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DAY - 61

GENETICS + BIOTECHNOLOGY

Genetics

About

- Genetics is the **study of heredity**. Heredity is a biological process where a parent passes certain genes onto their children or offspring. Every child inherits genes from both of their biological parents and these genes, in turn, express specific traits. Some of these traits may be physical for example hair and eye color and skin color etc. On the other hand, some genes may also carry the risk of certain diseases and disorders that may pass on from parents to their offspring.
- The **genetic information lies within the cell nucleus** of each living cell in the body. The information can be considered to be retained in a book for example. Part of this book with the genetic information comes from the father while the other part comes from the mother.
- Genes generally express their functional effect through the production of proteins, which are complex molecules responsible for most functions in the cell. **Proteins are made up of one or more polypeptide chains**, each of which is composed of a sequence of amino acids, and the DNA sequence of a gene (through an RNA intermediate) is used to produce a specific amino acid sequence. This process begins with the production of an RNA molecule with a sequence matching the gene's DNA sequence, a process called transcription.

Chromosomes

- The genes lie within the chromosomes. Humans have **23 pairs** of these small thread-like structures in the nucleus of their cells. 23 or half of the total 46 comes from the mother while the other 23 comes from the father.
- The **chromosomes contain genes** just like pages of a book. Some chromosomes may carry thousands of important genes while some may carry only a few. The chromosomes, and therefore the genes, are made up of the chemical substance called **DNA (Deoxyribo Nucleic Acid).** The chromosomes are very long thin strands of DNA, coiled up tightly.
- At one point along their length, **each chromosome has a constriction**, called the **centromere**. The centromere divides the chromosomes into two 'arms': a long arm and a short arm. **Chromosomes are numbered from 1 to 22** and these are common for both sexes and called autosomes. Two chromosomes have been given the letters X and Y and termed sex chromosomes. The X chromosome is much larger than the Y chromosome.
- The genes are further made up of unique codes of chemical bases comprising **of A, T, C andG** (Adenine, Thymine, Cytosine, and Guanine). These chemical bases make up combinations with permutations and combinations. These are akin to the words on a page.
- **Thesechemical bases are part of the DNA.** The words when strung together act as the blueprints that tell the cells of the body when and how to grow, mature and perform various functions. With age, the genes may be affected and may develop faults and damages due to environmental and endogenous toxins.
- **Women have 46 chromosomes** (44 autosomes plus **two copies of the X chromosome**) in their body cells. They have half of this or 22 autosomes plus an X chromosome in their egg cells.

- **Men have 46 chromosomes** (44 autosomes plus **an X and a Y chromosome**) in their body cells and have half of these 22 autosomes plus an X or Y chromosome in their sperm cells.
- When the egg joins with the sperm, the resultant baby has 46 chromosomes (with either an **XX in a female** baby or **XY in a male baby**).

The work of Mendel

- Before Gregor Mendel, theories for a hereditary mechanism were based largely on logic and speculation, not on experimentation. In his monastery garden, Mendel carried out a large number of cross-pollination experiments between variants of the garden pea, which he obtained as pure-breeding lines. He crossed peas with yellow seeds to those with green seeds and observed that the progeny seeds were all yellow.
- Mendel also analyzed pure lines that differed in pairs of characters, such as seed color (yellow versus green) and seed shape (round versus wrinkled). The cross of yellow round seeds with green wrinkled seeds resulted in the generation of yellow and round seeds, revealing the dominance of the yellow and round traits.

Genes and genetics

- Each gene is a piece of genetic information. **All the DNA in the cell makes up for the human genome**. There are about 20,000 genes located on one of the 23 chromosome pairs found in the nucleus.
- To date, about 12,800 genes have been mapped to specific locations (loci) on each of the chromosomes. This database was begun as part of the Human Genome Project. The project was officially completed in April 2003 but the exact number of genes in the human genome is still unknown.

Genome Sequencing

- Genome is an **organism's complete set of DNA**, including all of its genes.
  - Each genome contains all of the information needed to build and maintain that organism. In humans, a copy of the entire genome—more than 3 billion DNA base pairs—is contained in all cells that have a nucleus.
- It 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.
- Sequencing the genome doesn't immediately lay open the genetic information 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.

Genome editing

- Genome editing/gene editing is a group of technologies that give scientists the **ability to change an organism's DNA**. These technologies allow genetic material to be added, removed, or altered at particular locations in the genome.
- Several approaches to genome editing have been developed. A recent one is known as **CRISPR-Cas9**, which is short for **Clustered Regularly Interspaced Short Palindromic Repeats** and CRISPR-associated protein 9.
- The CRISPR-Cas9 system is faster, cheaper, more accurate, and more efficient than other existing genome editing methods.

CRISPR-Cas9

- It is a unique technology that enables geneticists and medical researchers to edit parts of the genome by **removing, adding or altering sections of the DNA sequence**.

