built under the National Supercomputing Mission by C-DAC (Center for Development of Advanced Computing) at IIT-BHU (Varanasi)
- At present, Indian Institute of Tropical Meteorology has Pratyush, National Centre for Medium-Range Weather Forecasting has Mihir and Indian Institute of Science has SERC-Cray and Param Pravega as supercomputers in India
- PARAM Sidhi-AI is India's fastest AI Super Computer
- **Frontier is the world's fastest supercomputer**
- The CDC 6600, released in 1964, is sometimes considered the first supercomputer.

Cloud Computing

- Cloud computing is the on-demand availability of computer system resources, especially data storage (cloud storage) and computing power, without direct active management by the user
- **Software as a service**: SaaS is considered to be part of cloud computing. It is a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted.
- **Infrastructure as a service**: Introduced in 2012 by Oracle, Infrastructure as a service (IaaS) is a cloud computing service model by means of which computing resources are hosted in a public, private, or hybrid cloud. It provides you with high-level APIs used to dereference various low-level details of underlying network infrastructure like backup, data partitioning, scaling, security, physical computing resources, etc
- **Platform as a service**: Platform as a service (PaaS) or application platform as a service (aPaaS) or platform-based service is a category of cloud computing services that allows customers to provision, instantiate, run, and manage a modular bundle comprising a computing platform and one or more applications, without the complexity of building and maintaining the infrastructure typically associated with developing and launching the application(s); and to allow developers to create, develop, and package such software bundles

QUANTUM COMPUTING

- Quantum computing is a type of computation that harnesses the collective properties of quantum states, such as superposition, interference, and entanglement, to perform calculations. The devices that perform quantum computations are known as quantum computers

- **The most widely used model is the quantum circuit, based on the quantum bit, or "qubit", which is somewhat analogous to the bit in classical computation**.
- A qubit can be in a 1 or 0 quantum state, or in a superposition of the 1 and 0 states.
- World's First Quantum Computer is the D-Wave
- **India's first quantum computing park "Greater Karnavati Quantum Computing Technology Park at Gandhinagar**
- QSim is India's first quantum computer simulator toolkit

Near-field communication

- Enables communication between two electronic devices over a distance of 4 cm (1 1⁄2 in) or less by radio waves
- Act as electronic identity documents, used in contactless payments, NFC based e-tickets etc

FASTag

- FASTag is an electronic toll collection system in India, operated by the National Highway Authority of India (NHAI).
- It employs Radio Frequency Identification (RFID)
- On 19 October 2019, it was announced that FASTag will be mandatory on all National Highways from 1 December 2019 and non-FASTag users will be charged double the toll

Aadhaar

- Aadhaar is a 12-digit unique identity number that can be obtained voluntarily by the citizens of India and resident foreign nationals who have spent over 182 days in twelve months immediately preceding the date of application for enrolment, based on their biometric and demographic data
- World's largest biometric ID system
- Data is collected by the Unique Identification Authority of India (UIDAI), a statutory authority established in January 2009 by the Government of India, under the jurisdiction of the Ministry of Electronics and Information Technology, following the provisions of the Aadhaar (Targeted Delivery of Financial and other Subsidies, benefits and services) Act, 2016
- **ADHAAR ENABLED PAYMENT SYSTEM (AEPS):** AEPS is a bank led model which allows online interoperable financial transaction at PoS (Point of Sale / Micro ATM) through the Business Correspondent (BC)/Bank Mitra of any bank using the Aadhaar authentication.

UPI

- Unified Payments Interface (UPI) is an instant real-time payment system developed by National Payments Corporation of India (NPCI). The interface facilitates inter-bank peer-to-peer (P2P) and person-to-merchant (P2M) transactions.
- It is regulated by the Reserve Bank of India (RBI) and works by instantly transferring funds between two bank accounts on a mobile platform.

Razorpay

- Razorpay is the in-between mode of payment which transact the payments to the other banks which are connected and available in all kinds of banks, credit, debit, wallets (Netflix, Airtel, Swiggy, and others).

OTT

- Over-the-top
- OTT technology is the software and equipment that makes it possible to bypass traditional streaming technology and broadcast video content over the internet
- Examples include Netflix, Amazon prime, Disney Hot star etc..

