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for Prelims - 2023

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Science and Technology

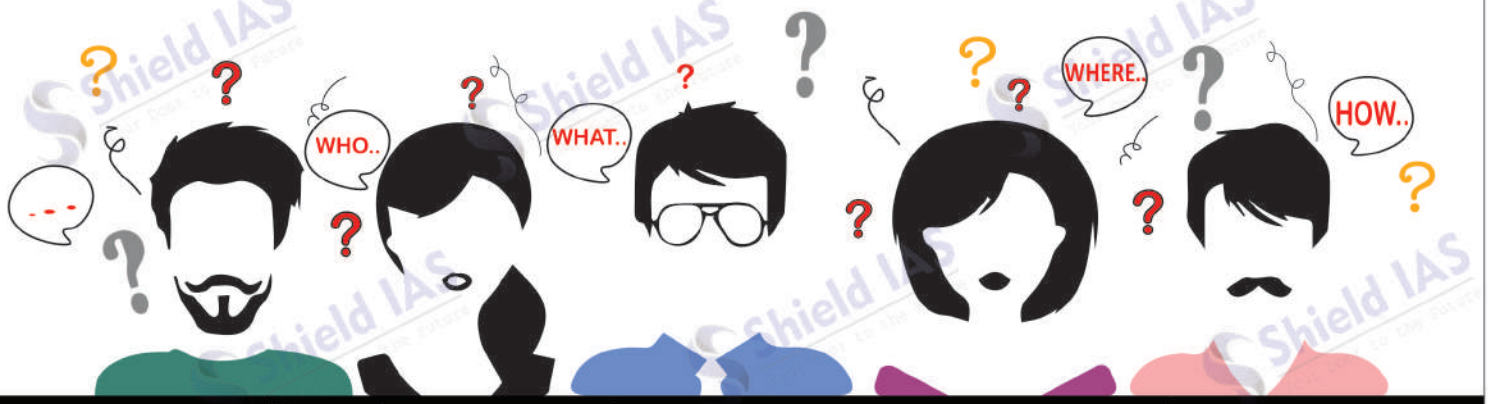
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SCIENCE AND TECHNOLOGY

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- **Builds confidence for handling MCQs.**

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1	HISTORY 1- ANCIENT, MEDIEVAL, ART & CULTURE
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4	ECONOMY AND SOCIAL DEVELOPMENT
5	GEOGRAPHY AND ENVIRONMENT
6	SCIENCE AND TECHNOLOGY
7	IMPORTANT GOVT. SCHEMES
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Note: Additional booklet **number 9** on important topics of current affairs will be released in **April, 2023.**



RECOMMENDATION OF OUR SELECTED STUDENTS

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Also, the complete set of study material provided by SHIELD IAS is recommended for comprehensive coverage of General Studies topics for both preliminary and Mains stage of civil services examination.

AMOL SRIVASTAVA
AIR-83 UPSC CSE 2017

I would recommend the study material provided by Shield IAS for the UPSC Civil Services preparation to cover the General Studies syllabus. The Rapid Revision Books would help the aspirants for speedy revision for the Civil Services (Preliminary) examination. The books have been prepared by my mentors who helped me in clearing my Civil Services Exam in 2015-16.

HARSH KUMAR
IFS – 2016

I, Nidhin K Biju, IRS of 2020 batch, want to suggest the aspirants preparing for UPSC civil services Examination to read SHIELD IAS Rapid Revision books for swift coverage of syllabus for the UPSC Civil Services (Preliminary) exams. These books will help in targeted revision for confident attempt in the examination. I would also recommend reading the SHIELD IAS UPSC study material as a set of standard books for covering the entire General Studies syllabus (Prelims and Main Examinaton).

- Nidhin

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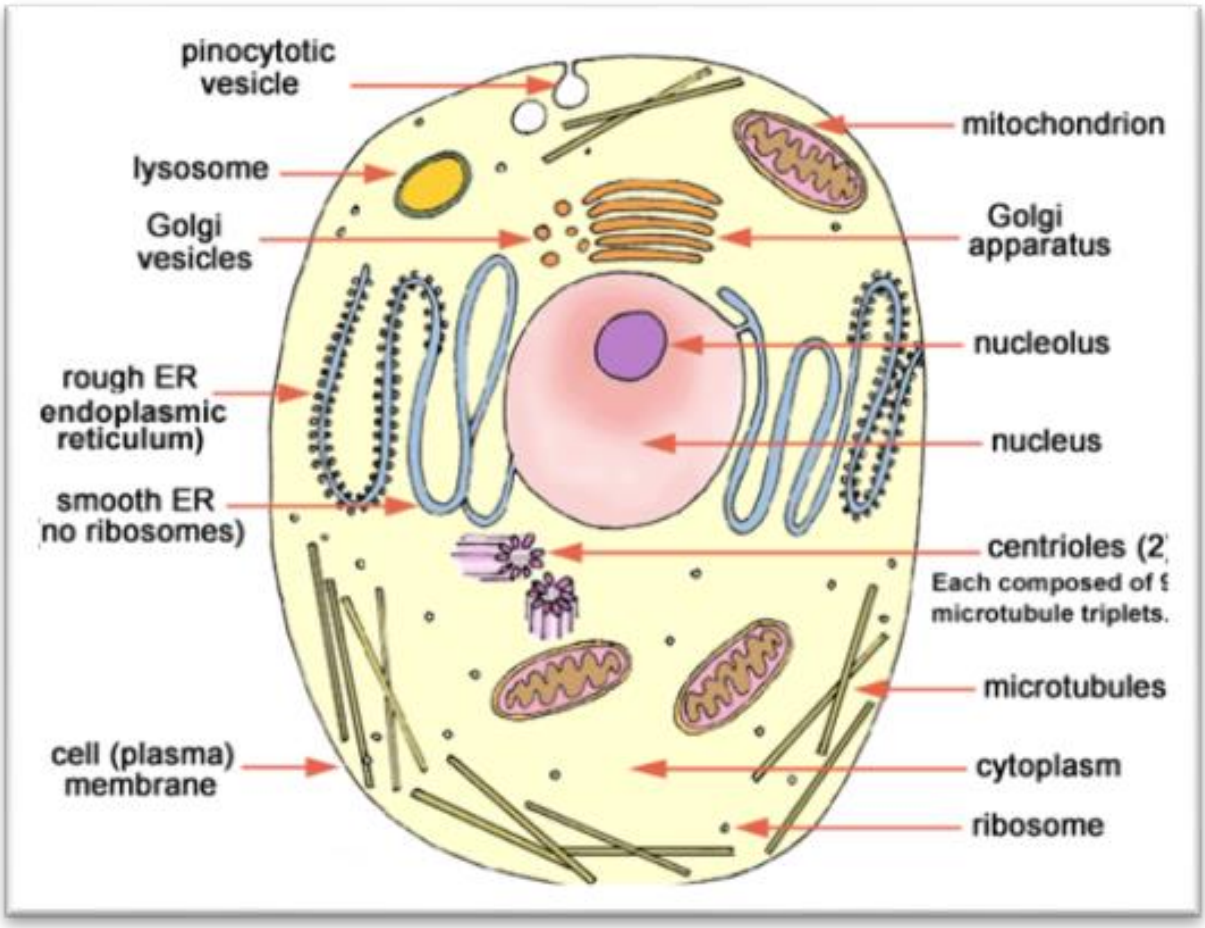
SCIENCE AND TECHNOLOGY

(SPECIAL EDITION FOR PRELIMS 2023)

SCIENCE

➡ BIOLOGICAL CELL

- It only takes **one biological cell to create an organism**. In fact, there are countless species of single-celled organisms, and indeed multi-cellular organisms like ourselves.
- A single cell is able to keep itself functional by owning a series of **'miniature machines' known as organelles**. The following list looks at some of these organelles and other characteristics typical of a fully functioning cell.



Mitochondrion	An important cell organelle involved in respiration.
Cytoplasm	A fluid surrounding the contents of a cell and forms a vacuole.
Golgi Apparatus	The processing area for the creation of a glycoprotein.

Endoplasmic Reticulum	An important organelle heavily involved in protein synthesis.
Vesicles	Packages of substances that are to be used in the cell or secreted by it.
Nucleus	The "brain" of a cell containing genetic information that determines every natural process within an organism.
Cell Membrane	Also known as a plasma membrane, this outer layer of a cell assists in the movement of molecules in and out the cell plays both a structural and protective role.
Lysosomes	Membranous sacs that contain digestive enzymes.
Cell Wall	A structure that characteristically is found in plants and prokaryotes and not animals that plays a structural and protective role.

CELL SPECIALISATION:

Cells can become specialized to **perform a particular function** within an organism, usually as part of a larger tissue consisting of many of the same cells working in tandem, for example;

- Nerve cells to operate as part of the nervous system to send messages back and forth via the brain at the center of the nerve system.
- Skin cells for waterproof protection and protection against pathogens in the open-air environment.
- Xylem tubes to transport water around plants and to provide structural support for the plant as a whole.

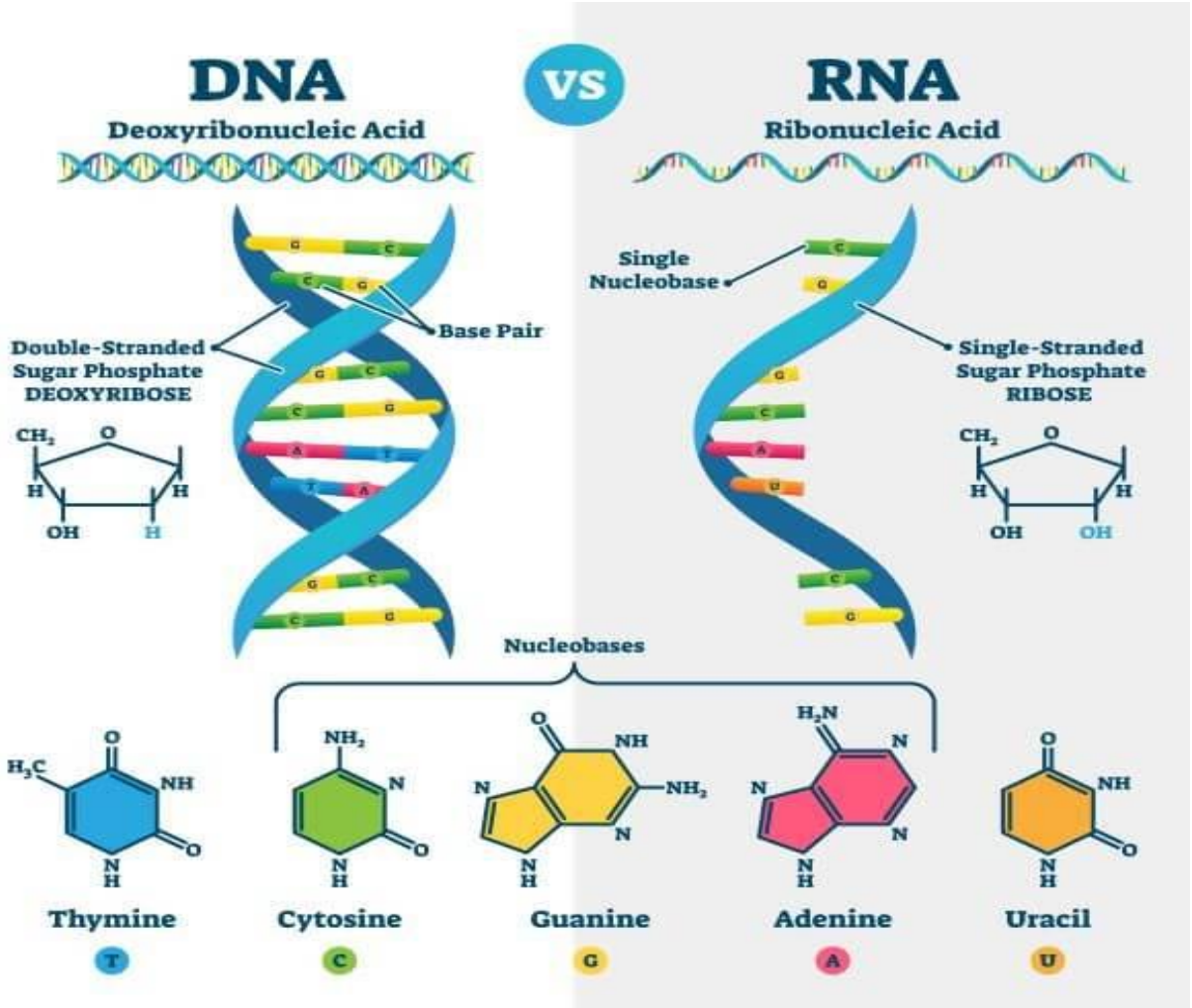
  Cells combine their efforts in these tissue types to **perform a common cause**. The task of the specialized cell will determine in what way it is going to be specialized, because different cells are suited to different purposes, as illustrated in the above list and below example:
- Muscle cells are long and smooth in structure and their elastic nature allows these cells to perform flexible movements, just as they do in our own bodies.
- Some white blood cells contain powerful digestive enzymes to eliminate pathogens by breaking them down to the molecular level.
- Cells at the back of the eye are sensitive to light stimuli, and thus can interpret differences in light intensity which can, in turn, be interpreted by our nervous system and brain.

CELL TRANSPORT:

There are three methods in which ions are transported through the cell membrane into the cell:-

- **Active Transport** – Active transport is the transport of molecules with the active assistance of a carrier that can transport the material against a natural concentration gradient.
- **Passive Transport (Diffusion)** – The movement of molecules from areas of high concentration (i.e. outside a cell) to areas of low concentration (i.e. within a cell) via a carrier. This process does not require energy.
- **Simple Diffusion** – The movement of molecules from areas of high concentration to areas of low concentration in a free state. Osmosis of water involves this type of diffusion through a selectively permeable membrane (i.e. plasma membrane)

➡ DNA and RNA



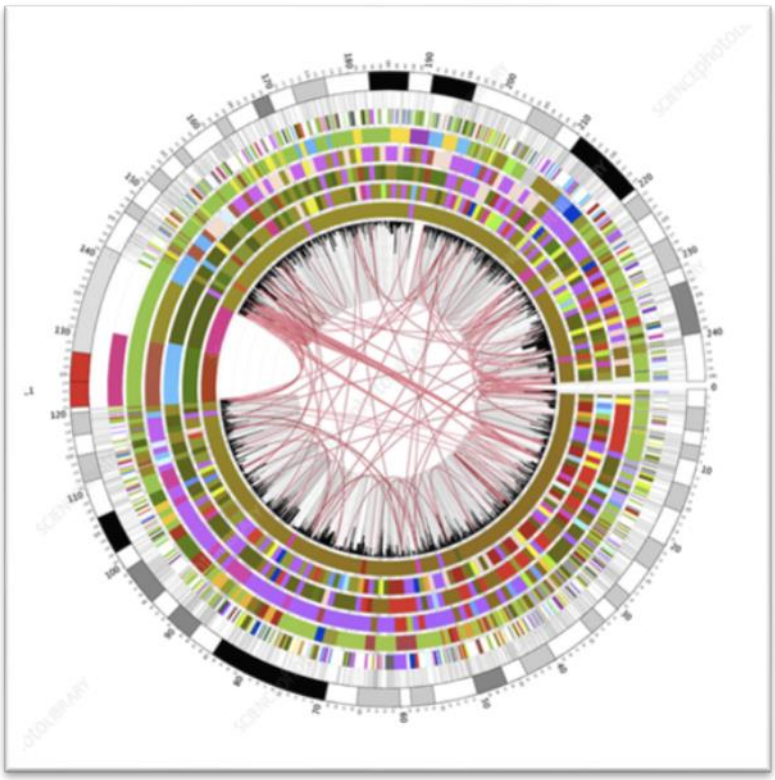
Parameter	DNA	RNA
Structure	DNA is a double-stranded molecule consisting of a long chain of nucleotides. B type of helix.	It is a single-stranded helix consisting of a short chain of nucleotides. A type of helix.
Function	Transmits genetic information to make other cells and new organisms. Long-term storage of genetic information	It transfers the genetic code from the nucleus to the ribosomes to make proteins.
Propagation	DNA is self-replicating.	Synthesized from DNA.
Composition	Deoxyribose sugar phosphate backbone adenine, guanine, cytosine, thymine bases.	Ribose sugar phosphate backbone adenine, guanine, cytosine, uracil bases.

Location	In the nucleus of a cell and in the mitochondria.	Located in the cytoplasm, nucleus, and in the ribosome.
Nitrogenous Bases and Pairing	GC(Guanine pairs with Cytosine) A-T(Adenine pairs with Thymine).	GC(Guanine pairs with Cytosine) A-U(Adenine pairs with Uracil)
Molecular Weight	2 to 6 million	25,000 to 2 million
Stability	DNA is a more stable molecule than RNA. DNA is stable under alkaline conditions.	Much more reactive than DNA and is not stable in alkaline conditions.
Ultraviolet (UV) Sensitivity	DNA is vulnerable to damage by ultraviolet light.	Much more resistant to damage from UV light than DNA.

➡ GENOME

A genome is an organism's complete set of genetic instructions. Each genome contains all of the information needed to build that organism and allow it to grow and develop.

- Our bodies are made up of millions of cells, each with their own complete set of instructions for making us, like a recipe book for the body. This set of instructions is known as our genome and is made up of DNA. Each cell in the body, for example, a skin cell or a liver cell, contains this same set of instructions:



- The instructions in our genome are made up of DNA.
- Within DNA is a unique chemical code that guides our growth, development and health.
- This code is determined by the order of the four nucleotide bases that make up **DNA, adenine, cytosine, guanine and thymine, A, C, G and T for short**.

- DNA has a twisted structure in the shape of a double helix.
- Single strands of DNA are coiled up into structures called **chromosomes.**
- Your chromosomes are located in the nucleus within each cell.
- Within our chromosomes, sections of DNA are "read" together to form genes.
- Genes control different characteristics such as eye colour and height.

- All living things have a unique genome.
- The human genome is made of **3.2 billion bases of DNA** but other organisms have different genome sizes.

GENOME MAP

- A genome map helps scientists navigate around the genome. Like road maps and other familiar maps, a genome map is a set of landmarks that tells people where they are, and helps them get where they want to go.
- The landmarks on a genome map might include **short DNA sequences**, regulatory sites that turn genes on and off, and genes themselves. Often, genome maps are used to **help scientists find new genes**.
- Road maps chart well-known territory surveyed with astonishing precision, but a genome map is a map of a new frontier.
- Some parts of the genome have been mapped in great detail, while others remain relatively uncharted territory. It may turn out that a few landmarks on current genome maps appear in the wrong place or at the wrong distance from other landmarks. But over time, as scientists continue to explore the genome frontier, maps will become more accurate and more detailed. A genome map is a work in progress.

WHAT DOES A GENOME MAP LOOK LIKE?

- Most everyday maps have length and width, latitude and longitude, like the world around us. But a genome map is **one-dimensional—it is linear**, like the DNA molecules that make up the genome itself. A genome map looks like a straight line with landmarks noted at irregular intervals along it, much like the towns along the map of a highway. The landmarks are usually inscrutable combinations of letters and numbers that stand for genes or other features—for example, D14S72, GATA-P7042, and so on.

WHAT IS THE DIFFERENCE BETWEEN A GENOME MAP AND A GENOME SEQUENCE?

- Both are portraits of a genome, but a genome map is less detailed than a genome sequence. A sequence spells out the order of every DNA base in the genome, while a map simply identifies a series of landmarks in the genome.
- Sometimes mapping and sequencing are completely separate processes. For example, it's possible to determine the location of a gene—to "map" the gene—without sequencing it. Thus, a map may tell you nothing about the sequence of the genome, and a sequence may tell you nothing about the map.
- Genome maps help scientists find genes, particularly those involved in human disease. This process is much like a scientific game of hot and cold. Scientists study many families affected by a disease, tracing the inheritance of the disease and of specific genome landmarks through several generations. Landmarks that tend to be inherited along with the disease are likely to be located close to the disease gene and become "markers" for the gene in question.
- Once they have identified a few such markers, scientists know the approximate location of the disease gene. In this way, they narrow down their search from the entire 3-billion-base-pair genome to a region of the genome a few million base pairs long.

➡ GENOME SEQUENCING

- Genome sequencing is figuring out the **order of DNA nucleotides, or bases, in a genome**—the order of As, Cs, Gs, and Ts that make up an organism's DNA. The human genome is made up of over 3 billion of these genetic letters.
- Today, DNA sequencing on a large scale—the scale necessary for ambitious projects such as sequencing an entire genome—is mostly done by high-tech machines. Much as your eye scans a sequence of letters to read a sentence, these machines "read" a sequence of DNA bases.
- A DNA sequence that has been translated from life's chemical alphabet into our alphabet of written letters might look like this:



- That is, in this particular piece of DNA, an **adenine (A) is followed by a guanine (G), which is followed by a thymine (T), which in turn is followed by a cytosine (C), another cytosine (C),** and so on.

WHAT IS GENOME SEQUENCING?

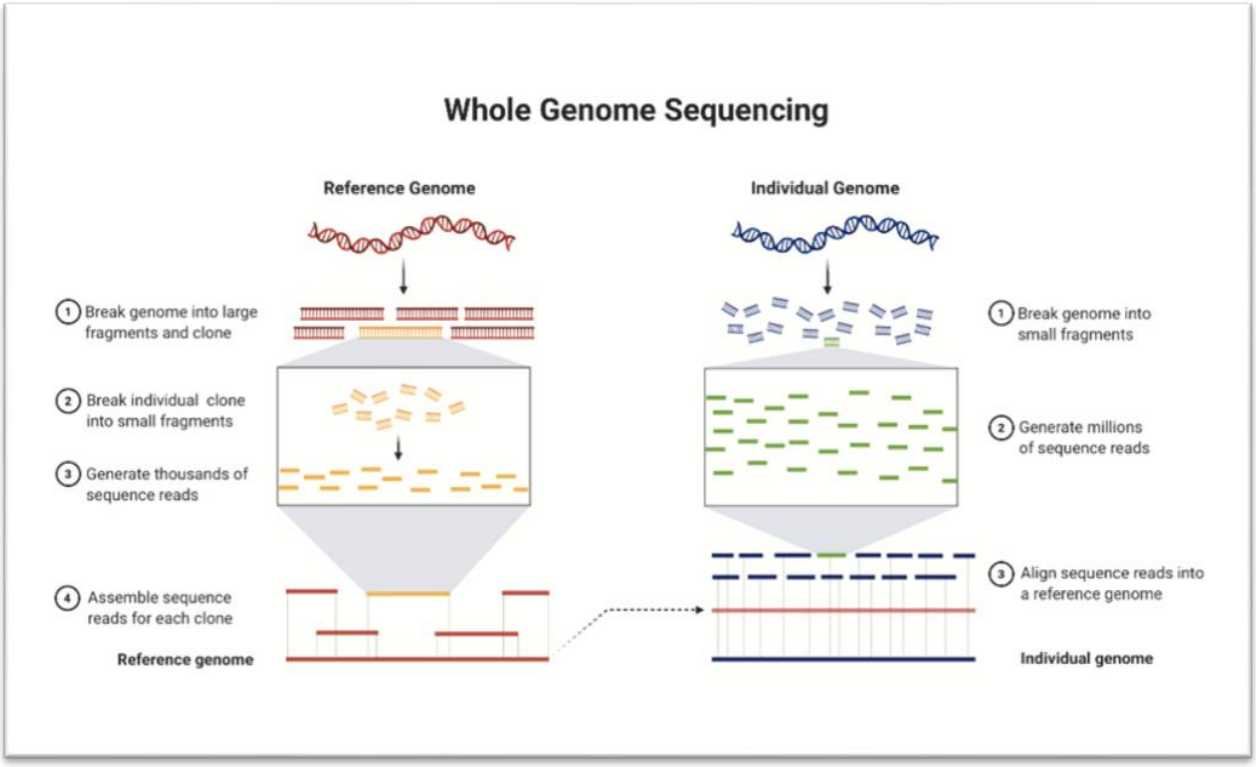
- Genome sequencing is often compared to **"decoding,"** but a sequence is still very much in code. In a sense, a genome sequence is simply a **very long string of letters in a mysterious language**.
- When you read a sentence, the meaning is not just in the sequence of the letters. It is also in the words those letters make and in the grammar of the language. Similarly, the human genome is more than just its sequence.
- Imagine the genome as a book written without capitalization or punctuation, without breaks between words, sentences, or paragraphs, and with strings of nonsense letters scattered between and even within sentences.
- So sequencing the genome doesn't immediately lay open the genetic secrets of an entire species. Even with a rough draft of the human genome sequence in hand, much work remains to be done. Scientists still have to translate those strings of letters into an understanding of how the genome works: what the various genes that make up the genome do, how different genes are related, and how the various parts of the genome are coordinated. That is, they have to figure out what those letters of the genome sequence mean.

WHY IS GENOME SEQUENCING SO IMPORTANT?

- Sequencing the genome is an important step towards understanding it.
- At the very least, the genome sequence will represent a valuable shortcut, helping scientists find genes much more easily and quickly. A genome sequence does contain some clues about where genes are, even though scientists are just learning to interpret these clues.
- Scientists also hope that being able to study the entire genome sequence will help them understand how the genome as a whole works—how genes work together to direct the growth, development and maintenance of an entire organism.
- Finally, **genes account for less than 25 percent of the DNA in the genome**, and so knowing the entire genome sequence will help scientists study the parts of the genome outside the genes. This includes the regulatory regions that control **how genes are turned**

on an off, as well as long stretches of "nonsense" or "junk" DNA—so called because we don't yet know what, if anything, it does.

➡ WHOLE GENOME SEQUENCING



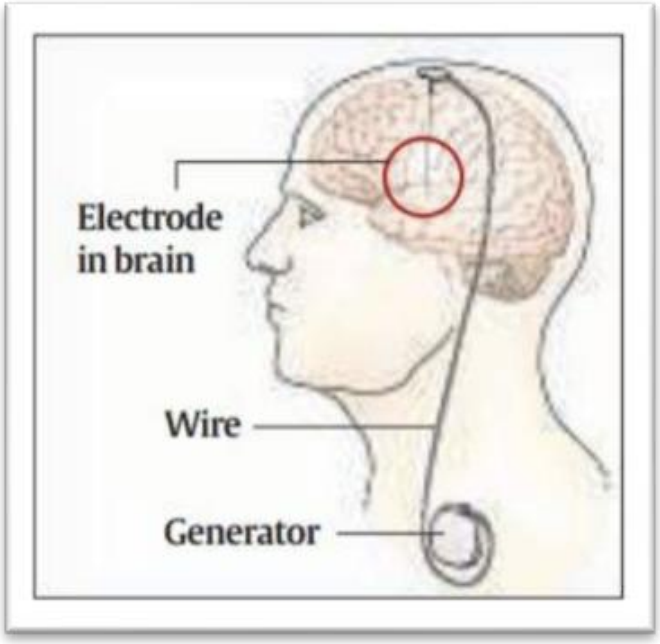
- Whole-genome sequencing (WGS) is a **comprehensive method for analyzing entire genomes**.
- Genomic information has been instrumental in **identifying inherited disorders**, **characterizing the mutations** that drive cancer progression, and **tracking disease outbreaks**. Rapidly dropping sequencing costs and the ability to produce large volumes of data with today's sequencers make whole-genome sequencing a powerful tool for genomics research.
- While this method is commonly associated with sequencing human genomes, the scalable, **flexible nature of next-generation sequencing (NGS) technology** makes it equally useful for sequencing any species, such as agriculturally important livestock, plants, or disease-related microbes.

ADVANTAGES

- Provides a high-resolution, base-by-base view of the genome.
- Captures both large and small variants that might be missed with targeted approaches.
- Identifies potential causative variants for further follow-up studies of gene expression and regulation mechanisms.
- Delivers large volumes of data in a short amount of time to support assembly of novel genomes.

➡ DEEP BRAIN STIMULATION

- Physicians at the University of California, San Francisco (UCSF) have successfully treated a patient with severe depression by recognising and tapping into the brain circuits linked with depressive brain patterns. The physicians have tried to reset these patterns, which they have said is the equivalent of using a pacemaker for the heart.
- The work, which represents a landmark in the use of neuroscience to treat psychiatric disorders, has been published in the journal **Nature Medicine**.
- The doctors used an existing technique called **deep brain stimulation (DBS),** customising it for this patient's case.
- DBS is a **surgical procedure** in which **electrodes are implanted into certain brain areas**. These electrodes, or leads, generate electrical impulses that control abnormal brain activity.
- The electrical impulses can also adjust for the chemical imbalances within the brain that cause various conditions.
- A DBS system has three components (see illustration):



- **The electrode, or lead**. This is a thin, insulated wire inserted through a small opening in the skull and implanted into a specific brain area.
- **The extension wire**. This too is insulated, and is passed under the skin of the head, neck and shoulder, connecting the electrode to the third component of the system.
- **The internal pulse generator (IPG)** is the third component. It is usually implanted under the skin in the upper chest, according to the AANS.

- Conditions that are traditionally treated using DBS include dystonia, epilepsy, essential tumour, obsessive-compulsive disorder and Parkinson's disease.
- In treating depression, however, previous clinical trials with DBS has shown limited success because most devices are only able to deliver constant electrical stimulation to one area of the brain.
- During this treatment, UCSF physicians customised a new DBS device, which would stimulate the brain whenever it recognised the depressive pattern. Additionally, the team of physicians had also found a neural biomarker that indicated the onset of symptoms. Using the customised DBS device, they were able to stimulate a different area of the brain, which in turn created immediate therapy for the brain.

➡ FRAGILE X SYNDROME

- Fragile X syndrome (FXS) is a **genetic disorder**. FXS is caused by changes in a gene that scientists called **FMR1 gene** when it was first discovered.
- The FMR1 gene usually makes a protein called **FMRP.** FMRP is needed for brain development.
- People who have FXS do not make this protein. People who have other fragile X-associated disorders have changes in their FMR1 gene but usually make some of the protein.
- FXS **affects both males and females**. However, females often have milder symptoms than males. The exact number of people who have FXS is unknown, but a review of research studies estimated that about 1 in 7,000 males about 1 in 11,000 females have been diagnosed with FXS.

SIGNS THAT A CHILD MIGHT HAVE FXS INCLUDE:

- Developmental delays (not sitting, walking, or talking at the same time as other children the same age);
- Learning disabilities (trouble learning new skills); and
- Social and behavior problems (such as not making eye contact, anxiety, trouble paying attention, hand flapping, acting and speaking without thinking, and being very active).
- Males who have FXS usually have some degree of intellectual disability that can range from mild to severe. Females with FXS can have normal intelligence or some degree of intellectual disability. Autism spectrum disorder (ASD) also occur more frequently in people with FXS.

- FXS can be diagnosed by **testing a person's DNA from a blood test**. A doctor or genetic counselor can order the test. Testing also can be done to find changes in the FMR1 gene that can lead to fragile X-associated disorders.
- A diagnosis of FXS can be helpful to the family because it can provide a reason for a child's intellectual disabilities and behavior problems.
- This allows the family and other caregivers to learn more about the disorder and manage care so that the child can reach his or her full potential.

➡ DIABETES

- Diabetes is a disease that occurs when your blood glucose, also called blood sugar, is too high.
- Blood glucose is **your main source of energy and comes from the food you eat**.
- Insulin, **a hormone made by the pancreas**, **helps glucose from food get into your cells to be used for energy**. Sometimes your body doesn't make enough—or any—insulin or doesn't use insulin well. Glucose then stays in your blood and doesn't reach your cells.
- Over time, having too much glucose in your blood can cause health problems. Although diabetes has no cure, you can take steps to manage your diabetes and stay healthy.
- Sometimes people call diabetes "a touch of sugar" or "borderline diabetes." These terms suggest that someone doesn't really have diabetes or has a less serious case, but every case of diabetes is serious.

WHAT ARE THE DIFFERENT TYPES OF DIABETES?

- **Type 1 diabetes**: If you have type 1 diabetes, your body does not make insulin. Your immune system attacks and destroys the cells in your pancreas that make insulin. Type 1 diabetes is u**sually diagnosed in children and young adults,** although it can appear at any age. People with type 1 diabetes need to take insulin every day to stay alive.
- **Type 2 diabetes**: If you have type 2 diabetes, your **body does not make or use insulin well**. You can develop type 2 diabetes at any age, even during childhood. However, this type of diabetes o**ccurs most often in middle-aged and older people**. Type 2 is the most common type of diabetes.
- **Gestational diabetes**: Gestational diabetes **develops in some women when they are pregnant**. Most of the time, this type of diabetes goes away after the baby is born. However, if you've had gestational diabetes, you have a greater chance of developing type 2 diabetes later in life. Sometimes diabetes diagnosed during pregnancy is actually type 2 diabetes.
- **Other types of diabetes:** Less common types include monogenic diabetes, which is an inherited form of diabetes, and cystic fibrosis-related diabetes.
- **Health problems :** Over time, high blood glucose leads to problems such as**:-** heart disease, stroke. kidney disease, eye problems, dental disease, nerve damage, foot problems.

➡ MUCORMYCOSIS

- Mucormycosis (sometimes called **zygomycosis)** is a serious but rare fungal infection caused by a group of molds called **mucormycetes.** These fungi live throughout the environment, particularly in soil and in decaying organic matter, such as leaves, compost piles, or rotten wood.
- People get mucormycosis by coming in **contact with the fungal spores** in the environment. For example, the lung or sinus forms of the infection can occur after someone breathes in spores. These forms of mucormycosis usually occur in people who have health problems or take medicines that lower the body's ability to fight germs and sickness.
- Mucormycosis can also develop on the skin after the fungus enters the skin through a cut, scrape, burn, or other type of skin trauma.

TYPES OF MUCORMYCOSIS

- **Rhinocerebral (sinus and brain) mucormycosis** is an infection in the sinuses that can spread to the brain. This form of mucormycosis is most common in people with uncontrolled diabetes and in people who have had a kidney transplant.
- **Pulmonary (lung) mucormycosis** is the most common type of mucormycosis in people with cancer and in people who have had an organ transplant or a stem cell transplant.
- **Gastrointestinal mucormycosis** is more common among young children than adults, especially premature and low birth weight infants less than 1 month of age, who have had antibiotics, surgery, or medications that lower the body's ability to fight germs and sickness.
- **Cutaneous (skin) mucormycosis**: occurs after the fungi enter the body through a break in the skin (for example, after surgery, a burn, or other type of skin trauma). This is the most common form of mucormycosis among people who do not have weakened immune systems.

- **Disseminated mucormycosis** occurs when the infection spreads through the bloodstream to affect another part of the body. The infection most commonly affects the brain, but also can affect other organs such as the spleen, heart, and skin.

TYPES OF FUNGI THAT MOST COMMONLY CAUSE MUCORMYCOSIS

Examples are: Rhizopus species, Mucor species, Rhizomucor species, Syncephalastrum species, Cunninghamella bertholletiae, Apophysomyces species, and Lichtheimia (formerly Absidia) species.

Symptoms of rhinocerebral (sinus and brain) mucormycosis include:

- One-sided facial swelling
- Headache
- Nasal or sinus congestion
- Black lesions on nasal bridge or upper inside of mouth that quickly become more severe
- Fever

Symptoms of pulmonary (lung) mucormycosis include:

- Fever
- Cough
- Chest pain
- Shortness of breath
- Cutaneous (skin) mucormycosis can look like blisters or ulcers, and the infected area may turn black. Other symptoms include pain, warmth, excessive redness, or swelling around a wound.

Symptoms of gastrointestinal mucormycosis include:

- Abdominal pain
- Nausea and vomiting
- Gastrointestinal bleeding
- Disseminated mucormycosis typically occurs in people who are already sick from other medical conditions, so it can be difficult to know which symptoms are related to mucormycosis. Patients with disseminated infection in the brain can develop mental status changes or coma.

TREATMENT

Common antifungal medications that doctor may prescribe for mucormycosis include:

- amphotericin B (given through an IV)
- posaconazole (given through an IV or orally)
- isavuconazole (given through an IV or orally)

➡ EPIGENETICS

- Epigenetics is the **study of how your behaviours and environment can cause changes that affect the way your genes work.** Unlike genetic changes, epigenetic changes are reversible and do not change your DNA sequence, but they can change how your body reads a DNA sequence.
- Gene expression refers to how often or when proteins are created from the instructions within your genes. While genetic changes can alter which protein is made, **epigenetic changes affect gene expression to turn genes "on" and "off**." Since your environment and behaviours, such as diet and exercise, can result in epigenetic changes, it is easy to see the connection between your genes and your behaviours and environment.

HOW DOES EPIGENETICS WORK?

Epigenetic changes affect gene expression in different ways. Types of epigenetic changes include:

- **DNA Methylation:** DNA methylation works by **adding a chemical group to DNA**. Typically, this group is added to specific places on the DNA, where it blocks the proteins that attach to DNA to "read" the gene. This chemical group can be removed through a process called demethylation. Typically, methylation turns genes "off" and demethylation turns genes "on."
- **Histone modification**: DNA wraps around proteins called histones. DNA wrapped tightly around histones cannot be accessed by proteins that "read" the gene. Some genes are wrapped around histones and are turned "off" while some genes are not wrapped around histones and are turned "on." Chemical groups can be added or removed from histones and change whether a gene is unwrapped or wrapped ("on" or "off").
- **Non-coding RNA:** Your DNA is used as instructions for making coding and non-coding RNA. Coding RNA is used to make proteins. Non-coding RNA helps control gene expression by attaching to coding RNA, along with certain proteins, to break down the coding RNA so that it cannot be used to make proteins. Non-coding RNA may also recruit proteins to modify histones to turn genes "on" or "off."

HOW CAN YOUR EPIGENETICS CHANGE?

Your epigenetics change as you age, both as part of normal development and aging and in response to your behaviours and environment.

- **Epigenetics and Development**: Epigenetic changes begin before you are born. All your cells have the same genes but look and act differently. As you grow and develop, epigenetics helps determine which function a cell will have, for example, whether it will become a heart cell, nerve cell, or skin cell.
- **Epigenetics and Age**: Your epigenetics change throughout your life. Your epigenetics at birth is not the same as your epigenetics during childhood or adulthood.
- **Epigenetics and Reversibility**: Not all epigenetic changes are permanent. Some epigenetic changes can be added or removed in response to changes in behavior or environment.

  Epigenetics and Health: Epigenetic changes can affect your health in different ways:

- **Infections:** Germs can change your epigenetics to weaken your immune system. This helps the germ survive.
- **Cancer:** Certain mutations make you more likely to develop cancer. Likewise, some epigenetic changes increase your cancer risk. For example, having a mutation in the BRCA1 gene that prevents it from working properly makes you more likely to get breast and other cancers.
- **Nutrition During Pregnancy**: A pregnant woman's environment and behavior during pregnancy, such as whether she eats healthy food, can change the baby's epigenetics. Some of these changes can remain for decades and might make the child more likely to get certain diseases.

➡ PLASMA

Plasma is the often forgotten part of blood. White blood cells, red blood cells, and platelets are important to body function. But plasma also plays a key role. This **fluid carries the blood components throughout the body.**

FACTS ABOUT PLASMA

- Plasma is the **largest part of your blood.** It, makes up **more than half (about 55%)** of its overall content. When separated from the rest of the blood, plasma is a light yellow liquid. Plasma carries **water, salts and enzymes**.
- The main role of plasma **is to take nutrients, hormones, and proteins to the parts of the body** that need it. Cells also put their waste products into the plasma. The plasma then helps remove this waste from the body. Blood plasma also carries all parts of the blood through your circulatory system.

HOW DOES PLASMA KEEP YOU HEALTHY?

- Plasma is a critical part of the treatment for many serious health problems. This is why there are blood drives asking people to donate blood plasma.
- Along with water, salt, and enzymes, plasma also contains important components. These include **antibodies, clotting factors, and the proteins albumin and fibrinogen**. When you donate blood, healthcare providers can separate these vital parts from your plasma. These parts can then be concentrated into various products. These products are then used as treatments that can help save the lives of people suffering from burns, shock, trauma, and other medical emergencies.
- The proteins and antibodies in plasma are also used in therapies for rare chronic conditions. These include autoimmune disorders and hemophilia. People with these conditions can live long and productive lives because of the treatments. In fact, some health organizations call plasma "the gift of life."

➡ ALZHEIMER'S DISEASE

- Alzheimer's disease is a condition that **affects the brain**. The symptoms are mild at first and become more severe over time. It is named after **Dr. Alois Alzheimer**, who first described the condition in 1906.
- Common symptoms of Alzheimer's disease include **memory loss, language problems**, and **impulsive or unpredictable behaviour.**
- **Dementia** is an umbrella term for a range of conditions that involve a loss of cognitive functioning.
- Alzheimer's disease is the most common type of dementia. It involves plaques and tangles forming in the brain. Symptoms start gradually and are most likely to include a decline in cognitive function and language ability.
- Other types of dementia include **Huntington's disease**, **Parkinson's disease**, and **Creutzfeldt-Jakob disease**. A person can have more than one type of dementia.
- These features mean that information cannot pass easily between different areas of the brain or between the brain and the muscles or organs.
- As the symptoms worsen, it becomes harder for people to remember recent events, to reason, and to recognize people they know. Eventually, a person with Alzheimer's disease may need full-time assistance.
- According to the National Institute on Aging, Alzheimer's disease is the sixth leading cause of death in the U.S. However, other recent estimates suggest that it may be the third leading cause of death, just behind heart disease and cancer.

SYMPTOMS

- Alzheimer's disease is a progressive condition, meaning that the symptoms get worse over time. Memory loss is a key feature, and this tends to be one of the first symptoms to develop.
- The symptoms appear gradually, over months or years. If they develop over hours or days, a person may require medical attention, as this could indicate a stroke.

SYMPTOMS OF ALZHEIMER'S DISEASE INCLUDE:

Memory loss: A person may have difficulty taking in new information and remembering information. This can lead to:

- repeating questions or conversations
- losing objects
- forgetting about events or appointments
- wandering or getting lost

COGNITIVE DEFICITS:

A person may experience difficulty with reasoning, complex tasks, and judgment. This can lead to:

- a reduced understanding of safety and risks
- difficulty with money or paying bills
- difficulty making decisions

- difficulty completing tasks that have several stages, such as getting dressed

PROBLEMS WITH RECOGNITION:

A person may become less able to recognize faces or objects or less able to use basic tools. These issues are not due to problems with eyesight.

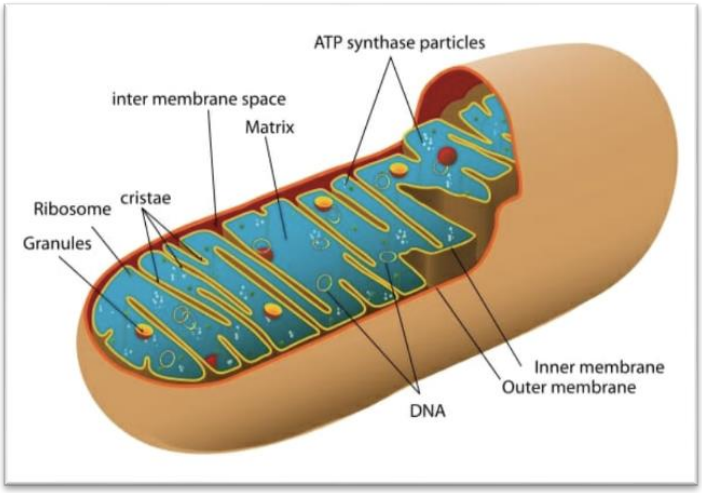
- Problems with spatial awareness: A person may have difficulty with their balance, trip over, or spill things more often, or they may have difficulty orienting clothing to their body when getting dressed.
- Problems with speaking, reading, or writing: A person may develop difficulties with thinking of common words, or they may make more speech, spelling, or writing errors.

PERSONALITY OR BEHAVIOUR CHANGES:

A person may experience changes in personality and behavior that include:

- becoming upset, angry, or worried more often than before
- a loss of interest in or motivation for activities they usually enjoy
- a loss of empathy
- compulsive, obsessive, or socially inappropriate behaviour.

➡ MITOCHONDRIA



- Popularly known as the **"Powerhouse of the cell,"** mitochondria (singular: mitochondrion) are a **double membrane-bound organelle** found in most eukaryotic organisms.
- They are **found inside the cytoplasm and essentially function** as the cell's "digestive system."
- They play a major role in **breaking down nutrients and generating energy-rich molecules for the cell**. Many of the biochemical reactions involved in cellular respiration take place within the mitochondria.
- The term 'mitochondrion' is derived from the Greek words **"mitos" and "chondrion"** which means "thread" and "granules-like", respectively.
- It was first described by a German pathologist named Richard Altmann in the year 1890.

STRUCTURE OF MITOCHONDRIA

- The mitochondrion is a double-membraned, rod-shaped structure found in both plant and animal cell.
- Its size ranges from **0.5 to 1.0 micrometre in diameter**.

- The structure comprises an outer membrane, an inner membrane, and a **gel-like material called the matrix.**
- The outer membrane and the inner membrane are **made of proteins and phospholipid layers** separated by the intermembrane space.
- The outer membrane covers the surface of the mitochondrion and has a large number of special proteins known as porins.
- It is freely permeable to ions, nutrient molecules, energy molecules like the ADP and ATP molecules.

Cristae

- The inner membrane of mitochondria is rather complex in structure. It has many folds that form a layered structure called **cristae,** and this helps in increasing the surface area inside the organelle. The cristae and the proteins of the inner membrane aids in the production of ATP molecules.
- The inner membrane is strictly permeable only to oxygen and to ATP molecules. A number of chemical reactions take place within the inner membrane of mitochondria.

Mitochondrial Matrix

- The mitochondrial matrix is a viscous fluid that contains a mixture of enzymes and proteins. It also comprises ribosomes, inorganic ions, mitochondrial DNA, nucleotide cofactors, and organic molecules. The enzymes present in the matrix play an important role in the synthesis of ATP molecules.

FUNCTIONS OF MITOCHONDRIA

- The most important function of mitochondria is to produce energy through the process of oxidative phosphorylation. It is also involved in the following process:

- Regulates the **metabolic activity** of the cell
- Promotes the **growth of new cells** and cell multiplication
- Helps in **detoxifying ammonia** in the liver cells
- Plays an **important role in apoptosis** or programmed cell death
- Responsible for **building certain parts of the blood and various hormones** like testosterone and oestrogen
- Helps in **maintaining an adequate concentration of calcium ions** within the compartments of the cell
- It is also involved in various cellular activities like cellular differentiation, cell signalling, cell senescence, controlling the cell cycle and also in cell growth.