- CRISPRs are specialized stretches of DNA. The protein **Cas9** (or "CRISPR-associated") is an **enzyme that acts like a pair of molecular scissors**, capable of cutting strands of DNA. It allows researchers to easily alter DNA sequences and modify gene function.
- It is the simplest yet powerful tool for editing genomes and also termed as the most versatile and precise method of genetic manipulation.

Biotechnology

About

- Biotechnology is defined as the industrial application of living organisms and their biological processes such as biochemistry, microbiology, and genetic engineering, to make the best use of the microorganisms for the benefit of mankind.
- **Different types of biotechnology**
  - **Green biotechnology:** Green biotechnology is defined as **the application of biological techniques to plants** to improve the nutritional quality, quantity and production economics. It is done by implanting foreign genes to plant economically important species. This **contains three main areas**: plant tissue culture; plant genetic engineering and plant molecular marker-assisted breeding.
  - **Red biotechnology:** Red biotechnology is concerned with the **discovery and development of innovative drugs and treatments**.A key prerequisite was an increasing understanding of how proteins function, their roles in communication between and within cells, and the diseases caused when these proteins malfunction. This includes **Gene Therapy, Stem Cells, Genetic Testing**, etc.
  - **White biotechnology:** This field of biotechnology is **connected with the industry**. White biotech uses molds, yeasts, bacteria, and enzymes to produce goods and services or parts of products. It offers a wide range of **bio-products like detergents, vitamins, antibiotics, etc.** Most of the white biotech processes result in the saving of water, energy, chemicals and the reduction of waste compared to traditional methods.
  - **Blue biotechnology:** Blue biotechnology is concerned with the application of molecular biological methods **to marine and freshwater organisms**. It involves the use of these organisms, and their derivatives, for multiple purposes, the most remarkable are the identification process and development of new active ingredients from marine origin.
  - **Yellow biotechnology:** Yellow biotechnology' refers to biotechnology with **insects — analogous to the green (plants) and red (animals) biotechnology**. Active ingredients or genes in insects are characterized and used for research or application in agriculture and medicine.

Applications

- **Biopharmaceuticals:** The drugs are being developed with the use of microorganisms without using any **synthetic materials and chemicals**. Large molecules of **proteins** are usually the source of biopharmaceutical drugs. They when targeted in the body attack the hidden mechanisms of the diseases and destroy them **without any side effect**(s). Now scientists are trying to develop such biopharmaceutical drugs that can be treated against diseases like hepatitis, cancer and heart diseases.
- **Gene therapy:** It is used in delicacy and diagnoses of diseases like **cancer and Parkinson's**. The apparatus of this technique is that the fit genes are under attack in the body which **either obliterate the injured cells or replace them**. In some cases, the fit genes make corrections in the genetic information and that is how the genes start performance in the favor of the body.
- **Flowers:** There is **extra to agricultural biotechnology** than just hostility disease or civilizing food quality. There is some simply aesthetic application and an example of this is the use of gene recognition and transfer techniques **to improve the color, smell, size and other features of flowers.**

- **Plant and Animal Reproduction:** Enhancing plant and animal behavior by traditional methods like cross-pollination, grafting, and cross-breeding is time-consuming. Biotech advance let for specific changes to be made **rapidly, on a molecular level through over-expression or removal of genes, or the introduction of foreign genes**.
- **Food processing** is a process by which **non-palatable and easily perishable raw materials are converted to edible and potable foods and beverages**, which have a longer shelf life. The method, by which the microbial organisms and their derivatives are used to increase the edibility and the shelf life of foods, is known as fermentation.
- **Bioremediation:** The process of **cleaning up the hazardous substances into non-toxic compounds** is called the Bioremediation process. This process is majorly used for any kind of technology clean up that uses the natural microorganisms.

Biotechnology Projects

Human Genome Project

- The "genome" of any given individual is unique; **mapping the "human genome"** involved sequencing a small number of individuals and then assembling these to get a complete sequence for each chromosome. The **finished human genome is thus a mosaic, not representing any one individual.**
- The Human Genome Project (HGP) was an **international scientific research project.**
- It can help us understand diseases including: genotyping of specific viruses to direct appropriate treatment.
- Identification of mutations linked to different forms of cancer.
- The design of medication and a more accurate prediction of their effects.
- Advancement in forensic applied sciences.
- Biofuels and other energy applications.
- Agriculture, animal husbandry, bioprocessing; risk assessment; bioarchaeology, anthropology, and evolution.
- Commercial development of genomics research related to DNA based products, a multibillion-dollar industry.

Gene editing:

- This is a technique that allows the scientist to **edit the gene sequence and then modify it** to bring the desired changes. It helps to understand the sequence of genes and then use gene editing to cure incurable diseases like **Tay-Sachs and perhaps cystic fibrosis** through the modification of genes.
- In addition to that, gene editing can be used as a research tool to simply learn more about these diseases.