Blockchain

- The blockchain was popularized by a person (or group of people) using the name Satoshi Nakamoto in 2008 to serve as the public transaction ledger of the cryptocurrency bitcoin
- Information about transactions is stored on countless computers spread across the globe
- Each block on the blockchain contains its own unique hash, along with the unique hash of the block before it. When the information on a block is edited in any way, that block's hash code changes—however, the hash code on the block after it would not. This discrepancy makes it extremely difficult for information on the blockchain to be changed without notice

Non-fungible token (NFT)

- A non-fungible token (NFT) is a financial security consisting of digital data stored in a blockchain, a form of distributed ledger.
- The ownership of an NFT is recorded in the blockchain, and can be transferred by the owner, allowing NFTs to be sold and traded.
- NFTs can be created by anybody, and require few or no coding skills to create.
- NFTs typically contain references to digital files such as photos, videos, and audio. Because NFTs are uniquely identifiable, they differ from cryptocurrencies, which are fungible. The market value of an NFT is associated with the digital file it references.

VIRTUAL PRIVATE NETWORK

- A Virtual Private Network is an encrypted network created over a public network (usually the internet) for a remote user (usually a company)
- Used for safe transmission of data
- It prevents unauthorized people from eavesdropping on the traffic and allows the user to conduct work remotely
- VPN technology is widely used in corporate environments

PKI

- A public key infrastructure is a set of roles, policies, hardware, software and procedures needed to create, manage, distribute, use, store and revoke digital certificates and manage public-key encryption

- The private key is secret and known only to the user. The keys are used to encrypt (scramble) and decrypt (unscramble) messages using a mathematical algorithm.
- The combination of public and private keys issued by the Certification Authority is the key to the success and security of any PKI system.

API

- An application programming interface (API) is the medium by which different software interact
- It is a connection between computers or between computer programs.
- It is a type of software interface, offering a service to other pieces of software
- Examples Travel booking, Pay with PayPal etc

CBDC

- A central bank digital currency (CBDC) (also called digital fiat currency or digital base money is a digital currency issued by a central bank, rather than by a commercial bank.
- The present concept of CBDCs was inspired by Bitcoin and similar blockchain-based cryptocurrencies, but differs from such a virtual currency and cryptocurrency in that a CBDC is or would be issued by a state.
- Most CBDC implementations will likely not use or need any sort of distributed ledger such as a blockchain

Web 2.0, Web 3.0 and Web 4.0

- Web 2.0 and Web 3.0 refer to successive iterations of the web, compared with the original Web 1.0 of the 1990s and early 2000s. Web 2.0 is the current version of the internet (a term often used interchangeably with the web) with which we are all familiar, while Web 3.0 represents its next phase.
- Web 2.0 makes it possible for user-generated content to be viewed by millions of people around the world virtually in an instant; this unparalleled reach has led to an explosion of this type of content in recent years.
- Defining features of Web 3.0 include decentralization using blockchain; trustlessness and permissionlessness; artificial intelligence (AI) and machine learning; and connectivity and ubiquity.
- Web 4.0 is known as the symbiotic web. The purpose of the symbiotic web is the symbiotic interaction between man and machine. The boundary between man and machine will blur.

3D Printing

- Variety of processes in which material is deposited, joined or solidified under computer control to create a three-dimensional object, with material being added together (such as plastics, liquids or powder grains being fused together), typically layer by layer

- One of the key advantages of 3D printing is the ability to produce very complex shapes or geometries that would be otherwise impossible to construct by hand
- Fused filament fabrication (FFF), also known as fused deposition modeling (with the trademarked acronym FDM), or called filament free form fabrication, is a 3D printing process that uses a continuous filament of a thermoplastic material.

4D Printing

- 4D printing is an additive manufacturing process in which the printed object changes shape with time, temperature, or some other type of stimulation. 4D printing allows for the creation of dynamic structures with adjustable shapes, properties or functionality
- Characteristics include self-assembly, self-repair, multi-functionality, reconfiguration and shape shifting.