DISORDERS ASSOCIATED WITH MITOCHONDRIA

- Any irregularity in the way mitochondria functions can directly affect human health, but often, it is difficult to identify because symptoms differ from person to person. Disorders of the mitochondria can be quite severe; in some cases, it can even cause an organ to fail.
- **Mitochondrial diseases:** Alpers Disease, Barth Syndrome, Kearns-Sayre syndrome (KSS)

➡ AMYOTROPHIC LATERAL SCLEROSIS (ALS)

- It is a group of **rare neurological diseases** that mainly involve the nerve cells (neurons) responsible for controlling voluntary muscle movement.
- It belongs to a wider group of disorders known as **motor neuron diseases**, which are caused by gradual deterioration (degeneration) and death of **motor neurons**.
- **Motor neurons** are nerve cells that extend from the brain to the spinal cord and to muscles throughout the body. These motor neurons initiate and provide vital communication links between the brain and the voluntary muscles.
- ALS is progressive, meaning the symptoms get worse over time. Currently, there is no cure for ALS and no effective treatment to halt, or reverse, the progression of the disease.
- It is also known as **Lou Gehrig's disease,** it causes lethal respiratory paralysis within several years of diagnosis.

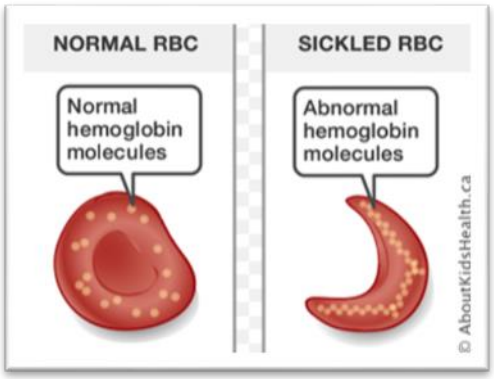
➡ BROWN FAT

- **Brown adipose tissue (BAT) or brown fat** makes up the adipose organ together with white adipose tissue (or white fat).
- Brown adipose tissue is found in almost all mammals.
- It is especially **abundant in new-borns** and in **hibernating mammals**, also present and metabolically active in adult humans, but its prevalence decreases as humans age.
- Brown fat contains **many more mitochondria** than does white fat.
- These mitochondria are the “engines” in brown fat that burn calories to produce heat.
- Because of brown fats ability to burn calories, scientists are looking for ways to **exploit its power to help fight obesity**.
- In adults exposed to cold temperatures, brown fat may serve as an ‘internal heating jacket’ to keep blood warm as it flows back to the heart and brain from our chilly extremities.
- Brown fat helps babies — who do not have the ability to shiver — to stay warm.
- It offers potential to combat the **Metabolic syndrome conditions**.
- **Metabolic syndrome conditions** IS cluster of conditions that includes -increased blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels — that occur together, increasing risk of heart disease, stroke and diabetes.

➡ SICKLE CELL ANAEMIA

- It is a major **genetic disease** that affects most countries in the **African Region**.
- In sickle cell disease, the normal round shape of red blood cells become like **crescent moons**.
- Round red blood cells can move easily through the blood vessels but sickled shaped cells interconnect and can result in **blood clots.**
- These blood clots can cause extreme pain in the back, chest, hands and feet.
- The disrupted blood flow can also cause damage to bones, muscles and organs.

- People with sickle cell disease often feel weak, tired and look pale.
- At the moment the only remedy available for the disease is a dangerous and expensive bone marrow transplant.
- **Regions:** In countries such as Cameroon, Republic of Congo, Gabon, Ghana and Nigeria the prevalence is between 20% to 30% while in some parts of Uganda it is as high as 45%.



➡ BIO-POLYMER

- It is a generic term used to describe a very **long molecule consisting of structural units and repeating units** connected by **covalent chemical bonds**.
- Modern polymers are very useful. For instance, they can be used as:

- ✓ New packaging materials;
- ✓ Waterproof coatings for fabrics (e.g. for outdoor clothing);
- ✓ Fillings for teeth;
- ✓ Dressings for cuts;
- ✓ Hydrogels (e.g. for soft contact lenses and disposable nappy liners);
- ✓ Smart materials (e.g. shape memory polymers for shrink-wrap packaging).

WHAT IS BIO-POLYMER?

It is a polymer that is developed from living beings. It is a biodegradable chemical compound that is regarded as the most organic compound in the ecosphere. The name "Biopolymer" indicates that it is a bio-degradable polymer.

- Some Biopolymer **examples are:** Proteins, Carbohydrates, DNA, RNA, Lipids, Nucleic acids, Peptides
- These polymers play an essential role in nature. They are extremely useful in performing functions like storage of energy, preservation and transmittance of genetic information and cellular construction.
- These polymers are carbon neutral and can always be renewed. These are sustainable as they are composed of living materials.
- Starch based biopolymers can be used for creating conventional plastic by extruding and injection moulding.

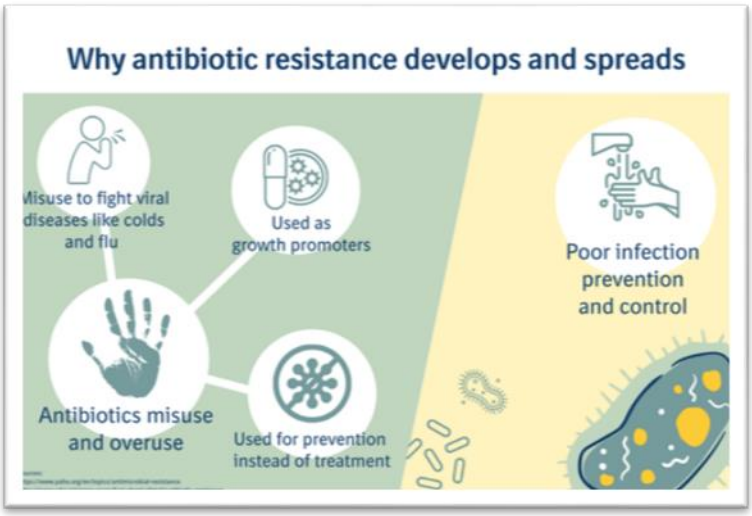
➡ CHOANOFLAGELLATES

- The choanoflagellates are a group of free-living unicellular and colonial flagellate eukaryotes considered to be the closest living relatives of the animals.
- They help to reconstruct animal origins and elucidate core mechanisms underlying animal cell and developmental biology.

- In the beginning, the environment of Earth was devoid of oxygen. It was high in methane, was not fit for animal life.
- At the same time, it could 'host' microorganisms which could cope with the incoming sunlight and use it to generate energy for living. This was around 3.4 billion years ago.
- In the process, these microorganisms **generated the gaseous waste product called oxygen**.
- About 2 Byr, later the amount of oxygen on Earth became an important component of the Earths' surface, and amenable for animal life.
- Choanoflagellates are the closest living relatives of animals that appeared nearly a billion years ago.
- Over time, animal cells also evolved to produce increased amounts of molecules called **reactive oxygen species (ROS),** which are involved in many essential cell activities but toxic at high levels.
- In addition, more complexity necessitates a substantial increase in the genome size of the animal with concomitant increase in all transactions in the cell: DNA, the genetic material in the cells of the various organs, their transcription of the information to messenger RNA (mRNAs), then translation of these into the amino acid sequences that make individual proteins in the cells through what are called tRNAs — at least one per amino acid.
- If a wrong interpretation of the genetic code at the protein level occurs, it will lead to functional disorders and even diseases.

➡ ANTIMICROBIAL RESISTANCE

- Antimicrobial resistance (AMR) is a global health and development threat. It requires urgent multisectoral action in order to achieve the Sustainable Development Goals (SDGs).
- WHO has declared that **AMR is one of the top 10 global public health threats** facing humanity.
- **Misuse and overuse of antimicrobials** are the main drivers in the development of drug-resistant pathogens.



- Antimicrobials – including **antibiotics, antivirals, antifungals and antiparasitics** – are medicines used to prevent and treat infections in humans, animals and plants.
- Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.
- As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become increasingly difficult or impossible to treat.

- Lack of clean water and sanitation and inadequate infection prevention and control promotes the spread of microbes, some of which can be resistant to antimicrobial treatment.

WHY IS ANTIMICROBIAL RESISTANCE A GLOBAL CONCERN?

- The emergence and spread of drug-resistant pathogens that have acquired new resistance mechanisms, leading to antimicrobial resistance, continues to threaten our ability to treat common infections.
- Especially alarming is the rapid global spread **of multi- and pan-resistant bacteria (also known as "superbugs")** that cause infections that are not treatable with existing antimicrobial medicines such as antibiotics.
- Antibiotics are becoming increasingly ineffective as drug-resistance spreads globally leading to more difficult to treat infections and death.
- **New anti-bacterials are urgently needed** – for example, to treat carbapenem-resistant gram-negative bacterial infections as identified in the WHO priority pathogen list.
- The cost of AMR to national economies and their health systems is significant as it affects productivity of patients or their caretakers through prolonged hospital stays and the need for more expensive and intensive care.
- Without effective tools for the prevention and adequate treatment of drug-resistant infections and improved access to existing and new quality-assured antimicrobials, the number of people for whom treatment is failing or who die of infections will increase.
- **Medical procedures, such as surgery,** including caesarean sections or hip replacements, cancer chemotherapy, and organ transplantation, will become more risky.

➡ SOIL MICROBES

- Soil microorganisms exist in large numbers in the soil as long as there is a carbon source for energy. A large number of bacteria in the soil exists, but because of their small size, they have a smaller biomass.
- **Actinomycetes** are a factor of 10 times smaller in number but are larger in size so they are similar in biomass to bacteria.
- Fungus population numbers are smaller but they dominate the soil biomass when the soil is not disturbed.
- Bacteria, actinomycetes, and protozoa are hardy and can tolerate more soil disturbance than fungal populations so they dominate in tilled soils while fungal and nematode populations tend to dominate in untilled or no-till soils.

There are more microbes in a teaspoon of soil than there are people on the earth.

WHAT ARE THE DIFFERENT TYPES OF SOIL MICROBES?

There are five different types of soil microbes: bacteria, actinomycetes, fungi, protozoa and nematodes. Each of these microbe types has a different job to boost soil and plant health.

1. **Bacteria:** Bacteria is the crucial workforce of soils. They are the final stage of breaking down nutrients and releasing them to the root zone for the plant. In fact, the Food and Agriculture Organization once said "Bacteria may well be the most valuable of life forms in the soil."
2. **Actinomycetes:** Actinomycetes were once classified as fungi, and act similarly in the soil. However, some actinomycetes are predators and will harm the plant while others living in the soil can act as antibiotics for the plant.
3. **Fungi:** Like bacteria, fungi also lives in the rootzone and helps make nutrients available to plants. For example, **Mycorrhizae** is a fungi that facilitate water and nutrient uptake by the roots and plants to provide sugars, amino acids and other nutrients.
4. **Protozoa:** Protozoa are larger microbes that love to consume and be surrounded by bacteria. In fact, nutrients that are eaten by bacteria are released when protozoa in turn eat the bacteria.
5. **Nematodes:** Nematodes are microscopic worms that live around or inside the plant. Some nematodes are predators while others are beneficial, eating pathogenic nematodes and secreting nutrients to the plant.

MICROBIAL SOIL ORGANIC MATTER DECOMPOSITION

- Organic matter decomposition serves two functions for the microorganisms, providing energy for growth and suppling carbon for the formation of new cells.
- **Soil organic matter (SOM)** is composed of the **"living" (microorganisms), the "dead" (fresh residues), and the "very dead" (humus) fractions.**
- The "very dead" or humus is the long-term SOM fraction that is thousands of years old and is resistant to decomposition.
- Soil organic matter has two components called the **active (35 percent) and the passive (65 percent) SOM**.
- Active SOM is composed of the "living" and "dead" fresh plant or animal material which is food for microbes and is composed of easily digested sugars and proteins.
- The **passive SOM is resistant to decomposition by microbes and is higher in lignin.**
- Microbes need regular supplies of active SOM in the soil to survive in the soil.
- Long-term no-tilled soils have significantly greater levels of microbes, more active carbon, more SOM, and more stored carbon than conventional tilled soils.
- A majority of the microbes in the soil exist under starvation conditions and thus they tend to be in a dormant state, especially in tilled soils.
- Dead plant residues and plant nutrients become food for the microbes in the soil.
- Soil organic matter (SOM) is basically all the organic substances (anything with carbon) in the soil, both living and dead.
- SOM includes plants, blue green algae, microorganisms (bacteria, fungi, protozoa, nematodes, beetles, springtails, etc.) and the fresh and decomposing organic matter from plants, animals, and microorganisms.

SOIL ORGANIC MATTER CAN BE BROKEN DOWN INTO ITS COMPONENT PARTS.

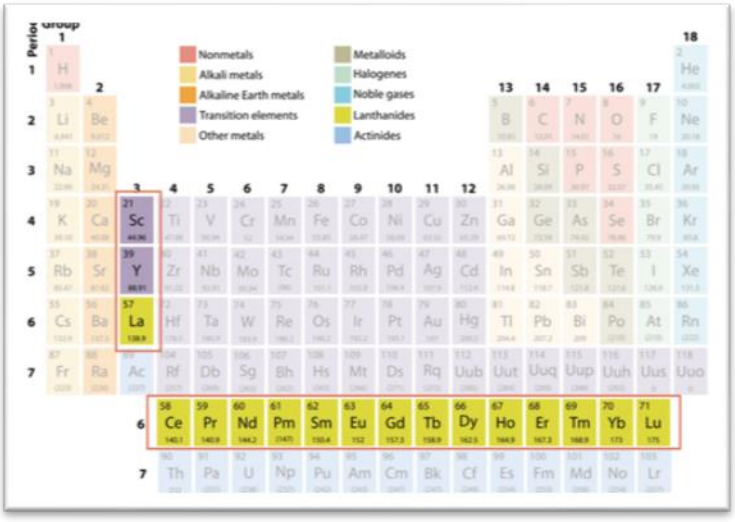
- One hundred grams (g) or 100 pounds (lbs) of dead plant material yields about 60–80 g (lbs) of carbon dioxide, which is released into the atmosphere.
- The remaining 20–40 g (lbs) of energy and nutrients is decomposed and turned into about 3–8 g (lbs) of microorganisms (the living), 3–8 g (lbs) of non-humic compounds (the dead), and 10–30 g (lbs) of humus (the very dead matter, resistant to decomposition).
- The molecular structure of SOM is mainly carbon and oxygen with some hydrogen and nitrogen and small amounts of phosphorus and sulfur.
- Soil organic matter is a by-product of the carbon and nitrogen cycles.

➡ RARE EARTH ELEMENTS

China's dominance in these minerals, key to the future of manufacturing, is a cause for concern for the West.

- In 2019, the U.S. imported 80% of its rare earth minerals from China.
- The EU gets 98% of its supply from China.
- Amid the transition to green energy, in which rare earth minerals are sure to play a role, China's market dominance is enough to sound an alarm in western capitals.

What if China were to cut off the U.S. and Europe from access to rare minerals that are essential to electric vehicles, wind turbines and drones?



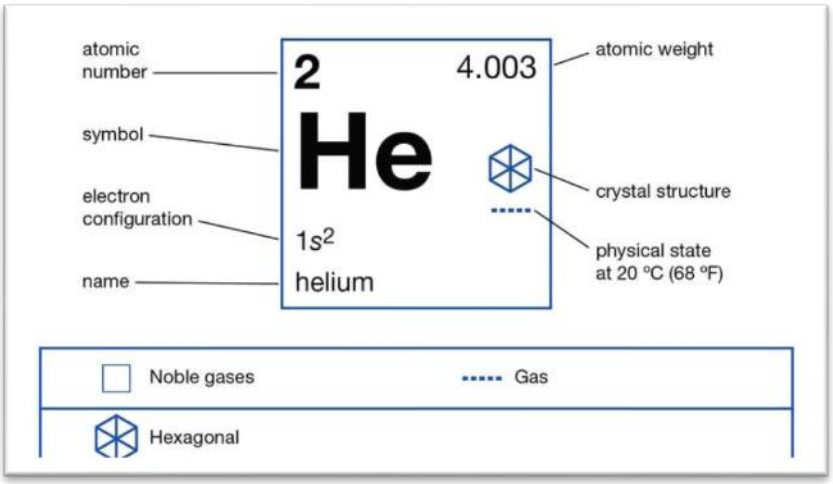
REE

- The rare earth elements (REE) are a set of **seventeen metallic elements**. These include the fifteen lanthanides on the periodic table plus scandium and yttrium.
- Rare earth elements are an essential part of many **high-tech devices**.
- Rare-earth elements (REE) are necessary components of more than 200 products across a wide range of applications, especially high-tech consumer products, such as cellular telephones, computer hard drives, electric and hybrid vehicles, and flat-screen monitors and televisions.
- Significant defense applications include electronic displays, guidance systems, lasers, and radar and sonar systems. Although the amount of REE used in a product may not be a significant part of that product by weight, value, or volume, the REE can be necessary for the device to function. For example, magnets made of REE often represent only a small fraction of the total weight, but without them, the spindle motors and voice coils of desktops and laptops would not be possible.
- The Japanese call them "the seeds of technology." The US Department of Energy calls them "technology metals."

- In 1993, 38 percent of world production of REEs was in China, 33 percent was in the United States, 12 percent was in Australia, and five percent each was in Malaysia and India. Several other countries, including Brazil, Canada, South Africa, Sri Lanka, and Thailand, made up the remainder. However, in 2008, China accounted for more than 90 percent of world production of REEs, and by 2011, China accounted for 97 percent of world production. Beginning in 1990 and beyond, supplies of REEs became an issue as the Government of China began to change the amount of the REEs that it allows to be produced and exported. The Chinese Government also began to limit the number of Chinese and Sino-foreign joint-venture companies that could export REEs from China.

➡ HELIUM

- Helium (He), chemical element, **inert gas of Group 18 (noble gases)** of the periodic table.
- The **second lightest element** (only hydrogen is lighter), helium is a **colourless, odourless, and tasteless gas** that **becomes liquid at −268.9** °C (−452 °F).
- The **boiling and freezing points of helium are lower than those of any other known substance**.



- Helium is the only element that cannot be solidified by sufficient cooling at normal atmospheric pressure; it is necessary to apply pressure of 25 atmospheres at a temperature of 1 K (−272 °C, or −458 °F) to convert it to its solid form.
- Helium was discovered in the gaseous atmosphere surrounding the Sun by the French astronomer Pierre Janssen.
- The British chemist Sir William Ramsay discovered the existence of helium on Earth in 1895.
- Helium **constitutes about 23 percent of the mass of the universe** and is thus second in abundance to hydrogen in the cosmos. Helium is concentrated in stars, where it is synthesized from hydrogen by nuclear fusion.
- Although helium occurs in Earth's atmosphere only to the extent of 1 part in 200,000 (0.0005 percent) and small amounts occur in radioactive minerals, meteoric iron, and mineral springs, great volumes of helium are found as a component (up to 7.6 percent) in natural gases in the United States (especially in Texas, New Mexico, Kansas, Oklahoma, Arizona, and Utah). Smaller supplies have been discovered in Algeria, Australia, Poland, Qatar, and Russia. Ordinary air contains about 5 parts per million of helium, and Earth's crust is only about 8 parts per billion.

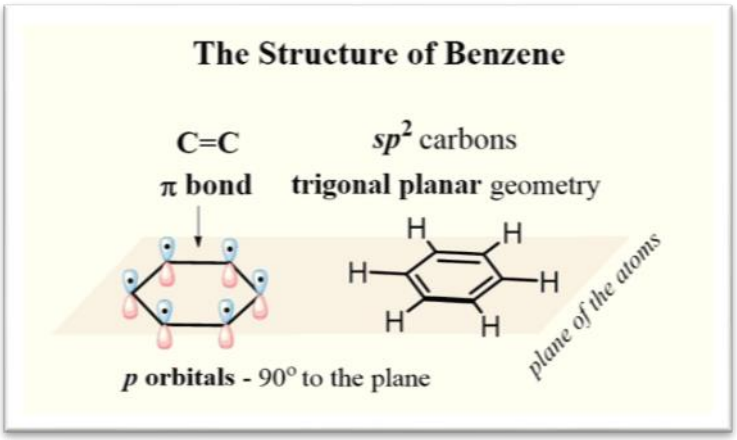
PRODUCTION AND USES

- Helium gas (98.2 percent pure) is isolated from natural gas by liquefying the other components at low temperatures and under high pressures. **Adsorption of other gases on cooled, activated charcoal yields 99.995 percent pure helium.** Some helium is supplied from **liquefaction of air on a large scale**; the amount of helium obtainable from 1,000 tons (900 metric tons) of air is about 112 cubic feet (3.17 cubic metres), as measured at room temperature and at normal atmospheric pressure.
- **Uses:** Helium is **used as an inert-gas atmosphere for welding metals** such as aluminum; in **rocket propulsion** (to pressurize fuel tanks, especially those for liquid hydrogen, because only helium is still a gas at liquid-hydrogen temperature); in **meteorology** (as a lifting gas for instrument-carrying balloons); in **cryogenics** (as a coolant because liquid helium is the coldest substance); and in high-pressure **breathing operations (**mixed with oxygen, as in scuba diving and caisson work, especially because of its low solubility in the bloodstream).
- **Meteorites and rocks** have been analyzed for helium content as a means of dating.

➡ BENZENE

- Benzene is **a colorless, sweet-smelling chemical** that can be derived from natural gas, crude oil, or coal.
- Benzene is primarily used as a feedstock, or raw material, to make other industrial chemicals, such as ethylbenzene, cumene and cyclohexane. Benzene is also used as a solvent in the chemical and pharmaceutical industries.
- Most benzene exposure **comes from the air from a number of sources, including forest fires, auto exhaust and gasoline** from fueling stations. Benzene in cigarette smoke is a major source of exposure. Very low levels of benzene have been detected in fruits, vegetables, nuts, dairy products, eggs and fish. Most people are exposed to only very tiny amounts of benzene from water and food.

USES & BENEFITS

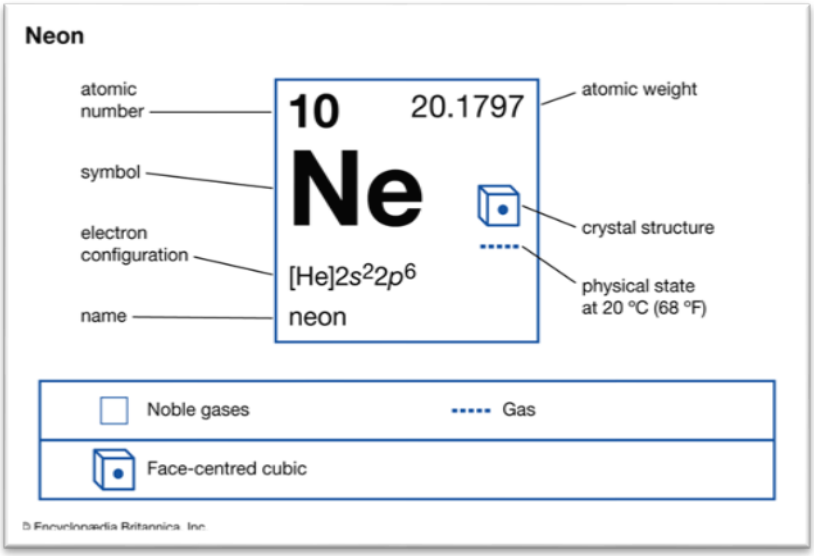


- As a building block chemical, benzene is reacted with other chemicals to produce a variety of other chemistries, materials and, ultimately, consumer goods.
- Benzene is used to **make other chemicals** like ethylbenzene, cumene and cyclohexane, which are then reacted and used in the **manufacture of a variety of materials and plastics** such as polystyrene, ABS, and nylon. There can be many steps in the process that starts with the benzene molecule and ends with a completed material or consumer product. For example, benzene is a building block used to make ethylbenzene,

which is then used to make styrene, which is used to make polystyrene. The end material, polystyrene, is a completely different material chemically than benzene.

- For consumer products where benzene is used as a building block or intermediate, the benzene is typically fully reacted in a closed system, with little to no benzene remaining in the finished consumer product.
- Benzene also is used to make some types of lubricants, rubbers, dyes, detergents, drugs, explosives and pesticides.
- Benzene is **naturally found in crude oil**. Crude oil is refined into gasoline by using heat, pressure and chemicals in the refinery to separate the spectrum of petroleum products from crude oil. The refining process yields gasoline and a number of other petroleum products, including diesel and jet fuels, solvents, lubricating oils, many of which include small amounts of benzene.

➡ NEON

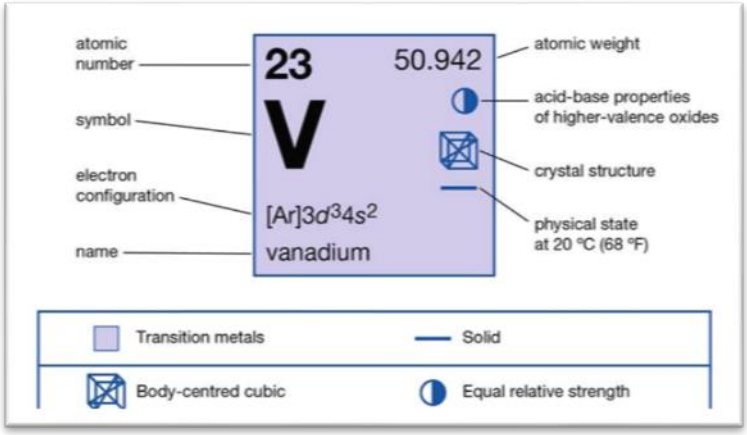


- Neon (Ne), chemical element, **inert gas of Group 18 (noble gases)** of the periodic table, used in electric signs and fluorescent lamps.
- **Colourless, odourless, tasteless**, and **lighter than air**, neon gas **occurs in minute quantities in Earth's atmosphere** and **trapped within the rocks of Earth's crust**.
- Though neon is about 31/2 times as plentiful as helium in the atmosphere, dry air contains only 0.0018 percent neon by volume.
- This element is **more abundant in the cosmos than on Earth**.
- Neon **liquefies at −246.048 °C (−411 °F)**.
- When **under low pressure, it emits a bright orange-red light if an electrical current** is passed through it. This property is utilized in neon signs (which first became familiar in the 1920s), in some fluorescent and gaseous conduction lamps, and in high-voltage testers.
- The name neon is derived from the **Greek word neos, "new**."
- Neon was discovered (1898) by the British chemists Sir William Ramsay and Morris W. Travers as a component of the most volatile fraction of liquefied crude argon obtained from air. It was immediately recognized as a new element by its unique glow when electrically stimulated.
- Its **only commercial source is the atmosphere**, in which it is 18 parts per million by volume.

- Because its boiling point is −246 °C (−411 °F), neon remains, **along with helium and hydrogen**, in the small fraction of air that resists liquefaction upon cooling to −195.8 °C (−320.4 °F, the boiling point of liquid nitrogen).
- Neon is isolated from this cold, gaseous mixture by bringing it into **contact with activated charcoal, which adsorbs the neon and hydrogen;** removal of hydrogen is effected by adding enough oxygen to convert it all to water, which, along with any surplus oxygen, condenses upon cooling.
- Processing 88,000 pounds of liquid air will produce one pound of neon.
- No stable chemical compounds of neon have been observed. Molecules of the element consist of single atoms.
- Natural neon is a mixture of three stable isotopes: **neon-20 (90.92 percent); neon-21 (0.26 percent); and neon-22 (8.82 percent).**
- Neon was the first element shown to consist of more than one stable isotope.
- In 1913, application of the technique of mass spectrometry revealed the existence of neon-20 and neon-22. The third stable isotope, neon-21 was detected later.
- Twelve radioactive isotopes of neon also have been identified.

➡ VANADIUM

- **Vanadium (V), chemical element, silvery white soft metal of Group 5 (Vb)** of the periodic table. It is alloyed with steel and iron for high-speed tool steel, high-strength low-alloy steel, and wear-resistant cast iron.



- Vanadium was discovered (1801) by the Spanish mineralogist **Andrés Manuel del Río**, who named it erythronium but eventually came to believe it was merely impure chromium. The element was rediscovered (1830) by the Swedish chemist Nils Gabriel Sefström, who named it after Vanadis, the Scandinavian goddess of beauty and youth, a name suggested by the beautiful colours of vanadium's compounds in solution. The English chemist Henry Enfield Roscoe first isolated the metal in 1867 by hydrogen reduction of vanadium dichloride, VCl_2, and the American chemists John Wesley Marden and Malcolm N. Rich obtained it 99.7 percent pure in 1925 by reduction of vanadium pentoxide, V_2O_5, with calcium metal.
- Found combined in various minerals, coal, and petroleum, vanadium is the **22nd most abundant element in Earth's crust**. Some commercial sources are the minerals **carnotite, vanadinite, and roscoelite**. (Deposits of the important vanadium-bearing mineral patronite occurring in coal at Mina Ragra, Peru, have been materially depleted.) Other commercial sources are vanadium-bearing magnetite and flue dust from smokestacks

and boilers of ships burning certain Venezuelan and Mexican oils. China, South Africa, and Russia were the leading producers of vanadium in the early 21st century.

- Vanadium is obtained from ores as **vanadium pentoxide (V_2O_5)** through a variety of smelting, leaching, and roasting processes. The pentoxide is then reduced to ferrovanadium or vanadium powder. The preparation of very pure vanadium is difficult because the metal is quite reactive toward oxygen, nitrogen, and carbon at elevated temperatures.
- Vanadium metal, sheet, strip, foil, bar, wire, and tubing have found use in high-temperature service, in the chemical industry, and in bonding other metals. Because the major commercial use of vanadium is in **steel and cast iron,** to which it lends ductility and shock resistance, most of the vanadium produced is used with iron as ferrovanadium (about 85 percent vanadium) in making vanadium steels.
- Vanadium (added in amounts between 0.1 and 5.0 percent) has two effects upon steel: **it refines the grain of the steel matrix, and with the carbon present it forms carbides.** Thus, vanadium steel is especially strong and hard, with improved resistance to shock. When the very pure metal is required, it may be obtained by processes similar to those for titanium.
- Very pure vanadium metal resembles titanium in being quite corrosion resistant, hard, and steel grey in colour.

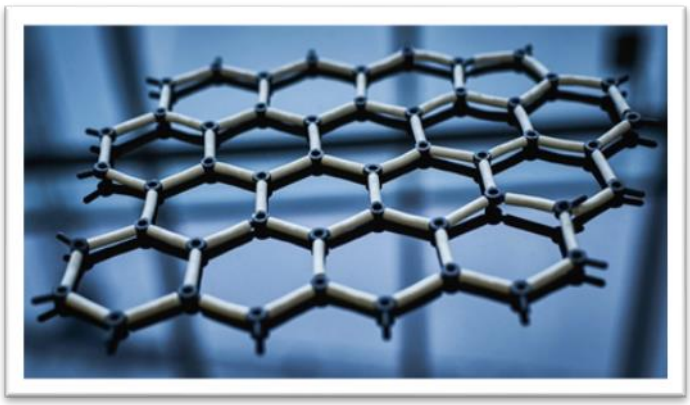
➡ GEOGRAPHICAL INDICATION (GI)

- A geographical indication is a sign used on goods that have a specific geographical origin and possess qualities or a reputation **due** to that place of origin.
- India enacted the **Geographical Indications of Goods (Registration & Protection)Act, 1999** and came into force with effect from 15th September 2003.
- It helps in protection and increase in exports of a product. A geographical indication consists of the name of the place of origin of the goods.
- Under Articles 1(2) and 10 of the **Paris Convention for the Protection of Industrial Property**, geographical indications are covered as an element of IPRs. They are also covered under Articles 22 to 24 of the **Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement** of the WTO.
- **Difference between a Geographical Indication and a Trademark**
- A trademark is a sign used by a company to distinguish its goods and services from those produced by others. It gives its owner the right to prevent others from using the trademark.
- A geographical indication guarantees to consumers that a product was produced in a certain place and has certain characteristics that are due to that place of production. It may be used by all producers who make products that share certain qualities in the place designated by a geographical indication.

➡ GRAPHENE

- Graphene consists of a single layer of carbon atoms arranged in a hexagonal lattice, each atom bound to its neighbours by chemical bonds.

- The elasticity of these bonds produces resonant vibrations known as **phonons.**
- Graphene has been described as wondrous stuff — of being the strongest material ever tested, almost 300 times stronger than steel.
- It is also the best heat- and electricity-conducting material to be discovered.



- It could also become a valuable aid in filtering water.

GRAPHENE HAS A NUMBER OF PROPERTIES WHICH MAKES IT INTERESTING FOR SEVERAL DIFFERENT APPLICATIONS SUCH AS:

- ✓ It is an ultimately thin, mechanically very strong, transparent and flexible conductor.
- ✓ Its conductivity can be modified over a large range either by chemical doping or by an electric field.
- ✓ The mobility of graphene is very high, which makes the material very interesting for **electronic high frequency applications**.
- ✓ Since graphene is a transparent conductor it can be used in applications such as touch screens, light panels and solar cells, where it can replace the rather fragile and expensive Indium-Tin-Oxide (ITO).
- ✓ Flexible electronics and gas sensors are other potential applications.
- ✓ New types of composite materials based on graphene with great strength and low weight could also become interesting for use in satellites and aircraft

➡ STANDARD MODEL OF PHYSICS

- The standard model identifies elementary particles into Quarks, Leptons and Bosons.
- **ANTIMATTER:** Every known matter has an antimatter which has the same mass and volume; only difference being the inherent charge. Antimatter has an opposite charge when compared to its matter. While the Anti-matter of a proton is called **Anti-Proton**, the Antimatter of an electron is called **Positron.**

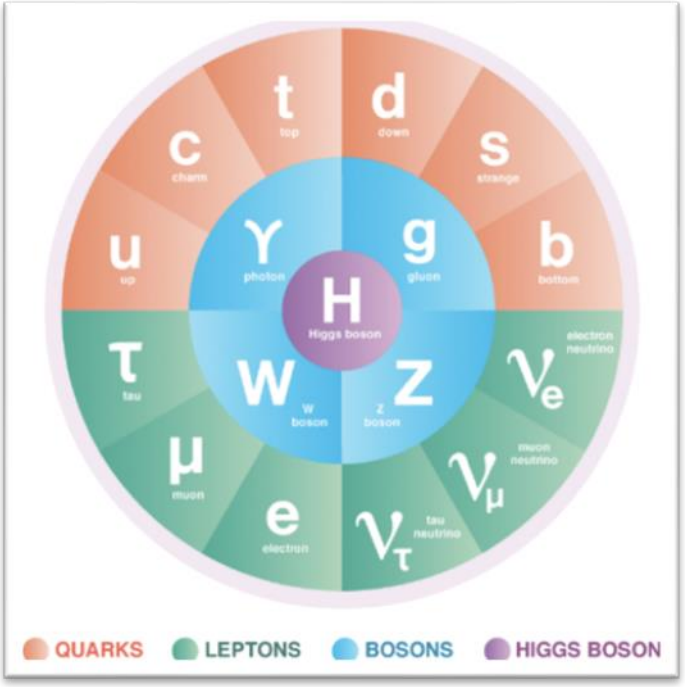
QUARKS

- Quarks are elementary particles propounded in the standard model.
- They join to form **hadrons**, such as protons and neutrons, which are components of the nuclei of atoms.
- The antiparticle of a quark is the **antiquark**.
- There are 6 principal quarks and hence 6 anti quarks.

- Quarks and antiquarks are the only two fundamental particles that interact through all four **fundamental forces of physics**: **gravitation**, **electromagnetism**, and the **strong interaction** and **weak interactions**.
- A quark exhibits confinement, which means that the quarks are not observed independently but always in combination with other quarks.
- This makes determining the properties (mass, spin, and parity) impossible to measure directly.

LEPTONS

- Like quarks, Leptons too are of 6 kinds. However, they do not have any fractional charge. The leptons are: ELECTRON, MUON, TAU and 3 Types OF NEUTRINOS
- Electron being a Lepton is a fundamental elementary particle.



FERMION

- Fermions are particles which have half-integer spin and therefore are constrained by the **Pauli exclusion principle**.
- Particles with integer spin are called bosons. Fermions include electrons, protons, neutrons.
- Fermions include all quarks and leptons.
- The fact that electrons are fermions is foundational to the buildup of the periodic table of the elements since there can be only one electron for each state in an atom (only one electron for each possible set of quantum numbers).
- The fermion nature of electrons also governs the behavior of electrons in a metal where at low temperatures all the low energy states are filled up to a level called the Fermi energy.

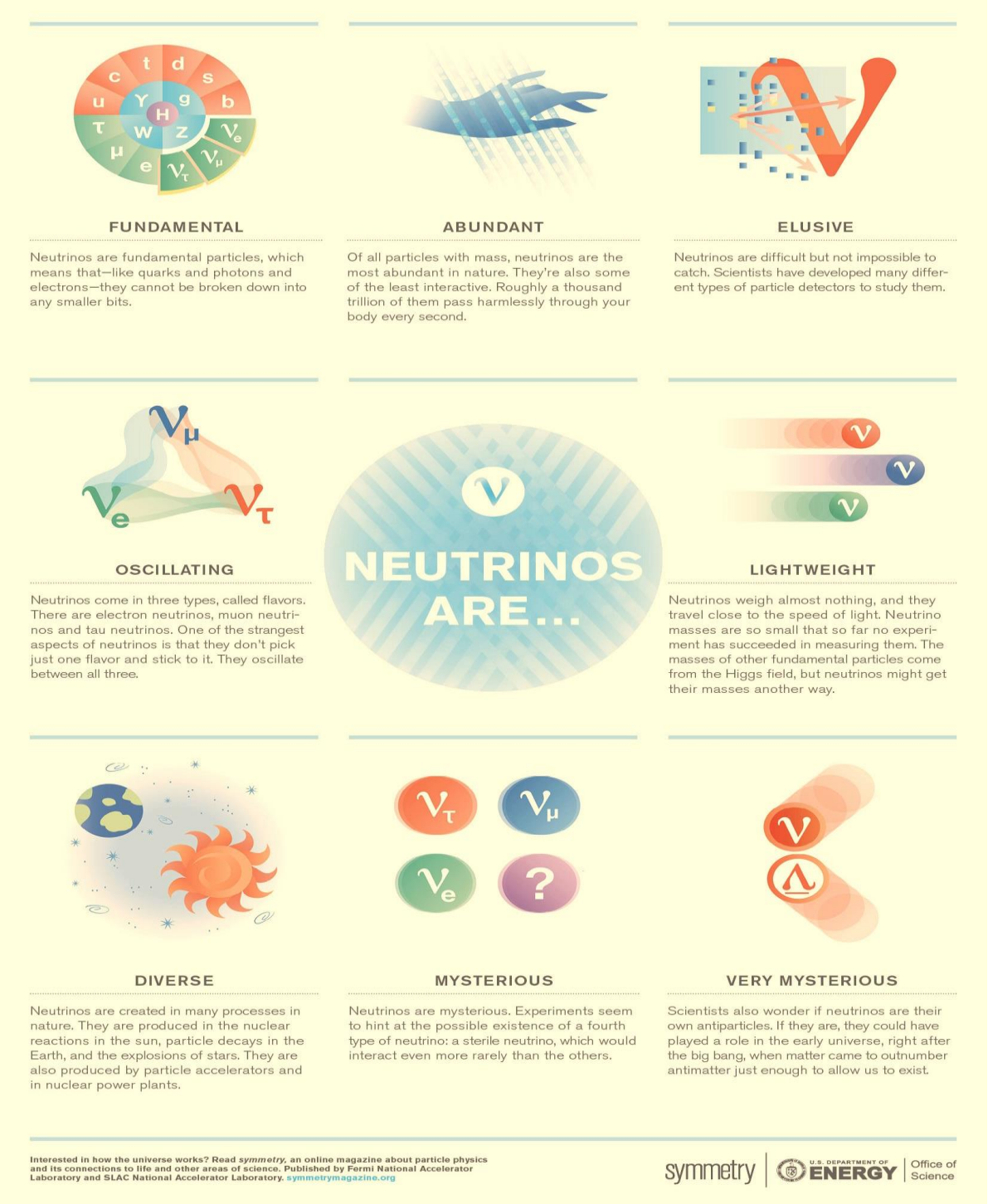
- **BOSON:** Boson is a **collective name** given to particles that carry forces. It has been named after Indian scientist Satyendra Nath Bose. Gravity as a force of nature is yet not accepted by the Standard Model due to the failure to discover its Boson. Strong Nuclear Force is the strongest known force while gravity is the weakest.

➡ NEUTRINOS

- They are produced by the **decay** of radioactive elements. After Photons(light carriers) they are the most abundant particles in the cosmos. They propagate over large distances even through solid matter.
- They **have** mass, but it is exceedingly small, a tiny fraction of the mass of a proton.
- There are 3 types of neutrinos, called **flavors**.

- One related to the electron, one related to muon and the third type is related to tau.
- The main difference between the neutrinos and their "relatives" is that neutrinos are electrically neutral, while the electron, muon, and tau are electrically charged.

- Neutrinos are difficult to detect, because they do not readily interact with other forms of matter. But using special equipment located in deep underground laboratories where no other cosmic particles can penetrate, scientists have detected neutrinos and discovered some of their properties.



NEUTRINOS OSCILLATION

- The earth receives majority of the neutrinos from the sun itself. For years' scientists were trying to figure out an anomaly between the observed and the theoretical data of the neutrinos observed.
- The studies held by the Super-Kamiokande detector in Japan showed that up to two thirds of number of neutrinos were missing in measurements performed on Earth.
- This was explained by the "metamorphosis" of the 3 neutrinos into one another called neutrino oscillation. This oscillation implies that Neutrinos have mass, however very small.

➡ DARK MATTER & DARK ENERGY

DARK MATTER

- It was in 1930s when Fritz Zwicky observed that many galaxies were moving faster than theoretical calculations. This implied that there was some mysterious gravitational pull towards the centre of those galaxies. The quantity of matter needed to exert such a pull far exceed the observed matter. This extra matter which invisible and undetected has been termed as Dark Matter.
- Gradually many astronomers started researching on dark matter. It was when the Andromeda Galaxy was observed to be moving faster than expected that dark matter took the centre stage of astronomical research.

CHARACTERISTICS OF DARK MATTER

- It has not yet been observed yet directly. It doesn't interact with matter and is completely invisible to light and other forms of electromagnetic radiation making it impossible to detect.
- Scientists are confident it exists because of the gravitational effects it has on galaxies and galaxy clusters.
- The light from distant galaxies gets distorted and magnified by massive, invisible clouds of dark matter in the phenomenon known as **Gravitational Lensing**.
- There are 2 schools of thoughts on the existence of Dark Matter. While one school supports the idea of MACHOS (MAssive Compact Halo ObjectS) the other advocated WIMPS(Weakly Interacting Massive ParticleS).
- MACHOS are made up of Baryons(protons and neutrons) while WIMPS consists of Exotic particles which in turn are non-baryonic
- Dark matter responds to **2 of the Fundamental Forces**: Weak Nuclear Force and Gravitational Force.

DARK ENERGY: Roughly 68% of the universe is dark energy. it is a property of space so does not get diluted as space expands. As more space comes into existence, more of this energy-of-space appears. As a result, dark energy causes the universe to expand faster and faster.

IMPACTS OF DARK MATTER AND DARK ENERGY ON UNIVERSE

- While Dark matter exerts a "pull" on the universe, Dark Energy has a contrasting expansionary effect. As is it evident, our universe is expanding, indicating that Dark Energy has a greater abundance than dark matter. By the laws of cosmology, the total amount of

mass in the universe cannot increase. Hence while the amount of Dark matter remains constant, Dark Energy which is a property of space itself is bound to increase exponentially. Eventually, Dark energy would overcome the influence of dark matter and lead to further expansion of the universe.

➡ GOD PARTICLE

- Peter Higgs suggested that particles did not have mass just after Big Bang. As the universe cooled and temperature fell below the critical point, an invisible force field got formed which has been termed the Higgs Field.
- The associated particles with the Higgs field have been termed the **Higgs Boson.** It has been theorized that any particle that interacted with these Higgs Boson got mass and those particles that were left out of the Higgs field remained massless.
- As these Higgs Bosons have the capability to grant mass, the primary condition for the existence of matter, they were termed as the God particle.
- The Big Bang Theory is the leading explanation about how the universe began. It talks about the universe as we know it starting with a small singularity, then inflating over the next 13.8 billion years to the cosmos that we know today.

➡ SOLAR ECLIPSE

- A solar eclipse occurs when the **moon gets between Earth and the sun**, and the moon casts a shadow over Earth. A solar eclipse can only take place at the phase of new moon, when the moon passes directly between the sun and Earth and its shadows fall upon Earth's surface.
- There are four types of solar eclipses: total, annular, partial and hybrid.

TOTAL SOLAR ECLIPSES



- The sun's 864,000-mile diameter is fully 400 times greater than that of our moon, which measures just about 2,160 miles. But the moon also happens to be about 400 times closer to Earth than the sun (the ratio varies as both orbits are elliptical), and as a result, when the orbital planes intersect and the distances align favorably, the new moon can appear to completely blot out the disk of the sun.
- On the **average a total eclipse occurs somewhere on Earth about every 18 months.**
- There are actually two types of shadows: the **umbra i**s that part of the shadow where all sunlight is blocked out. The umbra takes the shape of a dark, slender cone. It is surrounded

by the **penumbra**, a lighter, funnel-shaped shadow from which sunlight is partially obscured.

- During a total solar eclipse, the moon casts its umbra upon Earth's surface; that shadow can sweep a third of the way around the planet in just a few hours. Those who are fortunate enough to be positioned in the direct path of the umbra will see the sun's disk diminish into a crescent as the moon's dark shadow rushes toward them across the landscape.
- During the brief period of totality, when the sun is completely covered, the beautiful corona — the tenuous outer atmosphere of the sun — is revealed. Totality may last as long as 7 minutes 31 seconds, though most total eclipses are usually much shorter.

PARTIAL SOLAR ECLIPSES



- A **partial solar eclipse occurs when only the penumbra (the partial shadow) passes over you**. In these cases, a part of the sun always remains in view during the eclipse. How much of the sun remains in view depends on the specific circumstances.
- Usually the penumbra gives just a glancing blow to our planet over the polar regions; in such cases, places far away from the poles but still within the zone of the penumbra might not see much more than a small scallop of the sun hidden by the moon. In a different scenario, those who are positioned within a couple of thousand miles of the path of a total eclipse will see a partial eclipse.
- The closer you are to the path of totality, the greater the solar obscuration. If, for instance, you are positioned just outside of the path of the total eclipse, you will see the sun wane to a narrow crescent, then thicken up again as the shadow passes by.