GM Mustard Issue

- **DMH-11 is a Genetically Modified (GM) mustardhybrid**. Hybrids are normally obtained by crossing 2 genetically diverse plants from the same species. The **1st-generation offspring resulting from it has higher yields** than what either of the parents is individually capable of giving.
- But there is **no natural hybridization system in mustard**, unlike in, say, cotton, maize or tomato. This is because **its flowers contain both the female (pistil) and male (stamen) reproductive organs**, making the plant naturally self-pollinating. What scientist has done is to create a viable hybridization system in mustard using GM technology. The resulting GM mustard hybrid, it is claimed, gives 25-30% more yield than the best varieties such as 'Varuna' currently grown in the country.
- Scientists at the **Centre for Genetic Manipulation of Crop Plants (CGMCP) in Delhi University**, however, showed that this problem could be addressed by crossing Indian mustard cultivars with

juncea lines of East European origin like **'Early Heera' and 'Donskaja'**. The combination of the 2 divergent gene pools enhanced the crossing options; the resultant F1 progeny were found to exhibit significant heterosis.

Terminologies associated with the biotechnology

- **Cell:** The cell is the **basic structure** of the body. The human body is built of billions and trillions of cells. Each cell contains the hereditary material and can make copies of themselves by reproducing and multiplying. After a specific life span, the old cells die off. Parts of the cell are called organelles.
- **DNA:** Deoxyribonucleic acid (DNA) is a **molecule** that encodes the genetic instructions used in the development and functioning of all known living organisms.
- **GENE:** A gene is a **segment of nucleic acid** that contains the information necessary to produce a functional product, usually a protein. The genes are made up of a coding alphabet of 4 nucleotides made up of 4 bases:-**Adenine (A), Thymine (T), Guanine (G) and Cytosine (C)** present in DNA.
- **Genetic engineering:** Techniques to **alter the chemistry of genetic material** (DNA and RNA), to introduce these into host organisms and thus change the phenotype of the host organism.
- **Gene Therapy:** This is in a way, **genetic engineering of humans**, which would allow a person suffering from a disabling genetic disorder to lead a normal life.
- **Genome Resource Bank:** Genome Resource Bank (GRB) is a **frozen repository of biological materials**, including sperm and embryos, tissue, blood products, and DNA. It is going to being used as a conservation tool for protecting and preserving biodiversity.
- **Human Genome Project:** The Human Genome Project aimed to **identify all the genes (approx. 25,000) in human DNA** and to determine the sequence of the three billion chemical base pairs that make up human DNA. Efforts were made to create databases to store this information and develop tools to do comprehensive data analysis.
- **Bioinformatics:** Bioinformatics is an independent discipline that**merges the field of molecular biology and computer science**. This mainly involves the transformation of biological polymers such as nucleic acid molecules and proteins into sequences of digital symbols. The symbols and their meaning for the protein sequences have also been generated.
- **Bioremediation:** Bioremediation is the **use of microorganisms for the degradation of hazardous chemicals** in soil, sediments, water, or other contaminated materials. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment.
- **Biosensors:** Biosensors are **biophysical devices that can detect the presence of specific substances** e.g. sugars, proteins, hormones, pollutants and a variety of toxins in the environment.
- **Bioreactors:** Bioreactors can be thought of as **vessels in which raw materials are biologically converted into specific products**, individual enzymes, etc., using microbial plant, animal or human cells.
- **Bioprospecting** is an umbrella term describing the process of **discovery and commercialization of new products** based on biological resources, typically in less-developed countries. Bioprospecting often draws on indigenous knowledge about

the uses and characteristics of plants and animals. In this way, **bioprospecting includes biopiracy**, the exploitative appropriation of indigenous forms of knowledge by commercial actors, as well as the search for previously unknown compounds in organisms that have never been used in traditional medicine.

- **Biopiracy** is a situation where indigenous knowledge of nature, originating with indigenous people, is **used by others for profit, without permission** from and with little or no compensation or recognition to the indigenous people themselves.
- **Green consumerism** refers to **recycling, purchasing and using eco-friendly products** that minimize damage to the environment. This involves decisions such as using Energy Start appliances that consume less power, buying hybrid cars that emit less carbon dioxide, using solar and wind power to generate electricity and buying locally grown vegetables and fruits.
- **A Comprehensive Environmental Pollution Index (CEPI)** is a very useful tool to **capture thehealth dimensions of the environment including** air, water, and land. The CEPI is intended to act as an early warning tool and can help in categorizing the industrial clusters/areas in terms of priority of planning needs for interventions.
- **Bioregionalism** is a **political, cultural, and ecological system** or set of views based on naturally defined areas called bioregions, similar to ecoregions. Bioregions are defined through **physical and environmental features**, including watershed boundaries and soil and terrain characteristics. Bioregionalism stresses that the determination of a bioregion is also a cultural phenomenon, and emphasizes local populations, knowledge, and solutions.
- **Bioethics:** Bioethics is the **branch of ethics, philosophy, and social commentary** that deals with the biological sciences and its impact on society.
- **Vaccine:** A preparation that contains an agent or its components, administered to stimulate an immune response that will **protect a person from illness due to that agent**. A therapeutic (treatment) vaccine is given after the disease has started and is intended to reduce or arrest the progress of the disease. A preventive (prophylactic) vaccine is intended to prevent the disease from starting. Agents used in vaccines may be whole-killed (inactive), live-attenuated (weakened) or artificially manufactured. It can be created using the recombinant DNA process.
- **Vector:** A **vehicle that carries foreign genes** into an organism and inserts them into the organism's genome. Modified viruses are used as vectors for gene therapy.
- **Virus:** A submicroscopic particle that **caninfect other organisms**. It **cannot reproduce on its own** but infects an organism's cell to use that cell's reproductive machinery to create more viruses. It usually consists of a DNA or RNA genome enclosed in a protective protein coat.
- **Stem cell:** A **fundamental cell** that has the potential to develop into any of the 210 different cell types found in the human body. **Human life begins with stem cells**, which divide again and again and branch off into special roles, like becoming liver or heart cells. They are an important resource for disease research and for the development of new ways to treat disease.
- **Amniocentesis:** A procedure used in prenatal diagnosis **to look at the chromosomes of the developing fetus**. A flexible needle is inserted into the mother's uterus through the abdomen to remove a sample of the fluid surrounding the fetus (amniotic fluid). This sample can then be analyzed by karyotype to look for changes in the