Artificial Intelligence

- Intelligence demonstrated by machines, as opposed to natural intelligence displayed by animals including humans
- **Artificial Neural Network**: Collection of connected units or nodes called artificial neurons, which loosely model the neurons in a biological brain
- **Machine Learning**: Machine learning (ML) is the study of computer algorithms that can improve automatically through experience and by the use of data
- **Deep Learning**: Subset of Machine learning. It is an attempt to simulate the behavior of the human brain—albeit far from matching its ability—allowing it to "learn" from large amounts of data (big data). Facial recognition, voice recognition, handwritten text and signatures, translate language, money laundering and fraud identification etc are some examples
- Turing test is a test for intelligence in a computer, requiring that a human being should be unable to distinguish the machine from another human being by using the replies to questions put to both.
- The term "reverse Turing test" has also been applied to a Turing test (test of humanity) that is administered by a computer. In other words, a computer administers a test to determine if the subject is or is not human. Such procedures, called CAPTCHAs, are used in some anti-spam systems to prevent automated bulk use of communications systems.
- "CAPTCHA" is an acronym for "Completely Automated Public Turing test to tell Computers and Humans Apart" so that the original designers of the test regard the test as a Turing test to some degree.

Humanoid Robot

- A humanoid robot is a robot resembling the human body in shape.
- Male version is Android, female version is Gynoid
- **Sophia:** She is a social humanoid robot developed by Hong Kong based company Hanson Robotics. Sophia was activated on February 14, 2016, and made her first public appearance at

South by Southwest Festival (SXSW) in mid-March 2016 in Austin, Texas, United States. She is able to display more than 60 facial expressions. In October 2017, Sophia became a Saudi Arabian citizen, the first robot to receive citizenship of any country. In November 2017, Sophia was named the United Nations Development Programme first ever Innovation Champion, and is the first non-human to be given any United Nation title

- **Manav**: It is India's first 3D-printed humanoid robot. The two kilo, two-feet tall robot has an inbuilt vision and sound processing capability which allows it to walk, talk and dance — just in response to human commands.
- **Atlas:** It is a bipedal humanoid robot primarily developed by the American robotics company Boston Dynamics, with funding and oversight from the U.S. Defense Advanced Research Projects Agency (DARPA). The 1.8-meter (6 ft) robot is designed for a variety of search and rescue tasks, and was unveiled to the public on July 11, 2013
- **Nadine**: Nadine is an empathetic robot that returns greetings, makes eye contact, and remembers all the conversations that have been had with her. She is a human-like robot with personality, mood, and emotions. The face and hands of Nadine are created by a Japanese company Kokoro, similar to her creator, Professor Nadia Thalmann.
- **Junco Chihira**: Junco Chihira is a very realistic android robot created by Toshiba. Junco works full-time in a tourist information center in Tokyo.

Drones

- An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without any human pilot, crew, or passengers on board.
- Applications include military operations, forest fire monitoring, aerial photography, product deliveries, agriculture, policing and surveillance, infrastructure inspections, science, smuggling, drone racing etc.

Immersive technology

- Integration of virtual content with the physical environment in a way that allows the user to engage naturally with the blended reality
- **Virtual reality**: Simulated experience that can be similar to or completely different from the real world.
- **Augmented reality**: Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory
- **Mixed reality**: In mixed reality, digital information is represented by holograms—objects made of light and sound—that appear in the space around you. Through artificial intelligence, these holograms respond to commands and interact with real-world surfaces in real time for a more natural and intuitive experience

- **Metaverse**: Metaverse is a hypothetical iteration of the Internet as a single, universal and immersive virtual world that is facilitated by the use of virtual reality (VR) and augmented reality (AR) headsets and AR capable mobile devices

Mobile Technology

- **Long Term Evolution (LTE):** LTE is a standard for high-speed cellular data communication for 4G systems. It provides a download speed of about 100 Mbps and an upload speed of about 50 Mbps. It does not provide good quality voice calls while using the data services.
- **Voice over Long Term Evolution (VoLTE):** VoLTE in 4G is a much-standardized system to make high-definition voice calls. It allows the users to make voice calls while using the data services without changing the quality of the voice.
- At present, the 300 MHz~3 GHz spectrum used in the first to fourth generation wireless communications has the advantages of penetration and wide coverage
- Wave frequency band allocated for 5G communication networks in the spectrum of various countries is about 3~6 GHz