ANNULAR SOLAR ECLIPSES



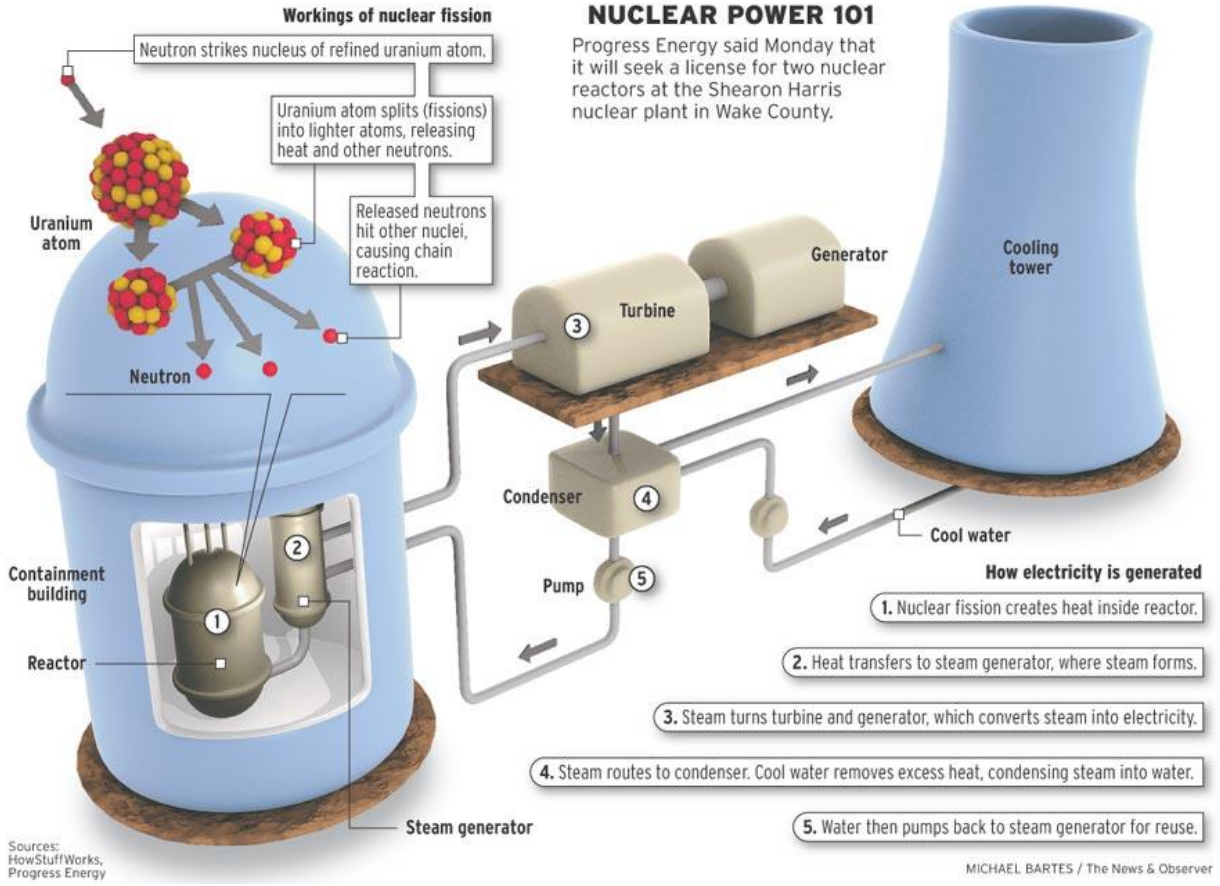
- An annular eclipse, though a rare and amazing sight, is far different from a total one.
- The sky will darken ... somewhat; a sort of weird twilight since so much of the sun still shows. The annular eclipse is a subspecies of a partial eclipse, not total. The maximum duration for an annular eclipse is 12 minutes 30 seconds.
- However, an annular solar eclipse is similar to a total eclipse in that the moon appears to pass centrally across the sun. The difference is, the moon is too small to cover the disk of the sun completely. Because the moon circles Earth in an elliptical orbit, its distance from Earth can vary from 221,457 miles to 252,712 miles. But the dark shadow cone of the moon's umbra can extend out for no longer than 235,700 miles; that's less than the moon's average distance from Earth.

- So if the moon is at some greater distance, the tip of the umbra does not reach Earth. During such an eclipse, the **antumbra**, a theoretical continuation of the umbra, reaches the ground, and anyone situated within it can look up past either side of the umbra and see an **annulus, or "ring of fire"** around the moon.

HYBRID SOLAR ECLIPSES

- These are also called **annular-total ("A-T") eclipses**. This special type of eclipse occurs when the moon's distance is near its limit for the umbra to reach Earth. In most cases, an A-T eclipse starts as an annular eclipse because the tip of the umbra falls just short of making contact with Earth; then it becomes total, because the roundness of the planet reaches up and intercepts the shadow tip near the middle of the path, then finally it returns to annular toward the end of the path.
- Because the moon appears to pass directly in front of the sun, total, annular and hybrid eclipses are also called **"central" eclipses** to distinguish them from eclipses that are merely partial.
- Of all solar eclipses, about 28% are total; 35% are partial; 32% annular; and just 5% are hybrids.

➡ NUCLEAR REACTOR



- A nuclear reactor is the most important part of a nuclear power plant. It is where the **nuclear chain reactions occur** that produce energy by fission. The heat thus produced can be used to produce electricity.
- The **main purpose of a reactor is to contain and control the energy released**.
- **Uranium** is used as the nuclear fuel in the reactors.
- The heat produced by **nuclear reactions is used to convert the water into steam**, which is further converted into **carbon-free electricity** with the help of turbines.

MAIN COMPONENTS OF A NUCLEAR REACTOR

Core	It contains all the fuel and generates the heat required for energy production.
Coolant	It passes through the core, absorbing the heat and transferring into turbines.
Turbine	Transfers energy into the mechanical form.
Cooling Tower	It eliminates the excess heat that is not converted or transferred.
Neutron Moderator	Moderators are used for reducing the speed of fast neutrons released from the fission reaction and making them capable of sustaining a nuclear chain reaction Usually, water, solid graphite, and heavy water are used as a moderator in nuclear reactors. Commonly-used moderators include regular (light) water (in 74.8% of the world's reactors), solid graphite (20% of reactors), heavy water (5% of reactors).
Containment	The enveloping structure that separates the nuclear reactor from the surrounding environment.
Neutron Poison	A neutron poison (also called a neutron absorber or a nuclear poison) is a substance with a large neutron absorption cross-section.

TYPES OF NUCLEAR REACTOR

Light Water Reactors (LWR)	○ LWR is a type of **Thermal Neutron Reactor**. ○ Uses **Normal Water** instead of Heavy Water as its coolant and Neutron Moderator. ○ BWR & PWR are Light Water Reactors. ○ The BWR drives the steam turbine when the reactor core **heats the water converting it into steam**. ○ The PWR drives the **steam turbine in two stages**. ○ **Pressurized water has a higher boiling point**. The reactor core heats the water without producing any steam in the core. ○ This pressurized hot water then exchanges heat with a **secondary low-pressure water** unit which turns into steam. ○ This steam drives the steam turbine.

Heavy Water Reactors	○ HWR is also a type of **Thermal Neutron Reactor**. ○ Uses **Heavy Water (deuterium oxide D2O)** as its coolant and Neutron Moderator. ○ The HWR follows the working principle of the Pressurized Water Reactor. ○ Even though **Heavy Water is very expensive**, it allows the nuclear reactor to operate without any fuel enrichment due to the enhanced neutron economy. ○ This also allows the Nuclear reactor to use alternate fuel cycles.
Gas-Cooled Reactors	○ In Gas-Cooled reactors, gas is replaced as a **coolant** and that drives the turbine. ○ These reactors are called **High-Temperature Gas-Cooled Reactors (HTGRs).** ○ Gases like **Helium & Carbon-Dioxide** are used as coolants. ○ HTGRs provide high thermal efficiency (Upto 50%) as they can operate at high temperatures. ○ HTGRs can have multiple applications other than power production which involve heat processes like hydrogen fuel cells, water desalination, oil refineries, etc. ○ Gas being, not the most efficient coolant, HTGRs need a highly-efficient back-up coolant.
Fast Reactors	○ The reactors discussed above use moderators that slow the high-energy (fast) neutrons down to low-energy (slow). ○ Fast reactors don't use moderators and use Fast Neutrons. ○ To sustain the fission reaction by fast neutrons, the fission material needs to be highly enriched. ○ Uranium enrichment is very expensive thus making the use of Fast reactors uneconomical.

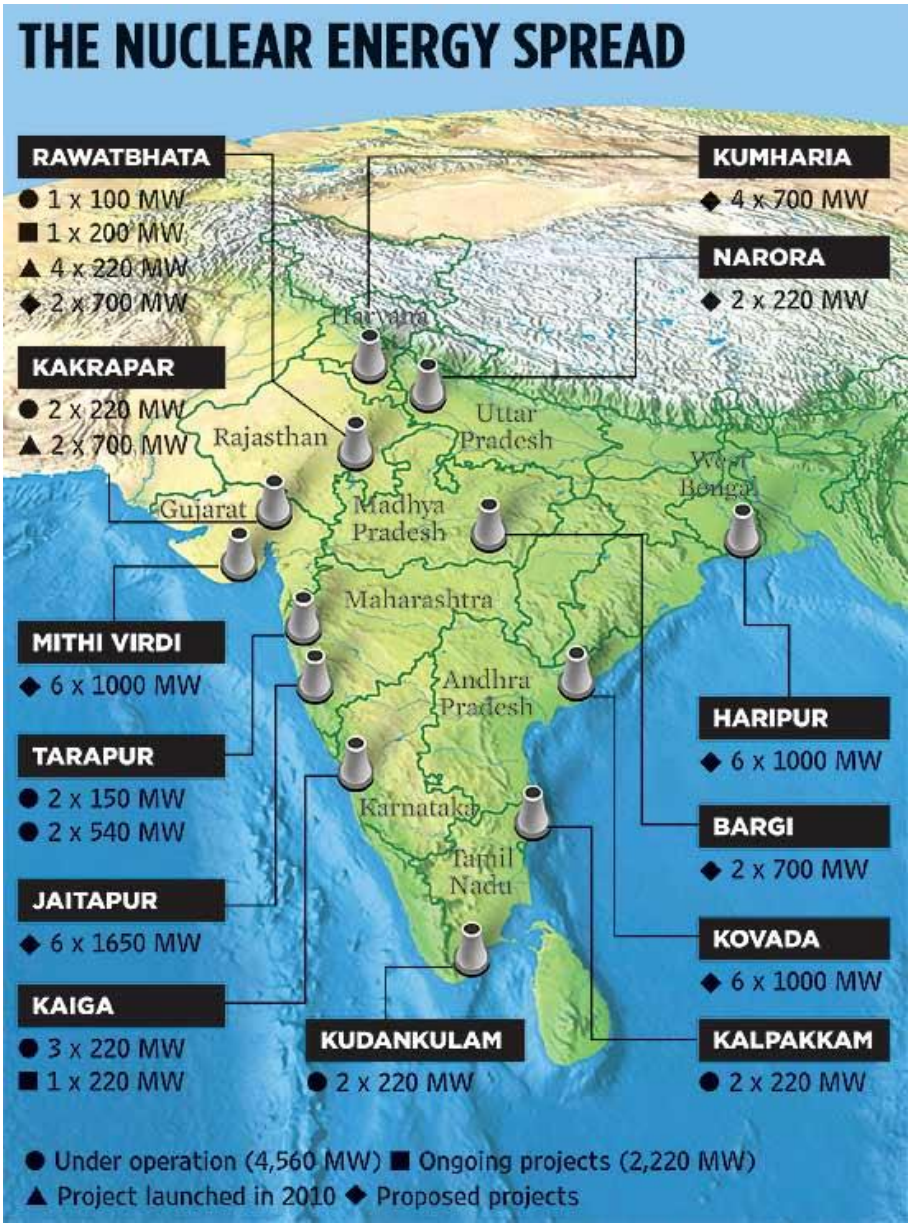
WHAT IS CRITICAL MASS?

- A critical mass is the **smallest amount of fissile material needed for a sustained nuclear chain** reaction.
- The critical mass of a fissionable material depends upon its nuclear properties, its density, its shape, its enrichment, its purity, its temperature, and its surroundings.
- When a nuclear chain reaction in a mass of fissile material is self-sustaining, the mass is said to be in a critical state in which there is no increase or decrease in power, temperature, or neutron population.

➡ NUCLEAR ENERGY

- India has consciously proceeded to explore the possibility of tapping nuclear energy for the purpose of power generation.

- In this direction a **three-stage nuclear power programme** was formulated by **Homi Bhabha in the 1950s.**
- The **Atomic Energy Act, 1962** was framed and implemented with the set objectives of using two naturally occurring elements Uranium and Thorium as nuclear fuel in Indian Nuclear Power Reactors.
- In December, 2021, the Government of India informed Parliament about building ten indigenous Pressurised Heavy Water Reactors (PHWRs) to be set up in fleet mode and had granted "in principle approval" for 28 additional reactors, including 24 to be imported from France, the U.S. and Russia.



- Recently, the Centre has given in-principle (first step) approval for setting up of six nuclear power reactors at **Jaitapur in Maharashtra**.
- Jaitapur would be the world's most powerful nuclear power plant. There would be six state-of-the-art Evolutionary Power Reactors (EPRs) with an installed capacity of 9.6 GWe that will produce low carbon electricity.
- The six nuclear power reactors, which will have a capacity of 1,650 MW each, will be set up with technical cooperation from France.

WHY NUCLEAR ENERGY?

Availability of Thorium	○ India is the leader of the new resource of nuclear fuel called Thorium, which is considered to be the nuclear fuel of the future. ○ With the availability of Thorium, India has the potential to be the first

	nation to realise the dream of a fossil fuel-free nation.
Cuts Import Bills	○ Nuclear energy will also relieve the nation of about $100 billion annually which we spend on importing petroleum and coal.
Stable and Reliable Source	○ The greenest sources of power are definitely solar and wind. But solar and wind power, despite all their advantages, are not stable and are dependent excessively on weather and sunshine conditions. ○ Nuclear power, on the other hand, provides a relatively clean, high-density source of reliable energy with an international presence.
Cheaper to Run	○ Nuclear power plants are cheaper to run than their coal or gas rivals. It has been estimated that even factoring in costs such as managing radioactive fuel and disposal nuclear plants cost between 33 to 50% of a coal plant and 20 to 25% of a gas combined-cycle plant.

CHALLENGES TO ADOPTION OF NUCLEAR ENERGY

Capital Intensive	Nuclear power plants are capital intensive and recent nuclear builds have suffered major cost overruns.
Insufficient Nuclear Installed Capacity	In 2008, the Atomic Energy Commission projected that India would have 650GW of installed capacity by 2050; the current installed capacity is only 6.78 GW.
Lack of Public Funding	Nuclear power has never received the quantum of generous subsidy the fossil fuel received in the past and renewable is receiving currently. In absence of public funding, nuclear power will find it tough to compete against natural gas and renewables in the future.
Acquisition of Land	Land acquisition and selection of location for Nuclear Power Plant (NPP) is also a major problem in the country. NPP's like Kudankulam in Tamil Nadu and Kovvada in Andhra Pradesh have met with several delays due to the land acquisition related challenges.
Impact of Climate Change	Climate change will increase the risk of nuclear reactor accidents. During the world's increasingly hot summers, several nuclear power plants have already had to be temporarily shut down or taken off the grid. Further, nuclear power plants depend on nearby water sources to cool their reactors, and with many rivers drying up, those sources of water are no longer guaranteed. The frequency of such extreme weather events is likely to increase in the future.
Nuclear Waste	Another side effect of nuclear power is the amount of nuclear waste it produces. Nuclear waste can have drastically bad effects on life, causing cancerous growths, for instance, or causing genetic problems for many generations of animals and plants.

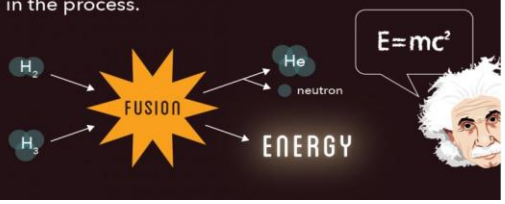
➡ NUCLEAR FUSION

How does FUSION ENERGY work?

Fusion is the energy source of the SUN AND STARS. Scientists think it has the potential to provide virtually limitless CARBON-FREE ELECTRICITY to power our lives on Earth.



Fusion is a NUCLEAR REACTION that occurs when two light nuclei smash together and *fuse* to create a heavier nucleus -- releasing energy in the process.



HOW TO MAKE FUSION

By replicating the conditions in the core of the Sun, scientists hope to create a STAR ON EARTH, allowing them to study fusion reactions as they happen.

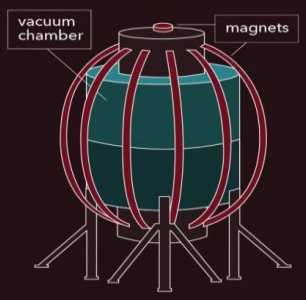
1. CREATE PLASMA. Plasma is one of the four states of matter (the others are liquid, solid and gas). Lightning, the Sun and the inside of lit fluorescent light bulbs are examples. In the lab, scientists superheat hydrogen gas to create and energize plasma.
2. APPLY PRESSURE. Pressure keeps the plasma bottled up and the nuclei colliding with each other. The fusion reactions powering the Sun rely on gravity for this confining force. On Earth, we use powerful magnetic fields to confine the plasma.
3. REPEAT. The Sun is a continuous fusion reaction. Even though not every collision creates fusion, the ones that do produce enough energy to keep it burning. Scientists hope to create a continuous fusion reaction inside a special machine called a tokamak.

FUSION MACHINES

A TOKAMAK is an experimental machine designed to create and study fusion reactions. These machines generate a doughnut-shaped plasma in a vacuum chamber and heat it up until it's hotter than the center of the sun.

America's newest tokamak lives at the Department of Energy's PRINCETON PLASMA PHYSICS LABORATORY. And it just received a big upgrade.

- 100 MILLION DEGREE PLASMAS
- 2X THE MAGNETIC FIELD OF ITS PREDECESSOR
- 2X THE POWER TO HEAT THE PLASMA
- 5X THE PLASMA LIFETIME
- 8 FAST CAMERAS TAKING UP TO 400,000 FRAMES PER SECOND
- 30 EXPERIMENTS PER DAY
- 60 RESEARCH INSTITUTIONS COLLABORATING



NSTX-U
National Spherical Torus Experiment - Upgrade

A FUSION POWER PLANT?

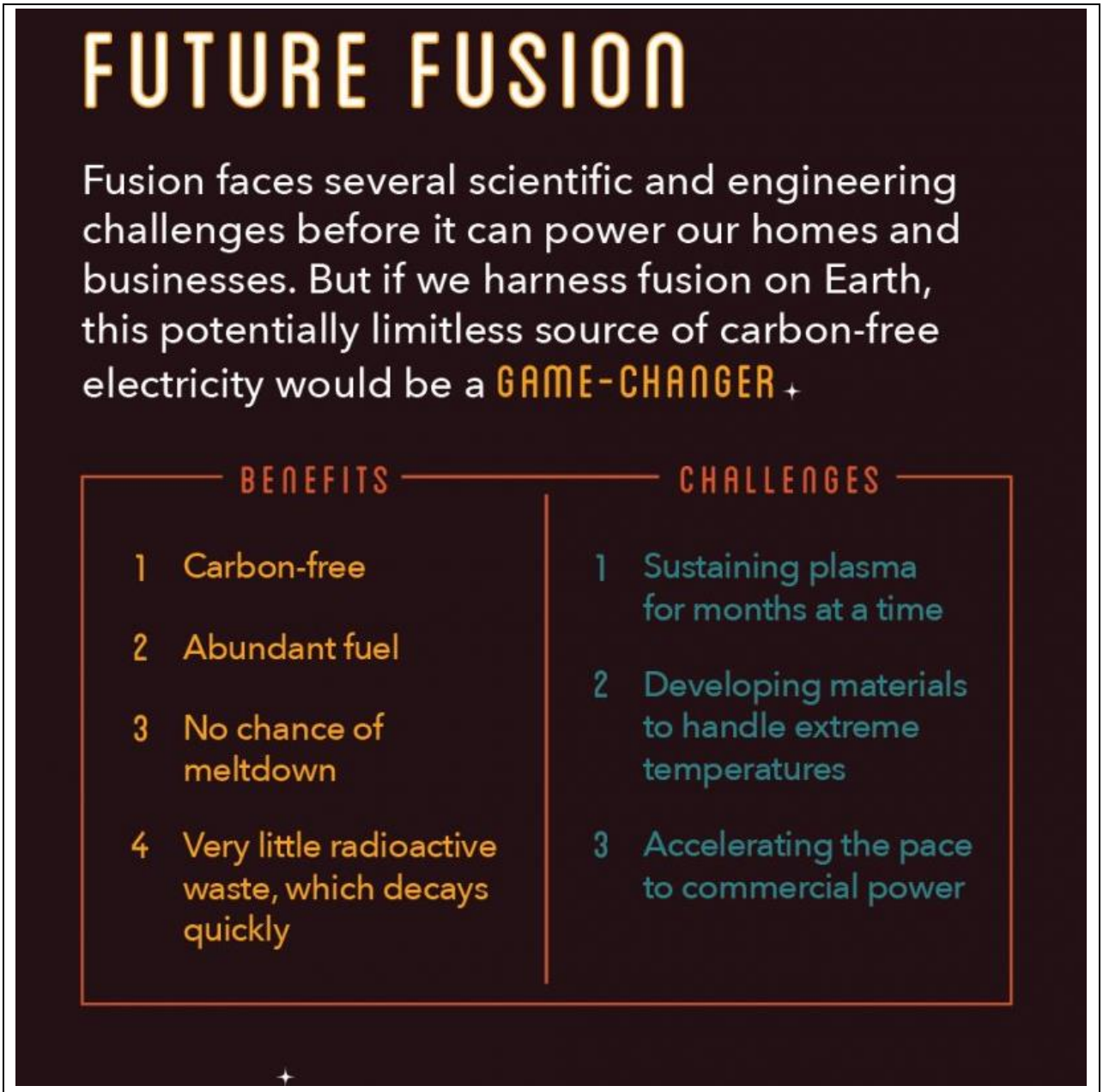
Creating fusion reactions in the lab takes a lot of energy. For fusion to work as a source of electricity, scientists need to learn how to harness a SELF-SUSTAINING PLASMA that produces more energy than what's needed to create it.

In a fusion power plant, the plasma's thermal energy would heat water, create steam and spin a turbine to generate electricity.



Unlike a traditional power plant, the fuel would practically NEVER RUN OUT.

The hydrogen isotope deuterium used as fuel is derived from ordinary seawater



➡ ATOMIC ENERGY REGULATORY BOARD (AERB)

- The Atomic Energy Regulatory Board (AERB) was constituted on November 15, 1983, by the President of India by exercising the powers conferred by the **Atomic Energy Act, 1962** to carry out certain regulatory and safety functions under the Act.
- The regulatory authority of AERB is derived from the rules and notifications promulgated under the Atomic Energy Act, 1962 and the Environment Protection Act, 1986.
- AERB's headquarters is in Mumbai.
- The Atomic Energy Regulatory Board is the primary institution tasked to look at issues regarding everything related to nuclear safety. It was constituted on **15 November 1983** by

the President of India by exercising the powers conferred by **Section 27 of the Atomic Energy Act, 1962**.

- The mission of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health and the environment. Currently, the Board consists of a full-time Chairman, an ex officio Member, three part-time Members, and a Secretary.

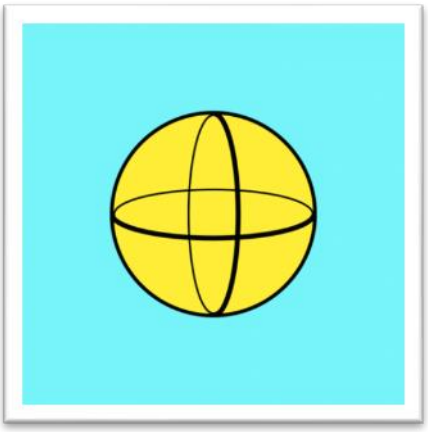
FUNCTIONS OF AERB

- Develop safety policies in nuclear, radiation, and industrial safety areas for facilities under its purview.
- Develop Safety Codes, Guides, and Standards for siting, design, construction, commissioning, operation and decommissioning of different types of nuclear and radiation facilities.
- Grant consents for siting, construction, commissioning, operation and decommissioning, after an appropriate safety review and assessment, for the establishment of nuclear and radiation facilities.
- Ensure compliance with the regulatory requirements prescribed by AERB.
- Prescribe the acceptance limits of radiation exposure to occupational workers and members of the public and acceptable limits of environmental releases of radioactive substances.
- Review the emergency preparedness plans for nuclear and radiation facilities.
- Prescribe the syllabi for training and review the training program, qualifications, and licensing policies for personnel of nuclear and radiation facilities.
- Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.
- Promote research and development efforts in the areas of safety.
- Notifying the public, the 'nuclear incident', occurring in the nuclear installations in India, as mandated by the Civil Liability for Nuclear Damage Act, 2010.

TECHNOLOGY

➡ QUANTUM COMPUTER

- *A quantum computer harnesses some of the almost-mystical phenomena of quantum mechanics to deliver huge leaps forward in processing power. Quantum machines promise to outstrip even the most capable of today's—and tomorrow's—supercomputers***.**
- *The secret to a quantum computer's power lies in its ability to generate and manipulate* ***quantum bits****, or qubits.*



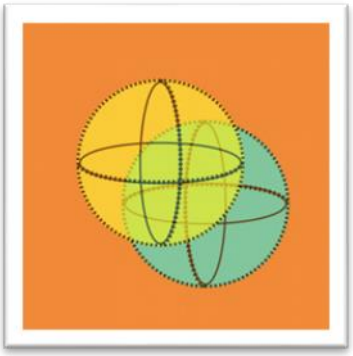
WHAT IS A QUBIT?

- Today's computers use bits—a stream of electrical or optical pulses representing 1s or 0s. Everything from

your tweets and e-mails to your iTunes songs and YouTube videos are essentially long strings of these binary digits.

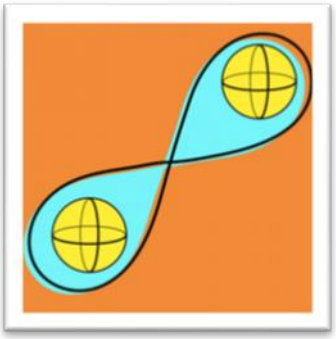
- Quantum computers, on the other hand, use qubits, which are typically **subatomic particles such as electrons or photons.** Generating and managing qubits is a scientific and engineering challenge. Some companies, such as IBM, Google, and Rigetti Computing, use superconducting circuits cooled to temperatures colder than deep space. Others, like IonQ, trap individual atoms in electromagnetic fields on a silicon chip in ultra-high-vacuum chambers. In both cases, the goal is to isolate the qubits in a controlled quantum state.
- Qubits have some quirky quantum properties that mean a connected group of them can provide way more processing power than the same number of binary bits. One of those properties is known as **superposition** and another is called **entanglement.**

WHAT IS SUPERPOSITION?



- Qubits can represent numerous **possible combinations of 1 and 0** at the same time. This ability to simultaneously be in **multiple states is called superposition**. To put qubits into superposition, researchers manipulate them using precision lasers or microwave beams.
- Thanks to this counterintuitive phenomenon, a quantum computer with several qubits in superposition can crunch through a vast number of potential outcomes simultaneously. The final result of a calculation emerges only once the qubits are measured, which immediately causes their quantum state to "collapse" to either 1 or 0.

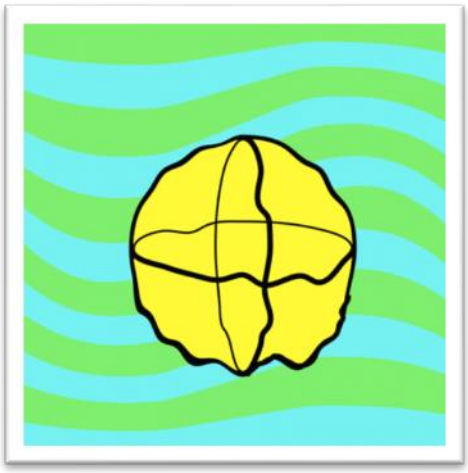
WHAT IS ENTANGLEMENT?



- Researchers can generate pairs of qubits that are "entangled," which means the two members of a pair exist in a single quantum state. Changing the state of one of the qubits will instantaneously change the state of the other one in a predictable way. This happens even if they are separated by very long distances.
- Nobody really knows quite how or why entanglement works. It even baffled Einstein, who famously described it as "spooky action at a distance." But it's key to the power of quantum computers. In a conventional computer, doubling the number of bits doubles its processing power. But thanks to entanglement, adding extra qubits to a quantum machine produces an exponential increase in its number-crunching ability.
- Quantum computers harness entangled qubits in a kind of quantum daisy chain to work their magic. The machines' ability to speed up calculations using specially designed quantum algorithms is why there's so much buzz about their potential.
- That's the good news. The bad news is that quantum machines are way more error-prone than classical computers because of **decoherence.**

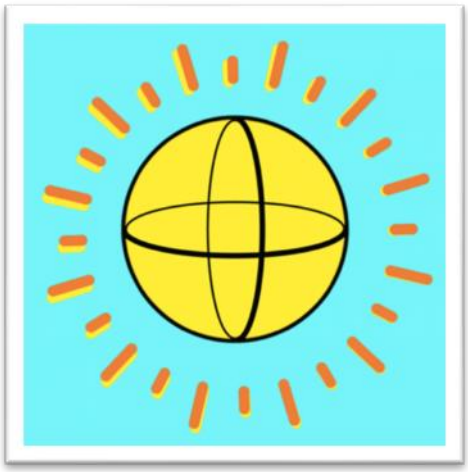
WHAT IS DECOHERENCE?

- The interaction of qubits with their environment in ways that cause their quantum behaviour to decay and ultimately disappear is called **decoherence.**



- Their quantum state is extremely fragile. The slightest **vibration or change in temperature—disturbances known as "noise" in quantum-speak**—can cause them to tumble out of superposition before their job has been properly done. That's why researchers do their best to protect qubits from the outside world in those supercooled fridges and vacuum chambers.
- But despite their efforts, noise still causes lots of errors to creep into calculations. Smart quantum algorithms can compensate for some of these, and adding more qubits also helps. However, it will likely take thousands of standard qubits to create a single, highly reliable one, known as a "logical" qubit. This will sap a lot of a quantum computer's computational capacity.
- And there's the rub: so far, researchers haven't been able to generate more than 128 standard qubits (see our qubit counter here). So we're still many years away from getting quantum computers that will be broadly useful.
- That hasn't dented pioneers' hopes of being the first to demonstrate **"quantum supremacy."**

WHAT IS QUANTUM SUPREMACY?



- It's the point at which a **quantum computer can complete a mathematical calculation** that is demonstrably beyond the reach of even the most powerful supercomputer.
- It's still unclear exactly how many qubits will be needed to achieve this because researchers keep finding new algorithms to boost the performance of classical machines, and supercomputing hardware keeps getting better. But researchers and companies are working hard to claim the title, running tests against some of the world's most powerful supercomputers.
- There's plenty of debate in the research world about just how significant achieving this milestone will be. Rather than wait for supremacy to be declared, companies are already starting to experiment with quantum computers made by companies like IBM, Rigetti, and D-Wave, a Canadian firm. Chinese firms like Alibaba are also offering access to quantum machines. Some businesses are buying quantum computers, while others are using ones made available through cloud computing services.

WHERE IS A QUANTUM COMPUTER LIKELY TO BE MOST USEFUL FIRST?

- One of the most promising applications of quantum computers is for **simulating the behaviour of matter down to the molecular level.** Auto manufacturers like Volkswagen and Daimler are using quantum computers to **simulate the chemical**

composition of electrical-vehicle batteries to help find new ways to improve their performance. And pharmaceutical companies are leveraging them to **analyze and compare compounds that could lead to the creation of new drugs**.

- The machines are also great for optimization problems because they can crunch through vast numbers of potential solutions extremely fast. Airbus, for instance, is using them to help **calculate the most fuel-efficient ascent and descent paths for aircraft**. And Volkswagen has unveiled a service that calculates the optimal routes for buses and taxis in cities in order to minimize congestion. Some researchers also think the machines could be used to accelerate artificial intelligence.
- It could take quite a few years for quantum computers to achieve their full potential. Universities and businesses working on them are facing a shortage of skilled researchers in the field—and a lack of suppliers of some key components. But if these exotic new computing machines live up to their promise, they could transform entire industries and turbocharge global innovation.

➡ SUPERCOMPUTER OF META

Facebook-parent Meta announced that it is building an AI supercomputer, the AI Research SuperCluster (RSC) which will be the fastest supercomputer in the world once fully built by mid-2022.

WHAT ARE SUPERCOMPUTERS?

- A supercomputer can perform high-level processing at a faster rate when compared to a normal computer.
- Supercomputing is measured in **floating-point operations per second (FLOPS).**
- Supercomputers are made up of thousands of powerful machines which use better artificial intelligence (AI) models to improve operations processing huge amounts of data in less time.
- They work together to perform complex operations that are not possible with normal computing systems.
- AI supercomputers are built by combining **multiple graphic processing units (GPUs)** into compute nodes, which are then connected by a high-performance network fabric to allow fast communication between those GPUs.

WHAT IS THE RSC?

- RSC is a **powerful supercomputer that can perform tasks** like translating text between languages and help identify potentially harmful content on Meta's platform.
- It can run **computer vision workflows up to 20 times faster**.
- It can train **large-scale Natural Language Processing (NLP) models** 3 times faster.
- It can help its researchers build better AI models that can work across different languages, seamlessly analyse text, images and video together.
- It also powers real-time voice translations to large groups of people speaking different languages so that they can collaborate on a research project, and develop new augmented reality tools.

WHAT IS THE ROLE OF SUPERCOMPUTERS AND RSC IN THE METAVERSE?

- The AI supercomputers will help build the foundation of metaverse to create AI agents in that environment for

  - rich user interaction
  - mimicking the real world
  - provide high-performance computing to specific tasks

- Meta computes that RSC will pave the way toward building technologies for the metaverse where AI-driven applications and products will play an important role.
- RSC can keep people safe in the metaverse through its training models that can detect harmful content faster than earlier systems.

➡ GEOSPATIAL TECHNOLOGY

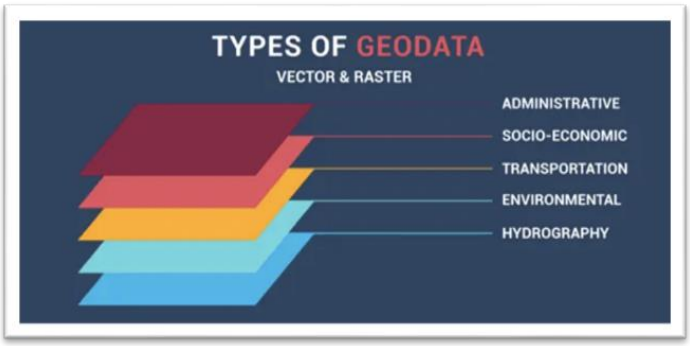
- *India has a robust ecosystem in geospatial, with the Survey of India (SoI), the Indian Space Research Organisation (ISRO), remote sensing application centres (RSAC)s, and the National Informatics Centre (NIC) in particular, and all ministries and departments, in general, using geospatial technology.*
- ***Geospatial definition:** Any data that is **indicated by or related to a geographic location**. Geospatial technology collects and analyzes the geospatial data.*
- *Among the most prominent hurdles is the absence of a sizeable geospatial market in India. There is no demand for geospatial services and products on a scale linked to India's potential and size. This is mainly due to the lack of awareness among potential users in government and private. The other hurdle has been the lack of skilled manpower across the entire pyramid.*

WHAT IS GEOSPATIAL DATA?

- Geospatial data, also known as **geodata**, has locational information connected to a dataset such as address, city or ZIP code. Geospatial data can also come from Global Positioning System (GPS) data, geospatial satellite imagery, telematics devices, IoT and geotagging.

WHAT ARE THE TYPES OF GEOSPATIAL DATA?

The two main types of geospatial data are **vector data** and **raster data**.



- **Vector Data**: Uses **geometric shapes to show the location and shape of geographic features**. Points, lines and polygons can represent things like cities, roads and waterways. Vector data is scalable, has small file sizes and ideal for depicting boundaries.

- **Raster Data**: Represents **data through a digital image** such a scanned map or photograph. It also includes aerial and satellite imagery. Raster data uses a cell-based format called stairsteping to record data as pixels or grids with an image. Spatial analysis depends heavily on raster datasets.

WHAT IS GEOSPATIAL TECHNOLOGY?

- Geospatial technology is used to collect, analyse and store geographic information. It uses software to map geographic locations while analysing the impact of human activity.
- Geographic Information System (GIS) uses digital software to combine maps and datasets about environmental events and socioeconomic trends.
- GIS creates layered maps to better analyse complex data. The layering is possible because each data point is connected to a precise location on Earth. Other forms of geospatial technology include GPS, remote sensing, and geofencing.

A BRIEF HISTORY OF GEOSPATIAL

- One of the biggest moments **in geospatial history was the launch of Google Maps in 2005**. It made mapping technology available to a mass audience.
- But the seeds for what we know of geospatial technology today were **first planted in 1832**. During a cholera outbreak in Paris that year, French cartographer **Charles Picquet created one of the first heat maps** to show where the incidents of illness were concentrated.
- When **cholera struck London in 1854, physician John Snow built upon the Paris example**. In addition to making a map that depicts the location of cholera deaths, he used spatial analysis of the data to show the connection between contaminated water sources and cholera.
- By the early **1900s, photozincography** was invented. It was a form of map printing with separate layers. Each layer could visually represent data on the map.
- In the 1960s, Roger Tomlinson pioneered the concept of a Geographic Information System (GIS) that took traditional cartography to a new level. The advent of satellites focused on national security, scientific, and commercial ventures provided images of the Earth's surface and human activity for the first time, opening up more ways to visualize data. A GIS combines a base map with the capture, manipulation and management of data. A GIS map can contain unlimited amounts of data. This geospatial data not only lets users visualize and analyze the data, it helps users better understand trends, relationships and patterns.
- GIS was further refined until the early 2000s when Google Maps produced a user-friendly version for the masses in 2005.
- Since then, geospatial technology has evolved from the desktop to a cloud-based system. Geospatial databases used to be proprietary but open source software has changed that, making access to this type of information more widespread.

GEOSPATIAL TECHNOLOGIES:

Geospatial technologies provide data for a number of industries that include the military, utility companies, urban planners and industrial engineers. The application of geospatial data is useful for biodiversity conservation, forest fire suppression, agricultural monitoring, humanitarian relief and any field that could benefit from better visualization and analysis of geographic data.

- **Remote Sensing**: Space or airborne camera and sensor platforms provide imagery and data at great detail. Images that can zoom into less than one meter are available on some commercial satellites.
- **Geographic Information System (GIS):** Offers software that can map a specific geographic location anywhere on Earth and analyze geospatial data. GIS geospatial can also detect patterns in the data.



- **Global Positioning System (GPS):** Provides coordinate locations for military and civilian use.
- **Internet Mapping Technologies**: Google Earth and Microsoft Virtual Earth are examples of geospatial software and geospatial mapping tools that makes it easier for people to view and share geospatial data.

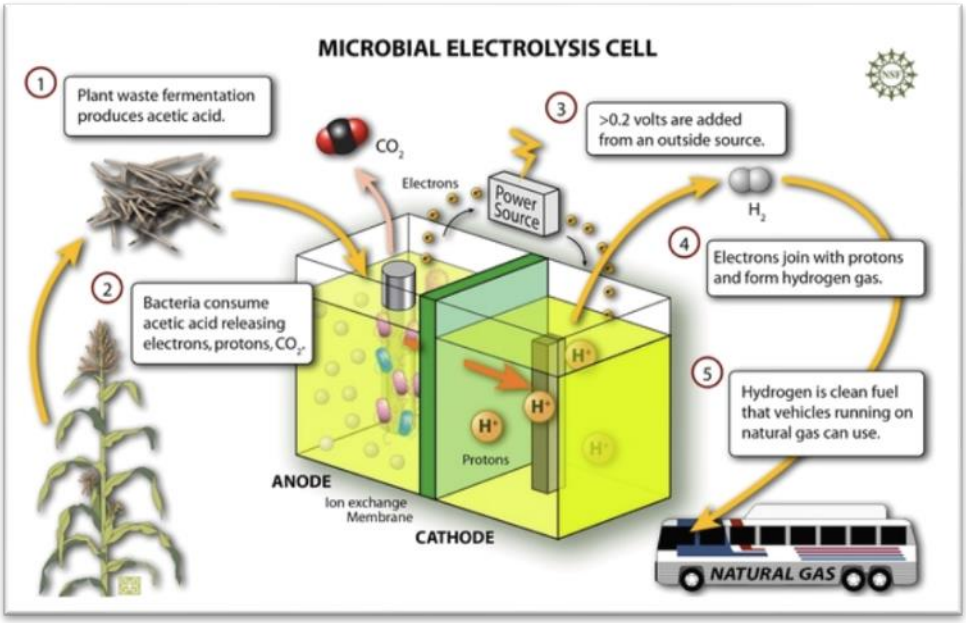
FUTURE OF GEOSPATIAL TECHNOLOGY:

The future of geospatial technology largely involves the further integration of machine learning and AI. Mapping as a service, drones and autonomous vehicles are growth areas driving geospatial technology adoption.

- **Geospatial AI**: Places a geographic component on machine learning. App users can provide real-time information about traffic or other conditions in their surroundings. Myriads of contributors improve the accuracy of geospatial data, allowing for better predictions when managing things like traffic flow. Also known as Geo AI.
- **Autonomous Vehicles**: The eye of an autonomous vehicle is **LiDAR (Light Detection and Ranging),** which is a sensing method that uses pulsed laser light to measure variable distances. Geospatial technology make LiDAR possible and mapping companies will take it to the next level to make autonomous driving safer and more accessible.
- **Mapping as a Service**: Not every map found online is high-resolution. But geospatial mapping technology can make on-demand maps of any location desired. The maps can be created based on customer needs and used for any number of industries, including construction. Geospatial imagery and the Mapping as a Service market could reach $8 billion by 2025.
- **Drones:** Drones used for aerial mapping will become more common. Combined with GIS and high precision sensors, the drone-capture images can fly over acres of land to gather data to influence everything from farming to urban planning.

➡ MICROBIAL FUEL CELL

- The concept behind **microbial fuel cells** is that these rely on bacteria to generate an electrical current.
- These fuel cells have broad usage possibilities and are one of the **cleanest known energy sources.**



- Powered by living microorganisms with clean and sustainable features; they can generate electricity from broad range of organic substrates under natural conditions.
- Microbial fuel production is probably the only technology, in which the electricity is being generated from oxidation of organic compounds in room temperature.
- There is no need to burn anything, and the process is not depending on sunlight
- **Application**-MFC technology is unique because of its multifunctional application: for example, wastewater and slime, collected in wastewater treatment plants can be also used as food for bacteria.
- Although the idea that microorganisms can generate electricity was introduced in 1911, it became more actively investigated in the 2000s. Groups of researchers around the world are working with the MFC technology, attempting to improve the efficiency of the cells.
- **What about the Future?** It is envisaged that the microbial fuel cell (MFC) technology could one day be used in the Developing World in areas lacking sanitation and installed in homes in the Developed World to help clean waste before it flows into the municipal sewerage network, reducing the burden on water companies to treat effluent.

➡ STEM CELL TRANSPLANT

- *A U.S. patient **with leukemia has become the first woman and the third person to date to be cured of HIV after receiving a stem cell transplant from a donor** who was naturally resistant to the virus that causes AIDS.*
- *A **bone marrow transplant is a medical treatment that replaces your bone marrow with healthy cells.** The replacement cells can either come from your own body or from a donor.*

- *A bone marrow transplant* ***is also called a stem cell transplant*** *or, more specifically, a* ***hematopoietic stem cell transplant****.*
- *Transplantation can be used to treat certain types of cancer, such as leukemia, myeloma, and lymphoma, and other blood and immune system diseases that affect the bone marrow.*

WHAT ARE STEM CELLS? WHAT IS BONE MARROW?

- Stem cells are **special cells that can make copies of themselves** and change into the many different kinds of cells that your body needs. There are several kinds of stem cells and they are found in different parts of the body at different times.
- Cancer and cancer treatment can damage your hematopoietic stem cells.
- **Hematopoietic stem cells are stem cells that turn into blood cells**.
- **Bone marrow is soft, spongy tissue** in the body that contains hematopoietic stem cells. It is found in the centre of most bones.
- Hematopoietic stem cells **are also found in the blood** that is moving throughout your body.