chromosomes. The procedure can be done after 15 weeks of pregnancy. There is a 0.5% risk of miscarriage associated with this procedure, which means one in 200 women will miscarry following this procedure.

- **Embryonic stem cells:** Cells that are **removed from the early embryo** and can become any of the 210 cell types found in the human body. Researchers are looking at the great potential stem cells have in developing new treatments for disease and injury.

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NATIONAL SPACE AGENCIES

1. Indian Space Research Organization (ISRO)

- The **Indian Space Research Organization (ISRO) is the pioneer space exploration agency of the Government of India, headquartered at Bengaluru**. ISRO was **formed in 1969** with a vision to develop and harness space technology in national development, while pursuing planetary exploration and space science research. **ISRO replaced its predecessor, INCOSPAR (Indian National Committee for Space Research), established in 1962 by India's first Prime Minister Pt. Jawaharlal Nehru and scientist Vikram Sarabhai, considered amongst the founding fathers of Indian space program**.
- ISRO, by successfully demonstrating its unique and cost-effective technologies, has gained place among the elite space agencies in the world over the years. **The first Indian satellite, Aryabhata, was built by the ISRO and launched with the help of the Soviet Union on April 19, 1975**. **The year 1980 marked the launch of Rohini, which was the first satellite to be successfully placed in the orbit by SLV-3**, an Indian made launch vehicle.
- **Recent Missions- Chandrayaan, Gaganyaan-2, Mangalyaan etc.**

2. Vikram Sarabhai Space Centre (VSSC)

- The **VSSC at Thiruvananthapuram is the largest among the ISRO facilities for the development of satellite launch vehicles and associated technology**. The centre had its beginnings as the Thumba Equatorial Rocket Launching Station (TERLS) in 1962. It was **renamed in honour of Dr. Vikram Sarabhai**, the father of the Indian space program.
- **November 21, 1963 marked India's first venture into space, with the launch of a two-stage Nike Apache sounding rocket from TERLS. The first rockets launched were built in United States**.
- The Vikram Sarabhai Space Centre is one of the main research and development establishments within ISRO. VSSC is an entirely indigenous facility working on the development of sounding rockets, the Rohini and Menaka launchers, and the Augmented Satellite Launch Vehicle (ASLV), Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV) and GSLV Mk III families of launch vehicles.
- The VSSC pursues research and development in the fields of aeronautics, avionics, composites, computer and information technology, control guidance and simulation, launch vehicle design, mechanical engineering, mechanisms vehicle integration and testing, propellants polymers and materials, propulsion propellants and space ordnance, and systems reliability.
- Current focus of VSSC is on the (GSLV), the GSLV Mk III and the Reusable Launch Vehicle- Technology Demonstrator (RLV-TD).
- VSSC also has programs focused on applications of space technology including village resource centres, telemedicine, tele-education, disaster management support and outreach through Direct To Home television broadcast.

3. ISRO Satellite Centre (ISAC)

- The **ISRO Satellite Centre (ISAC) is the leading centre of ISRO for design, development, fabrication and testing of all Indian made satellites**. It was established in the year of 1972 as Indian Scientific Satellite Project (ISSP) in Bengaluru.
- The centre has produced more than 50 satellites including the INSAT series, the Indian Remote Sensing series, as well as the GSAT communication satellites. Organisations under the umbrella of ISAC include the Laboratory for Electro-Optics Systems (LEOS) and the ISRO Satellite Integration and Testing Establishment (ISITE).
- The **LEOS is mainly responsible for research, development and production of Sensors for ISRO programmes**. The ISITE houses all facilities for building a spacecraft under-one-roof. It provides necessary support for testing sub-systems and spacecraft to meet the requirements of space environment.