Previous Year Questions

1. India's first supercomputer is known as (2014)

a) SAGA
b) EKA
c) PARAM 2000
d) **PARAM 8000**

2. Where was India's first computer installed? (2014)

a) Indian Institute of Technology, Delhi
b) Indian Iron and Steel Co. Ltd. Burnapur
c) **Indian Statistical Institute, Calcutta**
d) Indian Institute of Science, Bangalore

3. A packet of information that travels between a Browser and the Web server is known as (2016)

a) Malware
b) Adware
c) Spyware
d) **Cookie**

4. Which district has become the first one in India to have high – speed Rural Broadband Network? (2015)

a) Ajmer of Rajasthan

b) Vidisha of Madhya Pradesh
c) Idukki of Kerela
d) Kamrup of Assam

5. What is Aadhar? (2015)
a) A modern version of the Permanent Account Number (PAN)
b) The popular name of the Kisan Credit Card
c) **A 12-digit individual identification number issued by the Unique Identification Authority of India**
d) The bank account number under the Pradhan Mantri Jan Dhan Yojana

6. MS-Word is an example of (2016)
a) Complier
b) **Application software**
c) System software
d) Operating system

7. Which one of the following pairs is the third generation (3G) mobile telecommunication? (2016)
a) **WiMAX and UMTS**
b) GPRS and EDGE
c) WiMAX and EDGE
d) UMTS and GPRS

Miscellaneous Information

Research stations in Antarctica

- Multiple governments have set up permanent research stations in Antarctica and these bases are widely distributed.
- **Dakshin Gangotri was the first Indian scientific research base station established in Antarctica**, as a part of the Indian Antarctic Program.It has weakened and become just a supply base.
- **Maitri is India's second permanent research station in Antarctica**. It was built and finished in 1989. Maitri is situated on the rocky mountainous region called Schirmacher Oasis. India also built a freshwater lake around Maitri known as Lake Priyadarshini.
- **Bharti, India's latest research station operation since 2012**. It has been constructed to help researchers work in safety despite the harsh weather. It is India's first committed research facility and is located about 3000 km east of Maitri.
- In 2008, India commissioned the Sagar Nidhi, for research. An ice-class vessel, it can cut through the thin ice of 40 cm depth and is the first Indian vessel to navigate Antarctic waters.

Antarctic Treaty

- This is a Convention on Conservation of Antarctic Marine Living Resources and a protocol on environment Protection

- India is a signatory to this treaty which came into effect on June 23, 1961.

Research Stations in the Arctic

- A number of governments maintain permanent research stations in the Arctic. Also known as Arctic bases, polar stations or ice stations, these bases are widely distributed across the northern polar region of the earth
- Abisko Scientific Research Station by Swedenis the 1st research station
- **India launched its first scientific expedition to the Arctic Ocean in 2007 and opened a research base named "Himadri"** at the International Arctic Research Base at Ny-Alesund, Svalbard, Norway in July 2008 for carrying out studies in disciplines like Glaciology, Atmospheric sciences & Biological sciences.

Nobel Prize 2021

- The Nobel Prize in Physics 2021: **Syukuro Manabe and Klaus Hasselmann** or the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming; **Giorgio Parisi** for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales
- The Nobel Prize in Chemistry 2021: **Benjamin List and David W.C. MacMillan** for the development of asymmetric organocatalysis
- The Nobel Prize in Physiology or Medicine 2021: **David Julius and Ardem Patapoutian** for their discoveries of receptors for temperature and touch

Techniques

- Western blot is an Analytical technique in molecular biology and immunogenetics to detect specific proteins in a sample of tissue homogenate or extract.
- The northern blot, or RNA blot, is a technique used in molecular biology research to study gene expression by detection of RNA (or isolated mRNA) in a sample
- A Southern blot is a method used in molecular biology for detection of a specific DNA sequence in DNA samples.
- The eastern blot, or eastern blotting, is a biochemical technique used to analyze protein post-translational modifications including the addition of lipids, phosphates, and glycoconjugates.