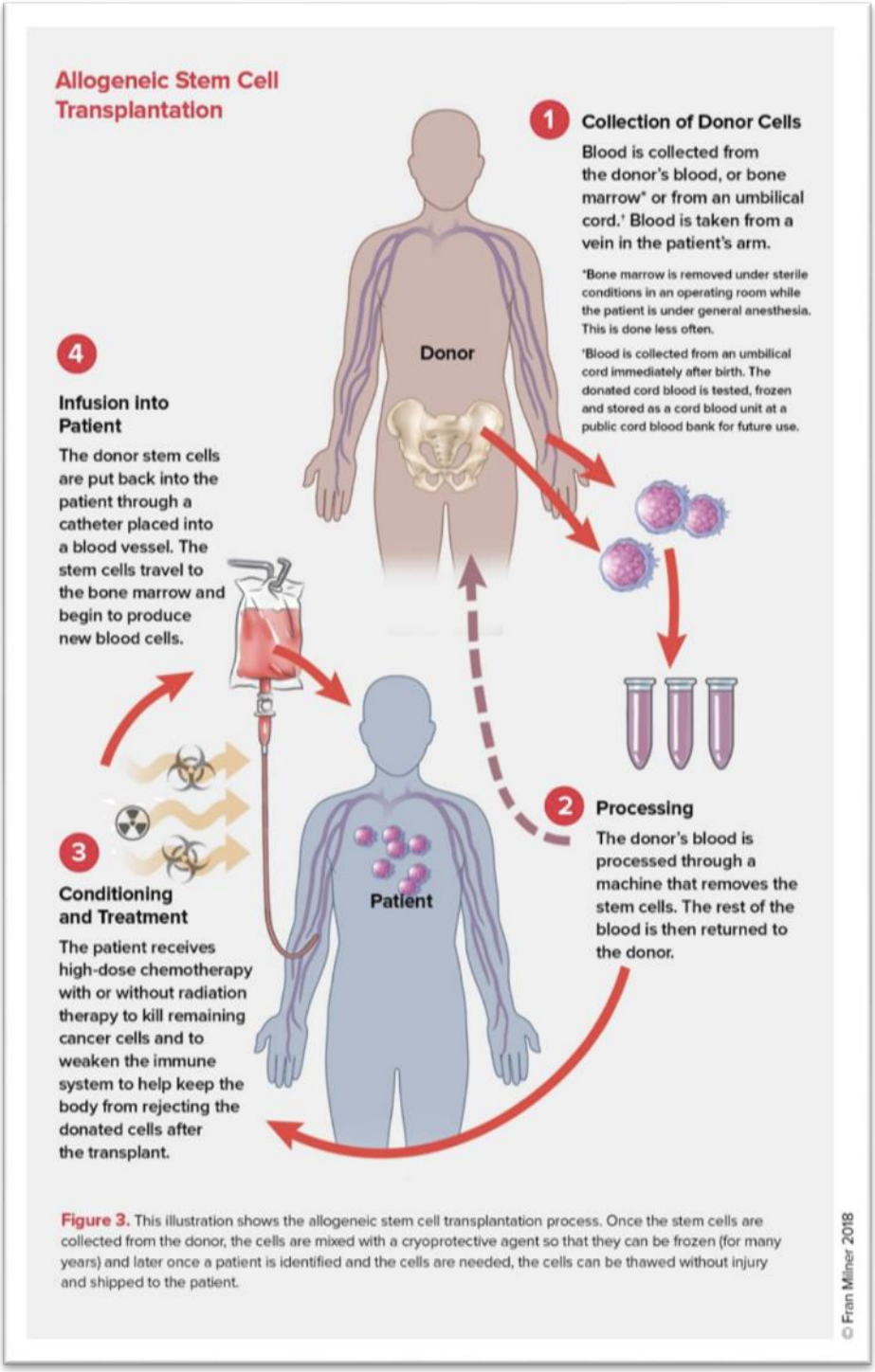


Figure 3. This illustration shows the allogeneic stem cell transplantation process. Once the stem cells are collected from the donor, the cells are mixed with a cryoprotective agent so that they can be frozen (for many years) and later once a patient is identified and the cells are needed, the cells can be thawed without injury and shipped to the patient.

- When hematopoietic stem cells are damaged, they may not become red blood cells, white blood cells, and platelets. These blood cells are very important and each one has a different job:

- **Red blood cells carry oxygen** throughout your body. They also take carbon dioxide to your lungs so that it can be exhaled.
- **White blood cells are a part of your immune system**. They fight pathogens, which are the viruses and bacteria that can make you sick.
- **Platelets form clots to stop bleeding**.

- A bone marrow/stem cell transplant is a medical procedure by which healthy stem cells are transplanted into your bone marrow or your blood. This restores your body's ability to create the red blood cells, white blood cells, and platelets it needs.

WHAT ARE THE DIFFERENT TYPES OF TRANSPLANT?

- There are different types of bone marrow/stem cell transplants. The 2 main types are:

- **Autologous transplant**. Stem cells for an autologous transplant **come from your own body.** Sometimes, cancer is treated with a high-dose, intensive chemotherapy or radiation therapy treatment. This type of treatment can damage your stem cells and your immune system. That's why doctors remove, or rescue, your stem cells from your blood or bone marrow before the cancer treatment begins.
- After chemotherapy, the stem cells are returned to your body, restoring your immune system and your body's ability to produce blood cells and fight infection. This process is also called an **AUTO transplant or stem cell rescue**.

- **Allogenic transplant.** Stem cells for an allogenic transplant **come from another person,** called a donor. The donor's stem cells are given to the patient after the patient has chemotherapy and/or radiation therapy. This is also called an **ALLO transplant**.
- Many people have a “graft-versus-cancer cell effect” during an ALLO transplant. This is when the new stem cells recognize and destroy cancer cells that are still in the body. This is the main way ALLO transplants work to treat the cancer.
- Finding a “donor match” is a necessary step for an ALLO transplant. A match is a healthy donor whose blood proteins, called **human leukocyte antigens (HLA),** closely match yours. This process is called HLA typing.

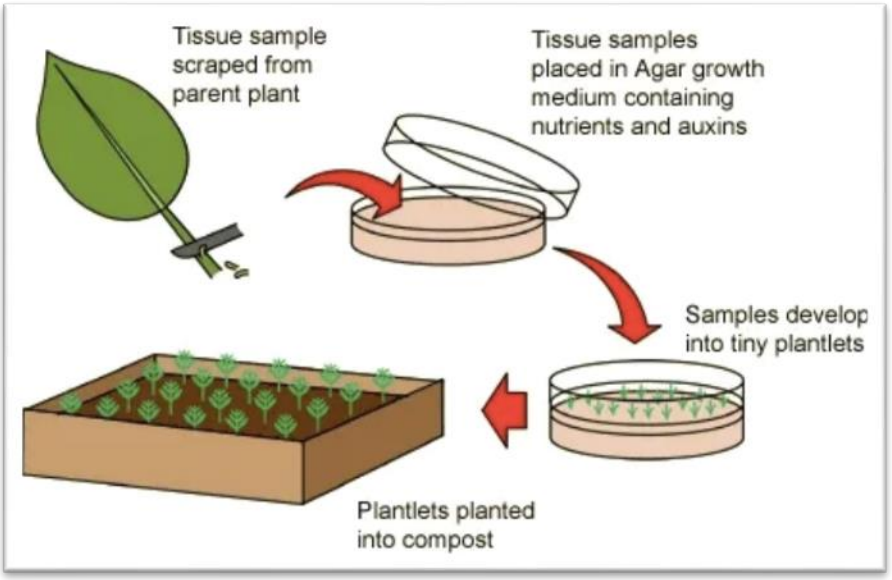
➡ TISSUE CULTURE

- It is the growth of tissues or cells in an **artificial medium separate from the organism**.
- This is typically facilitated via **use of a liquid, semi-solid, or solid growth media**, such as broth or agar. Tissue culture commonly refers to the culture of animal cells and tissues, with the more specific term plant tissue culture being used for plants.
- Tissue culture **means growing cells in vitro**, from tissues taken from a multicellular organism. The term tissue culture is often substituted with the word cell culture.

- After the cells are extracted from a donor organism, they are bathed in the culture medium, which helps in the revival of the cells, as they contain energy sources and important nutrients.

WHAT IS GROWTH MEDIUM OR CULTURE MEDIUM OR NUTRIENT BROTH AND WHAT DOES IT CONTAIN?

- A growth medium or culture medium or nutrient broth **is a solution which is freed of all microorganisms through sterilization**.
- Sterilization is achieved by applying heat under pressure for a specific time period. However, the solution contains all the microorganisms required for growth, such as algae, fungi, bacteria and protozoans.
- When the Agar is added to the medium **it solidifies.**
- Some media are made up of inorganic salts and one or more inorganic compounds. This is a chemical or synthetic defined media.
- Different types of living cells or tissue cultures can also be used as part of the media. There are types of media which are made up of an assortment of ingredients like plant or animal tissue extracts.



- Some of the examples are **peptone, meat extract, yeast extract.**
- There are special-purpose media like enriched media and selective media. Enriched media consists of nutrients that help in growth and selective media consists of substances that help in the growth of selective organisms and prevent the growth of other organisms.

CELLS CAN BE GROWN IN THREE WAYS

- Chemically defined synthetic medium using tissue extract.
- The culture medium of biological origin like blood serum.
- A mixture of the culture medium of biological origin and chemically defined synthetic medium.
- Some of the important prerequisites in a medium are it must have the essential nutrients for the cells in the right proportions and it must be suitably acid or alkaline.

HOW ARE CULTURES GROWN?

- Usually grown as a single layer
- Usually grown either on glass or a plastic surface or as a suspension in a liquid or a semi-solid medium.

HOW TO START A CULTURE?

- A small sample of the tissue is spread out on the medium or in the medium.
- Later the tube or plate or flask containing the culture is incubated.
- The temperature maintained should be approximately that of the tissue environment.
- Usually, at the start of the culture, single cells are used, this results in the growth of clones, which are a set of uniform biological populations.

WHAT ARE PRIMARY CULTURES?

- Primary culture usually involves collecting normal cells, tissues, or organs which are collected through biopsy from a living organism.
- In this type of culture, the cells, tissues and organs under study are functioning as per its natural condition.
- There will be more mutations, change in chromosome structure and cell functions when the samples are maintained in culture for a longer duration.

WHAT IS THE HAYFLICK LIMIT?

- This discovery is named after American Biologist Leonard Hayflick. It is the **point at which cells will stop growing in primary culture.**

HOW TO PROCESS THE CULTURED CELLS AND TISSUES?

- There are different ways of examining the live cultures.
- Directly through microscope
- Photographs and motion pictures were taken through the microscope.
- As per objectives of the experiment, cells, tissues and organs could either be preserved, killed or stained for any additional examination.
- Samples can also be embedded on materials like resin which can be cut into thin sections which will help in discerning further details under light or electron microscope.
- Scientists try to understand the changes in the cells in the tissue culture when they are subjected to numerous experiments by adding viruses, and any type of disease-causing organisms. Even drugs, vitamins and hormones are added to understand how cells will react.

WHAT ARE THE DISCOVERIES IN BIOLOGICAL SCIENCES DUE TO RESEARCH IN TISSUE CULTURE?

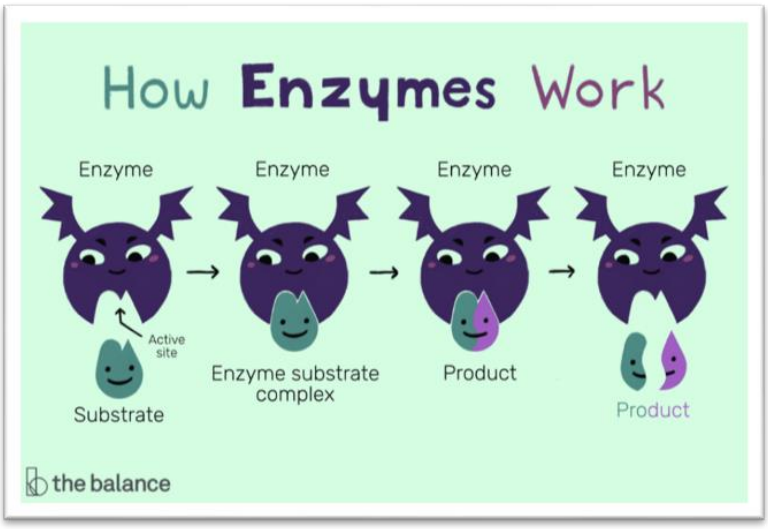
- Information on cells regarding their composition and form.
- The biochemical and genetic activity of cells.
- Metabolism, nutrition and specialized function of cells
- Differences between normal cells and abnormal cells
- The effects caused on cells by physical, chemical and biological agents.
- Assisted in identifying infections, enzyme deficiencies, chromosomal activities.
- Helped in formulating test drugs and vaccines.
- Tissue culture technique helped in developing vaccines for measles, influenza, mumps, poliomyelitis and other infectious diseases. These vaccines played a crucial role in improving the health of the population, especially with regards to the measles and rubella campaign.
- Tissue culture studies have clarified the genetic causes of certain hereditary diseases.

➡ ENZYMES

- Enzymes are proteins made from **amino acids**. It is made up of hundreds and thousands of amino acids stringed together in a very specific and unique order.
- Any chemical reaction inside a cell or any work that goes on inside a cell is the handiwork of enzymes inside the cell.
- The word enzyme was coined in 1878 by German Scientist Wilhelm Kuhne.

HOW DO ENZYMES FUNCTION?

- Enzymes act as **biological catalysts (biocatalysts).**
- Catalysts accelerate chemical reactions.
- The molecules upon which enzymes may act are called **substrates,** and the enzyme converts the substrates into different molecules known as products.
- Almost all metabolic processes in the cell need enzyme catalysis in order to occur at rates fast enough to sustain life.
- Metabolic pathways depend upon enzymes to catalyze individual steps.



- Like all catalysts, enzymes increase the reaction rate by lowering its activation energy. Some enzymes can make their conversion of substrate to product occur many millions of times faster. An extreme example is orotidine 5′-phosphate decarboxylase, which allows a reaction that would otherwise take millions of years to occur in milliseconds.

WHAT ARE THE DIFFERENT TYPES OF ENZYMES?

- **Hydrolases** – They break chemical bonds when water is added. There are more than 200 types of hydrolases.
- **Oxidoreductases** – They are involved in catalyzing oxidation and reduction reactions.
- **Transferases** – Involved in the transfer of functional groups from a donor molecule to an acceptor molecule.
- **Isomerases** – There are 4 different sub-categories under this. They bring about structural changes within the molecule.
- **Ligases** – An example is DNA ligase which catalyzes ligation or repair of breaks in DNA.
- **Lyases** – They are also called synthase enzymes.

5 Examples of Digestive Enzymes

- **Amylase** – helps in breaking down large starch molecules, this enzyme is produced in the mouth.

- **Pepsin** – helps in breaking down proteins, this is produced in the stomach.
- **Trypsin** – helps in breaking down proteins, this is produced in the pancreas.
- **Pancreatic lipase** – helps in breaking down fats, once again this enzyme is produced in the pancreas.
- **Ribonuclease and deoxyribonuclease** – helps in breaking down DNA and RNA, this enzyme is also produced in Pancreas.

➡ MICROCHIP

The Ministry of External Affairs signed an agreement for the second phase of the Passport Seva Programme (PSP) for rolling out of microchip-embedded e-passports.

- The focus will be on faster delivery of passports to the citizens and creating a more effective integration between various wings of the Government like the MEA and the local police network that can work in harmony for verification of applicants and quick tracing in case of emergencies.
- The move is likely to **make passports tamper-proof and facilitate hassle-free immigration** worldwide.
- An e-Passport, also known as an electronic passport or a biometric passport, **combines an electronic chip with a biometric identifier.** The new chip-embedded e-passports will have security elements to prevent unauthorised reading of data stored on the chip.
- A **microchip (sometimes just called a "chip")** is a unit of packaged computer circuitry (usually called an integrated circuit) that is manufactured from a material such as silicon at a very small scale.
- Microchips are **made for program logic** (logic or microprocessor chips) and for computer memory (memory or RAM chips).
- Microchips are also made that include **both logic and memory and for special purposes such as analog-to-digital conversion, bit slicing, and gateways.**
- All passports in India are printed on booklets. Still, this new initiative by the Indian Government is a big step towards adhering to protocols set by the International Civil Aviation Organisation (ICAO).
- Under the second phase, an electronic file system for processing passports across the passport issuance ecosystem; Security Operation Centre (SOC) and monitoring & supervision through a Network Operation Centre (NOC) will also be created.

E-PASSPORT INDIA BENEFITS

1. The e-passport will be secured with biometric data.
2. The e-passport will enable smooth passage through immigration posts worldwide.
3. The e-passport will comply with the International Civil Aviation Organisation (ICAO) standards.
4. The chip on the e-passport will restrict the unauthorised transfer of data through radio-frequency identification (RFID).
5. The e-passport will also deter identity theft and forgery.

➡ FACIAL RECOGNITION TECHNOLOGY (FRT)

- Facial recognition is an algorithm-based technology which **creates a digital map of the face** by identifying and mapping an individual's facial features, which it then matches against the database to which it has access.
- The captured face along with its features is stored into a database, which can be integrated with any kind of software that may be used for security purposes, banking services, etc.
- In the **Automated Facial Recognition System (AFRS),** the large database (containing photos and videos of peoples' faces) is used to match and identify the person.
- Image of an unidentified person, taken from CCTV footage, is compared to the existing database using Artificial Intelligence technology, for pattern-finding and matching.

USES:

1:1 verification:	○ The facial map is obtained for the purpose of matching it against the person's photograph on a database to authenticate their identity. ○ For example, **1:1 verification** is used to unlock phones.
1: n identification:	○ The facial map is obtained from a photograph or video and then matched against the entire database to identify the person in the photograph or video. ○ Law enforcement agencies such as the Delhi Police usually procure FRT for **1: n identification**.

WHY IS THE USE OF FACIAL RECOGNITION TECHNOLOGY HARMFUL?

Inaccuracy & Misuse	○ Issues related to **"Misidentification"** due to inaccuracy of the technology. ○ Issues related to **"Mass Surveillance"** due to misuse of the technology.
Race & Gender	○ It has also been reported that its accuracy rates fall starkly based on race and gender. ○ This can result in a **false positive**, where a person is misidentified as someone else, or a false negative where a person is not verified as themselves. ○ Cases of a false positive result can lead to bias against the individual who has been misidentified.
Exclusion	○ Cases of false negative results can also lead to exclusion of the individual from accessing essential schemes which may use FRT as a means of providing access. ○ For example, failure of the biometric based authentication under Aadhaar which has led to many people being excluded from receiving essential government services which in turn has led to starvation deaths.
Violation to	○ Government although plans to address the question of privacy through

Privacy	the legal framework like data privacy regime, but keeping in mind the objectives it aims to achieve with the use of such technology, it comes into conflict with one another.
Reliability & Authenticity	○ As the data collected may be used in the court of law during the course of a criminal trial, the reliability and the admissibility of the data along with the standards and procedure followed would be taken into consideration.
Absence of Data Protection Law	○ FRT systems in the absence of data protection laws that would mandate necessary safeguards in the collection and storage of user data is also a point of concern.

WAY FORWARD

- In this digital age, data is a valuable resource that should not be left unregulated. In this context, the time is right for India to have a robust data protection regime.
- The government would also have to respect the privacy of the citizens while strengthening the right to information.
- Additionally, the technological leaps made in the last two to three years also need to be addressed knowing that they have the capacity to make the law redundant.
- Given the size of India's population and comparatively understaffed administration, the well-planned use of such nascent technology is a probable solution, provided there are sufficient safeguards to address its inherent concerns including the issue of privacy.

➡ LOG4J VULNERABILITY

Log4Shell, an internet vulnerability that affects millions of computers, involves an obscure but nearly ubiquitous piece of software, Log4j. The software is used to record all manner of activities that go on under the hood in a wide range of computer systems.

WHAT DOES LOG4J DO?

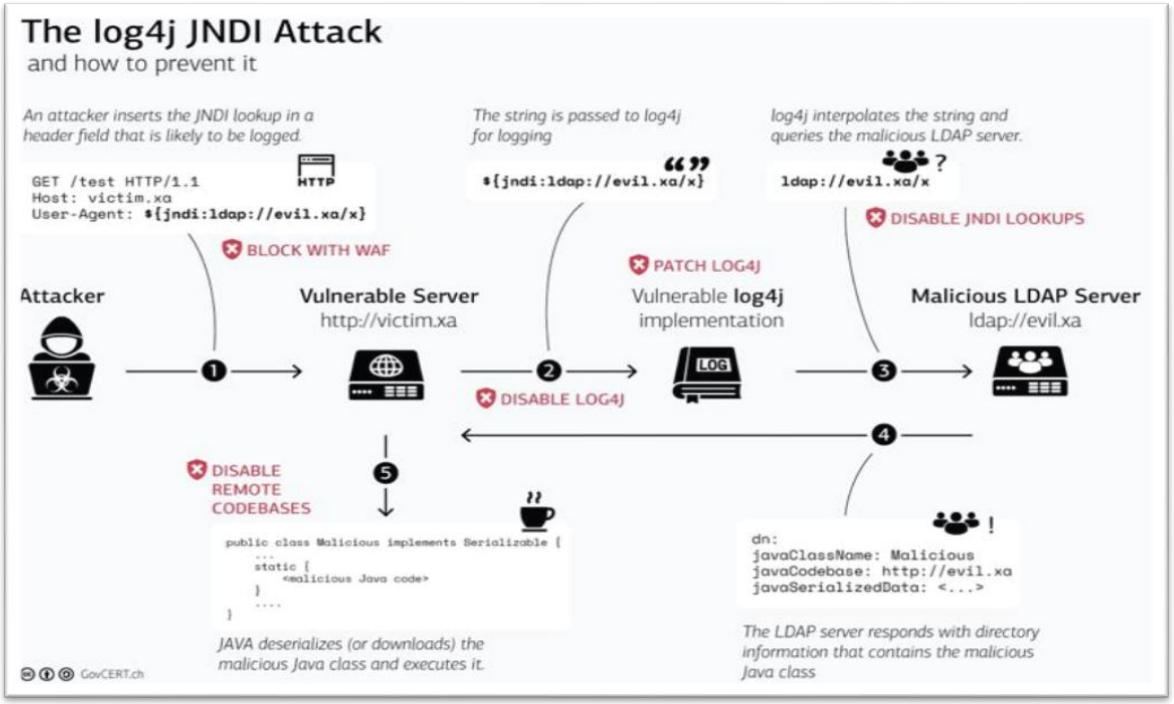
- Log4j **records events** – errors and routine system operations – and **communicates diagnostic messages** about them to system administrators and users. It's open-source software provided by the Apache Software Foundation.
- A common example of Log4j at work is when you type in or click on a bad web link and get a 404 error message. The web server running the domain of the web link you tried to get to tells you that there's no such webpage. It also records that event in a log for the server's system administrators using Log4j.
- Similar diagnostic messages are used throughout software applications. For example, in the online game Minecraft, Log4j is used by the server to log activity like total memory used and user commands typed into the console.

HOW DOES LOG4SHELL WORK?

- Log4Shell works by abusing a feature in Log4j that allows users to specify custom code for formatting a log message. This feature allows Log4j to, for example, log not only the username associated with each attempt to log in to the server but also the person's real name,

if a separate server holds a directory linking user names and real names. To do so, the Log4j server has to communicate with the server holding the real names.

- Unfortunately, this kind of code can be used for more than just formatting log messages. Log4j allows **third-party servers to submit software code that can perform all kinds of actions on the targeted computer.** This opens the door for nefarious activities such as stealing sensitive information, taking control of the targeted system and slipping malicious content to other users communicating with the affected server.



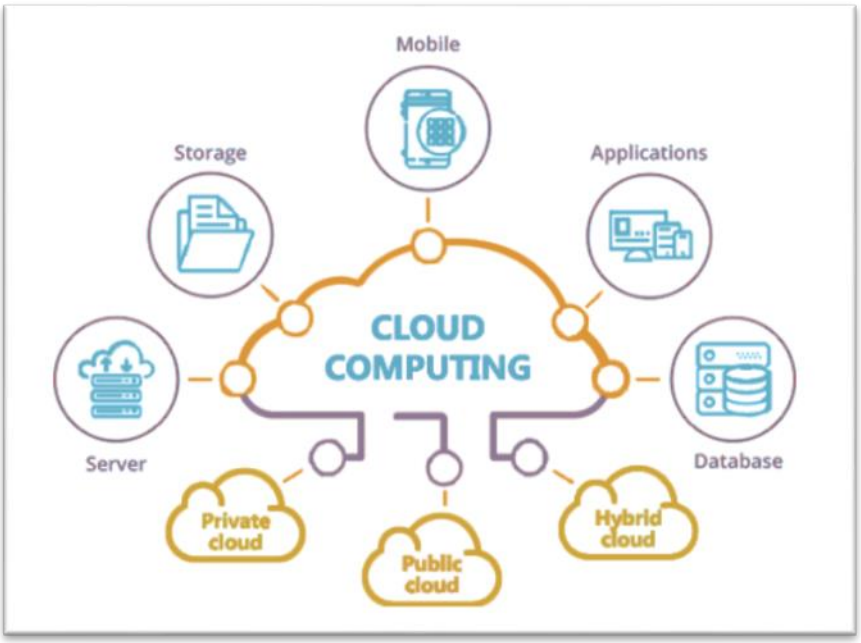
LOG4J IS EVERYWHERE

- One of the major concerns about Log4Shell is Log4j's position in the software ecosystem. Logging is a fundamental feature of most software, which makes Log4j very widespread. In addition to popular games like Minecraft, it's used in cloud services like Apple iCloud and Amazon Web Services, as well as a wide range of programs from software development tools to security tools.
- This means hackers have a large menu of targets to choose from: **home users, service providers, source code developers and even security researchers.** So while big companies like Amazon can quickly patch their web services to prevent hackers from exploiting them, there are many more organizations that will take longer to patch their systems, and some that might not even know they need to.

➡ CLOUD COMPUTING

Cloud computing transforms IT infrastructure into a utility: It lets you 'plug into' infrastructure via the internet, and use computing resources without installing and maintaining them on-premises.

WHAT IS CLOUD COMPUTING?



- Cloud computing is on-demand access, via the internet, to computing resources—applications, servers (physical servers and virtual servers), data storage, development tools, networking capabilities, and more—hosted at a remote data center managed by a cloud services provider (or CSP). The CSP makes these resources available for a monthly subscription fee or bills them according to usage.

  Compared to traditional on-premises IT, and depending on the cloud services you select, cloud computing helps do the following:
- **Lower IT costs:** Cloud lets you offload some or most of the costs and effort of purchasing, installing, configuring, and managing your own on-premises infrastructure.
- **Improve agility and time-to-value:** With cloud, your organization can start using enterprise applications in minutes, instead of waiting weeks or months for IT to respond to a request, purchase and configure supporting hardware, and install software.

  Cloud also lets you empower certain users—specifically developers and data scientists—to help themselves to software and support infrastructure.
- **Scale more easily and cost-effectively:** Cloud provides elasticity—instead of purchasing excess capacity that sits unused during slow periods, you can scale capacity up and down in response to spikes and dips in traffic. You can also take advantage of your cloud provider's global network to spread your applications closer to users around the world.
- The term 'cloud computing' also refers to the technology that makes cloud work. This includes some form of virtualized IT infrastructure—**servers, operating system software, networking, and other infrastructure that's abstracted, using special software**, so that it can be pooled and divided irrespective of physical hardware boundaries. For example, a single hardware server can be divided into multiple virtual servers.
- Virtualization enables **cloud providers to make maximum use of their data center resources**. Not surprisingly, many corporations have adopted the cloud delivery model for their on-premises infrastructure so they can realize maximum utilization and cost savings vs. traditional IT infrastructure and offer the same self-service and agility to their end-users.
- If you use a computer or **mobile device at home or at work, you almost certainly use some form of cloud computing every day,** whether it's a cloud application like **Google**

Gmail or Salesforce, streaming media like Netflix, or cloud file storage like Dropbox.

- **Services: IaaS** (Infrastructure-as-a-Service), **PaaS** (Platform-as-a-Service) , and **SaaS** (Software-as-a-Service) are the three most common models of cloud services.

TYPES OF CLOUD COMPUTING

PUBLIC CLOUD

- Public cloud is a type of cloud computing in which a cloud service provider makes computing resources—anything from SaaS applications, to individual virtual machines (VMs), to bare metal computing hardware, to complete enterprise-grade infrastructures and development platforms—available to users over the public internet.
- These resources **might be accessible for free, or access might be sold according to subscription-based or pay-per-usage pricing models.**
- The public cloud provider owns, manages, and assumes all responsibility for the data centers, hardware, and infrastructure on which its customers' workloads run, and it typically provides high-bandwidth network connectivity to ensure high performance and rapid access to applications and data.

PRIVATE CLOUD

- Private cloud is a cloud environment in which all cloud infrastructure and computing resources are **dedicated to, and accessible by, one customer only**.
- Private cloud combines many of the benefits of cloud computing—including elasticity, scalability, and ease of service delivery—with the **access control, security, and resource customization of on-premises infrastructure.**
- A private cloud is typically hosted on-premises in the customer's data center. But a private cloud can also be hosted on an independent cloud provider's infrastructure or built on rented infrastructure housed in an offsite data center.
- Many companies choose private cloud over public cloud because private cloud is an easier way (or the only way) to meet their regulatory compliance requirements. Others choose private cloud because their workloads deal with confidential documents, intellectual property, personally identifiable information (PII), medical records, financial data, or other sensitive data.

HYBRID CLOUD

- Hybrid cloud is just what it sounds like—a **combination of public and private cloud environments**. Specifically, and ideally, a hybrid cloud connects an organization's private cloud services and public clouds into a single, flexible infrastructure for running the organization's applications and workloads.
- The goal of hybrid cloud is to establish a **mix of public and private cloud resources**—and with a level of orchestration between them—that gives an organization the flexibility to choose the optimal cloud for each application or workload and to move workloads freely between the two clouds as circumstances change.
- This enables the organization to meet its technical and business objectives more effectively and cost-efficiently than it could with public or private cloud alone.

WHO USES HYBRID CLOUD?

- **Businesses across the spectrum of industries** have moved toward hybrid solutions to reduce costs and strain on local resources. From the financial sector to the health care industry, hybrid cloud environments have proven to be effective at not only improving computing and storage power, but also optimizing the scarce resource of physical space. Many organizations simply don't have the room available to deploy servers on-site.
- In the **health care space,** data privacy is paramount, and privately held computation resources are lacking. A hybrid cloud model is an ideal solution because it allows medical groups to retain patient data in a secure, private server while simultaneously leveraging the advanced computational power of a public IaaS model. Simply put, any industry that benefits from public cloud applications can also benefit from the hybrid model.

HYBRID CLOUD BENEFITS

Hybrid cloud computing enables an enterprise to deploy its most sensitive workloads in an on-premises cloud and to host less-critical resources on a third-party public cloud provider. This approach allows organizations to get the best of both private and public cloud models.

The core benefits of hybrid cloud include the following:

- **Flexibility.** Users work with various types of data in disparate environments and adjust their infrastructure. A company can build a hybrid cloud that works for its needs, using traditional systems as well as the latest cloud technology, without a full commitment to a vendor. Organizations savvy with a hybrid cloud setup can migrate workloads to and from their traditional infrastructure and a vendor's public cloud whenever necessary.
- **Cost management.** With a private cloud, organizations own and operate the data center infrastructure, which requires significant capital expense and fixed costs. Alternatively, the public cloud offers resources and services that are accounted as variable and operational expenses. Hybrid cloud users can choose to run workloads in whichever environment is more cost effective.
- **Agility and scalability.** Hybrid cloud offers more resource options via a public cloud provider vs. an organization's physical data center. This makes it easier to provision, deploy and scale resources to meet demand spikes. When demand exceeds capacity of the local data center, an organization can burst the application to the public cloud to access extra scale and capacity.
- **Resiliency and interoperability.** To increase resiliency, a business can run workloads redundantly in both private and public environments. Components of one workload can also run in both environments and interoperate.
- **Compliance.** Compliance restrictions on where data can reside mean organizations in highly regulated industries cannot move all workloads to the public cloud. With hybrid cloud, organizations can keep data in a private environment while operating workloads in the cloud, or they can operate workloads in a private data center and move data to and from the public cloud as needed. This allows companies to meet regulatory requirements and still benefit from the elasticity of the cloud.
- Other hybrid cloud advantages include consistency and support for greater standardization in IT management practices.
-

MULTICLOUD AND HYBRID MULTICLOUD

- Multicloud is the use of **two or more clouds from two or more different cloud providers**. Having a multicloud environment can be as simple using email SaaS from one vendor and image editing SaaS from another.
- But when enterprises talk about multicloud, they're typically talking about using multiple cloud services—including SaaS, PaaS, and IaaS services—from two or more of the leading public cloud providers.
- Hybrid multicloud is the use of two or more public clouds together with a private cloud environment.
- Organizations choose multicloud to avoid vendor lock-in, to have more services to choose from, and to access to more innovation. But the more clouds you use—each with its own set of management tools, data transmission rates, and security protocols—the more difficult it can be to manage your environment.
- Multicloud management platforms provide visibility across multiple provider clouds through a central dashboard, where development teams can see their projects and deployments, operations teams can keep an eye on clusters and nodes, and the cybersecurity staff can monitor for threats.

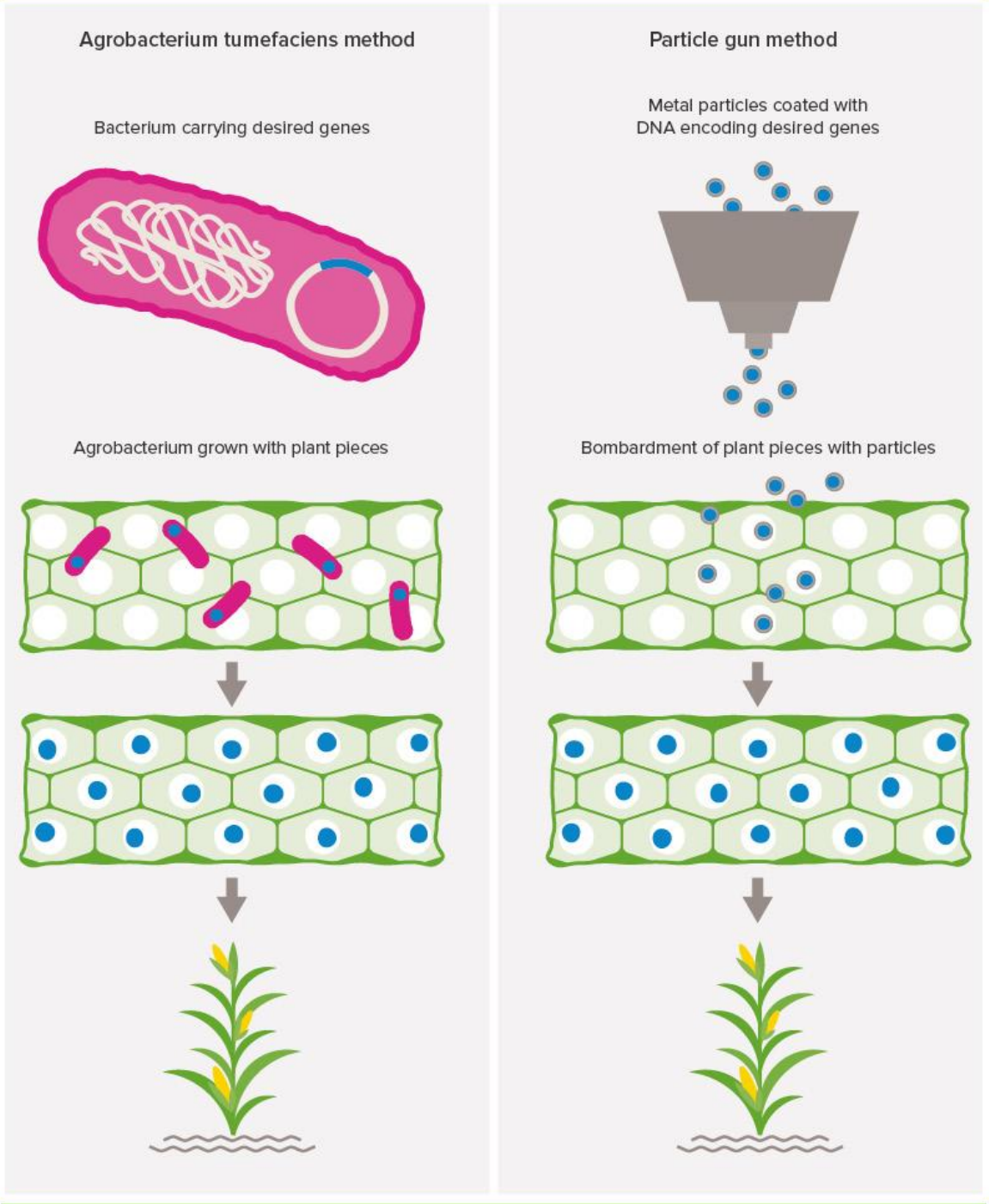
➡ GM CROPS

- GM is a technology that involves **inserting DNA into the genome of an organism**. To produce a GM plant, **new DNA is transferred into plant cells**. Usually, the cells are then grown in tissue culture where they develop into plants. The seeds produced by these plants will inherit the new DNA.
- The characteristics of all living organisms are determined by their genetic makeup and its interaction with the environment. The **genetic makeup of an organism is its genome,** which in all plants and animals is made of DNA. The genome contains genes, regions of DNA that usually carry the instructions for making proteins. It is these proteins that give the plant its characteristics. For example, the colour of flowers is determined by genes that carry the instructions for making proteins involved in producing the pigments that colour petals.
- Genetic modification of plants **involves adding a specific stretch of DNA into the plant's genome, giving it new or different characteristics**. This could include changing the way the plant grows, or making it resistant to a particular disease. The new DNA becomes part of the GM plant's genome which the seeds produced by these plants will contain.
- The **first stage** in making a GM plant requires **transfer of DNA into a plant cell**. One of the methods used to transfer DNA is to coat the surface of small metal particles with the relevant DNA fragment, and bombard the particles into the plant cells.
- Another method is to **use a bacterium or virus.** There are many viruses and bacteria that transfer their DNA into a host cell as a normal part of their life cycle. For GM plants, the bacterium most frequently used is called **Agrobacterium tumefaciens**.
- The gene of interest is transferred into the bacterium and the bacterial cells then transfer the new DNA to the genome of the plant cells. The plant cells that have successfully taken up the

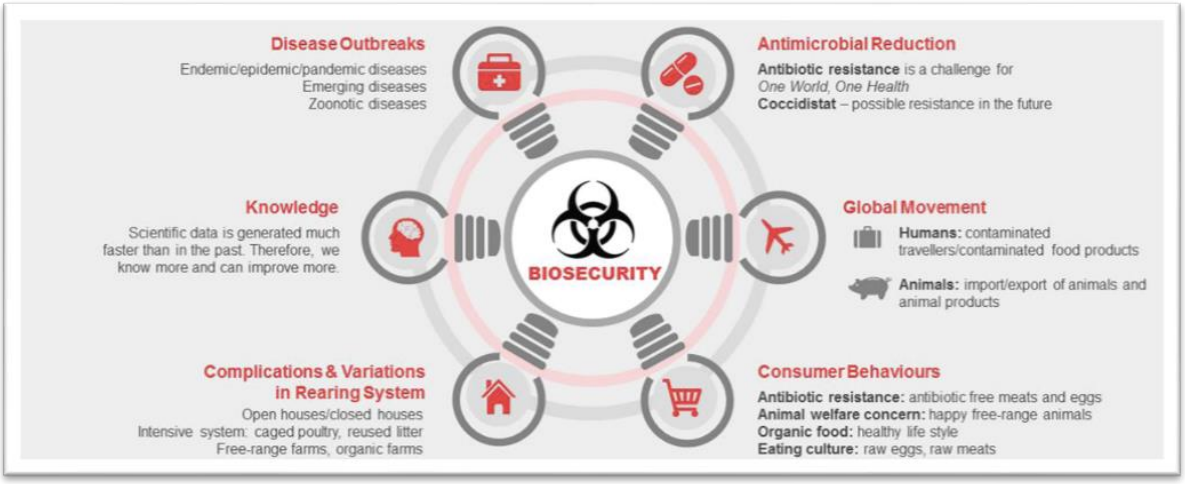
DNA are then grown to create a new plant. This is possible because individual plant cells have an impressive capacity to generate entire plants. On rare occasions, the process of DNA transfer can happen without deliberate human intervention. For example the sweet potato contains DNA sequences that were transferred thousands of years ago, from Agrobacterium bacteria into the sweet potato genome.

- There are other ways to change the genomes of crops, some of which are long established, such as mutational breeding, and others of which are new, such as genome editing.

FIGURE 2 DNA transfer procedures



➡ BIOSECURITY



- Biosecurity is defined by the Food and Agriculture Organization of the United Nations (FAO) as a strategic and **integrated approach that encompasses the policy and regulatory frameworks** (including instruments and activities) for analysing and managing relevant risks to human, animal and plant life and health, and associated risks to the environment.
- During these past years, biosecurity as a concept has evolved with its application and it has a great variability in meaning in different countries when used in various national instruments and primary laws. This, in the context of an increasing public awareness of the impact of adverse health and environmental practices fuelled by technological advances in detection and management of hazards to life and health, together with the often unresolved scientific debate that surrounds the potential of very low levels of hazards to result in adverse health or environmental impact.
- Biosecurity covers **food safety, zoonoses, the introduction of animal and plant diseases and pests, the introduction and release of living modified organisms (LMOs) and their products (e.g. genetically modified organisms or GMOs), and the introduction and management of invasive alien species.**
- Thus, biosecurity is a holistic concept of direct relevance to the sustainability of agriculture, and wide-ranging aspects of public health and protection of the environment, including biological diversity.

WHY DEVELOPING BIOSECURITY TOOLS?

Interest in managing these risks through biosecurity has risen considerably over the last 20 years with the rise of several trends:

- The increasing trade in food, plant and animal products, more international travel, new outbreaks of transboundary disease affecting animals, plants and people;
- The awareness of biological diversity and greater attention to the environment and the impact of agriculture on environmental sustainability;
- Changes in the way food, plants and animals are produced, processed and distributed, and the use of new technologies,

- The need to comply with global agreements governing the trade in agricultural and food products.

During the past 20 years, some governments have moved towards such integrated approach to biosecurity that harmonizes and rationalizes policy, legislation and core roles and responsibilities as a means to better manage relevant risks in food and agriculture. However, most countries continued to manage biosecurity along traditional, sector-oriented lines, resulting in a lack of strategic focus, inefficient use of scarce resources and less than optimal results.

WHAT CONSTITUTES A BIOSECURITY HAZARD?

Depending on the sector involved and as illustrated in the figure, there are various descriptions as to what constitutes a biosecurity hazard, All significant effects, positive and negative (hazards), should be systematically identified and their relative magnitudes considered in decision-making.

Box 1.4. Definitions of a hazard as applicable to different biosecurity sectors

Food safety	A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect (CAC).
Zoonoses	A biological agent that can be transmitted naturally between wild or domestic animals and humans (OIE).
Animal health	Any pathogenic agent that could produce adverse consequences on the importation of a commodity (OIE).
Plant health	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (IPPC).*
Plant health quarantine	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (IPPC).
"Biosafety" in relation to plants and animals	A living modified organism (LMO) that possesses a novel combination of genetic material obtained through the use of modern biotechnology that is likely to have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health (Cartagena Protocol on Biosafety).
"Biosafety" in relation to food	A recombinant DNA organism directly effecting or remaining in a food that could have an adverse effect on human health (Cartagena Protocol on Biosafety).
Invasive alien species	An invasive alien species outside its natural past or present distribution whose introduction and/or spread threatens biodiversity (CBD).

** IPPC does not usually use the term "hazard" but instead uses the term "pest". For a pest to be subject to pest risk analysis (PRA), it has to satisfy the criteria for definition of a quarantine pest*

WHAT IS THE RATIONALE FOR A HARMONIZED AND HOLISTIC APPROACH OF BIOSECURITY?

- Human, animal and plant life, health and protection of the environment but also agriculture and health are inextricably linked in many ways. Biosecurity hazards of various types exist in each sector and have high potential to move between sectors. For example, many animal pathogens readily infect humans; animal feed may be contaminated with mycotoxins and plant toxins.
- Changes in the environment, such as the loss of biological diversity and contamination of food and water sources, the size and scope of the global trade in animal feed and animal feed ingredients are examples of the immense potential for biosecurity hazards to move between and within countries.

- Further, international events may superimpose requirements for more integrated and harmonized approaches. In particular, there is an increased recognition of the potential for wide-scale food-borne threats to public or animal health from acts of terrorism is a new consideration in modern biosecurity systems.
- The merging of policies and values with science in biosecurity risk management presents considerable challenges and has different expression in different countries. As underlined in the FAO Toolkit, both risk assessment and risk management should thus be wrapped in a "sea of communication" that includes all stakeholders as appropriate.
- Core decisions should involve the balancing of scientific findings against questions of life and health expectations, likely economic and social impacts, but also the technical feasibility and cost-effectiveness of controls. The increasing number and stringency of sanitary and phytosanitary requirements, the recognition of the high cost of regulation and acknowledgement of limited public resources are other drivers of these holistic changes. On top of this, there are increasing demands from industry for better cost-effectiveness of biosecurity systems and greater accommodation of new technologies.

➡ BLOCKCHAIN TECHNOLOGY

- It is a foundational technology or a platform that allows d**esigning a secure way to record transactions and circulate it among signatories,** or any kind of target group with an Internet connection. At its core it is an extremely democratic ledger that cannot be arbitrarily manipulated and easily shareable.
- Blockchain's appeal is that it achieves this **without a central authority**.
- Blockchain burst into public consciousness because of its association with Satoshi Nakamoto, a mysterious individual or cabal that laid out a white paper on how blockchain could be applied to bitcoin, a virtual currency wrought from the principles of blockchain. Having money free of the fiat of Central governments raised utopian possibilities especially in a world where democracies complain of being subverted and labour and capital continue to be entangled in the elusive quest for equilibrium. Thereafter, it spawned its own hype-cycle, imitation currencies, association with the sordid and Dark Net. While cryptocurrencies have a bad reputation, Silicon Valley tech giants and investment banks are trying to salvage the underlying promise of blockchain and use it for other collaborations.
- **Every block in a blockchain** is a record of transactions and the more of the latter, the longer the chain. Just as worthless paper transforms into valuable currency with the signature of the RBI governor, blocks are great because they provide an unalterable document of the history of every transaction. In the **context of currency, it stores the place, time, value (rupee, for example) and location of a purchase.** There is minimal identifying information and every block is linked to a unique 'digital signature' of the transacting participants. Every block is distinguished from another through a unique code which is a string of numbers. When you use your debit or credit card to make a transaction, VISA or MasterCard employ their technology to verify your bank account, connect with banks and process a transaction.
- In blockchain applications, this verifying role is **outsourced to several computers on a network** — each has the exact same copy of the block. These computers verify the genuineness of transaction by solving mathematical problems.

- In the case of bitcoin, the computers are rewarded with bitcoin. This is stored in digital wallets and may be used like money provided there are sellers of real world goods who would accept bitcoins. Nowadays, they are frequently traded as another speculative, volatile asset.

WHERE CAN IT BE USED?

- Facebook launched **Libra,** a kind of blockchain-backed digital currency. Bank of America, JPMorgan, the New York Stock Exchange, Fidelity Investments, and Standard Chartered are testing blockchain technology as a replacement for paper-based and manual transaction processing in such areas as trade finance, foreign exchange, cross-border settlement, and securities settlement"
- **Ethereum** is another blockchain-based startup that looks to decentralise online information. Its ambition is beyond overturning online banking and it claims that if it were to work as envisioned, it will give users control over their data unlike the present where a lot of our privacy is ceded to Google and Amazon's servers. Some plan to apply blockchain to trace the origin of food and where it is grown and yet others to journalism and 'fact- checking' applications. Unlike blockchain's distributed computing philosophy, all these applications ultimately store information on a coalition of repositories.

Future scenario Technology has always proved to be disruptive, creating new opportunities and jobs and destroying old ones. If blockchain's appeal lies in its appeal to destroy intermediaries — banks, courts, lawyers — it is unlikely to be smooth sailing. Moreover, there is already serious theorising by economists that shows how blockchain has its own vulnerabilities and susceptibility to creating new hegemons, power networks, cartels and challenges to global energy consumption.