4. Satish Dhawan Space Centre (SDSC)/ Sriharikota High Altitude Range (SHAR)

- **SatishDhawan Space Centre (SDSC) or Sriharikota High Altitude Range (SHAR) is a rocket launch centre of ISRO**. It is **located in Sriharikota in Andhra Pradesh**. Features like a good launch azimuth corridor for various missions, nearness to the equator (benefiting eastward launches), and large uninhabited area for a safety zone make it an ideal spaceport.
- The SHAR facility now consists of two launch pads, with the second built in 2005. The second launch pad was used for launches beginning in 2005 and is a universal launch pad, accommodating all of the launch vehicles used by ISRO. The two launch pads will allow multiple launches in a single year, which was not possible earlier.
- **SHAR will be the main base for the Indian human spaceflight program**. A new third launch pad will be built specifically to meet the target of launching a manned space mission by 2017.

5. Liquid Propulsion System Centre (LPSC)

- **Liquid Propulsion Systems Centre (LPSC) is the lead Centre for development and realization of earth-to-orbit advanced propulsion stages for Launch Vehicles** and also the in-space propulsion systems for Spacecrafts. It is involved in the development of liquid and cryogenic propulsion for launch vehicles and satellites.
- The LPSC activities and facilities are spread across its two campuses viz., LPSC Headquarters and Design Offices and Spacecraft Propulsion Systems Unit.
- **LPSC is engaged in development of liquid and cryogenic propulsion stages for launch vehicles and auxiliary propulsion systems for both launch vehicles and satellites. Activities related to liquid propulsion stages, cryogenic propulsion stages and control systems for launch vehicles and spacecraft is done at Thiruvananthapuram. Precision fabrication facilities, development of transducers and integration of satellite propulsion systems are carried out at Bangalore**. The developmental and flight tests along with assembly and integration are done at ISRO Propulsion Complex, Mahendragiri in Tamil Nadu.

6. Space Applications Centre (SAC)

- The SAC focuses on the design of space-borne instruments for ISRO missions and development and operationalisation of applications of space technology for societal benefits. **It is engaged in the development of pay loads for communication, broadcasting, navigation, disaster monitoring, meteorology, oceanography, environment monitoring and natural resources survey**.
- This includes research and development of on-board systems, ground systems and end user equipment hardware and software. Some of the achievements of the Space Applications Centre include development of communication and meteorological payloads for INSAT satellites, optical and microwave payloads for IRS satellites.

- SAC provides its infrastructure to conduct training courses to the students of the Center for Space Science and Technology Education in Asia and The Pacific (CSSTEAP). SAC has three campuses, two of which are located at Ahmedabad and one at Delhi.

7. Antrix Corporation Limited

- **Antrix Corporation Limited (ACL) is a wholly owned Government of India Company, under the administrative control of Department of Space (DOS)**. It is the apex marketing agency under DOS with access to resources of DOS as well as Indian space industries.
- Antrix promotes and commercially markets the products and services emanating from the Indian Space Programme. **In the year 2008, the Company was awarded 'MINIRATNA' status**. The current business activities of Antrix are as follows:
  - Provisioning of communication satellite transponders to various users,
  - Providing launch services for customer satellites,
  - Marketing of data from Indian and foreign remote sensing satellites,
  - Building and marketing of satellites as well as satellite sub-systems,
  - Establishing ground infrastructure for space applications, and
  - Mission support services for satellites.

INTERNATIONAL SPACE ORGANIZATIONS

1. National Aeronautics and Space Administration (NASA)

- **NASA was established in 1958, succeeding the National Advisory Committee for Aeronautics (NACA)**. The new agency was to have a distinctly **civilian orientation, encouraging peaceful applications in space science**.
- Since its establishment, most US space exploration efforts have been led by NASA, including the Apollo Moon landing missions, the Skylab space station, and later the Space Shuttle.
- **NASA is supporting the International Space Station and is overseeing the development of the Orion Multi-Purpose Crew Vehicle, the Space Launch System and Commercial Crew vehicles**.
- The agency is also responsible for the Launch Services Program which provides oversight of launch operations and countdown management for uncrewed NASA launches.
- **Current Missions-** Juno, Curiosity, Cassini-Huygens, Dawn, Mars 2020 Rover, Kepler Space Telescope, New Horizon, James Webb Space Telescope.

2. ROSCOSMOS (Russian Space Agency)

- ROSCOSMOS is a State Corporation that was established in August 2015 to oversee and implement a comprehensive reform of the Russian space industry.
- State Space Corporation ROSCOSMOS ensures the implementation of the Russian government's space program and its legal regulation. ROSCOSMOS is also placing orders for the development, manufacture and supply of space equipment and space infrastructure objects.
- The state corporation is also responsible for international space cooperation and tasked with setting the stage for the future use of results of space activities in the social and economic development of Russia.

3. Japan Aerospace Exploration Agency (JAXA)

- The Japan Aerospace Exploration Agency (JAXA) was born through the merger of three institutions, namely the Institute of Space and Astronautical Science (ISAS), the National Aerospace Laboratory of Japan (NAL) and the National Space Development Agency of Japan (NASDA). It was designated as

a core performance agency to support the Japanese government's overall aerospace development and utilization. JAXA, therefore, can conduct integrated operations from basic research and development, to utilization.