Extra Terrestrial Life

- Extraterrestrial life, sometimes colloquially referred to as alien life, is life that may occur outside Earth and which did not originate on Earth.
- No extraterrestrial life has yet been conclusively detected, although efforts are underway. Such **life might range from simple forms comparable to prokaryotes, to intelligent beings, possibly bringing forth civilizations that might be far more advanced than humankind.**
- The science of extraterrestrial life in all its forms is known as **astrobiology or exbiology**, the multidisciplinary field that investigates the deterministic conditions and contingent events with which life arises, distributes, and evolves in the universe

National Science Day

- National Science Day is celebrated in India on 28 February each year to mark the discovery of the **Raman effect** by Indian physicist **Sir C. V. Raman on 28 February 1928.**
- National Science Day is celebrated to spread a message about the importance of science used in the daily life of the people
- The theme for NSD of the year 2022 is 'Integrated Approach in S&T for Sustainable Future'
- **Raman effect**: Raman scattering or the Raman effect is the inelastic scattering of photons by matter, meaning that there is both an exchange of energy and a change in the light's direction.

Sunrise industry

- A sunrise industry is one that is new or relatively new, is growing fast and is expected to become important in the future.
- Examples of sunrise industries include hydrogen fuel production, petrochemical industry, food processing industry, space tourism, online encyclopedias, etc

Previous Year Questions

1. India's permanent research station "Dakshin Gangotri" is located in (2014 & 2015)

a) Indian Ocean
b) Himalayas
c) Arabian Sea
d) **Antarctica**

2. Recently four Indian scientist met unnatural death in a place of Antarctica. The place is meant for research and experimental purpose. It is (1998)

a) Indira point
b) Lake Priyadarshini
c) Panganga
d) **Dakshin Gangotri**

3. What is ex-biology? (1998)

a) Science dealing with the physical and chemical state of dead bodies
b) Science dealing with the physical and chemical state of fossils
c) **Science dealing with life or possibility of life on other planets**
d) Science dealing with micro-organisms in the atmosphere

4. In India, National Science Day is observed on (2014)

a) 5th June
b) 5th September
c) **28th February**
d) 2nd October

5. Which one of the following industries is known as 'Sunrise Industry'? (2016)

a) Iron and Steel
b) Cotton and Textile
c) **Information Technology**
d) Tea and Coffee

Miscellaneous Questions

1. **What is the full form of RAM in a computer? (2006)**
   - **a) Random Access Memory**
   - b) Reasily Available Memory
   - c) Read At-a-time Memory
   - d) Ready to Access Memory
2. **One nautical mile is equal to (2006)**
   - a) 1.5 km
   - **b) 1.85 km**
   - c) 2.0 km
   - d) 2.5 km
3. **Where do you find the clock and calendar in/on your computer? (2016)**
   - **a) Taskbar**
   - b) Menu bar
   - c) Desktop
   - d) Start menu
4. **Which of the following groups has only the output devices? (2016)**
   - a) Scanner, keyboard, printer
   - b) Mouse, printer, monitor
   - c) Keyboard, monitor, printer
   - **d) Plotter, printer, monitor**
5. **What does the term 'Dolby B and Dolby C' printed on the tape recorders and other sound systems refer to? (2016)**
   - a) Frequency modulation system
   - b) Amplitude modulated system
   - **c) Noise reduction circuit**
   - d) Both d.c and a.c power can be used
6. **Which of the following can input images, pictures, etc. to a computer? (2016)**
   - a) Plotter
   - b) Mouse
   - c) Printer
   - **d) Scanner**
7. **Which of the following is an egg-laying mammal? (2020)**
   - **a) Platypus**
   - **b)** Bat
   - **c)** Whale
   - d) Seal
8. **A washing machine works on the principal of (2020)**
   - a) Gravitation
   - b) Acceleration
   - **c) Centrifugation**
   - d) Lineartension
9. **Rain drops are spherical in shape because of the phenomen on called (2020)**
   - a) Viscosity
   - b) Velocity
   - c) Residualpressure
   - d) **Surfacetension**