➡ DARK NET

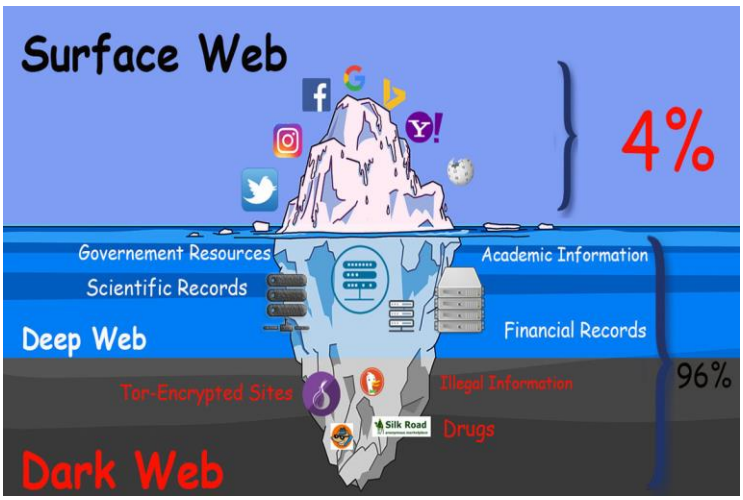
Instances of data leaks on the dark web/ dark net is on the rise. Dark web/ dark net is increasingly being used for various nefarious activities including data leaks, identity theft, illegal weapon sales, drug trafficking, cyber terrorism etc.

- Dark Net is a network of computers on the internet that are:- a) not accessible through the normal search engines and b) provide anonymity to the source of web content.
- In order to access the content of the dark net we need special software to get into this network of computers.
- In simple words web content on dark net is intentionally hidden in order to provide anonymity to service provider.

UNDERSTANDING DARK NET

- **Surface Web:** Whenever you search a webpage on a search engine like google the search engine has the ability to 'look for' and extract the content and present it in the form of a website/webpage. In order to do this the webpages are 'indexed' by the search engine. Only about 10-15% of all the web content are present on the surface web accessible by common searches.
- **Deep Web:** Deep Web on the other hand is a term used for all those web content or web pages that are there on the internet but are not indexed by search engines and therefore not

discernible by conventional search engines. In other words these webpages on deepweb they do not show up in conventional search engines like Google, Bing, Yahoo etc.



- About 75-85% of the web content/web pages are on the deep web. Common examples of web content on deep web include financial data, bank account details, emails, personal data etc. that are password protected and the only way to access these web pages is through login.
- **Dark Net:** Dark net is a part of deep web that is intentionally hidden in order to provide anonymity. In order to do this, deep net uses a specialised network of computers called **relays** through which the information passes. Commonly, information on dark net passes through at least 3 relay computers between the source and destination. In addition, the dark net uses network technology that hides the location of these relay computers (IP address) in order to ensure anonymity of the users. Can be accessed through **TOR (Anonymity Network)**

FEATURES

- While it is hidden from a search engine, the web pages on dark net can be accessed and downloaded by anyone who has the exact address of the webpage
- Dark net does not provide any protection against malware, virus attack etc.
- Since the data is routed through a number of relay computers between source and destination the communication is slower in dark net.

SCOPE OF DARK NET: Dark net is used for both legitimate and illegitimate activities.

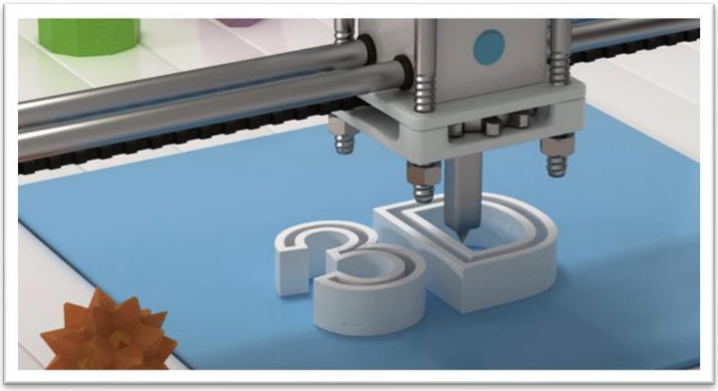
Legitimate Activities

- By virtue of its ability to provide anonymity, dark net is used by human rights activists, free internet activists, media personnel etc. in countries where there are severe restrictions, censorship on internet usage like that in China, Iran, Saudi Arabia etc.
- Dark net is also used by whistle blowers in order to maintain anonymity. (Read about Edward Snowden)
- Besides in the aftermath of glaring revelations on surveillance by USA's security agency NSA the number of users using dark net has increased for the want of privacy.

2. Illegitimate Activities

- While use of dark net is not illegal per say it has increasingly turned into a platform for various nefarious activities including illegal weapon sale, drug trafficking, child pornography, data theft, data leaks, cyber terrorism, hacking, organised crime, money laundering etc.

➡ 3D PRINTING



- 3D printing or **additive manufacturing is a process of making three dimensional solid objects** from a digital file.
- The creation of a 3D printed object is achieved using additive processes. In an **additive process an object is created by laying down successive layers of material until the object is created**. Each of these layers can be seen as a thinly sliced cross-section of the object.
- 3D printing is the **opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal** or plastic with for instance a milling machine.
- 3D printing enables you to produce complex shapes using less material than traditional manufacturing methods.
- The first 3D printer was created by **Charles W. Hull in the mid-1980s**.

HOW DOES 3D PRINTING WORK?

1. Much like traditional printers, 3D printers use a variety of technologies. The most commonly known is **fused deposition modeling (FDM), also known as fused filament fabrication (FFF).** In it, a filament—composed of acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), or another thermoplastic—is melted and deposited through a heated extrusion nozzle in layers.
2. Another technology used in 3D printing is **stereolithography.** In it, a UV laser is shined into a vat of ultraviolet-sensitive photopolymer, tracing the object to be created on its surface. The polymer solidifies wherever the beam touches it, and the beam "prints" the object layer by layer per the instructions in the CAD or CAM file it's working from.
3. In a variation on that, you also have **digital light projector (DLP) 3D printing**. This method exposes a liquid polymer to light from a digital light processing projector. This hardens the polymer layer by layer until the object is built, and the remaining liquid polymer is drained off.
4. **Multi-jet modeling** is an inkjet-like 3D printing system that sprays a coloured, glue-like binder onto successive layers of powder where the object is to be formed. This is among the fastest methods, and one of the few that supports multicolour printing.

WHAT ARE THE BENEFITS OF 3D PRINTING?

- With 3D printing, designers have the ability to quickly turn concepts into 3D models or prototypes (a.k.a. "rapid prototyping"), and implement rapid design changes.
- It lets manufacturers **produce products on demand** rather than in large runs, improving inventory management and reducing warehouse space. People in remote locations can fabricate objects that would otherwise be inaccessible to them.

- From a practical standpoint, 3D printing can save money and material versus subtractive techniques, as very little raw material is wasted. And it promises to change the nature of manufacturing, eventually letting consumers download files for printing even complex 3D objects—including, for example, electronics devices—in their own homes.

THE BENEFITS OF 3D PRINTING FOR AUTOMOTIVE

- **Faster product development**: Prototyping has become a key part of the product development process, offering a means to test and validate parts before they are manufactured. 3D printing offers a quick and cost-effective approach to designing and producing parts. Since the need for tooling is eliminated, product teams can significantly accelerate product development cycles.
- **Greater design flexibility**: The ability to produce designs quickly gives designers greater flexibility when testing multiple design options. 3D printing enables designers to make quick design changes and modifications in a fraction of the time.
- **Customisation**: 3D printing offers automakers a cost-effective and flexible way to produce customised parts. Within the luxury and motorsports segment of the industry, companies are already using the technology to produce personalised parts for both the interior and exterior parts of a vehicle.
- **Create complex geometries**: With the majority of car components requiring complex geometries like internal channels (for conformal cooling), thin walls and fine meshes, AM enables highly complex parts to be produced that are still lightweight and durable.

➡ INTERNET OF THINGS

- The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects.
- Embedded with electronics, Internet connectivity, and other hardware like sensors, these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled by computers and smart phone.

APPLICATIONS OF INTERNET OF THINGS:

- **Smart cities**: Cellular communication enabled Smart municipal bins will send alerts to municipal services when a bin needs to be emptied
- **Agriculture**: Sensing for soil moisture and nutrients, controlling water usage for plant growth and determining custom fertilizer are some simple uses of IoT.
- **Energy utilization**: Smart Grids will be able to detect sources of power outages, can automatically take inputs of solar panel, making possible distributed energy system
- **Healthcare**: Personalized analysis of an individual's health and tailor-made strategies to combat illness will be possible.
- **Manufacturing**: The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together.

- **Environmental monitoring**: to assist in environmental protection by monitoring air or water quality, atmospheric or soil conditions. It can even include areas like monitoring the movements of wildlife and their habitats
- **Supply chain**: By placing RFID tags on individual products, the exact location of single items in a large warehouse can be shared, thus saving search time, streamlining infrastructure, and lowering labour costs.

➡ MACHINE LEARNING

- Machine learning is an **application of artificial intelligence (AI)** that provides **systems the ability to automatically learn and improve from experience** without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves.
- The process of learning begins with observations or data, such as examples, direct experience, or instruction, in order to look for patterns in data and make better decisions in the future based on the examples that we provide. The primary aim is to allow the computers learn automatically without human intervention or assistance and adjust actions accordingly.
- But, using the classic algorithms of machine learning, text is considered as a sequence of keywords; instead, an approach based on semantic analysis mimics the human ability to understand the meaning of a text.

SOME MACHINE LEARNING METHODS

- Machine learning algorithms are often categorized as supervised or unsupervised.
- **Supervised machine learning algorithms can apply what has been learned in the past to new data using labelled examples** to predict future events. Starting from the analysis of a known training dataset, the learning algorithm produces an inferred function to make predictions about the output values. The system is able to provide targets for any new input after sufficient training. The learning algorithm can also compare its output with the correct, intended output and find errors in order to modify the model accordingly.
- In contrast, **unsupervised machine learning algorithms are used when the information used to train is neither classified nor labelled**. Unsupervised learning studies how systems can infer a function to describe a hidden structure from unlabelled data. The system doesn't figure out the right output, but it explores the data and can draw inferences from datasets to describe hidden structures from unlabelled data.
- **Semi-supervised machine learning algorithms** fall somewhere in between supervised and unsupervised learning, since they use both labelled and unlabelled data for training – typically a small amount of labelled data and a large amount of unlabelled data. The systems that use this method are able to considerably improve learning accuracy. Usually, semi-supervised learning is chosen when the acquired labelled data requires skilled and relevant resources in order to train it / learn from it. Otherwise, acquiring unlabelled data generally doesn't require additional resources.
- Reinforcement machine learning algorithms is a learning method that interacts with its environment by producing actions and discovers errors or rewards. Trial and error search and delayed reward are the most relevant characteristics of reinforcement learning. This

method allows machines and software agents to automatically determine the ideal behaviour within a specific context in order to maximize its performance. Simple reward feedback is required for the agent to learn which action is best; this is known as the reinforcement signal.

- Machine learning enables analysis of massive quantities of data. While it generally delivers faster, more accurate results in order to identify profitable opportunities or dangerous risks, it may also require additional time and resources to train it properly. Combining machine learning with AI and cognitive technologies can make it even more effective in processing large volumes of information.

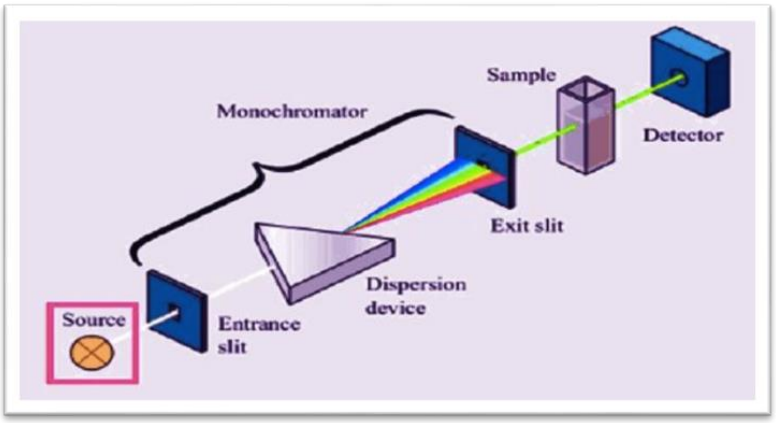
USES

- **Financial services:** Banks and other businesses in the financial industry use machine learning technology for two key purposes: to identify important insights in data, and prevent fraud. The insights can identify investment opportunities, or help investors know when to trade. Data mining can also identify clients with high-risk profiles, or use cyber-surveillance to pinpoint warning signs of fraud.
- **Health care:** Machine learning is a fast-growing trend in the health care industry, thanks to the advent of wearable devices and sensors that can use data to assess a patient's health in real time. The technology can also help medical experts analyse data to identify trends or red flags that may lead to improved diagnoses and treatment.
- **Oil and gas:** Finding new energy sources. Analysing minerals in the ground. Predicting refinery sensor failure. Streamlining oil distribution to make it more efficient and cost-effective. The number of machine learning use cases for this industry is vast – and still expanding.
- **Government:** Government agencies such as public safety and utilities have a particular need for machine learning since they have multiple sources of data that can be mined for insights. Analysing sensor data, for example, identifies ways to increase efficiency and save money. Machine learning can also help detect fraud and minimize identity theft.
- **Retail:** Websites recommending items you might like based on previous purchases are using machine learning to analyse your buying history. Retailers rely on machine learning to capture data, analyse it and use it to personalize a shopping experience, implement a marketing campaign, price optimization, merchandise supply planning, and for customer insights.
- **Transportation:** Analysing data to identify patterns and trends is key to the transportation industry, which relies on making routes more efficient and predicting potential problems to increase profitability. The data analysis and modelling aspects of machine learning are important tools to delivery companies, public transportation and other transportation organizations.

➡ ABSORPTION SPECTROSCOPY

- Researchers from IIT Madras and IISER Kolkata have developed a method to detect minute quantities of chemicals in solution. They use a variation of **absorption spectroscopy**.
- With this technique, they can, in principle, illuminate the insides of cells and detect minuscule quantities of substances present there.

SCIENCE OF ABSORPTION SPECTROSCOPY



- Absorption spectroscopy is a **tool to detect the presence of elements in a medium**.
- Light is shone on the sample, and after it passes through the sample is examined using a spectroscope.
- **Dark lines are seen in the observed spectrum** of the light passed through the substance, which correspond to the wavelengths of light absorbed by the intervening substance and are characteristic of the elements present in it.
- In usual methods, about a cubic centimetre of the sample is needed to do this experiment. In the method developed here, minute amounts of dissolved substances can be detected easily.
- Usually in absorption spectroscopy, the principle used is that **light because of its wavelike nature, shows diffraction patterns, that is, dark and light fringes, when it scatters off any object**. A related concept called the **Abbe criterion sets** a natural limit on the size of the object being studied. According to this criterion, the size of the observed object has to be at least of the order of the wavelength of the light being shone on it.
- In the method used by the researchers here, tiny, nano-sized particles that can absorb light being shone on them and re-emit red, blue and green light were employed.
- The absorption leaves a gap in the reflected light, which is what is observed and used to analyse the nature of the absorbing material.

INSIDE LIVING CELLS

- There are many potential applications. To study particles inside living cells, and the emission can be used as a tiny flash lamp to look for absorption from individual molecules in the close proximity to the particle.
- The future is to use it to measure individual molecules, see an absorption spectroscopy of a single DNA or protein molecule.

➡ CARBON CAPTURE AND STORAGE TECHNOLOGY

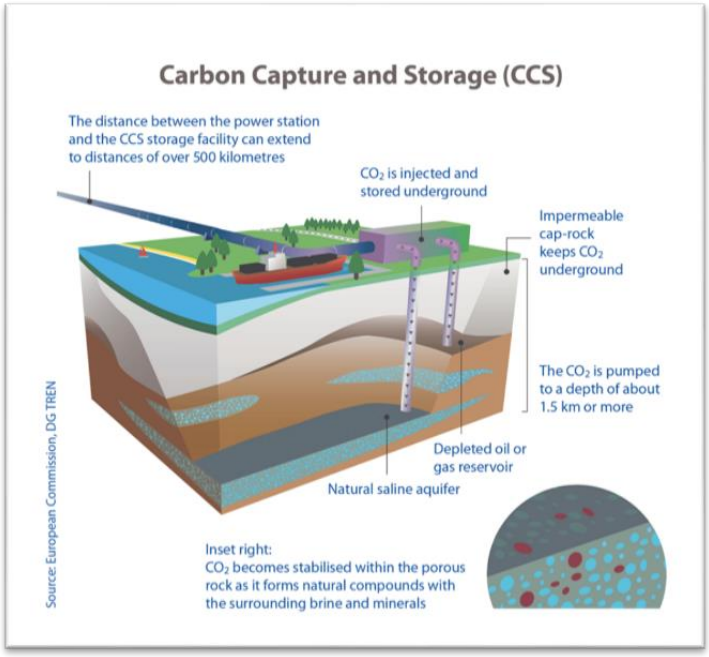
- Carbon capture and storage technology (CCS) has been hailed as a key component in the **world's shift towards renewable energy.**
- With global CO_2 emissions hitting a historic high, growing by more than 1.3% to a record of more than 33 billion tonnes, the need for tools that can help limit pollution has never been greater.
- The Global CCS Institute claims CO_2 emissions from fossil fuel combustion in the energy sector contribute roughly 30% to the amount of the pollutant present in the EU, specifically.

- Renewable energy presents a possible solution to this, but its ability to cater the world's power demand, which is expected to rise by 50% by 2030, according to the UK's Carbon Capture and Storage Association (CCSA), is up for debate – this is where CCS comes in.
- The International Energy Agency recently concluded that, to meet the goals of the Paris Agreement, CCS will need to contribute 32% of the extra effort to move from a 2C scenario to well below 2C.
- The Intergovernmental Panel on Climate Change (IPCC) has estimated that without CCS, the cost of trying to meet global climate change goals will increase by almost 140%.

Here we take a closer look at CCS and how it works.

WHAT IS CARBON CAPTURE AND STORAGE TECHNOLOGY?

- CCS is a technology reportedly capable of **capturing up to 90% of the CO2 emissions produced by the burning of fossil fuels** to generate electricity, as well as those used in industrial processes, and prevent it from polluting the atmosphere.
- Fossil fuel power plants can be built with the **technology already integrated** or it can also be **combined with renewable biomass to create a "carbon-negative"** mode the goes one step further by actually removing CO2 from the planet.



- The Global CCS Institute says there are 18 large-scale CCS facilities currently in operation, with an additional five under construction.
- Some carbon storage facilities date back multiple decades, such as the Sleipner project in the North Sea, while others remain under construction, like the Gorgon project in Western Australia.
- **First,** CCS involves capturing CO2, before transporting it to be stored in geological rock formations thousands of metres below the Earth's surface.
- The initial part of the process involves separating CO2 from the gasses produced in power generation and industrial processes, such as manufacturing cement or steel, by pre-combustion capture, post-combustion capture or oxy-fuel combustion.
- The pollutant is then transporting using either a pipeline or a ship in much the same way the millions of tonnes of CO2 are transported each year for various commercial purposes, chiefly by countries such as the US.
- It is then stored in depleted oil and gas fields or deep saline aquifer formations, which the Intergovernmental Panel on Climate Change (IPCC) says can retain 99% of the pollutant over a 1000-year period.

- At every point in the CCS chain, from production to storage, industry has at its disposal a number of process technologies that are well understood and have excellent health and safety records
- The commercial deployment of CCS will involve the widespread adoption of these techniques, combined with robust monitoring techniques and government regulation.

CAPTURING CO2

Pre-combustion capture

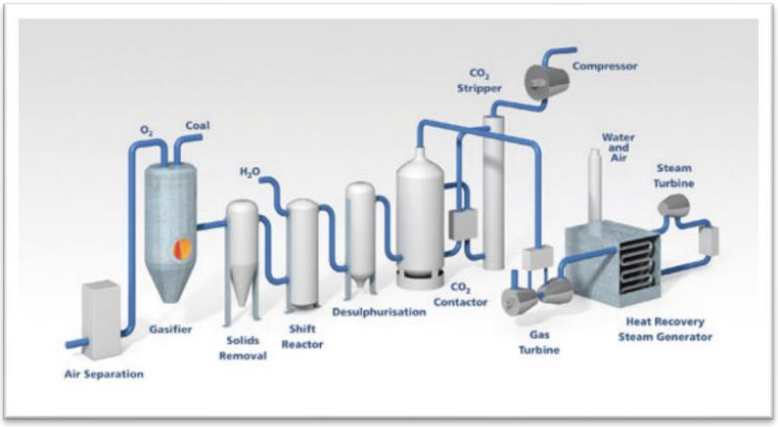
- Pre-combustion systems, as provided by manufacturing companies such as British engineering firm **Costain**, convert solid, liquid or gaseous fuel into a blend of hydrogen and CO2 using processes like "**gasification" or "reforming".**
- This can then be used to fuel electricity production, and the CCSA claims it will be able to power vehicles and provide heating, with extremely low emissions, in the future.

Post-combustion capture

- Post-combustion capture involves capturing the CO2 from the exhaust of a combustion system and absorbing it into a solvent, before removing and compressing the pollutant elements.
- CO2 can also be separated using high-pressure membrane filtration, as well as cryogenic separation processes.

Oxy-fuel combustion

- Using oxy-fuel combustion, oxygen is separated from the air before combustion, with the fuel then being combusted in oxygen using recycled flue-gas.
- This creates an atmosphere full of oxygen and nitrogen with flue-gases comprising CO2 and water, allowing for easier purification of the former.

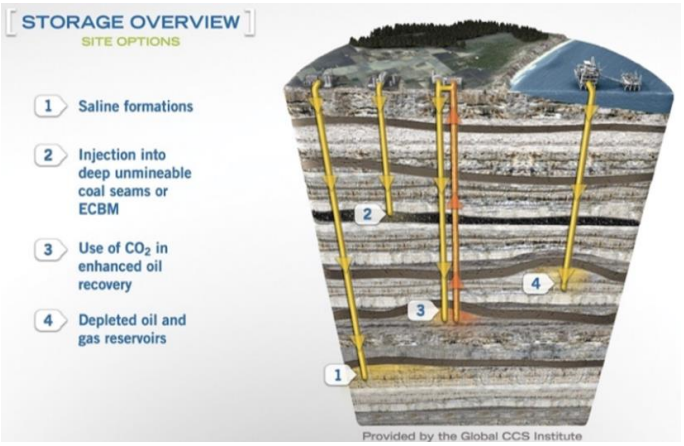


Transporting CO2

- Transporting captured CO2 involves many of the same techniques as used for oil and natural gas, including road tankers, ships and pipelines.
- Many of the networks in use today have been operational for more than 30 years, providing safe and regulation-consistent methods of getting the pollutant from A to B.
- The CCSA says: "There is significant potential for the development of local and regional CCS pipeline infrastructure, leading to CCS 'clusters' where CO2-intensive industries could locate".
- Developing clusters, where infrastructure can be shared by a number of industrial sources of carbon dioxide emissions, will result in the most cost-effective way to deliver CCS infrastructure development and ultimately lower costs to consumers.

STORING CO_2

- Storage sites for captured CO_2 range from **defunct oil and gas fields to underground saline formations, porous rocks filled with salt water, while it can also injected into depleting oil fields** to increase their output.
- After being injected into such a formation, the CO_2 is trapped by a layer of impermeable rock, known as the cap rock, preventing it from entering and polluting the atmosphere above in a process referred to as "structural storage."
- Deep saline aquifers offer the greatest storage capacity over the long term, according to the CCSA, but remain a relative unknown in many areas.



➡ BIOROCK TECHNOLOGY

- A biorock structure was installed one nautical mile off the Mithapur coast in the Gulf of Kachchh. The location for installing the biorock had been chosen keeping in mind the **high tidal amplitude in the Gulf of Kachchh**. The low tide depth where the biorock has been installed is four metres, and at high tide it is about eight metres.
- **Need:** Coral reefs were the most diverse ecosystem on the earth. They are getting degraded across the world and also in India by threats posed both by climate change induced acidification as well as by anthropogenic factors. India has four major coral reefs areas: Andaman and Nicobar Islands, Lakshadweep, Gulf of Mannar and the Gulf of Kachchh.

WHAT IS BIOROCK?

- It is the name given to the substance formed by **electro accumulation of minerals dissolved in seawater on steel structures** that are lowered onto the sea bed and are connected to a power source, in this case solar panels that float on the surface.

WHAT IS BIOROCK TECHNOLOGY?

- Biorock Technology, or **mineral accretion technology** is a method that applies **safe, low voltage electrical currents through seawater, causing dissolved minerals to crystallize on structures, growing into a white limestone** similar to that which naturally makes up coral reefs and tropical white sand beaches. This material has a strength similar to concrete. It can be used to make robust artificial reefs on which corals grow at very rapid rates.
- The change in the environment produced by e**lectrical currents accelerates formation and growth of both chemical limestone rock and the skeletons of corals** and other shell-bearing organisms.

- Biorock methods speed up coral growth in damaged areas and restore authentic coral reef habitat and species. Biorock structures become rapidly colonized by a full range of coral reef organisms, including fish, crabs, clams, octopus, lobster, sea urchins.
- Species typically found in healthy reef environments are given an electrical advantage over the weedy organisms which often overgrow them in reefs stressed by humans. The advantages corals gain from mineral accretion are cancelled if they no longer receive current, at which point weeds will overgrow the corals. If the current is maintained, coral reefs can often be restored even in areas where water quality would prevent their recovery by any other method.

  Future: Ongoing initiative of coral restoration using biorock technology could potentially help to sustain faster revival of corals. The technology helps corals, including the highly sensitive branching corals, to counter the threats posed by global warming.

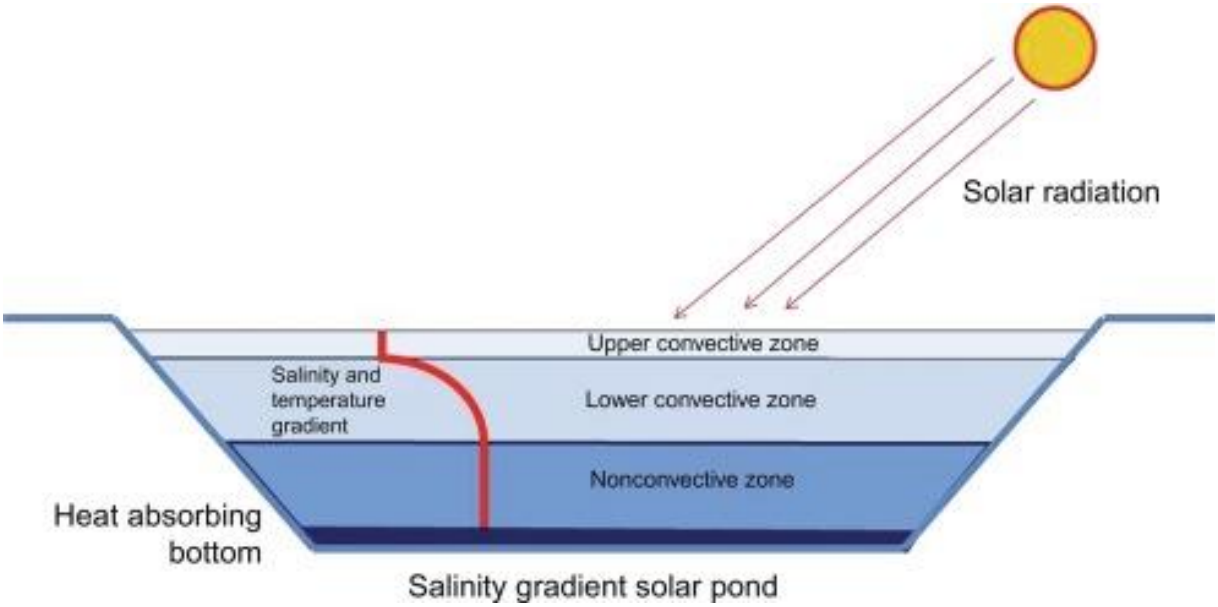
➡ DRS TECHNOLOGY

- The Decision Review System(DRS) is a technology based system in cricket to assist the match officials with their decision making.
- Using UDRS (Umpire's Review) the on-field umpire can take help of Third Umpire and players may request the Third Umpire to consider a decision of the on field umpires using DRS (Player's Review).
- The technologies used in Decision Review System are Television Replays, The Ball Tracking technology used to track the path of the ball, Microphones, Snickometer, Infra-Red imaging to detect temperature changes as the ball hits the pad or the bat. The Technologies Used in Decision Review System are:

1. **TELEVISION REPLAYS**: including Slow Motion which is mainly used to check whether the catch is cleanly taken or not.
2. **HAWK EYE:** Ball Tracking technology that plots the **trajectory of a bowling delivery** that has been interrupted by the batsmen/batswomen often by the pad and predict whether it would have hit the stumps or not. This technology is mainly used for **Leg Before Wicket(LBW) decisions** where the umpire can check whether the impact of the ball is in line to the stumps, whether the ball is hitting the stumps, and whether the ball is pitching outside the leg stump or not. These three conditions are mandatory for LBW decision which is reviewed using Hawk Eye Technology.
3. **SNICKOMETER:** Directional microphones to detect small sounds made as the ball passes the bat or the pad. It is mainly used for caught behind and LBW decisions. If the Snickometer shows spikes while passing the bat then it indicates that the ball has hit the bat which can be used for both caught behind and LBW decisions.
4. **HOTSPOT:** Infra-Red imaging system that shows where the ball has been in contact with the pad or the bat. It mainly shows the point of contact between the ball, bat and pad. It is mandatorily used to check whether the ball has hit the pad or the bat first in case of LBW and checks whether the ball has hit the bat or not in case of caught behind. It can be said as a substitute to Snickometer.

➡ SALINITY GRADIENT ENERGY

Salinity gradient power is the ***energy created from the difference in salt concentration between two fluids****, commonly fresh and salt water, e.g., when a river flows into the sea. There are two technologies for which demonstration projects are running and both use membranes.*



1. **Pressure Retarded Osmosis (PRO)** uses a membrane to separate a concentrated salt solution (like sea water) from freshwater. The freshwater flows through a semipermeable membrane towards the sea water, which increases the pressure within the seawater chamber. A turbine is spun as the pressure is compensated and electricity is generated.
2. **Reversed Electro Dialysis (RED)** uses the transport of (salt) ions through membranes. RED consists of a stack of alternating cathode and anode exchanging perm selective membranes. The compartments between the membranes are alternately filled with sea water and freshwater. The salinity gradient difference is the driving force in transporting ions that results in an electric potential, which is then converted to electricity.

- **Two main applications exist**: as standalone plants in estuaries where freshwater rivers run into the sea; and as hybrid energy generation processes recovering energy from high salinity waste streams. his could be for example, brine from desalination or salt mining, as well as waste water treatment plants. A possible third application is salinity gradient technologies applied to land based saltwater lakes or other types of salt water reserves.

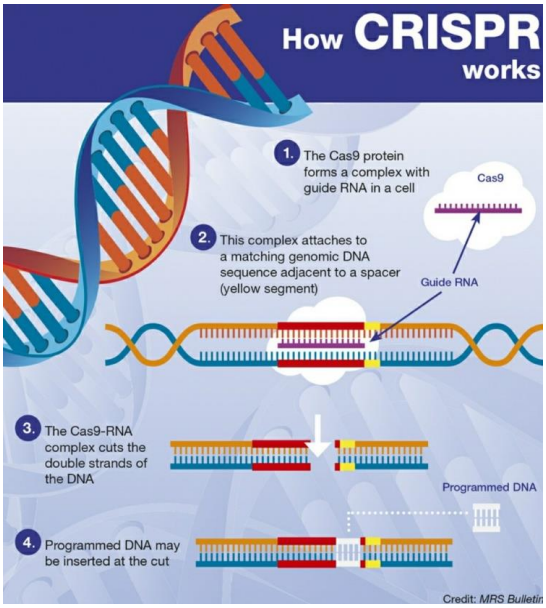
➡ CRISPR - Cas9

- **CRISPR** – Clustered, regularly interspaced, short palindromic repeats, is the technology and Cas9 is the protein that acts like a scissor.
- CRISPR technology is basically a gene-editing technology that can be used for the purpose of altering genetic expression or changing the genome of an organism.
- This technique is based on the natural defence mechanism found in some bacteria.

- It **uses a specific enzyme — Cas9 — to identify and eliminate predetermined genes and DNA sequences.**
- The technology can be used for targeting specific stretches of an entire genetic code or editing the DNA at particular locations.
- Its many potential applications include correcting genetic defects, treating and preventing the spread of diseases and improving crops.
- **It is a cheaper, more** effective, and endlessly adaptable form of gene manipulation, and it seems to work in every model organism.

HOW CRISPR - CAS9 TECHNOLOGY WORKS?

- In bacteria, Cas9 carries crRNA — the genetic information of viruses to identify where to make their cuts.
- The specific location of the genetic codes that need to be changed, or "edited", is identified on the DNA strand, and then, using the Cas9 protein, which acts like a pair of scissors, that location is cut off from the strand. A DNA strand, when broken, has a natural tendency to repair itself.
- **If Cas9 is assigned a specific RNA sequence and delivered to cells, it will hunt down corresponding sequences in the cellular DNA housed in the nuclei and perform a double-strand cut, severing the entire helix at a predetermined point.**



- Scientists intervene during this auto-repair process, supplying the desired sequence of genetic codes that binds itself with the broken DNA strand.

➡ PULSE OXIMETER

- A pulse oximeter is a small, lightweight device used to monitor the amount of oxygen carried in the body.
- This non-invasive tool attaches painlessly to your fingertip.
- Once the oximeter finishes its assessment, its screen will display the percent of oxygen in your blood coming from your heart—as well as your current pulse rate.

BLOOD OXYGEN SATURATION (SPO2)

- Your SpO2 reading is an **estimation of the amount of oxygen in your blood**.
- An SpO2 reading of 95% or greater is generally considered to be a normal oxygen level.
- **However, an SpO2 reading of 92% or less (at sea level) suggests that your blood is poorly saturated.**
- Insufficient saturation can cause a range of adverse health conditions—including chest pain, shortness of breath and increased heart rate.

Acceptable range of Oxygen in the blood:

- Acceptable normal ranges for patients without pulmonary pathology are from 95 to 99 percent.
- For a patient breathing room air at or near sea level, an estimate of arterial pO2 can be made from the blood-oxygen monitor "saturation of peripheral oxygen" (SpO2) reading.

How Pulse Oximeter works?

- A blood-oxygen monitor displays the percentage of blood that is loaded with oxygen.
- More specifically, it measures what percentage of haemoglobin, the protein in blood that carries oxygen, is loaded.

ACTUAL MECHANISM

- A typical pulse oximeter uses an electronic processor and a pair of small light-emitting diodes (LEDs) facing a photodiode through a translucent part of the patient's body, usually a fingertip or an earlobe.
- One LED is red, with wavelength of 660 nm, and the other is infrared with a wavelength of 940 nm.
- Small beams of light pass through the blood in the finger, measuring the amount of oxygen. It does this by measuring changes of light absorption in oxygenated or deoxygenated blood. This is a painless process. The pulse oximeter will thus be able to tell you your oxygen saturation levels along with your heart rate.

  In general, a lower heart rate at rest implies more efficient heart function and better cardiovascular fitness. For some people, a pulse rate below 60 bpm indicates abnormally slow heart action, also known as bradycardia. Bradycardia can cause a number of problematic symptoms—including fainting, fatigue, chest pains and memory problems.

➡ ELECTRONIC WASTE

- **Mobile phones, tablets, laptops**: the proliferation of digital devices is becoming a problem for the planet because once they come to the end of their useful lives — every year almost 50 million tons of technological scrap is generated — their recycle rate is poor. Improving it is vital to slowing climate change and avoiding harm to the environment.
- The **Organisation for Economic Co-operation and Development (OECD)** defines electronic waste as any device powered by electrical energy that has reached the end of its working life. So we're not just talking about mobiles. Let's have a look at some of the types of WEEE (Waste Electrical Electronic Equipment) that are around:

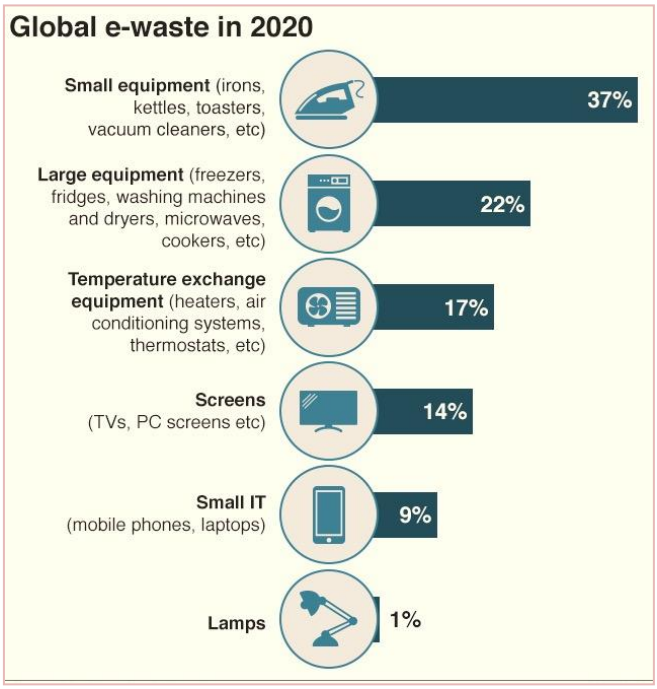
- Fridges, freezers and other cooling equipment.
- Computers and telecommunications equipment.
- Consumer electronic devices and solar panels.
- TVs, monitors and screens.
- LED bulbs.
- Vending machines.

THE PROBLEM OF TECHNOLOGICAL WASTE IN THE WORLD

- According to a UN report, the world generated 48.5 million tons of electronic waste in 2018. This figure highlights the growing importance of recycling, which also throws up some worrying statistics: a mere 20% of this waste is recycled. If we carry on like this, the UN estimates that we could reach 120 million tons of electronic scrap by 2050.
- The volume of e-waste produced worldwide and bad recycling management present a danger to the environment. Among the most common substances found in these discarded items are **cadmium, lead, lead oxide, antimony, nickel and mercury**. These toxic elements pollute rivers, lakes and seas, and release gases into the atmosphere that upset ecosystems. So reverting to a production and consumption model that reduces the amount of electronic waste cannot be put off any longer.
- Responsible consumption, capable of lengthening useful life and slowing the growth of this refuse is one of the answers to the problem. The reuse of technological devices has become the only option, in the face of an inefficient recycling system, to reduce the levels of electronic waste. In 2014 this French company opted for electronic refurbishment and was considered to be one of the most innovative in Europe.

HOW CAN WE REDUCE TECHNOLOGICAL GARBAGE?

Let's take a look at some of them:



Reduce: We are using more and more devices and replacing them more often. Changing this habit depends as much on the consumer — who should be less susceptible to marketing strategies that encourage consumption — as on manufacturers who are increasingly adopting policies like ecodesign.

Reuse: The experts in electronic recycling recommend that friends or family inherit devices that still work, or that they be offered on the second hand market. There is also the possibility of donating them to specialised charities.

Recycle: When the item no longer works and there is no chance of it being used by someone close, recycling should be the option. One option for the consumer is to hand the old device in to the shop where the new one is being purchased, or to some company that specialises in electronic refurbishment.

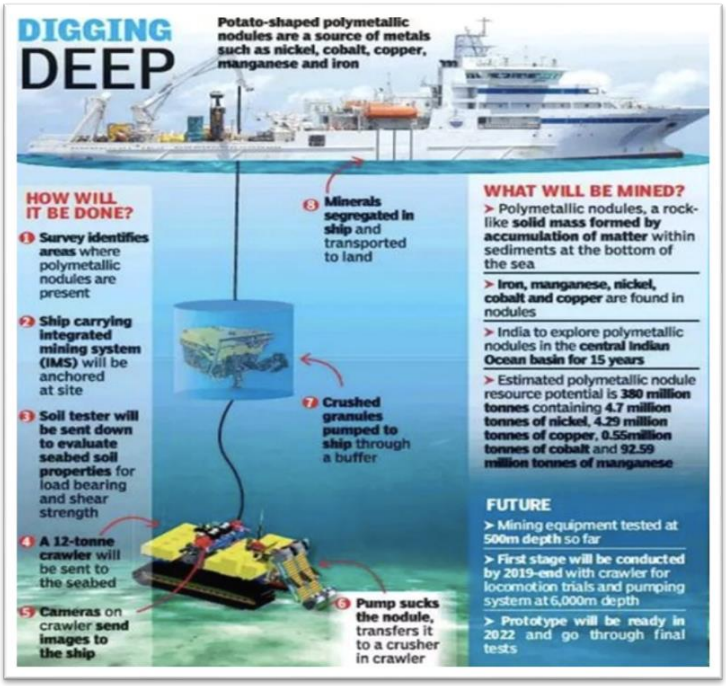
UN Sustainable Development Goal (SDG) 12 talks of the necessity to "ensure sustainable consumption and production patterns". Referring to discarded electronic devices, this means achieving ecologically acceptable management throughout their life cycle, as well as reducing the release of poisons into the atmosphere, water and soil to minimise their negative impact on health and the environment.

THE BENEFITS OF RECYCLING TECHNOLOGICAL WASTE

- According to a report, it is 13 times more costly to extract minerals from natural deposits than it is to recover them from technological waste for the manufacture of new devices. Obtaining minerals like platinum, copper and palladium does not just involve digging them up and processing them, it also requires the use of huge quantities of water and energy. This is where the concept of the circular economy comes in, based on the use of materials from recycled items and less dependence on the virgin resources extraction.
- Recycling electronic gadgets doesn't just improve the quality of the environment, it also brings other benefits. The International Telecommunication Union (ITU) reckons that these items, correctly recycled, could generate opportunities worth over $62.5 billion annually and create millions of new jobs worldwide. With this in mind, both this organisation and the UN have set themselves a target to increase global recycling to 30% and to reach 50% in countries with legislation on e-waste.
- Bad practices in the processing of e-waste are a handicap and, paradoxically, these abound in those countries that have the most of it. We are talking here about developing countries — SE Asia and Sub-Saharan Africa — which are generating a negative environmental impact through lack of the right infrastructures. Principal among the illegal methods is so-called "informal recycling", which consists of using toxic products in the open air and acid baths.

➡ DEEP OCEAN MISSION

- Oceans, which cover 70 per cent of the globe, remain a key part of our life. About 95 percent of Deep Ocean remains unexplored.
- For India, with its three sides surrounded by the oceans and around 30 per cent of the country's population living in coastal areas, ocean is a major economic factor supporting fisheries and aquaculture, tourism, livelihoods and blue trade.
- Oceans are also storehouse of food, energy, minerals, medicines, modulator of weather and climate and underpin life on Earth.
- Considering importance of the oceans on sustainability, the United Nations (UN) has declared the decade, **2021-2030 as the Decade of Ocean Science for Sustainable Development**.



- India has a unique maritime position. Its 7517 km long coastline is home to nine coastal states and 1382 islands. The Government of India's **Vision of New India by 2030**

enunciated in 2019 highlighted the **Blue Economy** as one of the ten core dimensions of growth.

- On this, the Cabinet Committee on Economic Affairs has approved the proposal of Ministry of Earth Sciences (MoES) on "Deep Ocean Mission", with a view to explore deep ocean for resources and develop deep sea technologies for sustainable use of ocean resources.
- The estimated cost of the Mission will be Rs. 4077 crore for a period of 5 years to be implemented in a phase-wise manner. The estimated cost for the first phase for the 3 years (2021-2024) would be Rs.2823.4 crore.
- Deep Ocean Mission with be a mission mode project to support the Blue Economy Initiatives of the Government of India. **Ministry of Earth Sciences (MoES)** will be the nodal Ministry implementing this multi-institutional ambitious mission.
- The Deep Ocean Mission consists of the following six major components:

1. **Development of Technologies for Deep Sea Mining, and Manned Submersible**: A manned submersible will be developed to carry three people to a depth of 6000 metres in the ocean with suite of scientific sensors and tools. Only a very few countries have acquired this capability. An Integrated Mining System will be also developed for mining Polymetallic Nodules from 6000 m depth in the central Indian Ocean. The exploration studies of minerals will pave way for the commercial exploitation in the near future, as and when commercial exploitation code is evolved by the International Seabed Authority, an UN organization. This component will help the Blue Economy priority area of exploring and harnessing of deep sea minerals and energy.
2. **Development of Ocean Climate Change Advisory Services**: A suite of observations and models will be developed to understand and provide future projections of important climate variables on seasonal to decadal time scales under this proof of concept component. This component will support the Blue Economy priority area of coastal tourism.
3. **Technological innovations for exploration and conservation of deep-sea biodiversity**: Bio-prospecting of deep sea flora and fauna including microbes and studies on sustainable utilization of deep sea bio-resources will be the main focus. This component will support the Blue Economy priority area of Marine Fisheries and allied services.
4. **Deep Ocean Survey and Exploration**: The primary objective of this component is to explore and identify potential sites of multi-metal Hydrothermal Sulphides mineralization along the Indian Ocean mid-oceanic ridges. This component will additionally support the Blue Economy priority area of deep sea exploration of ocean resources.
5. **Energy and freshwater from the Ocean**: Studies and detailed engineering design for offshore Ocean Thermal Energy Conversion (OTEC) powered desalination plant are envisaged in this proof of concept proposal. This component will support the Blue Economy priority area of off-shore energy development.
6. **Advanced Marine Station for Ocean Biology**: This component is aimed as development of human capacity and enterprise in ocean biology and engineering. This component will translate research into industrial application and product development through on-site business incubator facilities. This component will support the Blue Economy priority area of Marine Biology, Blue trade and Blue manufacturing.

➡ NANO UREA FERTILISER

- Nano urea is a **liquid fertilizer developed by IFFCO.** It is an alternative to conventional urea.
- It is essentially urea in the form of a nanoparticle.
- Urea is a chemical nitrogen fertilizer, white in colour, which artificially provides nitrogen, a major nutrient required by plants.
- **Aim:** It aims to reduce farmers' dependence on packaged urea.
- **Fertiliser Control Order (FCO) 1985:** It is based on existing rules that provisionally allow fertilizers to be used based on data from only two cropping seasons.
- The usual practice for recommending or rejecting a new fertilizer for commercial use required three seasons of independent assessment by the Indian Council of Agricultural Research (ICAR), but in the case of nano urea this was reduced to two.