- **Missions-** Development and Operation Transportation Systems Linking Ground and Space, Utilizing Space Through Satellites, Space Tracking and Communications Center, Human Space Activities / Utilization of the Space Environment, Research on Space Science, Research on Aeronautical Technology, and Fundamental Technology Research.

4. China National Space Administration

- China National Space Administration is the national space agency of China. It is responsible for the national space program and for planning and development of space activities.
- Founded in 1993.
- **Recent Missions- Chinese Lunar Exploration Programme, Mars Global Remote Sensing Orbitor and Long March 9**

SPACE TERMINOLOGIES

- **Apogee:** It is a point on the orbit where vertical distance of the satellite from the Earth's surface is maximum. The maximum distance of the satellite from Earth's surface is also called apogee of the orbit of the satellite.
- **Perigee:** It is a point on the orbit where vertical distance of the satellite from the Earth's surface is smallest. The smallest distance of the satellite from the Earth's surface is also called perigee of the orbit of the satellite.
- **Inclination:** The angle between the plane of orbit of the satellite and plane of the equator of Earth is called inclination of the orbit.

TYPES OF ORBITS

- **Polar Orbits –** A polar orbit is one in which a satellite passes above or nearly above both poles of the body being orbited (usually a planet such as the Earth) on each revolution.
  - These orbits have an inclination near 90 degrees. This allows the satellite to see virtually every part of the Earth as the Earth rotates underneath it. The important features of the satellites revolving in polar orbits are as follows:
  - A satellite in a polar orbit will pass over the equator at a different longitude on each of its orbits. It takes approximately 90 minutes for the satellite to complete one orbit.
  - These satellites have many uses like measuring ozone concentrations in the stratosphere or measuring temperatures in the atmosphere; earth mapping and observation; reconnaissance; study of weather etc.
- **Sun Synchronous Orbits –** A satellite whose time period is such that it makes exactly an integral number of revolutions (usually 13, 14 or 15) around earth in 24 hours. After passing over a certain place on Earth, next day it will again pass over the same place at the same time of day.
  - While Earth spins one rotation, relative to sun in 24 hours, the satellite makes an accurately integral number of revolutions. Thus, satellite will be able to look at that place and photograph it on consecutive days in identical illumination, Sun being in the same position relative to that place. Such an orbit is called a sun-synchronous orbit & the satellite moving in this orbit is called a sun-synchronous satellite. The important features of the satellites moving in the sun synchronous orbits are as follows:
  - These orbits allow a satellite to pass over a section of the Earth at the same time of day. Since there are 365 days in a year and 360° in a circle, it means that the satellite has to shift its orbit by approximately 1° per day. These satellites orbit at an altitude between 700 to 800 km.

- These satellites are very important for military and remote sensing purposes.

- **Geosynchronous Orbits/ Geostationary Orbit –** The satellites in these orbits circle the Earth at the same rate as the Earth spins. The orbit of such satellite is in the plane of equator, i.e. its inclination is 0o, at a height of about 36,000 km above the equator and keeps this distance constant.
  - Thus, it is a circular orbit. Hence, relative to any location on earth, the position of the satellite is stationary. This orbit is called geo-stationary orbit. A satellite revolving in this orbit is called a geo-stationary satellite. The important features of the satellites moving in the geostationary orbits are as follows:
  - Geosynchronous orbits allow the satellite to observe almost a full hemisphere of the Earth. These satellites are used to study large scale phenomenon such as hurricanes, or cyclones. These orbits are also used for communication satellites. The disadvantage of this type of orbit is that since these satellites are very far away, they have poor resolution. The other disadvantage is that these satellites have trouble monitoring activities near the poles.
- **Low Earth Orbit (LEO) –** The Low Earth Orbit extends from 200 km. to 1200 km. It means that it is relatively low in altitude, although well above anything that a conventional aircraft can reach. However LEO is still very close to the Earth, especially when compared to other forms of satellite orbit including geostationary orbit. The important features of the Low Earth Orbit are as follows:
  - Orbit times are much less than for many other forms of orbit. Less energy is expended placing the satellites in LEO than higher orbits. The lower orbit means the satellite and user are closer together and therefore path losses a less than for other orbits such as GEO. LEO satellites have shorter life spans than others.
  - Some speed reduction may be experienced as a result of friction from the low, but measurable levels of gasses, especially at lower altitudes. Radiation levels are lower than experienced at higher altitudes.
  - A variety of different types of satellite use the LEO orbit levels. These include different types and applications including communications satellites, earth monitoring satellites etc.
  - The International Space Station is in an LEO that varies between 320 km. (199 miles) and 400 km. (249 miles) above the Earth's surface.
- **Space Debris in LEO –** Apart from the general congestion experienced in Low Earth Orbit, the situation is made much worse by the general level of space debris that exists. There is a real and growing risk of collision and major damage – any collisions themselves are likely to create further space debris.
- **Medium Earth Orbits (MEO) –** They are in between LEO and geostationary orbits & operate about 8,000-20,000 km. above the earth. They are placed in an elliptical orbit.
  - The orbit is basically used for communication satellites.
  - Examples include GPS and Global Communication and Orblink.

LAUNCH VEHICLES

- **ASLV:**
  - Augmented Satellite Launch Vehicle (ASLV) was developed to act as a low cost intermediate vehicle to demonstrate and validate critical technologies.
  - With a lift off weight of 40 tonnes, the 23.8 m tall ASLV was configured as a 5 stage, all-solid propellant vehicle, with a mission of orbiting 150 kg class satellites into 400 km circular orbits.
  - The strap-on stage consisted of 2 identical 1m diameter solid propellant motors, Under the ASLV programme 4 developmental flights were conducted.
  - ASLV provided valuable inputs for further development.
- **PSLV**
  - The Polar Satellite Launch Vehicle, usually known as PSLV is the 1st operational launch vehicle of ISRO.

- PSLV is capable of launching 1600 kg satellites in 620 km. sun-synchronous polar orbit and 1050 kg. satellite in Geo-synchronous Transfer Orbit (GTO).
- In the standard configuration, it measures 44.4 m. tall, with a lift off weight of 295 tonnes.
- PSLV has 4 stages using solid and liquid propulsion systems alternately. The 1st stage is one of the largest solid propellant boosters in the world and carries 139 tonnes of propellant.
- A cluster of 6 strap-ons attached to the 1st stage motor, 4 of which are ignited on the ground and 2 are air-lit.
- The reliability rate of PSLV has been superb. With its variant configurations, PSLV has proved its multi-payload, multi-mission capability in a single launch and its Geosynchronous launch capability.

GSLV Mk I & II

- Geosynchronous Satellite Launch Vehicle (GSLV)-Mark I&II , is capable of placing INSAT-II class of satellites (2000 – 2,500 kg) into Geosynchronous Transfer Orbit (GTO). GSLV is a 3 stage vehicle GSLV is 49 m tall, with 4141 lift off weight.
- It has a maximum diameter of 3.4 m at the payload fairing. 1st stage comprises S125 solid booster with four liquid (L40) strap-ons. 2nd stage (GS2) is liquid engine and the 3rd stage (GS3) is a cryo stage. The vehicle develops a lift off thrust of 6573 km.

GSLV Mk III

- The GSLV-III or Geosynchronous Satellite Launch Vehicle Mark III is a launch vehicle currently under development by the Indian Space Research Organization.
- GSLV Mk III is conceived and designed to make ISRO fully self reliant in launching heavier communication satellites of INSAT-4 class, which weigh 4500 to 5000 kg.
- It would also enhance the capability of the country to be a competitive player in the multimillion dollar commercial launch market.
- The vehicle envisages multi-mission launch capability for GTO, LEO, Polar and intermediate circular orbits.

Reusable Launch Vehicle

- A reusable launch system (or reusable launch vehicle, RLV) is a launch system which is capable of launching a launch vehicle into space more than once. This contrasts with expendable launch systems, where each launch vehicle is launched once and then discarded.
- Reusable Launch Vehicle-Technology Demonstration (RLV-TD) Programme of ISRO is planned as a series of technology demonstration missions that have been considered as a first step towards realising a Two Stage To Orbit (TSTO) fully reusable vehicle.
- A Winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies using air breathing propulsion. These technologies will be developed in phases through a series of experimental flights.
- Hypersonic experiment (HEX) flight, the first in the series of experimental flights, will be followed by the Landing experiment (LEX), Return flight experiment (REX) and Scramjet Propulsion experiment (SPEX).
- RLV-TD HEX1 is planned to demonstrate the hypersonic aerothermo dynamic characterisation of winged re-entry body, autonomous mission management to land at a specified location and characterisation of hot structures.
- Application of these technologies would bring down the launch cost by a factor of 10.

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DAY - 63

MILITARY EXERCISES AND IT TELECOM

■ Joint Exercises conducted by Army:

S. No.	Country	Exercise
1.	Australia	Ex AUSTRA HIND
2.	Bangladesh	Ex SAMPRITI
3.	China	Ex HAND IN HAND
4.	France	Ex SHAKTI
5.	Indonesia	Ex GARUDA SHAKTI
6.	Kazakhstan	Ex PRABAL DOSTYK
7.	Kyrgyzstan	Ex KHANJAR
8.	Maldives	Ex EKUVERIN
9.	Mongolia	Ex NOMADIC ELEPHANT
10.	Myanmar	IMBEX
11.	Nepal	Ex SURYA KIRAN
12.	Oman	AL NAGAH
13.	Russia	Ex INDRA
14.	Seychelles	Ex LAMITIYE
15.	Sri Lanka	Ex MITRA SHAKTI
16.	Thailand	Ex MAITREE
17.	UK	Ex AJEYA WARRIOR
18.	USA	Ex YUDHABHAYAS
		Ex VAJRA PRAHAR
19.	Vietnam	VINBAX
20.	Multinational (ADMM Plus)	Ex FORCE 18