Properties	Nano fertilizers	Conventional fertilizers
Solubility and dispersion of mineral micronutrients	Improve solubility and dispersion of insoluble nutrients in soil, reduce soil absorption and fixation and increase the bioavailability	Less bioavailability to plants due to large particle size and less solubility
Nutrient uptake efficiency	Might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer resource	Bulk composite is not available for roots and decrease efficiency
Controlled-release modes	Release rate and release pattern of nutrients for water-soluble fertilizers might be precisely controlled through encapsulation in envelope forms	Excess release of fertilizers may produce toxicity and destroy ecological balance of soil
Effective duration of nutrient release	Nanofertilizers can extend effective duration of nutrient supply of fertilizers into soil	Used by the plants at the time of delivery, the rest is converted into insoluble salts in the soil
Loss rate of fertilizer nutrients	Reduce loss rate of fertilizer nutrients into soil by leaching and/or leaking.	High loss rate by leaching, rain off and drift.

POTENTIAL BENEFITS

Shelf life	○ It has a shelf life of a year and farmers need not be worried about "caking" when it comes in contact with moisture.
Pricing	○ It comes in a half-litre bottle priced at Rs 240, and carries no burden of subsidy currently. ○ By contrast, a farmer pays around Rs 300 for a 50-kg bag of heavily subsidised urea.
Efficiency	○ The conventional urea has an efficiency of about 25 percent; the efficiency of liquid nano urea can be as high as 85-90 per cent.
Absorption	○ Liquid nano urea is sprayed directly on the leaves and gets absorbed by the plant. ○ Fertilisers in nano form provide a targeted supply of nutrients to crops, as they are absorbed by the stomata, pores found on the epidermis of leaves.
Lower subsidy Bill	○ It will reduce the country's subsidy bill and it is aimed at reducing the unbalanced and indiscriminate use of conventional urea.
Other benefits	○ Application of Nano Urea results in better crop productivity. ○ This is regarded as an excellent alternative to chemical fertilisers because it

	promotes growth and reduces environmental pollution. o Nano-fertilisers also reduce the crop cycle period and increase crop yield. o The unique properties of nanoparticles, such as high absorption capacity, the increased surface to volume ratio, and controlled-release kinetics to targeted sites, make them a potential plant growth enhancer.

LIMITATIONS OF NANO-FERTILISERS

- Lack of a nano-fertiliser risk management system
- Lack of production and availability of nano fertilisers in required quantities. This limits the wider scale adoption of nano-fertilisers as a source of plant nutrients.
- The high cost of nano fertilisers.
- Lack of standardisation in the formulation process. This brings about different results of the same nanomaterial under various pedoclimatic conditions.

SPACE AND TECHNOLOGY

➡ BLACK HOLE

- *Astronomical observations suggest that a **significant part of the universe is made up of dark matter** which interacts with the rest of the universe **only through the gravitational pull**. Many large lab experiments have tried to detect elementary particles that could be candidates for dark matter.*
- *However, such dark matter particles have not been detected until now.*
- *So, the question arises – could dark matter be composed, at least partly, of **compact objects such as black holes?***
- *Several astronomical observations suggest that all galaxies are embedded in a "halo" of dark matter.*
- *The "**visible" galaxy is like a disc embedded in a dark matter halo** that is much larger in size.*
- *One hypothesis is that dark matter comprises a large number of compact objects such as **primordial black holes.***

Primordial black holes

When the universe was very young, hot and dense – soon after the Big Bang, it must have had quantum fluctuations of its density. This, in turn, would have caused some regions to become extremely dense, and therefore, to collapse under their own gravity to form the primordial black holes.

- A black hole is anything but empty space. Rather, it is a **great amount of matter packed into a very small area** - think of a star ten times more massive than the Sun squeezed into a sphere approximately the diameter of a city. The result is a gravitational field so strong that nothing, not even light, can escape.

- A black hole is a place in space where gravity pulls so much that even light cannot get out. The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.
- Because no light can get out, people can't see black holes. They are invisible. Space telescopes with special tools can help find black holes. The special tools can see how stars that are very close to black holes act differently than other stars.
- The idea of an object in space so massive and dense that light could not escape it has been around for centuries. Most famously, black holes were predicted by **Einstein's theory of general relativity**, which showed that when a massive star dies, it leaves behind a small, dense remnant core. If the core's mass is more than about three times the mass of the Sun, the equations showed, the force of gravity overwhelms all other forces and produces a black hole.

HOW BIG ARE BLACK HOLES?

- Black holes can be big or small. Scientists think the smallest black holes are as small as just one atom. These black holes are very tiny but have the mass of a large mountain. Mass is the amount of matter, or "stuff," in an object.
- Another kind of black hole is called **"stellar."** Its mass can be up to 20 times more than the mass of the sun. There may be many, many stellar mass black holes in Earth's galaxy. Earth's galaxy is called the Milky Way.
- The largest black holes are called "**supermassive."** These black holes have masses that are more than 1 million suns together. Scientists have found proof that every large galaxy contains a supermassive black hole at its center. The supermassive black hole at the center of the Milky Way galaxy is called **Sagittarius A**. It has a mass equal to about 4 million suns and would fit inside a very large ball that could hold a few million Earths.

HOW DO BLACK HOLES FORM?

- Scientists think the smallest black holes formed when the universe began.
- **Stellar black holes are made when the center of a very big star falls in upon itself, or collapses**. When this happens, it causes a **supernova.** A supernova is an exploding star that blasts part of the star into space.
- Scientists think supermassive black holes were made at the same time as the galaxy they are in.

IF BLACK HOLES ARE "BLACK," HOW DO SCIENTISTS KNOW THEY ARE THERE?

- A black hole c**annot be seen because strong gravity pulls all of the light into the middle of the black hole.** But scientists can see how the strong gravity affects the stars and gas around the black hole. Scientists can study stars to find out if they are flying around, or orbiting, a black hole.
- When a black hole and a star are close together, high-energy light is made. This kind of light cannot be seen with human eyes. Scientists use satellites and telescopes in space to see the high-energy light.

COULD A BLACK HOLE DESTROY EARTH?

- Black holes do not go around in space eating stars, moons and planets. Earth will not fall into a black hole because no black hole is close enough to the solar system for Earth to do that.
- Even if a black hole the same mass as the sun were to take the place of the sun, Earth still would not fall in. The black hole would have the same gravity as the sun. Earth and the other planets would orbit the black hole as they orbit the sun now.
- The sun will never turn into a black hole. The sun is not a big enough star to make a black hole.

➡ WEIRD GALAXY

*Astronomers led by researchers from the Netherlands have found **no trace of dark matter** in the galaxy **AGC 114905**.*

- A galaxy is a **gravitationally bound system of stars, stellar remnants, interstellar gas, dust,** and **dark matter**.
- Galaxies are categorized according to their **visual morphology** as elliptical, spiral, or irregular. Many are thought to have supermassive black holes at their centers.
- The space between galaxies is filled with a **tenuous gas (the intergalactic medium)** with an average density of less than one atom per cubic meter. Most galaxies are gravitationally organized into groups, clusters and superclusters.

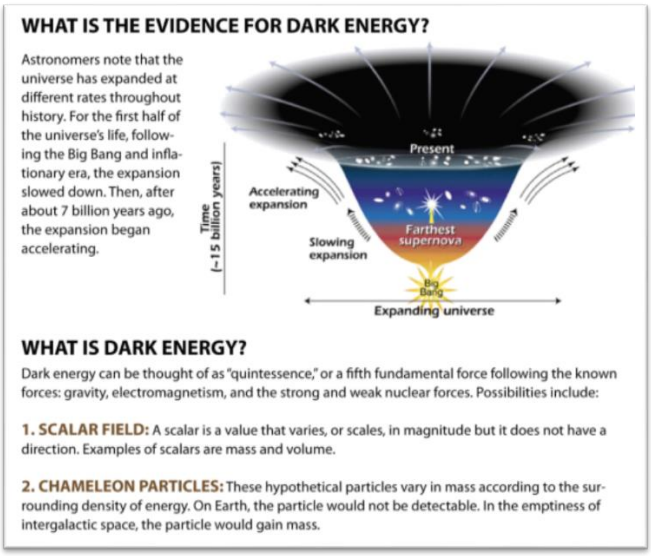
DARK MATTER

- It was in **1930s when Fritz Zwicky** observed that many galaxies were moving faster than theoretical calculations. This implied that there was some mysterious gravitational pull towards the centre of those galaxies. The quantity of matter needed to exert such a pull far exceed the observed matter. This extra matter which invisible and undetected has been termed as Dark Matter.
- Gradually many astronomers started researching on dark matter. It was when the Andromeda Galaxy was observed to be moving faster than expected that dark matter took the centre stage of astronomical research.

CHARACTERISTICS OF DARK MATTER

- It has not yet been observed yet directly. It doesn't interact with matter and is completely invisible to light and other forms of electromagnetic radiation making it impossible to detect.
- Scientists are confident it exists because of the gravitational effects it has on galaxies and galaxy clusters.
- The light from distant galaxies gets distorted and magnified by massive, invisible clouds of dark matter in the phenomenon known as **Gravitational Lensing**.
- There are 2 schools of thoughts on the existence of Dark Matter. While one school supports the idea of MACHOS (MAssive Compact Halo ObjectS) the other advocated WIMPS(Weakly Interacting Massive ParticleS).
- MACHOS are made up of Baryons(protons and neutrons) while WIMPS consists of Exotic particles which in turn are non-baryonic

- Dark matter responds to **2 of the Fundamental Forces**: Weak Nuclear Force and Gravitational Force.



DARK ENERGY: Roughly 68% of the universe is dark energy. it is a property of space so does not get diluted as space expands. As more space comes into existence, more of this energy-of-space appears. As a result, dark energy causes the universe to expand faster and faster.

IMPACTS OF DARK MATTER AND DARK ENERGY ON UNIVERSE

- While **Dark matter exerts a "pull" on the universe, Dark Energy has a contrasting expansionary effect.** As is it evident, our universe is expanding, indicating that Dark Energy has a greater abundance than dark matter.
- By the **laws of cosmology, the total amount of mass in the universe cannot increase**. Hence **while the amount of Dark matter remains constant, Dark Energy which is a property of space itself is bound to increase exponentially.** Eventually, Dark energy would overcome the influence of dark matter and lead to further expansion of the universe.

➡ MAGNETAR

An international group of researchers has succeeded in measuring for the first time the characteristics of a flare on a distant magnetar.

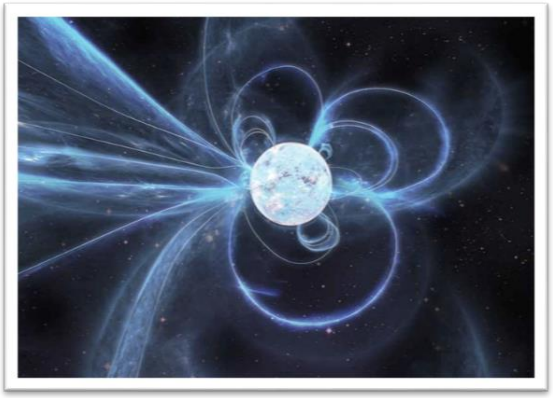
- Magnetars are the most **magnetic stars** in the universe.
- It is a rare compact type of neutron star teeming with energy and magnetism.
- It is an **exotic type of neutron star,** its defining feature that it has an ultra-powerful magnetic field.
- The field is about **1,000 times stronger than a normal neutron star** and about a trillion times stronger than the Earth's.
- Magnetars are relatively rare objects, with only about thirty having been spotted within the Milky Way so far.

WHAT IS THE RECENT STUDY?

- The studied **magnetar is about 13 million light years away**, in the direction of the NGC 253, a prominent galaxy in the Sculptor group of galaxies.
- Its flare spewed within a few tenths of a second as much energy as the Sun would shed in 100,000 years.
- It was captured accidentally on April 15, 2020, by the Atmosphere-Space Interactions Monitor instrument (ASIM) of the International Space Station.

- This is the first study to characterize such a flare from so distant a magnetar.

HOW DO MAGNETARS FORM?



- During the course of their evolution, massive stars – with masses around 10-25 times the mass of the Sun – eventually collapse and shrink to form very compact objects called neutron stars.
- A subset of these neutron stars is the so-called magnetars which possess intense magnetic fields.
- These are highly dense and have breathtakingly high rotation speeds – they have rotational periods that can be just 0.3 to 12.0 seconds.

WHAT CHARACTERIZES MAGNETARS?

- **Violent flares:** The observed giant flare lasted approximately 160 milliseconds and during this time 1039 joules of energy was released. The flare spewed as much energy in a tenth of a second that our Sun will radiate in 100,000 years.
- **Starquakes:** Eruptions in magnetars are believed to be due to instabilities in their magnetosphere, or "starquakes" produced in their crust – a rigid, elastic layer about one kilometer thick.
- This causes waves in the magnetosphere, and interaction between these waves causes dissipation of energy.

➡ EXOPLANET

- An exoplanet is any planet **beyond our solar system.**
- Most orbit other stars, but free-floating exoplanets, called **rogue planets**, orbit the galactic center and are untethered to any star.



- Most of the exoplanets discovered so far are in a relatively small region of our galaxy, the Milky Way. We know from NASA's Kepler Space Telescope that there are more planets than stars in the galaxy.
- By measuring **exoplanets' sizes (diameters)** and **masses (weights),** we can see compositions ranging from very rocky (like Earth and Venus) to very gas-rich (like Jupiter and Saturn).
- Exoplanets are made up of elements similar to those of the planets in our solar system, but their mixes of those elements may differ. Some planets may be dominated by water or ice, while others are dominated by iron or carbon. We've identified lava worlds covered in molten seas, puffy planets the density of Styrofoam and dense cores of planets still orbiting their stars.

- The **first exoplanets were discovered in the 1990s** and since then we've identified thousands using a variety of detection methods. It's pretty rare for astronomers to see an exoplanet through their telescopes the way you might see Saturn through a telescope from Earth. That's called **direct imaging**, and only a handful of exoplanets have been found this way (and these tend to be young gas giant planets orbiting very far from their stars).
- Now we live in a universe of exoplanets. The count of confirmed planets is in the thousands and rising. That's from only a small sampling of the galaxy as a whole. The count could rise to the tens of thousands within a decade, as we increase the number, and observing power, of robotic telescopes lofted into space.
- Most exoplanets are found through **indirect methods:** measuring the **dimming of a star** that happens to have a planet pass in front of it, called the **transit method,** or **monitoring the spectrum of a star for the tell-tale signs** of a planet pulling on its star and causing its light to subtly **Doppler shift.** Space telescopes have found thousands of planets by observing "transits," the slight dimming of light from a star when its tiny planet passes between it and our telescopes. Other detection methods include gravitational lensing, the so-called **"wobble method."**
- But when multiple methods are used together, we can learn the vital statistics of whole planetary systems – without ever directly imaging the planets themselves. The best example so far is the **TRAPPIST-1 system** about 40 light-years away, where seven roughly Earth-sized planets orbit a small, red star.
- The TRAPPIST-1 planets have been examined with ground and space telescopes. The space-based studies revealed not only their diameters, but the subtle gravitational influence these seven closely packed planets have upon each other; from this, scientists determined each planet's mass.
- So now we know their masses and their diameters. We also know how much of the energy radiated by their star strikes these planets' surfaces, allowing scientists to estimate their temperatures.

PLANET TYPES

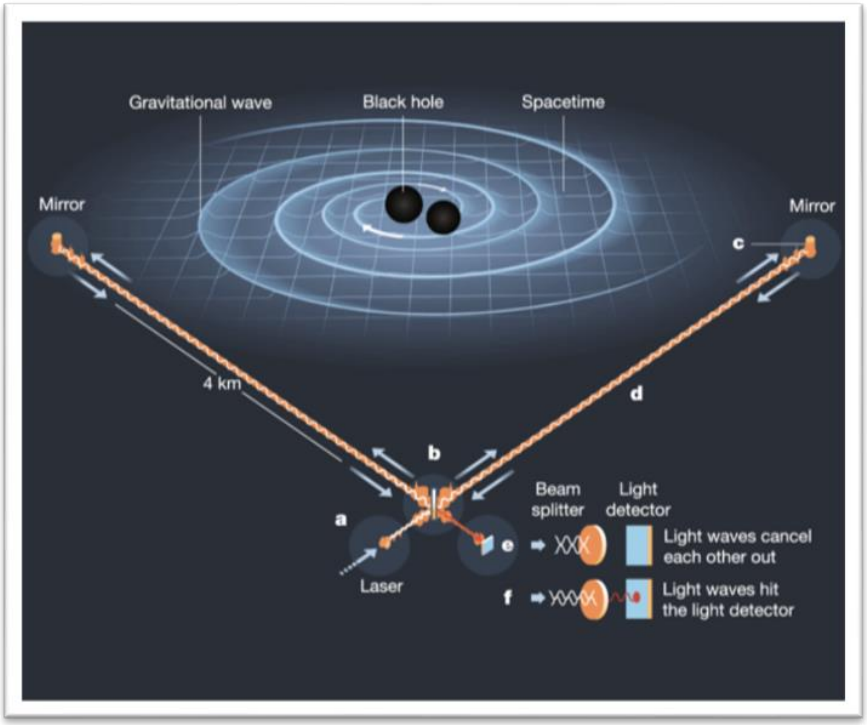
- Exoplanets come in a wide variety of sizes, from gas giants larger than Jupiter to small, rocky planets about as big around as Earth or Mars. They can be hot enough to boil metal or locked in deep freeze. They can orbit their stars so tightly that a "year" lasts only a few days; they can orbit two suns at once. Some exoplanets are sunless rogues, wandering through the galaxy in permanent darkness.

➡ GRAVITATIONAL WAVES

- Gravitational waves are **'ripples' in space-time** caused by some of the most violent and energetic processes in the Universe.
- Albert Einstein predicted the **existence of gravitational waves in 1916 in his general theory of relativity**. Einstein's mathematics showed that massive accelerating objects (such as neutron stars or black holes orbiting each other) would disrupt space-time in such a way that 'waves' of undulating space-time would propagate in all directions away from the

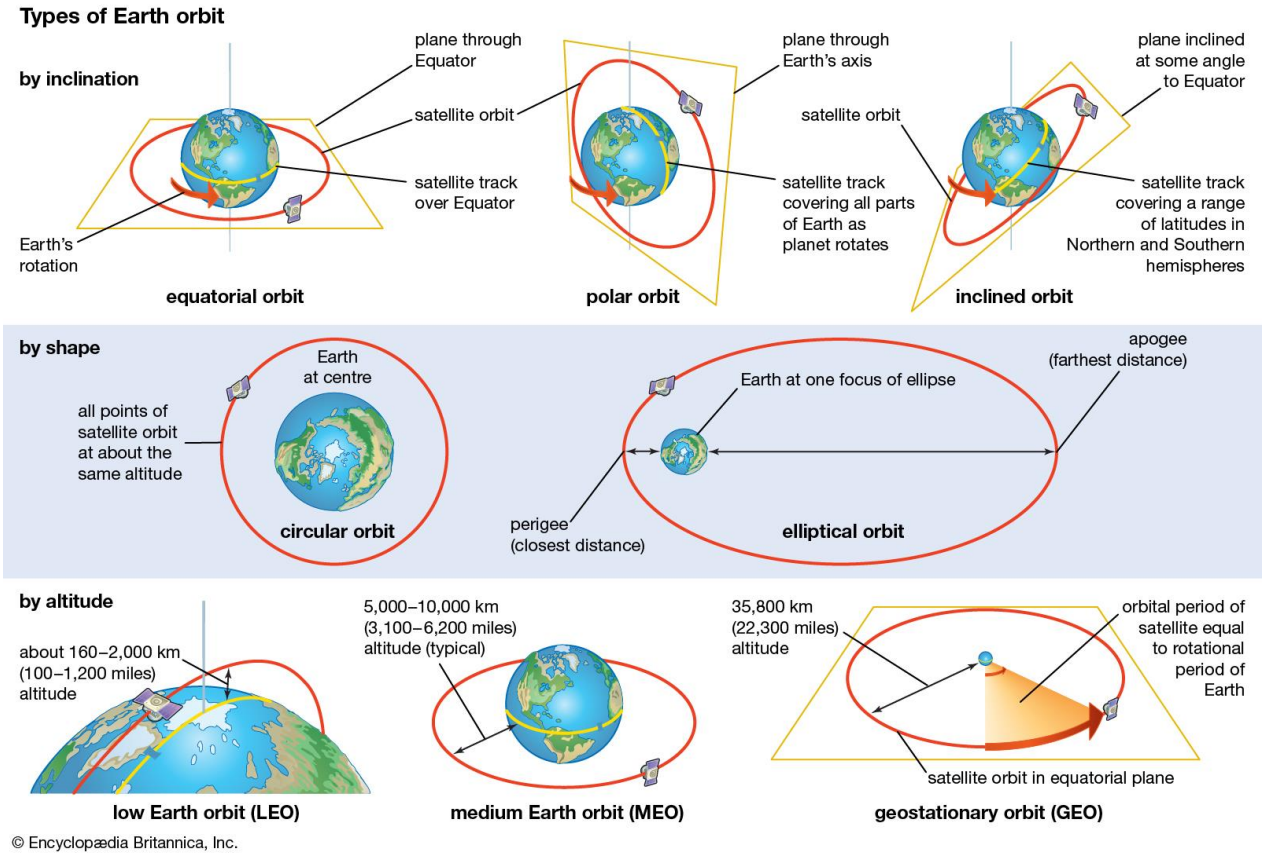
source. These cosmic ripples would travel at the speed of light, carrying with them information about their origins, as well as clues to the nature of gravity itself.

- The strongest gravitational waves are produced by cataclysmic events such as **colliding black holes, supernovae (massive stars exploding at the end of their lifetimes), and colliding neutron stars**. Other waves are predicted to be caused by the rotation of neutron stars that are not perfect spheres, and possibly even the remnants of gravitational radiation created by the Big Bang.
- Though Einstein predicted the existence of gravitational waves in 1916, the first proof of their existence didn't arrive until 1974, 20 years after his death. In that year, two astronomers using the Arecibo Radio Observatory in Puerto Rico discovered a binary pulsar, exactly the type of system that general relativity predicted should radiate gravitational waves. Knowing that this discovery could be used to test Einstein's audacious prediction, astronomers began measuring how the stars' orbits changed over time. After eight years of observations, they determined that the stars were getting closer to each other at precisely the rate predicted by general relativity if they were emitting gravitational waves. For a more detailed discussion of this discovery and work, see Look Deeper.



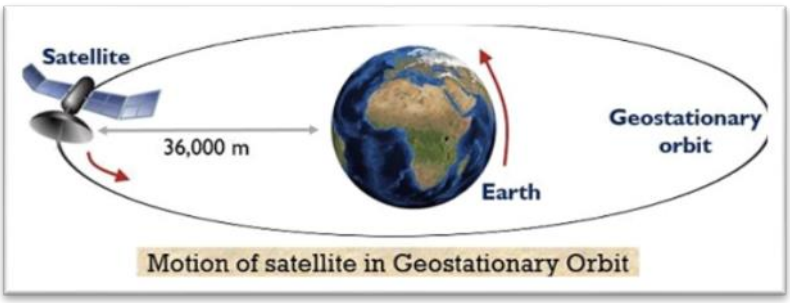
- Since then, many astronomers have studied **pulsar radio-emissions** *(pulsars are neutron stars that emit beams of radio waves)* and found similar effects, further confirming the existence of gravitational waves. But these confirmations had always come indirectly or mathematically and not through direct contact.
- All of this changed on September 14, 2015, when LIGO physically sensed the undulations in spacetime caused by gravitational waves generated by two colliding black holes 1.3 billion light-years away. LIGO's discovery will go down in history as one of humanity's greatest scientific achievements.
- While the processes that generate gravitational waves can be extremely violent and destructive, by the time the waves reach Earth they are thousands of billions of times smaller! In fact, by the time gravitational waves from LIGO's first detection reached us, the amount of space-time wobbling they generated was a 1000 times smaller than the nucleus of an atom! Such inconceivably small measurements are what LIGO was designed to make.

➡ TYPES OF EARTH ORBITS



➡ GEOSTATIONARY EARTH ORBIT

- It is also called **Geosynchronous Equatorial Orbit**.
- It is a **low inclination orbit**.
- It makes **satellites placed in it appear 'Stationary'**. [Reason – They have an orbital period that is the same as the earth's rotation period. Hence, the satellite/spacecraft returns to the same point in the sky at the same time each day.]



- **Communication satellites are often placed in GEO**. [Reason – This makes it easy for Earth Antennas to track them without rotation]
- The **GEO satellites are directly overhead at the Earth's equator**. [To an observer who is near to the pole, these will appear lower in the sky.]
- ISRO's Indian National Satellite System [INSAT] is placed in GEO. [It is one of the largest domestic communication satellite systems in the Asia-Pacific region.]

➡ LOW EARTH ORBIT (LEO)



- It is relatively closer to the Earth's surface than other orbits.
- The altitude from the earth's surface could be between **160 Km to 1000 Km**.
- The satellites placed in **LEO can have a tilted plane**.
- It is one of the **commonly used orbits**. [Reason – The satellites placed in it have more available routes as they don't have to follow a particular path around the Earth as the GEO]
- It is **used for satellite imaging**. [The images are of high resolution as the orbit is closer to the surface of the earth.]
- The **International Space Station (ISS) uses LEO** [It makes travel of astronauts easier]
- It is **used by remote sensing satellites**.

➡ MEDIUM EARTH ORBIT (MEO)

- The orbit, altitude of **which is between LEO and GEO, is known as Medium Earth Orbit**.
- It is also known as **Intermediate Circular Orbit**.
- It shares the similarity with LEO as the MEO satellites too do not have to track the path along the earth's equator.
- Navigation satellites and a number of artificial satellites are placed in MEO.
- **Global Positioning System (GPS) is placed in MEO** (20200 Km)
- Communication satellites too can be placed here. (Example – O3b MEO Satellite Constellation)

➡ POLAR ORBIT AND SUN-SYNCHRONOUS ORBIT (SSO)

- The SSO satellites travel past earth from north to south instead of west to east.
- These pass roughly over the earth's poles.
- The **altitude can go as low as 200 K however**, mostly the **satellites are placed between 600-800 km.**
- As the name suggests, the **SSO satellites are in synchrony with the sun**. [Meaning – The position is 'fixed' relative to the sun.]
- **SSO satellites always visit the same spot at the same local time** as they are sun-synchronous.
- It is **used for imaging, spy, and weather satellites**.

➡ GEOSTATIONARY TRANSFER ORBIT (GTO)

- The **orbits are used by the satellites to travel from one orbit to another**.
- It is a **Hohmann Transfer Orbit between LEO and GSO.**
- GTO **provides satellites a halt [intermediate step]** before they can be placed in their destination orbit. This way, it uses relatively less energy from built-in motors.
- The launchers do not have to directly place a satellite into GEO. Instead, it can first make use of GTO.
- It is a **highly eccentric orbit.** [Meaning – The path is elliptical]

➡ EARTH OBSERVING SATELLITE (EOS-01)

- It is an **Earth observing satellite** and shall play a crucial part in applications under agriculture, disaster management, and forestry support
- The **EOS-01 satellite** is ISRO's first space mission during the COVID-19 pandemic.

WHAT IS AN EARTH OBSERVING SATELLITE?

- A satellite which through **space sends signals to Earth and monitors the changes which occur on the Earth's surface is called an Earth Observing Satellite (EOS).**
- These satellites can **only be used for non-military purposes** and mainly for environmental benefits
- The first EOS which was launched by ISRO was in the year 1988 and was named IRS-1A
- Currently, there are seventeen such remote sensing Indian satellites present in the orbit. Thirteen of which are in Sun-synchronous orbit and the rest four are in Geostationary orbit
- Few of the important **Earth Observing Satellites include**: RISAT-2BR1, Cartosat Series, SCATSAT-1, INSAT-3D, IMS, Bhaskara-I, and Bhaskara-II

➡ DEPARTMENT OF SPACE

BACKGROUND

- With the setting up of Indian National Committee for Space Research **(INCOSPAR) in 1962**, the space activities in the country were initiated.
- In the same year, the work on **Thumba Equatorial Rocket Launching Station (TERLS)** near Thiruvananthapuram was also started.
- **Indian Space Research Organisation (ISRO)** was established in **August 1969.**
- The Government of India constituted the **Space Commission** and established the **Department of Space (DOS) in June 1972** and brought ISRO under DOS in September 1972.
- The Department of Space (DOS) has the primary objective of promoting development and application of space science and technology to assist in all-round development of the nation.

Towards this, DOS has evolved the following programmes:

- **Launch Vehicle programme** having indigenous capability for launching spacecrafts
- **INSAT Programme** for telecommunications, broadcasting, meteorology, development of education etc.
- **Remote Sensing Programme** for application of satellite imagery for various developmental purposes
- **Research and Development in Space Sciences and Technology** for serving the end of applying them for national development
- The **Space Commission formulates the policies and oversees the implementation** of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country.

DOS implements these programmes mainly through:

- Indian Space Research Organisation (ISRO)
- Physical Research Laboratory (PRL)
- National Atmospheric Research Laboratory (NARL)
- North Eastern-Space Applications Centre (NESAC)
- Semi-Conductor Laboratory (SCL)
- The Antrix Corporation, established in 1992 as a government owned company, markets the space products and services.

The establishment of space systems and their applications are coordinated by the national level committees, namely:

- INSAT Coordination Committee (ICC)
- Planning Committee on National Natural Resources Management System (PC-NNRMS)
- Advisory Committee of on Space Sciences (ADCOS)

Attached and Subordinate Offices of DOS

- U. R. Rao Satellite Centre (URSC), Bengaluru
- Indian Space Research Organisation (ISRO), Bengaluru

AUTONOMOUS / APEX INSTITUTIONS

NATIONAL ATMOSPHERIC RESEARCH LABORATORY (NARL), TIRUPATI

- National Atmospheric Research Laboratory (NARL) is an autonomous research laboratory fully funded by the Department of Space, Government of India and involved in carrying out fundamental and applied research in Atmospheric and Space Sciences.
- It had its humble beginning in 1992 as the National Mesosphere-Stratosphere-Troposphere (MST) Radar Facility.
- Over the years several complementary techniques such as Rayleigh/Mie lidars, wind profilers have been added.

NORTH EASTERN SPACE APPLICATIONS CENTRE (NESAC), SHILLONG

- The North Eastern Space Applications Centre (NESAC), a joint initiative of Department of Space (DOS) and the North Eastern Council (NEC) is a society registered under the Meghalaya Societies Registration Act, 1983.

- The Centre has provided more than 20 years of dedicated service to the eight states of North Eastern Region (NER) of India using space science and technology.

SEMI-CONDUCTOR LABORATORY (SCL), MOHALI

- Semi-Conductor Laboratory (SCL), an autonomous body under Department of Space, Government of India, is engaged in Research & Development in the area of Microelectronics to meet the strategic needs of the country.
- Formerly known as **Semiconductor Complex Limited**, a Government of India Enterprise, which was converted into Semi-Conductor Laboratory under Department of Space, Government of India w.e.f. September 1, 2006.
- SCL has integrated facilities / supporting infrastructure all under one roof and undertakes activities focused on Design, Development, Fabrication, Assembly & Packaging, Testing and Quality Assurance of CMOS and MEMS Devices for various applications.
- SCL is also engaged in Fabrication of Hi-Rel Boards, Radio Sonde Systems and indigenisation of electronic sub systems.

SPACE PHYSICS LABORATORY (SPL), MOHALI

- The Space Physics Laboratory (SPL) at Vikram Sarabhai Space Centre (VSSC) carries out research and studies in atmospheric science and other related space science activities.
- Ammonium Perchlorate Experimental Plant (APEP) at Aluva in Kerala and the ISRO Inertial Systems Unit (IISU) at Thiruvananthapuram in Kerala also form part of VSSC.

ACADEMIES / INSTITUTIONS (GRANT IN AID)

INDIAN CENTRE FOR SPACE PHYSICS (ICSP), KOLKATA

- Indian Centre for Space Physics (ICSP) is a premiere Research Institute dedicated to carry out research in various challenging branches of Astronomy, Astrophysics and Space Science.
- It is a Government aided institution, but majority of the research fund comes from projects from National and International funding agencies.
- Major projects are from ISRO and DST.

INDIAN INSTITUTE OF REMOTE SENSING (IIRS), DEHRADUN

- Formerly known as Indian Photo-interpretation Institute (IPI), the Institute was founded on 21st April 1966 under the aegis of Survey of India (SOI).
- It was established with the collaboration of the Government of The Netherlands on the pattern of Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente, formerly known as International Institute for Aerospace Survey and Earth Sciences, The Netherlands.
- The original idea of setting the Institute came from India's first Prime Minister Pandit Jawahar Lal Nehru during his visit to The Netherlands in 1957.

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY (IIST), THIRUVANANTHAPURAM

- Indian Institute of Space Science and Technology (IIST), situated at Thiruvananthapuram is a Deemed to be University under Section 3 of the UGC Act 1956.

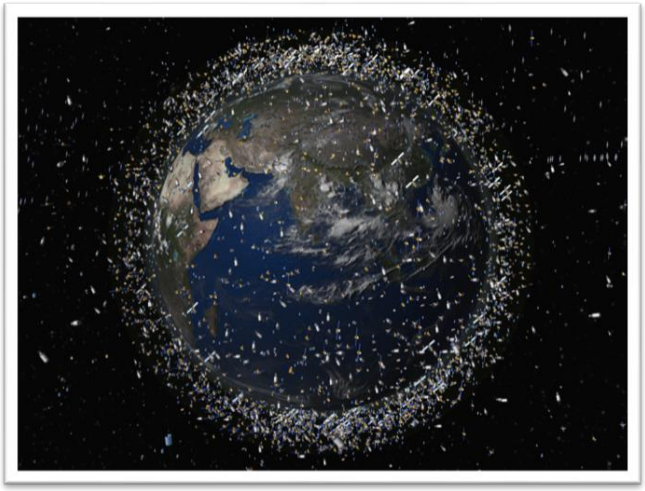
- IIST functions as an autonomous body under the **Department of Space, Government of India**.
- The idea of such an institute was mooted keeping in mind the need for high quality manpower for the Indian Space Research Organization, one of world's leading scientific organizations engaged in space research and space applications.
- The institute is the first of its kind in the country, to offer high quality education at the undergraduate, graduate, doctoral and post-doctoral levels on areas with special focus to space sciences, space technology and space applications.

PHYSICAL RESEARCH LABORATORY (PRL), AHMEDABAD

- Physical Research Laboratory (PRL), founded in 1947 by Dr. Vikram A. Sarabhai, is a premier scientific institution under the Department of Space, Government of India.
- The laboratory started with its focus on research areas of Astronomy and Cosmic Rays. In course of time, several new disciplines were added to its research theme.
- The current research activities of PRL are truly of multi-disciplinary nature at the cutting edge of science. These include Astronomy and Astrophysics, Space and Atmospheric Sciences, Solar Physics, Geosciences, Planetary Science, Atomic, Molecular & Optical Physics, Theoretical Physics & Cosmology.
- PRL currently has four campuses: the main campus at Navrangpura, Ahmedabad, with several world-class experimental and computing facilities; many leading laboratories in Thaltej campus, Ahmedabad; Optical and Infrared Observatory at Mount Abu, and Udaipur Solar Observatory at Udaipur.

➡ KESSLER SYNDROME

- In **1978, the NASA scientist Donald J. Kessler** proposed that a chain reaction of exploding space debris can end up making space activities and the use of satellites impossible for generations.
- He predicted that the number of objects that we keep launching into Low Earth Orbit (LEO) can create such a dense environment above the planet that inevitable collisions could cause a cascading effect. The space junk and shrapnel generated by one collision could make further collisions much more possible. And if you have enough collisions, the amount of space debris could overwhelm the orbital space entirely.



- What makes that situation possible is the fact that there are millions of micrometeoroids as well as man-made debris that is already orbiting Earth. The danger posed by even a small fragment that's traveling at high speeds is easy to see. As calculated by NASA, a 1-centimeter "paint fleck" traveling at 10km/s (22,000 mph) can cause the same damage as a 550-pound object traveling 60 miles per hour on Earth. If the size of the shard was increased to 10

centimeters, such a projectile would have the force of 7 kilograms of TNT. Now imagine thousands of such objects flying around at breakneck speeds and crashing into each other.

- If a chain reaction of exploding space junk did occur, filling the orbital area with such dangerous debris, the space program would indeed be in jeopardy. Travel that goes beyond the LEO, like the planned mission to Mars, would be made more challenging but still conceivably possible.
- What would, of course, be affected if the Kessler Syndrome's worst predictions came to pass, are all the services that rely on satellites. Core aspects of our modern life—GPS, television, military and scientific research—all of that would be under threat.
- NASA experienced a small-scale Kessler Syndrome incident in the 1970s when Delta rockets that were left in orbit started to explode into shrapnel clouds. This inspired Kessler, an astrophysicist, to show that there is a point when the amount of debris in an orbit gets to critical mass. At that point, the collision cascading would start even if no more things are launched into space. And once the chain of explosions begins, it can keep going until the orbital space can no longer be used.
- NASA says that its experts caution that we are already at critical mass in the low-Earth orbit, which is about 560-620 miles (900 to 1,000 kilometers) out.
- According to **NASA estimates**, the Earth's orbit currently has 500,000 pieces of space debris up to 10cm long, over 21,000 pieces of debris longer than 10cm, and more than 100 million pieces of space debris smaller than 1cm.

➡ SPACE SUSTAINABILITY

The U.K. hosted the fourth summit for Space Sustainability in London in collaboration with the Secure World Foundation.

WHAT DOES SUSTAINABILITY IN OUTER SPACE MEAN?

- The earth's **orbital environment has more than tripled in the past decade**. As the cost of missions reduce and the number of players increase, the complexity of missions and slot allotment issues also increase.
- With the emergence of large constellations and complex satellites, there is a **risk of collisions and interference with radio frequencies.**
- As the outer space is considered a shared natural resource, the **United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) in 2019** adopted a set of 21 voluntary, non-binding guidelines to ensure the long-term sustainability of outer space activities.
- One of the hot issues when it comes to space sustainability is **orbital crowding.**
- It poses a direct threat to the operations and safety of a mission and is likely to cause legal and insurance-related conflicts. Space debris is another prominent issue.
- After the completion of a mission, **an 'end-of-life protocol'** requires space objects to be moved to the graveyard orbit or to a low altitude. Neither of the options are sustainable in the long run.

- Other causes of concern are solar and magnetic storms which potentially damage communication systems. Such space weather threats need to be addressed along with the efforts to identify the terrestrial carbon footprint of outer space missions.
- **Long-term sustainability looks toward space research and development of technology** to ensure the reuse and recycling of satellites at every stage. The U.K. plan proposes active debris removal and in-orbit servicing.

U.K. PLAN FOR SPACE SUSTAINABILITY

- The U.K. calls for an **"Astro Carta"** for space sustainability, based on the Artemis Accords model for sustainable space exploration.
- The U.K. Space Sustainability plan mentions four primary elements:
  - to review the regulatory framework of the U.K.'s orbital activity;
  - to work with organisations such as the G-7 and the UN to emphasise international engagement on space sustainability;
  - to try and develop safety and quality-related metrics that quantify the sustainability of activities; and,
  - to induce additional funding of $6.1 million on active debris removal.
- The U.K. also confirmed investments in its National Space Surveillance and Tracking Programme, which works on collision assessment services for U.K.-licenced satellite operators.
- Post-Brexit, the U.K. space programme has been transformed. It now hopes to drive the sustainability factor internationally and provide an opportunity for the private sector to develop models that enhance operations' safety and reduce debris footprint.
- The U.K. **aims to draw investments** not only from government investors but also from others.

WHERE DOES INDIA STAND ON SPACE SUSTAINABILITY?

- The headquarters of the **Indian National Space Promotion and Authorisation Centre (In-SPACe) was formally inaugurated**.
- One can expect an increased role of the private sector in India's space activities.
- India hosts promising **start-ups like Agnikul and Skyroot**, which are developing launch vehicles for small payloads and Dhruva Space, which works on high-tech solar panels for satellites and satellite deployers.
- India is well on its way to create a subsystem that addresses global sustainability questions.
- The Indian Space Research Organisation (ISRO) has initiated **'Project NETRA'** to monitor space debris. The domestic surveillance system would provide first-hand information on the status of debris, which would aid further planning on protecting space assets.
- In April 2022, India and the U.S. signed a new pact for **monitoring space objects at the 2+2 dialogue.** The controlled **anti-satellite weapons (ASAT) tests** and the risk of collisions must be collectively addressed.
- To provide in-orbit servicing, ISRO is developing a docking experiment called **'SPADEX'.** It looks at docking a satellite on an existing satellite, offering support in re-fuelling and other in-orbit services while enhancing the capability of a satellite.

WAY FORWARD

- Outer space in the 2020s can no longer be considered a 'space race' because of the cost, when compared to the beginning of this century.
- Today, any entity (government or private) with the necessary access to resources and technology can invest in outer space. Sustainable practices in outer space would directly help reduce orbital crowding and collision risk while nurturing future technologies.
- As the natural course of evolution, the Plan for Space Sustainability, which includes private industries, is a timely move. This would serve as a model for other space programmes.
- However, the broad question of sustainability cannot be driven by one country/entity alone. While most National Space Programs set sustainability standards, a collective effort by all space players, with the active role of the **UN COPUOS or the United Nations Office for Outer Space Affairs (UNOOSA),** is needed to set equitable standards for the ease of activities. Many of the measures for sustainability are resource-consuming and expensive for medium-and-small space programs. In this case, private initiatives of sustainability standards would make accessibility more challenging, giving undue advantage to programs with stable investments.
- The **UK's Astro Carta idea** throws light on the need for addressing the principles and rules that guide the activities of entities in outer space.
- More clarity is required to know the exact framework and guiding principles of the Astro Carta to determine the path it intends to take.
- India has always emphasised cost-effective and efficient missions with problem-solving applications.
- Its debris footprint is minuscule; it has 114 debris among the 25,182 pieces, of sizes larger than 10 cm, in the lower earth orbits. The emerging private sector could be encouraged with a set of sustainability guidelines to ensure optimum utilisation of resources and increase the safety and productivity of missions.

➡ ASTEROID 16 PSYCHE

- A recent study has found that **asteroid 16 Psyche, which orbits between Mars and Jupiter**, could be made entirely of metal and is worth an estimated $10,000 quadrillion — more than the entire economy of Earth.
- Scientists believe that the asteroid may be the leftover core of an earlier planet that lost its crust and mantle after multiple collisions during the creation of our solar system.



WHAT IS ASTEROID 16 PSYCHE?

- Located around 370 million kilometres away from Earth, asteroid 16 Psyche is one of the most massive objects in the asteroid belt in our solar system. The somewhat potato-shaped asteroid has a diameter of around 140 miles, according to NASA.

- It was first discovered on March 17, 1853, by the Italian astronomer Annibale de Gasparis and was named after the ancient Greek goddess of the soul, Psyche.
- Unlike most asteroids that are made up of rocks or ice, scientists believe that Psyche is a dense and largely metallic object thought to be the core of an earlier planet that failed in formation.
- Metal asteroids are not commonly found in the solar system, and scientists believe that studying 16 Psyche may offer a rare glimpse of what the inside of a planet really looks like.

WHAT IS KNOWN ABOUT NASA'S PSYCHE MISSION?

- Scientists will only learn about the true composition of asteroid 16 Psyche if it is studied up close. NASA plans to do just that two years from now, when it will launch a SpaceX Falcon Heavy rocket from Cape Canaveral Air Force Station in Florida to orbit the asteroid for around 21 months.
- The unmanned spacecraft will reach the asteroid in January, 2026. The first objective of the mission is to capture a photograph of the metallic asteroid, after which the spacecraft will study and map it from a distance.
- Another objective of the mission is to determine whether the asteroid is, in fact, the core of an earlier planet or if it is merely made up of unmelted material. Based on the data collected, scientists will also ascertain the age and origins of the mammoth metallic asteroid.
- The mission was originally slated to take place in 2023, but was later moved up to 2022.

INDIA and SPACE SCIENCE

➡ LAUNCH VEHICLES



- **Launchers or Launch Vehicles** are used to carry spacecraft to space.
- India has two operational launchers**: Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).**
- GSLV with indigenous **Cryogenic Upper Stage** has enabled the launching up to 2 tonne class of communication satellites. The next variant of **GSLV is GSLV Mk III,** with **indigenous high thrust cryogenic engine and stage**, having the capability of launching 4 tonne class of communication satellites.
- In order to achieve high accuracy in placing satellites into their orbits, a combination of accuracy, efficiency, power and immaculate planning are required.
- ISRO's Launch Vehicle Programme spans numerous centres.

- **Vikram Sarabhai Space Centre**, located in Thiruvananthapuram, is responsible for the design and development of launch vehicles.
- **Liquid Propulsion Systems Centre and ISRO Propulsion Complex**, located at Valiamala and Mahendragiri respectively, develop the liquid and cryogenic stages for these launch vehicles.
- **Satish Dhawan Space Centre, SHAR**, is the space port of India and is responsible for integration of launchers. It houses two operational launch pads from where all GSLV and PSLV flights take place.

➡ SATELLITE LAUNCH VEHICLE-3 (SLV-3)

- SLV-3 was **India's first experimental satellite launch vehicle**, which was an **all solid, four stage vehicle** weighing 17 tonnes with a height of 22m and capable of placing 40 kg class payloads in Low Earth Orbit (LEO).
- SLV-3 was successfully launched on **July 18, 1980** from Sriharikota Range (SHAR), when **Rohini satellite, RS-1**, was placed in orbit, thereby making India the sixth member of an exclusive club of space-faring nations.
- SLV-3 employed an **open loop guidance** (with stored pitch programme) to steer the vehicle in flight along a pre-determined trajectory. The first experimental flight of SLV-3, in August 1979, was only partially successful. Apart from the July 1980 launch, there were two more launches held in May 1981 and April 1983, orbiting Rohini satellites carrying remote sensing sensors.
- The successful culmination of the SLV-3 project showed the way to advanced launch vehicle projects such as the Augmented Satellite Launch Vehicle (ASLV), Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous satellite Launch Vehicle (GSLV).

➡ AUGMENTED SATELLITE LAUNCH VEHICLE (ASLV)

- With a lift off weight of 40 tonnes, the 24 m tall ASLV was configured as a **five stage, all-solid propellant vehicle**, with a mission of orbiting **150 kg class satellites into 400 km circular orbits**.

- The Augmented Satellite Launch Vehicle (ASLV) Programme was designed to augment the payload capacity to 150 kg, thrice that of SLV-3, for **Low Earth Orbits (LEO).** While building upon the experience gained from the SLV-3 missions, ASLV proved to be a low cost intermediate vehicle to demonstrate and validate critical technologies, that would be needed for the future launch vehicles like strap-on technology, inertial navigation, bulbous heat shield, vertical integration and closed loop guidance.

- Under the ASLV programme four developmental flights were conducted. The first developmental flight took place on March 24, 1987 and the second on July 13, 1988. The third developmental flight, ASLV-D3 was successfully launched on May 20, 1992, when **SROSS-C (106 kg)** was put into an orbit of 255 x 430 km.
- ASLV-D4, launched on May 4, 1994, orbited SROSS-C2 weighing 106 kg. It had two payloads, **Gamma Ray Burst (GRB) Experiment** and **Retarding Potentio Analyser (RPA)** and functioned for seven years.

➡ POLAR SATELLITE LAUNCH VEHICLE (PSLV)

- Polar Satellite Launch Vehicle (PSLV) is the **third generation launch vehicle** of India.
- It is the **first Indian launch vehicle to be equipped with liquid stages**. After its first successful launch in October 1994, PSLV emerged as the reliable and versatile workhorse launch vehicle of India with 39 consecutively successful missions by June 2017. During 1994-2017 period, the vehicle has launched 48 Indian satellites and 209 satellites for customers from abroad.
- Besides, the vehicle successfully launched two spacecraft – **Chandrayaan-1 in 2008** and **Mars Orbiter Spacecraft in 2013** – that later traveled to Moon and Mars respectively.
- PSLV earned its title **'the Workhorse of ISRO'** through consistently delivering various satellites to Low Earth Orbits, particularly the IRS series of satellites. It can take up to 1,750 kg of payload to **Sun-Synchronous Polar Orbits** of 600 km altitude.
- Due to its unmatched reliability, PSLV has also been used to launch various satellites into **Geosynchronous and Geostationary orbits**, like satellites from the IRNSS constellation.

- **Fourth Stage**: PS4- The PS4 is the uppermost stage of PSLV, comprising of two Earth storable liquid engines.
- **Third Stage**: PS3- The third stage of PSLV is a solid rocket motor that provides the upper stages high thrust after the atmospheric phase of the launch.
- **Second Stage**: PS2- PSLV uses an Earth storable liquid rocket engine for its second stage, known as the Vikas engine, developed by Liquid Propulsion Systems Centre.
- **First Stage:** PS1-PSLV uses the S139 solid rocket motor that is augmented by 6 solid strap-on boosters.
- **Strap-on Motors**: PSLV uses 6 solid rocket strap-on motors to augment the thrust provided by the first stage in its PSLV-G and PSLV-XL variants. However, strap-ons are not used in the core alone version (PSLV-CA).

➡ GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE (GSLV)

- Geosynchronous Satellite Launch Vehicle Mark II (GSLV Mk II) is the **largest launch vehicle developed by India**, which is currently in operation.
- This **fourth generation launch vehicle** is a **three stage vehicle with four liquid strap-ons**. The indigenously developed cryogenic Upper Stage (CUS), which is flight proven, forms the third stage of GSLV Mk II.
- **Payload to GTO**: 2,500 kg- GSLV's primary payloads are **INSAT class of communication satellites** that operate from **Geostationary orbits** and hence are placed in **Geosynchronous Transfer Orbits** by GSLV.
- **Payload to LEO**: 5,000 kg-Further, GSLV's capability of placing up to 5 tonnes in Low Earth Orbits broadens the scope of payloads from heavy satellites to multiple smaller satellites.

- **Third Stage**: CUS- Developed under the Cryogenic Upper Stage Project (CUSP), the CE-7.5 is India's first cryogenic engine, developed by the Liquid Propulsion Systems Centre. CE-7.5 has a staged combustion operating cycle.
- **Second Stage**: GS2-One Vikas engine is used in the second stage of GSLV. The stage was derived from the PS2 of PSLV where the Vikas engine has proved its reliability.
- **First Stage**: GS1-The first stage of GSLV was also derived from the PSLV's PS1. The 138 tonne solid rocket motor is augmented by 4 liquid strap-ons.
- **Strap-on Motors**: The four liquid engine strap-ons used in GSLV are heavier derivatives of PSLV's PS2, and use one Vikas engine each.

➡ GSLV Mk III

- GSLV MkIII, chosen to launch **Chandrayaan-2 spacecraft**, is a **three-stage heavy lift launch** vehicle developed by ISRO. The vehicle has **two solid strap-ons, a core liquid booster and a cryogenic upper stage**.
- GSLV Mk III is designed to carry **4 ton class of satellites into Geosynchronous Transfer Orbit (GTO)** or about 10 tons to Low Earth Orbit (LEO), which is about twice the capability of the GSLV Mk II.
- The two strap-on motors of GSLV Mk III are located on either side of its core liquid booster. Designated as 'S200', each carries 205 tons of composite solid propellant and their ignition results in vehicle lift-off. S200s function for 140 seconds.
- During strap-ons functioning phase, the two clustered Vikas liquid Engines of L110 liquid core booster will ignite 114 sec after lift -off to further augment the thrust of the vehicle. These two engines continue to function after the separation of the strap-ons at about 140 seconds after lift -off.
- The first experimental flight of LVM3, the LVM3-X/CARE mission lifted off from Sriharikota on December 18, 2014 and successfully tested the atmospheric phase of flight. Crew module

Atmospheric Reentry Experiment was also carried out in this flight. The module reentered, deployed its parachutes as planned and splashed down in the Bay of Bengal.

- The first developmental flight of **GSLV Mk III, the GSLV-Mk III-D1** successfully placed **GSAT-19 satellite to a Geosynchronous Transfer Orbit (GTO)** on June 05, 2017 from SDSC SHAR, Sriharikota.
- GSLV MkIII-D2, the second developmental flight of GSLV MkIII successfully launched GSAT-29, a high throughput communication satellite on November 14, 2018 from Satish Dhawan Space Centre SHAR, Sriharikota
- GSLV MkIII-M1, successfully injected Chandrayaan-2, India's second Lunar Mission, in to Earth Parking Orbit on July 22, 2019 from Satish Dhawan Space Centre SHAR, Sriharikota.

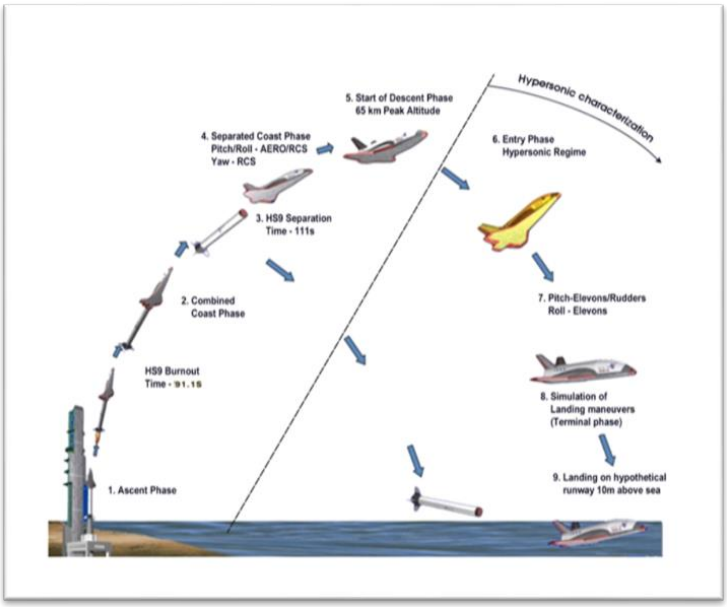
- **Payload to GTO**: 4,000 kg- GSLV Mk III will be capable of placing the 4 tonne class satellites of the GSAT series into Geosynchronous Transfer Orbits.
- **Payload to LEO:** 8,000 kg- The powerful cryogenic stage of GSLV Mk III enables it to place heavy payloads into Low Earth Orbits of 600 km altitude.
- **Cryogenic Upper Stage** : C25- The C25 is powered by CE-20, India's largest cryogenic engine, designed and developed by the Liquid Propulsion Systems Centre.
- **Solid Rocket Boosters** : S200- GSLV Mk III uses two S200 solid rocket boosters to provide the huge amount of thrust required for lift off. The S200 was developed at Vikram Sarabhai Space Centre.
- **Core Stage :** L110 Liquid Stage- The L110 liquid stage is powered by two Vikas engines designed and developed at the Liquid Propulsion Systems Centre.

➡ SOUNDING ROCKETS

- Sounding rockets are **one or two stage solid propellant rockets** used for probing the **upper atmospheric regions** and for space research.
- They also serve as easily affordable platforms to **test or prove prototypes of new components or subsystems** intended for use in launch vehicles and satellites.
- With the establishment of the **Thumba Equatorial Rocket Launching Station (TERLS) in 1963 at Thumb**a, a location close to the magnetic equator, there was a quantum jump in the scope for aeronomy and atmospheric sciences in India.
- The **launch of the first sounding rocket from Thumba** near Thiruvananthapuram, Kerala on 21 November 1963, marked the beginning of the Indian Space Programme . Sounding rockets made it possible to probe the atmosphere in situ using rocket-borne instrumentation.
- The first rockets were two-stage rockets imported from Russia (M-100) and France (Centaure). While the M-100 could carry a payload of 70 kg to an altitude of 85 km, the Centaure was capable of reaching 150 km with a payload of approximately 30 kg.
- ISRO started launching indigenously made sounding rockets from 1965 and experience gained was of immense value in the mastering of solid propellant technology. In 1975, all sounding rocket activities were consolidated under the Rohini Sounding Rocket (RSR) Programme. RH-75, with a diameter of 75mm was the first truly Indian sounding rocket, which was followed by RH-100 and RH-125 rockets. The sounding rocket programme was

the bedrock on which the edifice of launch vehicle technology in ISRO could be built. It is possible to conduct coordinated campaigns by simultaneously launching sounding rockets from different locations. It is also possible to launch several sounding rockets in a single day.

➡ REUSABLE LAUNCH VEHICLE – TECHNOLOGY DEMONSTRATOR (RLV-TD)



- RLV-TD is one of the most technologically challenging endeavours of ISRO towards developing essential technologies for a fully reusable launch vehicle to enable low cost access to space.
- The **configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft**. The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight. In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle.
- **RLV-TD consists of a fuselage (body), a nose cap, double delta wings and twin vertical tails.** It also features symmetrically placed active control surfaces called **Elevons and Rudder**.
- This technology demonstrator was boosted to Mach no: 5 by a conventional solid booster (HS9) designed for low burn rate.
- The selection of materials like special alloys, composites and insulation materials for developing an RLV-TD and the crafting of its parts is very complex and demands highly skilled manpower. Many high technology machinery and test equipment were utilised for building this vehicle.

OBJECTIVES OF RLV-TD:

- Hypersonic aero thermodynamic characterisation of wing body
- Evaluation of autonomous Navigation, Guidance and Control (NGC) schemes
- Integrated flight management
- Thermal Protection System Evaluation

RLV-TD was successfully flight tested in 2016 from SDSC SHAR Sriharikota validating the critical technologies such as autonomous navigation, guidance & control, reusable thermal protection system and re-entry mission management.

➡ SCRAMJET ENGINE - TD

- The first experimental mission of ISRO's Scramjet Engine towards the realisation of an **Air Breathing Propulsion System** was successfully conducted in 2016 from Satish Dhawan Space Centre SHAR, Sriharikota.
- After a flight of about 300 seconds, the vehicle touched down in the Bay of Bengal, approximately 320 km from Sriharikota. The vehicle was successfully tracked during its flight from the ground stations at Sriharikota. With this flight, critical technologies such as ignition of air breathing engines at supersonic speed, holding the flame at supersonic speed, air intake mechanism and fuel injection systems have been successfully demonstrated.
- The **Scramjet engine designed by ISRO uses Hydrogen as fuel and the Oxygen from the atmospheric air as the oxidiser.** This test was the maiden short duration experimental test of ISRO's Scramjet engine with a hypersonic flight at Mach 6.
- ISRO's Advanced Technology Vehicle (ATV), which is an advanced sounding rocket, was the solid rocket booster used for the test of Scramjet engines at supersonic conditions. ATV carrying Scramjet engines weighed 3277 kg at lift-off.

➡ COMMUNICATION SATELLITES

- The **Indian National Satellite (INSAT) system** is one of the largest domestic communication satellite systems in Asia-Pacific region with nine operational communication satellites placed in **Geo-stationary orbit**.
- **Established in 1983 with commissioning of INSAT-1B,** it initiated a major revolution in India's communications sector and sustained the same later.
- GSAT-17 joins the constellation of INSAT System consisting 15 operational satellites, namely - INSAT-3A, 3C, 4A, 4B, 4CR and GSAT-6, 7, 8, 9, 10, 12, 14, 15, 16 and 18.
- The INSAT system with more than 200 transponders in the **C, Extended C and Ku-bands** provides services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations.

➡ EARTH OBSERVATION SATELLITES

- Starting with **IRS-1A in 1988**, ISRO has launched many operational remote sensing satellites. Today, India has one of the largest constellations of remote sensing satellites in operation.
- Currently, *thirteen* operational satellites are in **Sun-synchronous orbit** – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1, and *four* in **Geostationary orbit**- INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR.
- Varieties of instruments have been flown onboard these satellites to provide necessary data in a diversified spatial, spectral and temporal resolutions to cater to different user requirements in the country and for global usage.

- The data from these satellites are used for several applications covering **agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management**.

➡ ASTROSAT

- **AstroSat is the first dedicated Indian astronomy mission** aimed at studying celestial sources in **X-ray, optical and UV spectral bands** simultaneously.
- The payloads cover the energy bands of Ultraviolet (Near and For), limited optical and X-ray regime (0.3 keV to 100keV).
- One of the unique features of AstroSat mission is that **it enables the simultaneous multi-wavelength observations** of various astronomical objects with a single satellite.
- AstroSat with a lift-off mass of 1515 kg was launched on September 28, 2015 into a 650 km orbit inclined at an angle of 6 deg to the equator by PSLV-C30 from Satish Dhawan Space Centre, Sriharikota.
- The minimum useful life of the AstroSat mission is expected to be 5 years.

➡ MARS ORBITER MISSION

- Mars Orbiter Mission is ISRO's **first interplanetary mission to planet Mars** with an orbiter craft designed to orbit Mars in an elliptical orbit of 372 km by 80,000 km.
- Mars Orbiter mission can be termed as a challenging technological mission and a science mission considering the critical mission operations and stringent requirements on propulsion, communications and other bus systems of the spacecraft.
- The primary driving technological objective of the mission is to design and realize a spacecraft with a capability to perform **Earth Bound Manoeuvre (EBM), Martian Transfer Trajectory (MTT) and Mars Orbit Insertion (MOI)** phases and the related deep space mission planning and communication management at a distance of nearly 400 million Km. Autonomous fault detection and recovery also becomes vital for the mission.

➡ SATELLITE NAVIGATION

- Satellite Navigation service is an emerging **satellite based system with commercial and strategic applications**.
- ISRO is committed to provide the satellite based Navigation services to meet the emerging demands of the Civil Aviation requirements and to meet the user requirements of the positioning, navigation and timing based on the independent satellite navigation system.
- To meet the Civil Aviation requirements, **ISRO is working jointly with Airport Authority of India (AAI) in establishing the GPS Aided Geo Augmented Navigation (GAGAN) system**.
- To meet the user requirements of the positioning, navigation and timing services based on the indigenous system, ISRO is establishing a regional satellite navigation system called **Indian Regional Navigation Satellite System (IRNSS).**

GPS AIDED GEO AUGMENTED NAVIGATION (GAGAN):

- This is a Satellite Based Augmentation System (SBAS) implemented jointly with Airport Authority of India (AAI).
- The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace.
- The system will be interoperable with other international SBAS systems and provide seamless navigation across regional boundaries.
- The GAGAN Signal-In-Space (SIS) is available through GSAT-8 and GSAT-10.

INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS) : NAVIC

- This is an independent Indian Satellite based positioning system for critical National applications.
- The main objective is to provide Reliable Position, Navigation and Timing services over India and its neighbourhood, to provide fairly good accuracy to the user.
- The IRNSS will provide basically two types of services

  - **Standard Positioning Service (SPS)**
  - **Restricted Service (RS)**

- To date, ISRO has built a total of nine satellites in the IRNSS series; of which eight are currently in orbit.
- Three of these satellites are in geostationary orbit (GEO) while the remaining in geosynchronous orbits (GSO) that maintain an inclination of 29° to the equatorial plane.
- The IRNSS constellation was named as **"NavIC" (Navigation with Indian Constellation)** and it was dedicated to the nation on the occasion of the successful launch of the IRNSS-1G satellite.
- The eight operational satellites in the IRNSS series, namely IRNSS-1A, 1B, 1C, 1D, 1E, 1F, 1G and 1I were launched on Jul 02, 2013; Apr 04, 2014; Oct 16, 2014; Mar 28, 2015; Jan 20, 2016; Mar 10, 2016, Apr 28, 2016; and Apr 12, 2018 respectively.

➡ SMALL SATELLITES

The small satellite project is envisaged to provide platform for stand-alone payloads for earth imaging and science missions within a quick turn around time. For making the versatile platform for different kinds of payloads, two kinds of buses have been configured and developed.

INDIAN MINI SATELLITE -1 (IMS-1)

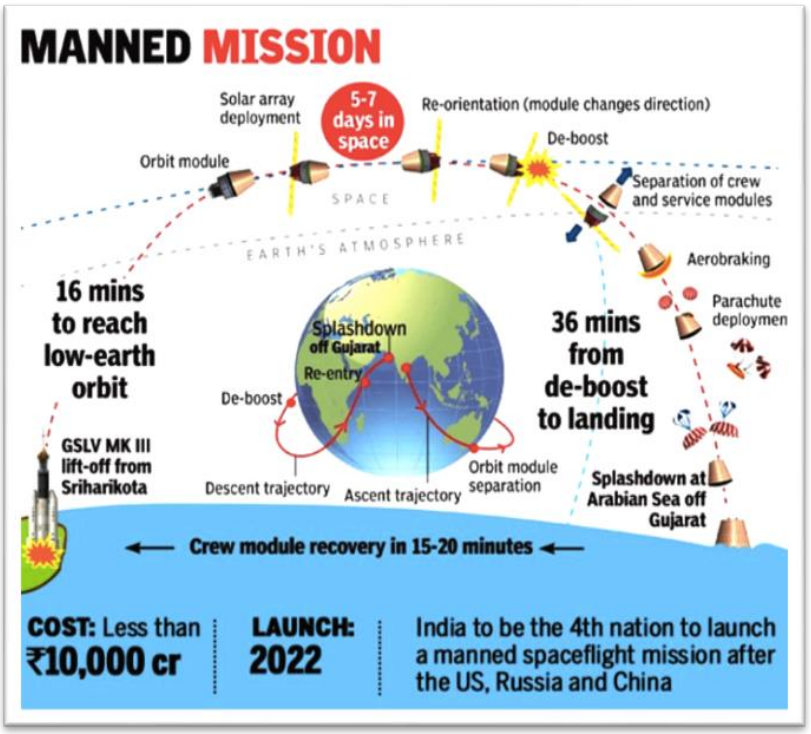
- IMS-1 bus has been developed as a versatile bus of 100 kg class which includes a payload capability of around 30 kg. The bus has been developed using various miniaturization techniques.
- The first mission of the IMS-1 series was launched successfully on April 28th 2008 as a co-passenger along with Cartosat 2A. Youthsat is second mission in this series and was launched successfully along with Resourcesat 2 in 2011.

INDIAN MINI SATELLITE -2 (IMS-2) BUS

- IMS-2 Bus is evolved as a standard bus of 400 kg class which includes a payload capability of around 200kg.
- IMS-2 development is an important milestone as it is envisaged to be a work horse for different types of remote sensing applications.
- The first mission of IMS-2 is **SARAL.**
- SARAL is a co-operative mission between ISRO and CNES with payloads from CNES and spacecraft bus from ISRO.

➡ GAGANYAAN

- The Gaganyaan Programme envisages undertaking the demonstration of human spaceflight to **Low Earth Orbit (LEO)** in the short-term and will lay the foundation for a sustained Indian human space exploration programme in the long run.
- The objective of Gaganyaan programme is to demonstrate indigenous capability to undertake human space flight mission to LEO.
- As part of this programme, two unmanned missions and one manned mission are approved by Government of India (GoI).



LIKELY BENEFITS

The Human spaceflight programme has both tangible and intangible benefits for the nation, which includes:

1. Progress towards a sustained and affordable human and robotic programme to explore the solar system and beyond.
2. Advanced technology capability for undertaking human space exploration, sample return missions and scientific exploration.
3. Future capability to actively collaborate in global space station development & to carry out scientific experiments of interest to the nation.

4. Create a broad frame work for wider Academia – Industry partnership in taking up development activities for national development.
5. Ample scope for employment generation and human resource development in advanced science and R&D activities.
6. Unique opportunity to inspire and excite Indian youth and steer many students toward careers in science and technology towards challenging jobs that encourage knowledge, innovation and creativity.
7. The programme will strengthen international partnerships and global security through the sharing of challenging and peaceful goals. Having a vibrant human spaceflight programme can be leveraged as a potent foreign policy tool.

The major new technologies required for Gaganyaan programme are as follows:

- Human rated launch vehicle
- Crew escape systems
- Habitable orbital module
- Life support system
- Crew selection and training and associated crew management activities

➡ GSLV F10 and EOS-03

- A technical anomaly preventing the ignition of the **GSLV-F10 rocket's cryogenic upper stage** and ISRO could not accomplish the mission to launch earth observation satellite EOS-03 into the intended orbit.
- **GSLV-F10 was ISRO's eighth flight with indigenous cryo**, 14th GSLV flight and 79th launch from Sriharikota.
- **EOS-03,** intended to be positioned in the geostationary transfer orbit initially, was supposed to reach the final geostationary orbit.
- It was expected to provide near real-time imaging of a large area of interest at frequent intervals, which could be used for quick monitoring of natural disasters, episodic events and any short-term events. The mission life of the satellite was 10 years.

KNOW ABOUT GSLV

- Geosynchronous Satellite Launch Vehicle Mark II (GSLV Mk II) is the **largest launch vehicle developed by India**, which is currently in operation.
- This **fourth generation launch vehicle** is a **three stage vehicle with four liquid strap-ons**. The indigenously developed cryogenic Upper Stage (CUS), which is flight proven, forms the third stage of GSLV Mk II.
- **Payload to GTO**: 2,500 kg- GSLV's primary payloads are **INSAT class of communication satellites** that operate from **Geostationary orbits** and hence are placed in **Geosynchronous Transfer Orbits** by GSLV.
- **Payload to LEO**: 5,000 kg-Further, GSLV's capability of placing up to 5 tonnes in Low Earth Orbits broadens the scope of payloads from heavy satellites to multiple smaller satellites.

- **Third Stage**: CUS- Developed under the Cryogenic Upper Stage Project (CUSP), the CE-7.5 is India's first cryogenic engine, developed by the Liquid Propulsion Systems Centre. CE-7.5 has a staged combustion operating cycle.
- **Second Stage**: GS2-One Vikas engine is used in the second stage of GSLV. The stage was derived from the PS2 of PSLV where the Vikas engine has proved its reliability.
- **First Stage**: GS1-The first stage of GSLV was also derived from the PSLV's PS1. The 138 tonne solid rocket motor is augmented by 4 liquid strap-ons.
- **Strap-on Motors**: The four liquid engine strap-ons used in GSLV are heavier derivatives of PSLV's PS2, and use one Vikas engine each.

➡ INDIAN SPACE ASSOCIATION (ISpA)

Indian Space Association (ISpA) *is an industry body consisting of various stakeholders of the Indian space domain.*

The members of the organisation include government bodies such as Indian Space Research Organisation (ISRO) and private telecom companies such as Bharti Airtel's One Web, Tata Group's Nelcom, L&T, MapMyIndia, and others.

WHY IS THE FORMATION OF ISPA SIGNIFICANT?

- Ever since the race to reach the space and then land on the Moon began between the US and the erstwhile USSR, governments across the world have poured millions of dollars to push the envelope in term of exploring the edges of the space. With time, governments and government agencies collaborated to explore newer planets and galaxies in search of life forms that exist outside Earth.
- In the recent past, private sector companies such as **Elon Musk's SpaceX, Richard Branson's Virgin Galactic, and Jeff Bezos' Blue Origin** have taken the lead in spaceflight, promising to start tourist flights to space.
- Though India too has made significant strides in space exploration over time, state-run ISRO has been at the centre and front of this progress. Several private sector companies, however, have shown an interest in India's space domain, with space-based communication networks coming to the fore.

WHAT DOES ISPA AIM TO ACHIEVE?

- One of the main goals of the organisation is to s**upplement the government's efforts towards making India a global leader in commercial space-based excursions**. Of late, ISRO's rockets have been carrying the payload and communication satellites of various countries; now, private players will also look to broach this space with the new organisation.
- ISpA said it **would engage with stakeholders across the ecosystem for the formulation of an enabling policy framework** which fulfils the government vision of leading commercial space exploration.
- ISpA will also work **towards building global linkages for the Indian space industry** to bring in critical technology and investments into the country to create more high skill jobs.

WHO ARE THE STAKEHOLDERS IN THIS ORGANISATION? HOW WILL THEY CONTRIBUTE?

- ISpA will be represented by leading domestic and global corporations that have advanced capabilities in space and satellite technologies.
- The founding members include telecom service providers such as Bharti Airtel, engineering firm Larson & Toubro, and other companies such as Nelco of Tata Group, OneWeb, Mapmyindia, Walchandnagar Industries and Alpha Design Technologies.
- Other core members include Godrej, Hughes India, Ananth Technology Limited, Azista-BST Aerospace Private Limited, BEL, Centum Electronics, and Maxar India.
- In India, the space-based communications network has taken off with several Indian and international companies betting on it as the next frontier to provide high-speed and affordable Internet connectivity to inaccessible areas as well. This includes SpaceX's StarLink, Sunil Bharti Mittal's OneWeb, Amazon's Project Kuiper, US satellite maker Hughes Communications, etc.
- OneWeb, for example, is building its initial constellation of 648 low-earth orbit satellites and has already put 322 satellites into orbit. Its services are expected to begin this year to the Arctic region including Alaska, Canada, and the UK. By late 2022, OneWeb will offer its high-speed, low latency connectivity services in India and the rest of the world.
- In addition, StarLink and Amazon are also in discussion with the Indian government for a licence to offer satellite-based Internet services. SpaceX has a plan to create a network of 12,000 satellites of which over 1,300 are already sky-borne.

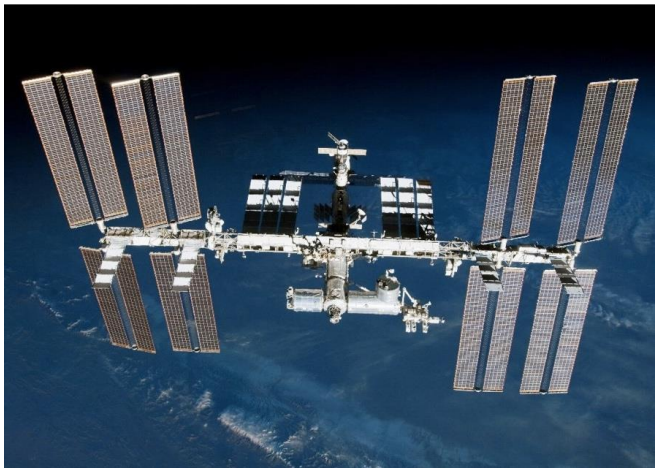
WHY IS SATELLITE-BASED INTERNET IMPORTANT IN INDIA?

- The expansion of the Internet in India is crucial to the government's dream of a digital India where a majority of government services are delivered directly to the customer. Although the government aims to connect all villages and gram panchayats with high-speed Internet over the next 1000 days through BharatNet, internet connectivity in hilly areas and far-flung places of Northeast India are still a challenge.
- To overcome this, industry experts suggest that satellite Internet will be essential for broadband inclusion in remote areas and sparsely populated locations where terrestrial networks have not reached. As of now, however, satellite communications remains limited to use by corporates and institutions that use it for emergency use, critical trans-continental communications and for connecting to remote areas with no connectivity.
- As of August this year, India had only 3 lakh satellite communications customers, compared with 45 lakh in the US and 21 lakh in the European Union.

➡ NASA TO DECOMMISSION ISS

- *The National Aeronautics and Space Administration (NASA) has announced plans to retire and decommission the International Space Station (ISS) by 2031.*
- *NASA plans to remove the ISS from its orbit around the earth and eventually plunge it into the ocean at a point farthest from human civilisation.*

ABOUT ISS



- The International Space Station (ISS) is a modular space station (habitable artificial satellite) 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).**
- Originally called **Freedom in the 1980s** by U.S. Pres. Ronald Reagan, who authorized the National Aeronautics and Space Administration (NASA) to build it within 10 years, it was redesigned in the 1990s to reduce costs and expand international involvement, at which time it was renamed.
- In 1993, the United States and Russia agreed to merge their separate space station plans into a single facility, integrating their respective modules and incorporating contributions from the European Space Agency (ESA) and Japan.
- Assembly of the International Space Station (ISS) began with the launches of the **Russian control module Zarya on November 20, 1998, and the U.S.-built Unity connecting node** the following month, which were linked in orbit by U.S. space shuttle astronauts.
- In mid-2000 the Russian-built module Zvezda, a habitat and control centre, was added, and in November of that year the ISS received its first resident crew, comprising Russian cosmonauts Sergey Krikalev and Yuri Gidzenko and American astronaut William Shepherd, who flew up in a Soyuz spacecraft.
- A NASA microgravity laboratory called **Destiny** and other elements were subsequently joined to the station, with the overall plan calling for the assembly, over a period of several years, of a complex of laboratories and habitats crossed by a long truss supporting four units that held large solar-power arrays and thermal radiators.
- Much of the early research work by ISS astronauts was to focus on long-term life-sciences and material-sciences investigations in the weightless environment.
- The **ISS became fully operational in May 2009** when it began hosting a six-person crew; this required two Soyuz lifeboats to be docked with the ISS at all times. The six-person crew typically consisted of three Russians, two Americans, and one astronaut from either Japan, Canada, or the ESA.
- After completion of the ISS, the shuttle was retired from service in 2011. Thereafter the ISS was serviced by Russia's Progress, Europe's ATV, Japan's H-II Transfer Vehicle, and two commercial cargo vehicles, SpaceX's Dragon and Orbital Sciences Corporation's Cygnus.
- 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 ISS is suited for testing the spacecraft systems and equipment required for possible future long-duration missions to the Moon and Mars.

➡ 1967 OUTER SPACE TREATY

- The United States and its Western allies submitted proposals in 1957 on reserving space exclusively for "peaceful and scientific purposes," but the Soviet Union rejected these efforts because it was preparing to launch the world's first satellite and test its first intercontinental ballistic missile.
- **In 1963, the UN General Assembly approved two resolutions** on outer space that subsequently became the basis for the Outer Space Treaty. **UN Resolution 1884** called on countries to refrain from stationing WMD in outer space. **UN Resolution 1962** set out legal principles on outer space exploration, which stipulated that all countries have the right to freely explore and use space.
- The United States and Soviet Union submitted separate draft outer space treaties to the UN General Assembly in June 1966. A mutually agreed treaty text was worked out over the next six months, and the UN General Assembly gave its approval of the treaty on December 19, 1966. The treaty opened for signature in Washington, Moscow, and London on January 27, 1967 and entered into force October 10, 1967.

- The **1967 Outer Space Treaty bans** the stationing of weapons of mass destruction (WMD) in outer space, prohibits military activities on celestial bodies, and details legally binding rules governing the peaceful exploration and use of space.

- The treaty entered into force Oct. 10, 1967, and has 110 states-parties, with another 89 countries that have signed it but have not yet completed ratification.

TREATY TERMS

- The treaty **forbids countries from deploying** "nuclear weapons or any other kinds of weapons of mass destruction" in outer space.
- The term "weapons of mass destruction" is not defined, but it is commonly understood to include nuclear, chemical, and biological weapons.
- The treaty, however, **does not prohibit the launching of ballistic missiles**, which could be armed with WMD warheads, through space.
- The treaty repeatedly emphasizes that space is to be used for peaceful purposes, leading some analysts to conclude that the treaty could broadly be interpreted as prohibiting all types of weapons systems, not just WMD, in outer space.

The treaty's key arms control provisions are in Article IV. States-parties commit not to:

- Place in orbit around the Earth or other celestial bodies any nuclear weapons or objects carrying WMD.
- Install WMD on celestial bodies or station WMD in outer space in any other manner.
- Establish military bases or installations, test "any type of weapons," or conduct military exercises on the moon and other celestial bodies.

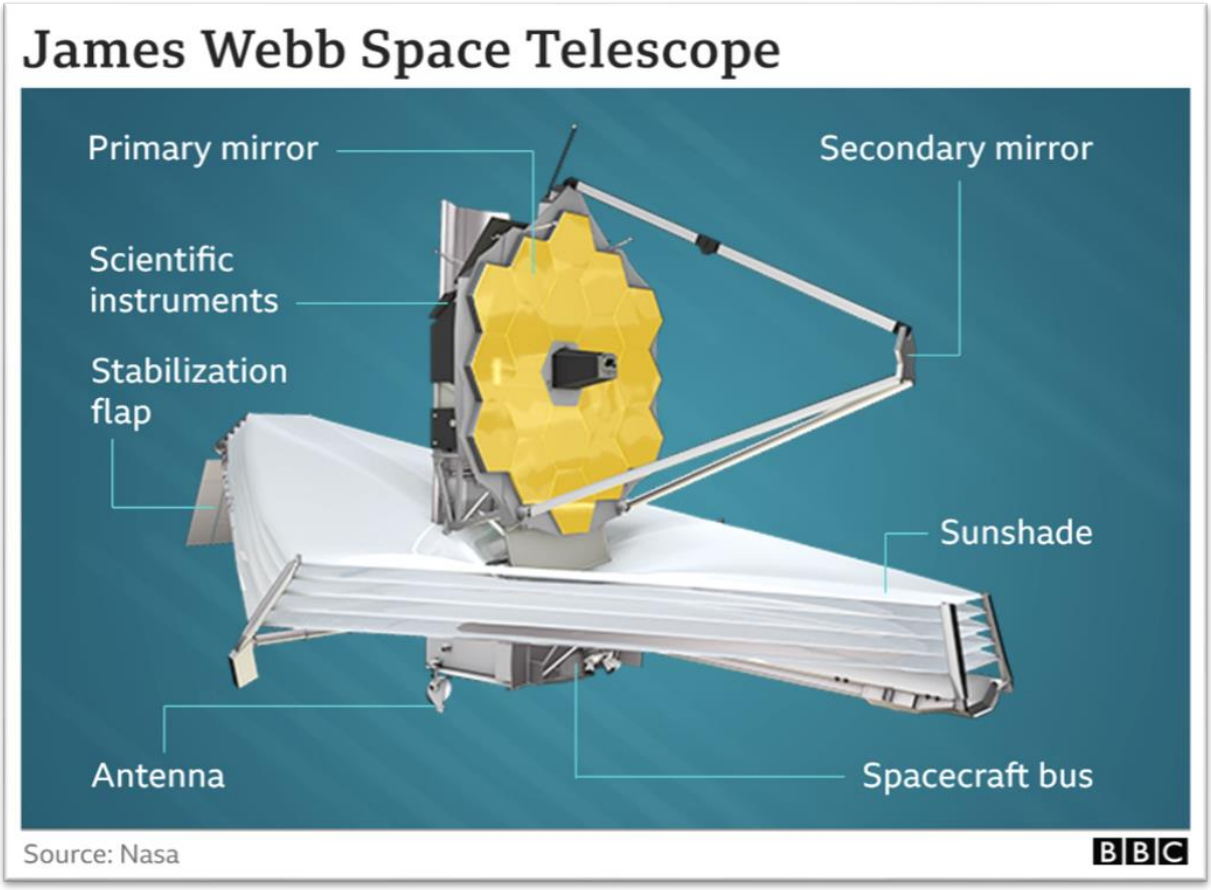
Other treaty provisions underscore that space is no single country's domain and that all countries have a right to explore it. These provisions state that:

- **Space should be accessible** to all countries and can be freely and scientifically investigated.
- **Space and celestial bodies are exempt from national claims** of ownership.

- Countries are to **avoid contaminating and harming space** or celestial bodies.
- **Countries exploring space are responsible and liable for any damage** their activities may cause.
- Space exploration is to be **guided by "principles of cooperation and mutual assistance,"** such as obliging astronauts to provide aid to one another if needed.

- Like other treaties, the Outer Space Treaty allows for amendments or member withdrawal.
- Article XV permits countries to propose amendments.
- An amendment can only enter into force if accepted by a majority of states-parties, and it will only be binding on those countries that approve the amendment.
- Article XVI states a country's withdrawal from the treaty will take effect a year after it has submitted a written notification of its intentions to the depositary states: the United States, Russia, and the United Kingdom.

➡ JAMES WEBB SPACE TELESCOPE



ABOUT THE TELESCOPE

- NASA's James Webb Space Telescope (JSWT) is an infrared space observatory was launched from **ESA's launch site at Kourou in French Guiana**, on board an **Arianespace Ariane 5 rocket**.

- The James Webb Space Telescope is the product of an impressive international collaboration between **NASA, the European Space Agency (ESA), and the Canadian Space Agency**.
- The $10 billion James Webb Space Telescope — NASA's largest and most powerful space science telescope — will probe the cosmos to **uncover the history of the universe from the Big Bang to alien planet formation and beyond**.
- It is one of NASA's Great Observatories, huge space instruments that include the likes of the Hubble Space Telescope to peer deep into the cosmos.
- It will take about 30 days for the James Webb Space Telescope to travel nearly a million miles (1.5 million kilometers) to its permanent home: **a Lagrange point — a gravitationally stable location in space.**
- The James Webb Space Telescope will **orbit the sun at the second Lagrange point (L2)**. **L2 is a spot in space near Earth that lies opposite from the sun**; this orbit will allow the telescope to stay in line with Earth as it orbits the sun. It has been a popular spot for several other space telescopes, including the **Herschel Space Telescope** and the **Planck Space Observatory.**
- According to NASA, the James Webb Space Telescope will focus on **four main areas**: **first light in the universe**, **assembly of galaxies in the early universe**, **birth of stars** and **protoplanetary systems**, and **planets (including the origins of life.)**
- The powerful James Webb Space Telescope is also expected to take amazing photos of celestial objects like its predecessor, the Hubble Space Telescope.

The telescope's science mandate is principally divided among four areas:

FIRST LIGHT AND REIONIZATION

- This refers to the early stages of the universe after the Big Bang started the universe as we know it today.
- In the first stages after the Big Bang, the universe was a **sea of particles** (such as electrons, protons and neutrons), and light was not visible until the universe cooled enough for these particles to begin combining.
- Another thing the telescope will study is what happened after the **first stars formed**; this era is called **"the epoch of reionization"** because it refers to when neutral hydrogen was reionized (made to have an electric charge again) by radiation from these first stars.

ASSEMBLY OF GALAXIES

- Looking at galaxies is a useful way to see how matter is organized on gigantic scales, which in turn gives us hints as to how the universe evolved.
- The spiral and elliptical galaxies we see today actually evolved from different shapes over billions of years, and one of telescope's goals is to look back at the earliest galaxies to better understand that evolution.
- Scientists are also trying to figure out how we got the variety of galaxies that are visible today, and the current ways that galaxies form and assemble.

BIRTH OF STARS AND PROTOPLANETARY SYSTEMS

- The Eagle Nebula's **"Pillars of Creation"** are some of the most famous birthplaces for stars. Stars come to be in clouds of gas, and as the stars grow, the radiation pressure they exert blows away the cocooning gas (which could be used again for other stars, if not too widely dispersed.)
- However, it's difficult to see inside the gas, the telescope's infrared eyes will be able to look at sources of heat, including stars that are being born in these cocoons.

PLANETS AND ORIGINS OF LIFE

- The last decade has seen vast numbers of exoplanets discovered, including with NASA's planet-seeking Kepler Space Telescope. James powerful sensors will be able to peer at these planets in more depth, including (in some cases) imaging their atmospheres.
- Understanding the atmospheres and the formation conditions for planets could help scientists better predict if certain planets are habitable or not.

➡ IRON FORTIFICATION

- Food Fortification is a scientifically proven, cost-effective, scalable and sustainable global intervention that addresses the issue of micronutrient deficiencies.
- In 2016, **FSSAI operationalized the Food Safety and Standards (Fortification of Foods) Regulations, 2016** for fortifying staples namely Wheat Flour and Rice (with Iron, Vitamin B12 and Folic Acid), Milk and Edible Oil (with Vitamins A and D) and Double Fortified Salt (with Iodine and Iron) to reduce the high burden of micronutrient malnutrition in India.
- The '+F' logo has been notified to identify fortified foods. Food Safety and Standards (Fortification of Foods) Regulations, 2018 were notified in the Gazette of India on 09.08.2018.

WHAT IS THE PROGRAM?

- Iron deficiency involves an insufficient supply of **iron to cells**, which can affect their growth and development.
- Iron deficiency is the most common cause of anaemia and may lead to a range of adverse physical and cognitive effects.
- Iron deficiency is most commonly tackled by **iron supplementation or iron fortification programs**.
- Iron supplementation can be administered orally, intravenously or intramuscularly, although daily oral iron supplementation is by far the most common method.
- **Iron fortification programs** usually involve mandatory, centralized mass fortification of staple foods, such as wheat flour. This report focuses on iron fortification programs but draws heavily on evidence from iron supplementation programs as well.

➡ SpaceX

SpaceX launched 4 astronauts to ISS on recycled rocket and capsule ***as part of NASA's SpaceX Crew-2 mission.***

- **Space Exploration Technologies Corp. (SpaceX)** is an American aerospace manufacturer, space transportation services and communications company headquartered in Hawthorne, California.
- SpaceX was founded in 2002 by **Elon Musk** with the goal of reducing space transportation costs to enable the colonization of Mars.
- SpaceX manufactures the **Falcon 9 and Falcon Heavy launch vehicles**, several rocket engines, Dragon cargo, crew spacecraft and **Starlink** communications satellites.

SPACEX'S ACHIEVEMENTS

- first privately funded liquid-propellant rocket to reach orbit (Falcon 1 in 2008),
- the first private company to successfully launch, orbit, and recover a spacecraft (Dragon in 2010),
- the first private company to send a spacecraft to the International Space Station (Dragon in 2012),
- the first vertical take-off and vertical propulsive landing for an orbital rocket (Falcon 9 in 2015),
- the first reuse of an orbital rocket (Falcon 9 in 2017),
- the first private company to send astronauts to orbit and to the International Space Station (SpaceX Crew Dragon Demo-2 in 2020).
- SpaceX has flown and reflown the Falcon 9 series of rockets over one hundred times.

NEW DEVELOPMENTS

- SpaceX is developing a satellite megaconstellation named **Starlink** to provide commercial internet service. In 2020 the Starlink constellation became the largest satellite constellation in the world.
- SpaceX is also developing **Starship,** a privately funded, fully reusable, super heavy-lift launch system for interplanetary spaceflight. Starship is intended to become the primary SpaceX orbital vehicle once operational, supplanting the existing Falcon 9, Falcon Heavy and Dragon fleet.

➡ AMAZONIA-1

- PSLV-C51, the first dedicated launch for NSIL, successfully launched Amazonia-1 and 18 Co-passenger satellites from Sriharikota
- After a flight of about 17 minutes 23 seconds, the vehicle injected the Amazonia-1 into its intended orbit and in the succeeding 1 hour 38 minutes, all the 18 co-passenger satellites successfully separated from the PSLV in a predetermined sequence.
- **Amazonia-1 is the optical earth observation satellite of National Institute for Space Research (INPE).** This satellite would further strengthen the existing structure by

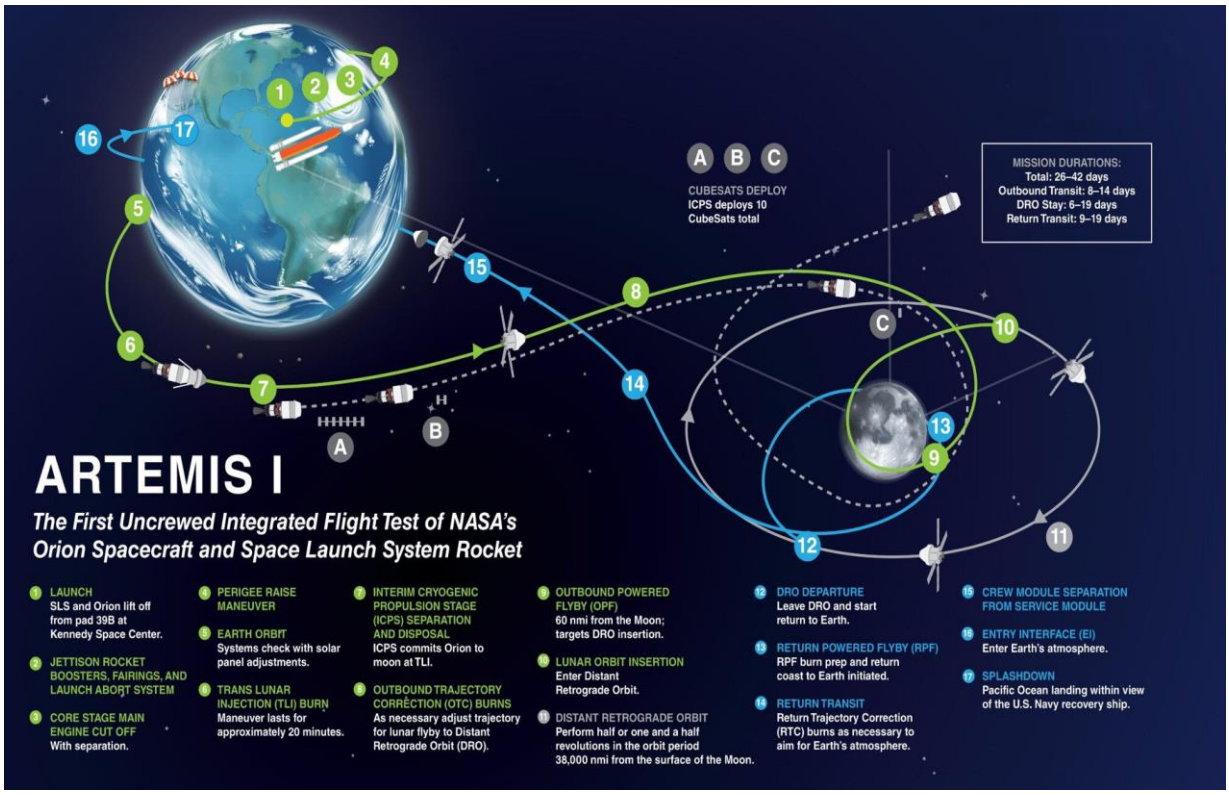
providing remote sensing data to users for monitoring deforestation in the Amazon region and analysis of diversified agriculture across the Brazilian territory.

- PSLV-C51/Amazonia-1 is the **first dedicated commercial mission of NewSpace India Limited (NSIL),** a Government of India company under Department of Space.
- The 18 co-passenger satellites onboard PSLV-C51 includes four from IN-SPACe and fourteen from NSIL. Out of 4 satellites from IN-SPACe, three were UNITYsats designed and built as a joint development by Jeppiaar Institute of Technology, Sriperumbudur (JITsat), G.H.Raisoni College of Engineering, Nagpur (GHRCEsat) and Sri Shakti Institute of Engineering and Technology, Coimbatore (Sri Shakthi Sat) and one was Satish Dhawan Sat (SDSAT) from Space Kidz India. The fourteen satellites from NSIL carried were the commercial satellites from India (1) and USA (13).
- PSLV-C51 is the 53rd flight of PSLV and 3rd flight of PSLV in 'DL' configuration (with 2 strap-on motors). This was the 78th launch vehicle mission from SDSC SHAR, Sriharikota.
- With this launch, the total number of customer satellites from foreign countries placed in orbit by PSLV is 342 satellites from 34 countries.

➡ ARTEMIS MISSION

RECENT

*The National Aeronautics and Space Administration (NASA) rolled out its **Artemis I moon mission** to the launchpad for testing at the Kennedy Space Centre in Florida, United States.*



WHAT IS ARTEMIS MISSION?

- NASA's Artemis mission is **touted as the next generation of lunar exploration**, and is named after the twin sister of Apollo from Greek mythology.
- Artemis is also the **goddess of the moon**.
- It is the first in a series of increasingly complex missions that will enable human exploration to the Moon and Mars.
- With the Artemis programme, **NASA aims to land humans on the moon by 2024**, and it also **plans to land the first woman and first person of colour on the moon.**
- NASA will establish an **Artemis Base Camp on the surface** and a gateway (the lunar outpost around the Moon) in lunar orbit to aid exploration by robots and astronauts.
- The gateway is a critical component of NASA's sustainable lunar operations and will serve as a multi-purpose outpost orbiting the moon.
- Other space agencies are also involved in the Artemis programme.

- Canadian Space Agency has committed to providing advanced robotics for the gateway,
- The European Space Agency will provide the International Habitat and the ESPRIT module, which will deliver additional communications capabilities among other things.
- The Japan Aerospace Exploration Agency plans to contribute habitation components and logistics resupply.

WHAT ARE KEY POINTS OF ARTEMIS I MISSION?

- Artemis I, formerly Exploration Mission-1, will be the first integrated flight test of NASA's Deep Space Exploration Systems:

- **Orion spacecraft:** Orion spacecraft is going to remain in space without docking to a space station, longer than any ship for astronauts has ever done before.
- **Space Launch System (SLS) rocket:** It is the most powerful rocket in the world — and travels 2,80,000 miles from the earth for over four to six weeks during the course of the mission.
- **Newly upgraded Exploration Ground Systems** at Kennedy Space Centre in Cape Canaveral, Florida.
- It is an uncrewed space mission where the spacecraft will launch on an SLS rocket.

- The primary operating goal of the mission is to assure a safe crew module entry, descent, splashdown, and recovery.
- SLS and Orion under Artemis I will be launched from the Kennedy Space Centre in Florida, U.S. in the summer of 2022.
- The mission will end with the Orion spacecraft's ability to return safely to the earth.

WHAT ARE THE FUTURE MISSIONS IN THE ARTEMIS PROGRAMME?

- The second flight under the programme will have crew on board and will test Orion's critical systems with humans onboard.
- Eventually, the learnings from the Artemis programme will be utilised to send the first astronauts to Mars.
- NASA plans on using the lunar orbit to gain the necessary experience to extend human exploration of space farther into the solar system.

DEFENCE TECHNOLOGY AND EQUIPMENTS

➡ NAVAL SYSTEMS & MATERIALS (NS & M)

- It comprises of **six laboratories** - Naval Physical & Oceanographic Laboratory (NPOL) at Kochi, Naval Science & Technological Laboratory (NSTL) at Visakhapatnam, Naval Materials Research Laboratory (NMRL) at Ambernath, Defence Metallurgical Research Laboratory (DMRL) at Hyderabad, Defence Materials Stores Research & Development Establishment (DMSRDE) at Kanpur, and Defence Laboratory (DLJ) at Jodhpur.
- The NS & M cluster is headed by the Director General (Naval Systems & Materials), with Headquarters at Visakhapatnam.
- NPOL, NSTL, NMRL, DMRL, DMSRDE and DLJ with DG Headquarters at Visakhapatnam.
- Naval Science & Materials cluster provides cutting edge naval and material solutions for the Armed Forces. The cluster has developed state-of-the-art underwater sensors and surveillance systems; underwater weapons and associated systems; Air Independent Propulsion systems; protection technologies for marine platforms; stealth and camouflage technologies for land, air and naval platforms; advanced metallic, ceramic, polymeric and composite materials for structural and functional application; and nuclear radiation management technologies.

Vision: To provide cutting-edge technologies and systems for the Indian Navy, and a complete materials solution to DRDO and the three services.

Mission: Development of

- State-of-the art underwater sensors & surveillance systems, underwater weapons & associated systems, Air Independent Propulsion systems, and protection technologies for marine platforms.
- Stealth and camouflage technologies for land, air and naval platforms.
- Advanced metallic, ceramic, polymeric and composite materials for structural and functional application.
- Nuclear radiation management technologies.

➡ AERONAUTICAL SYSTEMS

- Aeronautical Systems cluster is engaged in the development of s**tate-of-the-art unmanned Air Vehicles, Aero Gas Turbine Engine Technology, Airborne Surveillance Systems, Parachutes, Decelerators and Lighter-than-Air System**s.
- The cluster comprises of **four labs** – ADE, ADRDE, CABS, GTRE and a centre CEMILAC which provides concurrent airworthiness certification, support to indigenous development to certify upgrades and integration of imported and indigenous systems.
- **Vision:** To be a centre of excellence for design and development of state-of-the-art UAVs, Aero Gas Turbine Engine Technology, Airborne Surveillance Systems, Technologies and

Systems related to Parachute, Decelerators and Lighter-than-Air systems for the Services (Armed Forces).

- **Mission:** To design, develop and lead to production of UAVs; key technologies and infrastructure for building indigenous Airborne Surveillance systems; entire range of Parachutes and Lighter-than-Air Systems; design and develop affordable aero gas turbine engine systems and their derivatives to meet the needs of the Services (Armed Forces).

➡ ARMAMENT & COMBAT ENGINEERING SYSTEMS (ACE)

- It focuses on research & development of armaments, explosives, land based combat vehicles & engineering equipment. Labs under this cluster are also involved in the production of systems through Transfer of Technology (ToT).
- Armament labs have achieved high degree of self-reliance in a number of areas, viz., armaments, ammunitions, missiles, gun propellants, high explosives for warheads, pyrotechnics for various applications, synthesis and characterization of new energetic materials, electro explosive devices, high energy materials and pilot plant facilities.
- Combat Engineering labs are engaged in the development of systems / platforms like MBT, bridging systems, launchers for missiles & wheeled as well as tracked vehicles. Technologies developed by the labs include transmission & suspension for tracked vehicles, hydro-pneumatic systems for launchers, accurate forecast & control of avalanches, etc. ACE cluster includes eight labs – ACEM, ARDE, CVRDE, DTRL, HEMRL, PXE, R&DE(E), SASE, VRDE.

  Vision: To establish centers of excellence for technology development for realigning State of the Art Armaments, Combat Vehicles & Engineering Systems.

Mission

- Design and Development of State of the Art Technology and Systems in
- Armaments and High Energy Materials
- Armoured Vehicles & Mechanical Equipments
- Mobility & counter-mobility for Combat Equipments
- Intelligence Systems for Trafficability& safe mobility in all Terrain
- Working in Synergy with Academics, national research institutions, Services and through optimal utilization of collaborative efforts.

➡ MISSILES AND STRATEGIC SYSTEMS (MSS)

- MSS Cluster is responsible for the **design and development of state-of-the-art Missiles and Strategic Systems** required for the deterrence and defence of the country.
- The Cluster comprises of **five laboratories** - DRDL, RCI, ASL, TBRL, ITR, and various others centres for testing, integration and analysis of the systems being designed.
- MSS cluster is working on technologies like Aerodynamics and Airframe Design; Solid, Liquid, Ramjet and Scramjet Propulsion; Navigation, Control, Guidance and Homing

Systems; On-board Power Supply, Warhead Systems, Launch Systems as well as the Command and Control Systems for missile systems.

Vision: Empower the nation with state-of-the-art indigenous systems and technologies for missile based weapon systems deployable from underwater to outer space.

Mission

- Design, development and leading-to-production of systems and technologies for missile based weapon systems deployable from underwater to outer space.
- Ensure product support, product upgrade and end-of-life replacement.
- Establish critical infrastructure and facilities for design, testing and evaluation.

➡ ELECTRONICS AND COMMUNICATION SYSTEMS

- ECS Cluster has a mandate to design and develop electronic, electro-optical and laser based sensors and systems. The Cluster consists of laboratories DARE, DEAL, DLRL, IRDE, LASTEC, LRDE and the Cognitive Technology Lab.
- The cluster laboratories have developed state of art technologies in the fields of EW Systems, Radars, Electro-optic Equipment, Laser Sources & sensors, Directed Energy Weapon Systems and Communication Systems used in various Flagship Programmes and platforms of DRDO and ADA viz., Missile programmes, Unmanned Air Vehicles, Airborne Early Warning & Control System, Aerostats, Main Battle Tank, Integrated Coastal Surveillance System and Light Combat Aircraft etc. Apart from this, many of the systems and sensors developed by the Cluster Labs are deployed and are being used by Indian Armed forces and paramilitary services.

- **Vision:** To become a Centre of Excellence in the field of EW, DEW, EO, Laser, Radar and Communication Systems and related technologies.
- **Mission:** Design, Development, Evaluation and ToT leading to Production and Induction of Advanced EW, DEW, EO, Laser, Radar and Communication Systems and to establish self-reliance in these Critical Technologies.

➡ AERV

- The first batch of next-generation **Armoured Engineer Reconnaissance Vehicles (AERV),** indigenously designed and developed by DRDO, and manufactured by the Pune unit of Bharat Electronics Limited, was formally inducted into the Indian Army.
- It is a versatile **BMP-IIK amphibious Infantry Combat Vehicle (ICV) f**itted with instruments for **water reconnaissance, land reconnaissance, navigation** and **data backup**.



- AERV is **capable of measuring soil bearing capacity on riverbanks** to determine if they are motorable for military vehicles on **Go-No Go basis** (critical parameters for bridge laying), dry and wet gaps in day and night conditions, slopes and height of river banks or canals.
- AERVs can **navigate terrain using Military Grid Co-ordinate System**, measure and plot underwater beds and water currents of rivers or canals, store data from various instruments on Control Console for further analysis and decision-making.

➡ AGNI-P MISSILE

- Agni-P is a **two-stage canisterised solid propellant missile** with dual redundant navigation and guidance system.
- It has been termed as a new generation advanced variant of Agni class of missiles with improved parameters, including manoeuvring and accuracy.
- **Canisterisation of missiles reduces the time required to launch the missile** while improving the storage and ease of handling.
- The surface-to-surface ballistic missile has a range of 1,000 to 2,000 km.

AGNI CLASS OF MISSILES



- Agni class of missiles are the mainstay of India's nuclear launch capability, which also includes the Prithvi short-range ballistic missiles, submarine launched ballistic missiles and fighter aircraft.
- **Agni-V,** an Inter-Continental Ballistic Missile (ICBM) with a range of over 5,000 km, had been tested several times and validated for induction.
- The **Agni-P and Agni-5 ballistic missiles** trace their origins back to the Integrated Guided Missile Development Programme (IGMDP), which was spearheaded by former DRDO chief and ex-Indian president Dr APJ Abdul Kalam in the early 1980s.

➡ PINAKA

- The Pinaka, a Multi-Barrel Rocket-Launcher (MBRL) system named after Shiva's bow, can fire a salvo of 12 rockets over a period of 44 seconds.
- The new version is equipped with advanced technology to enhance its strength. The metal weight is lesser compared to the earlier version.
- The newly tested system can achieve a **range of up to 45km** which is a big feat for the Indian Army.
- The existing Pinaka system, which is already in the Army, has a range of up to 35-37km.

Significance:



The new incarnation of Pinaka represents one of the few examples of an evolutionary process being followed with an indigenous Indian weapon system.

BACKGROUND

- The development of the Pinaka multi-barrel rocket systems was started by the DRDO in the late 1980s, as an alternative to the **Multi Barrel Rocket Launcher systems of Russian make called the 'Grad',** which are still used by some regiments.
- After successful tests of Pinaka Mark-1 in the late 1990, it was first used successfully in the battlefield during the 1999 Kargil War. Subsequently, multiple regiments of the system came up over the 2000s.

Variants

- DRDO has also developed and successfully tested the **Mk-II and guided variants of the Pinaka**, which has a range of around 60 km, while the Guided Pinaka system has a range of 75 km and has integrated navigation, control and guidance system to improve the end accuracy and enhance the range.
- The navigation system of the Guided Pinaka missile is also aided by the Indian Regional Navigation Satellite System (IRNSS).
- In 2020, an enhanced version of the Pinaka Mark (Mk)-1 missile was successfully flight-tested from the Integrated Test Range in Chandipur, off the coast of Odisha.

➡ CHAFF TECHNOLOGY



The Defence Research and Development Organisation (DRDO) has developed an advanced ***Chaff technology to safeguard the fighter aircraft of the Air Force against hostile radar threats.***

DRDO's Defence Laboratory at Jodhpur developed the advanced chaff material and chaff cartridge — called 118/I — in collaboration with its Pune-based High Energy Materials Research Laboratory (HEMRL).

KNOW ABOUT CHAFF TECHNOLOGY

- Chaff is an **electronic countermeasure technology** used by militaries worldwide to protect naval ships or other sensitive targets from radar and radio frequency (RF) guiding mechanisms of the enemy missile.

- The **chaff rockets deployed in the air reflect as multiple targets for the missile guidance systems and deflecting adversary missiles,** thus protecting their own assets.
- DRDO has indigenously developed three variants of the critical technology namely **Short Range Chaff Rocket (SRCR), Medium Range Chaff Rocket (MRCR) and Long Range Chaff Rocket (LRCR).**

DIFFERENCE BETWEEN CHAFF AND FLARES:

- Both chaff and flares are defensive countermeasures deployed by military aircraft. The purpose is to confuse radar-guided or infrared-guided anti-aircraft missiles fired so that they could be diverted.
- Chaff is composed of many small **aluminium or zinc coated fibres stored on-board the aircraft in tubes**. In case the aircraft feels threatened by any radar tracking missiles, chaff is ejected into the turbulent wake of air behind the plane.
- Flares on being fired provide an **alternate strong IR (Infrared) source to heat-seeking anti-air missiles** so that they are lured away from the aircraft.

➡ DRONES



- Over the last one decade, drones, or unmanned aerial vehicles (UAVs), are being increasingly used for law and order, courier services, and surveillance and attack in the military domain. Modern drones are being used militarily since the 1990s, including by the US during the Gulf War.
- UAVs range from 250 g (maximum altitude 2,000 ft and range 2 km) to over 150 kg (300,00 ft and unlimited range).
- In India, the most commonly known drones are **quad- and hexacopters** used for civil and commercial purposes, and **Heron drones used for military surveillance.** Different UAVs operate under various technologies ranging from remote control by a human operator to using GPS and radio frequencies, and autopilot assistance.
- According to **Association of the US Army (AUSA),** the first attempted drone attack by a terror group can be traced to 1994 when Aum Shinrikyo, a Japanese doomsday cult, used a remote-controlled helicopter to spray sarin gas, but failed as the helicopter crashed.
- In 2013, al-Qaeda attempted an attack in Pakistan using multiple drones but security forces prevented it. The Islamic State has regularly used drones for attacks in Syria and Iraq, while the Taliban has used them for surveillance in Afghanistan. Hezbollah and Houthi rebels too have used them for attacks.
- In January 2018, a swarm of 13 drones attacked two Russian military bases in Syria. In August 2018, an assassination attempt was made on the President of Venezuela, Nicolãs Maduro, using two IED-carrying GPS-guided drones that exploded during a military ceremony the President was attending.
- According to AUSA, between 1994 and 2018, more than 14 planned or attempted terrorist attacks took place using drones. These have only increased in the last couple of years.

- Last year, drones were used to counter traditional platforms like tanks in the Armenia-Azerbaijan war.

HOW TO TACKLE THEM?

- The entire world is struggling with the problem of drone attacks. **Conventional radar systems are not meant for detecting small flying objects**, and, even if they are calibrated that way, they might confuse a bird for a drone and the system may get overwhelmed.
- Currently, border forces in India largely use eyesight to spot drones and then shoot them down. It is easier said than done as most rogue drones are very small and operate at heights difficult to target.
- India has been exploring technologies to detect and disable drones using **electromagnetic charge or shoot them down using laser guns.** Technology to disable their navigation, interfere with their radio frequency, or just fry their circuits using high energy beams have also been tested. None of these has, however, proven foolproof.
- "One would ideally like to have a tech wall that can disable drones coming from across the border. But drone attacks can be launched from within as well. Then there is the problem of swarm drones, where scores of drones overwhelm and confuse detection systems, resulting in some of the drones sneaking through," a security establishment officer said.

DOES INDIA HAVE ANTI-DRONE TECHNOLOGY?

- The Defence Research and Development Organisation (DRDO) has developed a **detect-and-destroy technology** for drones, but it is not yet into mass production. Then there is the challenge of the technology's strategic deployment and the money the government is ready to spend.
- The **DRDO's Counter-Drone System** was deployed for VVIP protection at the Republic Day parades in 2020 and 2021, the Prime Minister's Independence Day, and former US President Donald Trump's visit to Motera Stadium, Ahmedabad last year.
- The DRDO system, developed in 2019, has capabilities for **hardkill** (destroying a drone with lasers) and **softkill (jamming a drone's signals)**. It has a 360° radar that can detect micro drones up to 4 km, and other sensors to do so within 2 km. Its softkill range is 3 km and hardkill range between 150 m and 1 km.

WHAT ARE INDIA'S PLANS TO USE THEM IN WARFARE?

- The armed forces have been slowly inducting capacity. Last year the, Navy got two unarmed **SeaGuardian Predator** drones on lease from the US. The three forces want 30 of these UAVs between them.
- The military has been working towards using small drones for offensive capabilities as well.

➡ CYBER SECURITY

- Cyber security is the practice of defending computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks. It's also known as information technology security or electronic information security. The term applies in a variety of

contexts, from business to mobile computing, and can be divided into a few common categories.

- Network security is the practice of securing a computer network from intruders, whether targeted attackers or opportunistic malware.
- Application security focuses on keeping software and devices free of threats. A compromised application could provide access to the data its designed to protect. Successful security begins in the design stage, well before a program or device is deployed.
- Information security protects the integrity and privacy of data, both in storage and in transit.
- Operational security includes the processes and decisions for handling and protecting data assets. The permissions users have when accessing a network and the procedures that determine how and where data may be stored or shared all fall under this umbrella.
- Disaster recovery and business continuity define how an organization responds to a cyber-security incident or any other event that causes the loss of operations or data. Disaster recovery policies dictate how the organization restores its operations and information to return to the same operating capacity as before the event. Business continuity is the plan the organization falls back on while trying to operate without certain resources.
- End-user education addresses the most unpredictable cyber-security factor: people. Anyone can accidentally introduce a virus to an otherwise secure system by failing to follow good security practices. Teaching users to delete suspicious email attachments, not plug in unidentified USB drives, and various other important lessons is vital for the security of any organization.

TYPES OF CYBER THREATS: The threats countered by cyber-security are three-fold:

1. Cybercrime includes single actors or groups targeting systems for financial gain or to cause disruption.
2. Cyber-attack often involves politically motivated information gathering.
3. Cyberterrorism is intended to undermine electronic systems to cause panic or fear.

So, how do malicious actors gain control of computer systems? Here are some common methods used to threaten cyber-security:

MALWARE

- Malware means **malicious software**. One of the most common cyber threats, malware is software that a cybercriminal or hacker has created to disrupt or damage a legitimate user's computer. Often spread via an unsolicited email attachment or legitimate-looking download, malware may be used by cybercriminals to make money or in politically motivated cyber-attacks.
- There are a number of different types of malware, including:

- **Virus:** A self-replicating program that attaches itself to clean file and spreads throughout a computer system, infecting files with malicious code.
- **Trojans**: A type of malware that is disguised as legitimate software. Cybercriminals trick users into uploading Trojans onto their computer where they cause damage or collect data.
- **Spyware:** A program that secretly records what a user does, so that cybercriminals can make use of this information. For example, spyware could capture credit card details.
- **Ransomware:** Malware which locks down a user's files and data, with the threat of erasing it unless a ransom is paid.

- **Adware:** Advertising software which can be used to spread malware.
- **Botnets:** Networks of malware infected computers which cybercriminals use to perform tasks online without the user's permission.

- **SQL injection:** An SQL (structured language query) injection is a type of cyber-attack used to take control of and steal data from a database. Cybercriminals exploit vulnerabilities in data-driven applications to insert malicious code into a databased via a malicious SQL statement. This gives them access to the sensitive information contained in the database.
- **Phishing:** Phishing is when cybercriminals target victims with emails that appear to be from a legitimate company asking for sensitive information. Phishing attacks are often used to dupe people into handing over credit card data and other personal information.
- **Man-in-the-middle attack**: A man-in-the-middle attack is a type of cyber threat where a cybercriminal intercepts communication between two individuals in order to steal data. For example, on an unsecure WiFi network, an attacker could intercept data being passed from the victim's device and the network.
- **Denial-of-service attack:** A denial-of-service attack is where cybercriminals prevent a computer system from fulfilling legitimate requests by overwhelming the networks and servers with traffic. This renders the system unusable, preventing an organization from carrying out vital functions.

➡ LIFE SCIENCES

- Equipping the Services with the best, cutting-edge weapon systems and platforms do not really achieve their intended purpose until the integral human component of the war machine is also optimized in terms of psychological, physiological and nutritional well-being, with life support systems and protection from all conceivable operational hazards.
- It is in this very theatre that a group of laboratories in the DRDO comprising the Life Sciences (LS) cluster are focusing their R&D efforts.
- Right from the selection of officers and men for various types of jobs in the Armed Forces, promulgating optimized ration scales with provisioning of fresh and processed foods tailored to the Indian dietary habits and operational needs, developing acclimatization schedules for harsh terrain, specialized protective clothing, biomedical devices and protective gear, life support systems in hostile and challenging environments, countering strategies to overcome Chemical, Biological, Radiological and Nuclear(CBRN) threats.
- In addition to their detection, protection, decontamination and medical management of CBRN eventualities, psycho-socio-behavioral methodologies to cope with stresses, alternative systems/ strategies to enhance performance etc., all have been the contributions of these laboratories over the years.
- Over the last five decades, the endeavors of Life Sciences Cluster laboratories have been instrumental in:

- Defending against and recovering from CBRN hazards
- Saving lives through life support systems
- Sustaining operations by customized nutrition

- Optimizing performance through human engineering approach
- Reinforcing adaptation through acclimatization processes
- Reducing combat stress by counseling & training
- Creating specialized human capital by selection & training

Vision: To be a leader in optimizing the performance and wellbeing of the man behind the weapon through translational research in life sciences

Mission

- Design and Develop State-of-Art Technologies to Protect the Warfighters
- To Equip the Soldier with High Performance Protective Systems to Enhance Combat Efficiency

➡ MICRO ELECTRONIC DEVICES, COMPUTATIONAL SYSTEMS & CYBER SYSTEMS (MED & COS)

- The MED & CoS Cluster encompasses two areas viz. **Micro Electronic Devices (MED)** and **Computational Systems & Cyber Systems (CoS).**
- The Micro Electronic Devices (MED) sub-cluster focuses on thrust areas and technologies relating to Microwave Tubes, Solid State Electronics including Micro Electronic Device design and manufacturing.
- This sub-cluster comprises three laboratories namely, Advanced Numerical Research and Analysis Group (ANURAG), Hyderabad, Microwave Tube Research & Development Centre (MTRDC), Bengaluru, and Solid State Physics Laboratory (SSPL), Delhi.
- The Computational Systems (CoS) sub-cluster focuses on systems and technologies relating to Artificial Intelligence, Robotics, Command and Control, Networking, Information and Communication Security, Secure/Trusted Computing Platforms, HPC, Cryptology, Information Security, and Cyber Security leading to development of Mission Critical products for battle field communication and management systems. This sub-cluster comprises Centre for Artificial Intelligence & Robotics (CAIR), Bengaluru and Scientific Analysis Group (SAG), Delhi.

➡ C-295 MW TRANSPORT AIRCRAFT



- The procurement of **56 C-295MW transport aircraft from Airbus Defence and Space S.A., Spain** approved by the Cabinet Committee on Security marks the culmination of a decade-long process by the Indian Air Force (IAF) to replace the ageing Avro aircraft in service, pending signing of the formal contract.
- This is the first project of its kind in which a military aircraft will be manufactured in India under technology transfer by a private company and is expected to cost close to $3bn.

- The deal has become even more critical for the IAF as a separate project to jointly co-develop and produce a Medium Transport Aircraft (MTA) of 20 tonnes with Russia to replace the An-32s in service was scrapped after initial design discussions.
- The IAF has 56 Avro transport aircraft procured in the 1960s and in urgent need of replacement.
- The C-295MW is a transport aircraft of 5-10 tonne capacity and has a rear ramp door for quick reaction and para dropping of troops and cargo. It is powered by Pratt & Whitney PW127 engines, part of the PW100 family. All 56 aircraft will be installed with indigenous Electronic Warfare Suite.
- The project would give a boost to aerospace ecosystem in India wherein several Micro, Small and Medium Enterprises spread over the country would be involved in manufacturing of parts of the aircraft.
- On the project spread, the Ministry said that a large number of detail parts, sub-assemblies and major component assemblies of aero structure were scheduled to be manufactured in India. The programme would act as a catalyst in employment generation in the aerospace ecosystem of the country and was expected to generate 600 highly skilled jobs directly, over 3,000 indirect jobs and an additional 3,000 medium skill employment opportunities with more than 42.5 lakh man hours of work within the aerospace and defence sector of India.
- During the process of manufacturing in India, it is expected that all the suppliers of Tata Consortium who will be involved in special processes will gain and maintain globally recognised National Aerospace and Defence Contractors Accreditation Program accreditation. It will involve development of specialised infrastructure in form of hangars, buildings, aprons and taxiway.

➡ ICGS VIGRAHA



- Indian Coast Guard (ICG) **Ship Vigraha, seventh in the series of Offshore Patrol Vessels (OPVs)**, is commissioned on August 28, 2021.
- The ship will be based in Visakhapatnam, Andhra Pradesh and operate on the eastern seaboard under the **Operational and Administrative Control of the Commander, Coast Guard Region (East).**
- The 98-meter OPV, with a complement of 11 officers and 110 sailors, has been designed and built indigenously by Larsen & Toubro Ship Building Limited.
- It is fitted with advanced technology radars, navigation & communication equipment, sensors and machinery capable of operating in tropical sea conditions. The vessel is armed with a **40/60 Bofors gun and fitted with two 12.7 mm Stabilised Remote Control Gun with fire control system**. The ship is also equipped with integrated bridge system,

integrated platform management system, automated power management system and high-power external fire-fighting system.

- The ship is also designed to **carry one twin-engine Helicopter and four high speed boats for boarding operation, search & rescue, law enforcement and maritime patrol.**
- The ship is also capable of **carrying pollution response equipment to contain oil spill at sea**. The ship displaces approximately 2,200 tons and is propelled by two 9100 KW diesel engines to attain a maximum speed of 26 nautical miles per hour with endurance of 5000 nm at economical speed.
- The ship will be deployed extensively for EEZ surveillance and other duties as enshrined in the Coast Guard Charter to safeguard the country's maritime interests.

➡ MPATGM



- The defence ministry described the successful trial of the missile as a major boost for the government's 'Aatmanirbhar Bharat' (self-reliant India) campaign.
- The missile is being developed to strengthen the **combat capabilities of the Indian Army**.
- **Indigenously developed low weight, fire and forget Man Portable Antitank Guided Missile (MPATGM)** was launched from a man portable launcher integrated with thermal site and the target was mimicking a tank. The missile hit the target in direct attack mode and destroyed it with precision. The test has validated the minimum range successfully.
- The missile is incorporated with state-of-the-art Miniaturized Infrared Imaging Seeker along with advanced avionics. The test brings the development of indigenous third generation man portable Anti-Tank Guided Missile close to completion.
- The test brings the development of indigenous third-generation man-portable anti-tank guided missile close to completion

➡ KRIVAK CLASS SHIPS

- The Krivak class stealth ships are being built with technology transfer from Russia by Goa Shipyard Ltd. (GSL) under 'Make in India'. Engines for the ships are supplied by Ukraine.
- In October 2016, India and Russia signed an Inter-Governmental Agreement (IGA) for **four Krivak or Talwar stealth frigates.**
- The first two frigates will be built in Yantar Shipyard, in Kaliningrad, Russia. The following two will be built in GSL.

- The new Krivak frigates will have the same engines and armament configuration as Yantar's last three frigates - INS Teg, Tarkash and Trikand. These will be armed with BrahMos anti-ship and land attack missiles.



Use:

- They are primarily used to accomplish a **wide variety of naval missions** such as finding and eliminating enemy submarines and large surface ships.
- **Existing Frigates**: The navy already operates six Krivak III frigates. The first three joined the fleet between June 2003 and April 2004, followed by another three between April 2012 and June 2013. With the current contract, the navy will operate 10 Krivak frigates.

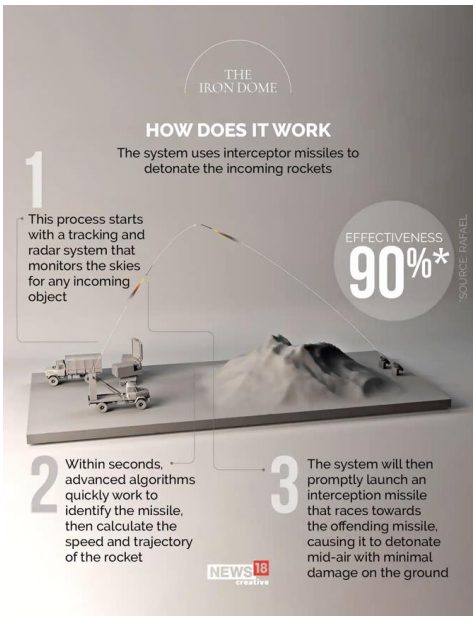
➡ PINAKA ROCKETS

- Defence Research and Development Organisation (DRDO) successfully test fired extended range version of indigenously developed Pinaka rocket from a Multi-Barrel Rocket Launcher (MBRL) in June 2021 at **Integrated Test Range (ITR), Chandipur off the coast of Odisha.**
- Twenty-five Enhanced Pinaka Rockets were launched in quick succession against targets at different ranges. All the mission objectives were met during the launches. The enhanced range version of Pinaka Rocket System can destroy targets at distances up to 45 kms.
- All the flight articles were tracked by Range instruments including Telemetry, Radar and Electro Optical Tracking System deployed by ITR & Proof and Experimental Establishment (PXE).
- The rocket system has been developed jointly by Pune based **Armament Research and Development Establishment (ARDE) and High Energy Materials Research Laboratory (HEMRL)** with manufacturing support from M/s Economic Explosives Limited, Nagpur. The development of Enhanced Pinaka system was taken up to achieve longer range performance.

- Pinaka is a **multibarrel rocket launch (MBRL) system** used by the Indian Army. Developed by the Defence Research and Development Organisation (DRDO), Pinaka integrates state-of-the-art technologies for delivering superior combat performance.
- Development of Pinaka commenced in 1986 at a Pune-based DRDO facility, known as Armament Research and Development Establishment (ARDE). DRDO was responsible for the overall design and development. The subsystems and components were developed by Tata Power SED, Larsen & Toubro and Ordnance Factories Board.

➡ IRON DOME SYSTEM

- The Israeli Defence Forces rely on the so-called **Iron Dome** to intercept and neutralise the rockets fired by militant groups, including Hamas.
- The Iron Dome got **operational in 2011.**
- Iron Dome is a **multi-mission system** capable of intercepting rockets, artillery, mortars and Precision Guided Munitions like very short range air defence (V-SHORAD) systems as well as aircraft, helicopters and Unmanned Aerial Vehicles (UAV) over short ranges of up to 70 km.
- It is an **all-weather system** and can engage multiple targets simultaneously and be deployed over land and sea.
- Iron Dome is manufactured by **Rafael Advanced Defence Systems Limited.** The radar system was developed by Elta. Its development was prompted after a series of rocket attacks on Israel by Hezbollah and Hamas in the 2000s.



➡ P-8I PATROL AIRCRAFT

- The US State Department has approved the sale of six P-8I patrol aircraft and related equipment to India.
- The six aircraft will come fitted with encrypted systems, as India has signed the Communications Compatibility and Security Agreement (COMCASA) with the US.
- The Defence Acquisition Council approved the procurement of the aircraft in 2019.

P-8I AIRCRAFT



- It is a **long-range maritime reconnaissance and Anti-Submarine Warfare Aircraft**.
- It is a **variant of the P-8A Poseidon aircraft** that Boeing company developed as a replacement for the US Navy's ageing P-3 fleet.
- With a maximum speed of 907 kmph and an operating range of over 1,200 nautical miles, the P-8Is detect threats and neutralize them if required, far before they come anywhere near Indian shores.
- **Indian Navy became the first international customer** for the P-8 aircraft in 2009.

INDO-US DEFENCE TIES:

- This proposed sale will help to strengthen the US-Indian strategic relationship.
- For the US, India continues to be an important force for political stability, peace, and economic progress in the Indo-Pacific and South Asia region.

PREVIOUS YEARS QUESTION

Q. Consider the following:

1. Aarogya Setu 2. COWIN
3. DigiLocker 4. DIKSHA

Which of the above are built on top of open-source digital platforms?

(a) 1 and 2 only (b) 2, 3 and 4 only
(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

Q. With reference to Web 3.0, consider the following statements:

1. Web 3.0 technology enables people to control their own data.
2. In Web 3.0 world, there can be blockchain based social networks.
3. Web 3.0 is operated by users collectively rather than a corporation

Which of the following given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. With reference to "Software as a Service (SaaS)", consider the following statements:

1. SaaS buyers can customise the user interface and can change data fields.
2. SaaS users can access their data through their mobile devices.
3. Outlook, Hotmail and Yahoo! Mail are forms of SaaS.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. Which one of the following statements best reflects the idea behind the "Fractional Orbital Bombardment System" often talked about in media?

(a) A hypersonic missile is launched into space to counter the asteroid approaching the Earth and explode it in space.
(b) A spacecraft lands on another planet after making several orbital motions.
(c) A missile is put into a stable orbit around the Earth and deorbits over a target on the Earth.
(d) A spacecraft moves along a comet with the same surface.

Q. Which one of the following is the context in which the term "qubit" is mentioned?

(a) Cloud Services
(b) Quantum Computing
(c) Visible Light Communication Technologies
(d) Wireless Communication Technologies

Q. Consider the following communication technologies:

1. Closed-circuit Television
2. Radio Frequency Identification
3. Wireless Local Area Network

Which of the above are considered of the Short-Range devices/technologies?

(a) 1 and 2 only. (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. Consider the following statements:

1. Biofilms can form on medical implants within human tissues.

2. Biofilms can form on food and food processing surfaces.
3. Biofilms can exhibit antibiotic resistance.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. Consider the following statements in respect of probiotics :

1. Probiotics are made of both bacteria and yeast.
2. The organisms in probiotics are found in foods we ingest but they do not naturally occur in our gut.
3. Probiotics help in the digestion of milk sugars.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) 1 and 3 (d) 2 and 3

Q. In the context of vaccines manufactured to prevent COVID-19 pandemic, consider the following statements:

1. The Serum Institute of India produced COVID-19 vaccine named Covishield using mRNA platform.
2. Sputnik V vaccine is manufactured using vector based platform.
3. COVAXIN is an inactivated pathogen based vaccine.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. If a major solar storm (solar flare) reaches the Earth, which of the following are the possible effects on the Earth?

1. GPS and navigation systems could fail.
2. Tsunamis could occur at equatorial regions.
3. Power grids could be damaged.
4. Intense auroras could occur over much of the Earth.
5. Forest fires could take place over much of the planet.
6. Orbits of the satellites could be disturbed.
7. Shortwave radio communication of the aircraft flying over polar regions could be interrupted.

Select the correct answer using the code given below:

(a) 1, 2, 4 and 5 only
(b) 2, 3, 5, 6 and 7 only
(c) 1, 3, 4, 6 and 7 only
(d) 1, 2, 3, 4, 5, 6 and 7

Q. Which one of the following statements best describes the role of B cells and T cells in the human body?

(a) They protect the environmental allergens. body
(b) They alleviate the body's pain and inflammation.
(c) They act as immunosuppressants in the body.
(d) They protect the body from the diseases caused by pathogens.

Q. Consider the following statements:

1. Other than those made by humans, nanoparticles do not exist in nature.
2. Nanoparticles of some metallic oxides are used in the manufacture of some cosmetics.
3. Nanoparticles of some commercial products which enter the environment are unsafe for humans.

Which of the statements given above is/are correct?

(a) 1 only (b) 3 only
(c) 1 and 2 (d) 2 and 3

Q. Consider the following statements: DNA Barcoding can be a tool to:

1. assess the age of a plant or animal.

2. distinguish among species that look alike.
3. identify undesirable animal or plant materials in processed foods.

Which of the statements given above is/are correct?

(a) 1 only (b) 3 only
(c) 1 and 2 (d) 2 and 3

Q. Water can dissolve more substances than any other liquid because.

(a) It is dipolar in nature.
(b) It is a good conductor of heat
(c) It has high value of specific heat
(d) It is an oxide of hydrogen

Q. With reference to street lighting, how do sodium lamps differ from LED lamps?

1. Sodium lamps produce light at 360 degrees but it is not so in the case of LED lamps.
2. As street lights, sodium lamps have a longer life span than LED lamps.
3. The spectrum of visible light from sodium lamps is almost monochromatic while LED lamps offer significant colour advantages in street lighting.

Select the correct answer using the code given below.

(a) 3 only (b) 2 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. The term "ACE2" is talked about in the context of

(a) genes introduced in the genetically modified plants
(b) development of India's own satellite navigation system
(c) radio collars for wildlife tracking
(d) spread of viral diseases

Q. Bisphenol A (BP(A), a cause of concern, is a structural/key component in the manufacture of which of the following kinds of plastics?

(a) Low-density polyethylene
(b) Polycarbonate
(c) Polyethylene terephthalate
(d) Polyvinyl Chloride

Q. "Triclosan" considered harmful when exposed to high levels for a long time, is most likely present in which of the following?

(a) Food preservatives
(b) Fruit ripening substances
(c) reused plastic containers
(d) Toiletries

Q. Which one of the following is a reason why astronomical distances are measured in light-years?

(a) Distance among stellar bodies do not change
(b) Gravity of stellar bodies does not change
(c) Light always travels in straight line
(d) Speed of light is always same

Q. With reference to recent developments regarding 'Recombinant vector Vaccines', consider the following statements:

1. Genetic engineering is applied in the development of these vaccines.
2. Bacteria and viruses are used as vectors.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q. In the context of hereditary diseases, consider the following statements:

1. Passing on mitochondrial diseases from parent to child can be prevented by mitochondrial replacement therapy either before or after in vitro fertilization of the egg.

2. A child inherits mitochondrial diseases entirely from the mother and not from the father.

Which of the statements given above is'/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q. Bollgard I and Bollgard II technologies are mentioned in the context of

(a) Clonal propagation of crop plants
(b) Developing genetically modified crop plants
(c) Production of plant growth substances
(d) Production of biofertilizers

Q. In a pressure cooker, the temperature at which the food is cooked depends mainly upon which of the following?

1. Area of the hole in the lid
2. Temperature of the flame
3. Weight of the lid

Select the correct answer using the code given below.

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1,2 and 3

Q. Consider the following:

1. Bacteria
2. Fungi
3. Virus

Which of the above can be cultured in an artificial/ synthetic medium?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q. Consider the following statements:

1. Adenoviruses have single-stranded DNA genomes whereas retroviruses have double-stranded DNA genomes.
2. Common cold is sometimes caused by an adenovirus whereas AIDS is caused by a retrovirus.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q. Which one of the following is used in preparing a natural mosquito repellent?

(a) Congress grass
(b) Elephant grass
(c) Lemon grass
(d) Nut grass

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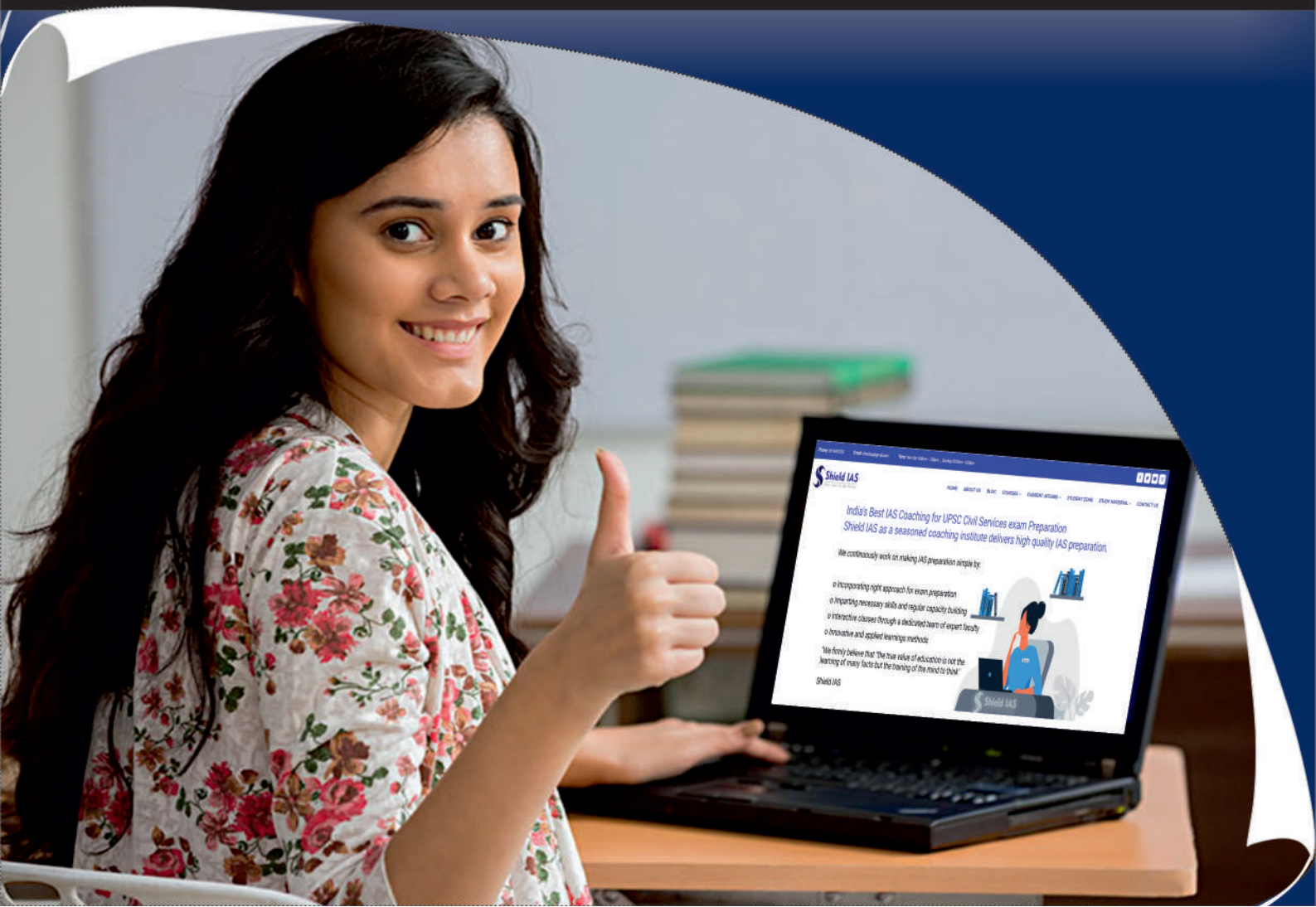
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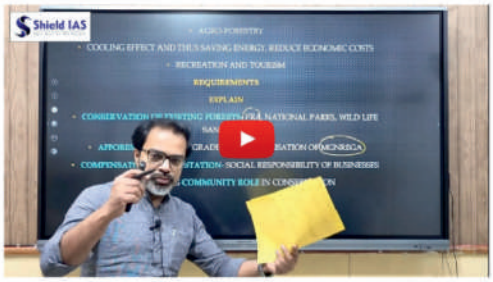
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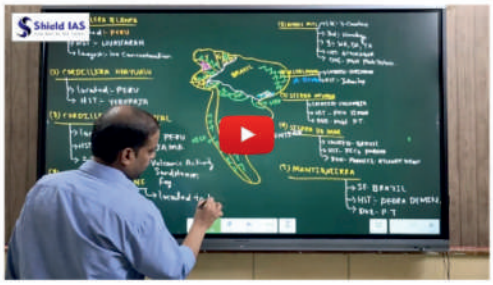
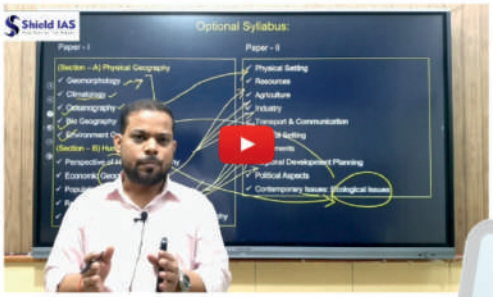
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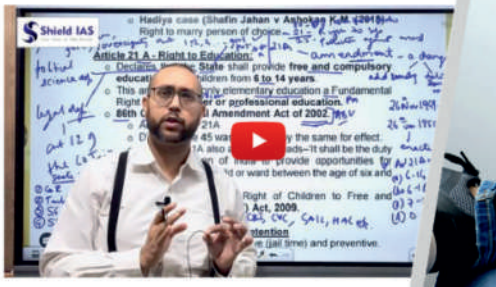













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+91 7303692587

@shieldias

First Floor 1/26, Lalita Park, Vikas Marg, Near Metro Station,
Laxmi Nagar, Delhi -110092. Metro Pillar No. 24

Inquiry Contact:
011-46512150, 7037272363

Email: shieldias@gmail.com
Log on to: Shieldias.in

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