■ Joint Exercises conducted by Navy:

S. No.	Country	Exercise
1.	Australia	AUSINDEX
2.	Bangladesh	IN-BN CORPAT
3.	Brazil & South Africa	IBSAMAR
4.	France	VARUNA
5.	Indonesia	IND-INDO CORPAT
		IND-INDO BILAT
6.	Malaysia	IN-MN Table Top Ex
7.	Myanmar	IMCOR
		IN-MN BILAT
8.	Oman	Naseem-al-Bahr
9.	Russia	INDRA NAVY
10.	Sri Lanka	SLINEX
11	Singapore	SIMBEX
12.	Thailand	INDO-THAI CORPAT
13	UAE	In-UAE BILAT
14	UK	KONKAN
15.	USA	MALABAR
		RIMPAC (Multilateral)
16	Multilateral Exercise by Brunei	ADMM+ Exercise
17	Multilateral Exercise by Indonesia	Ex KOMODO
18	Multilateral Exercise by India	MILAN

Joint Exercises conducted by Air Force:

S. No.	Country	Exercise
1.	Bangladesh	Table Top Ex
2.	Israel	Ex Blue Flag-17
3.	Oman	Ex EASTERN BRIDGE-IV

4.	Russia	Ex INDRA-17
5.	Singapore	JOINT MILITARY TRAINING
6.	Thailand	Ex SIAM BHARAT
7.	UAE	DESERT EAGLE-II
8.	UK	INDRADHANUSH-IV
9.	USA	RED FLAG 16-1
10.	Multinational Air Exercise	Ex Samvedna with Bangladesh, Nepal, Sri Lanka, UAE

India's Ballistic Missile Defence system

- The Indian Ballistic Missile Defence Programme, an initiative to develop and deploy a multi-layered ballistic missile defence system, is a two-tiered system consisting of two interceptor missiles, namely Prithvi Air Defence (PAD) missile for high altitude interception, and the Advanced Air Defence (AAD) Missile for lower altitude interception. The two-tiered shield will be able to intercept any incoming missile launched 5,000 km away.
- The Ballistic Missile Defence programme aims to provide an effective missile shield against incoming enemy ballistic and nuclear missiles.
- A hostile missile needs to be intercepted at boost (launch) point, mid-course (flight through space), or terminal phase (during atmospheric descent).

Components

- **PrithviDefence Vehicle:** It is capable of killing an incoming missile with a strike range of around 2,000 km outside the earth's atmosphere. It will replace the existing Prithvi Air Defense (PAD) which has a maximum interception altitude of 80 kilometres. The advantage of intercepting an incoming missile at such a high altitude is that the debris would not fall on the ground and there would be no collateral damage.
- **Advanced Air Defence:** The endo-atmospheric missile, capable of intercepting incoming targets at an altitude of 15 to 25 km successfully destroyed the incoming missile.

Anti-Satellite Test (ASAT)- Mission Shakti

- On March 27, 2019, India conducted Mission Shakti, an anti-satellite missile test, from the Dr A P J Abdul Kalam Island launch complex. **This was a technological mission carried out by DRDO**. **The satellite used in the mission was one of India's existing satellites operating in a lower orbit.** The test was fully successful and achieved all parameters and it required an extremely high degree of precision and technical capability.
- The significance of the test is that India has tested and successfully demonstrated its capability to interdict and intercept a satellite in outer space-based on complete indigenous technology. **With this test, the country joins an exclusive group of space-faring nations consisting of USA, Russia, and China.**
- The government has stated that it has no intention of entering into an arms race in outer space. The country has always maintained that space must be used only for peaceful purposes. The government has also stated that India is against the weaponization of Outer Space and support international efforts to reinforce the safety and security of space-based assets.
- **India is also a party to all the major international treaties relating to Outer Space.** India already implements several Transparency and Confidence Building Measures(TCBMs) – including registering space objects with the UN register, prelaunch notifications, measures in harmony with the UN Space Mitigation Guidelines, participation in Inter-Agency Space Debris Coordination (IADC) activities

about space debris management, undertaking SOPA (Space Object Proximity Awareness and COLA (Collision Avoidance) Analysis and numerous international cooperation activities, including hosting the UN-affiliated Centre for Space and Science Technology Education in Asia and Pacific. India has been participating in all sessions of the UN Committee on the Peaceful Uses of Outer Space.

- **India also supported UNGA resolution 69/32 on No First Placement of Weapons on Outer Space**. Equally, India supports the substantive consideration of the issue of **Prevention of an Arms Race in Outer Space (PAROS) in the Conference on Disarmament where it has been on the agenda since 1982**.

Important Indian Defence Missions

- The **Indian Armed Forces** are the overall unified military of the Republic of India encompassing the **Indian Army**, the **Indian Air Force** and the **Indian Navy**. The President of India serves as the commander-in-chief of the armed forces. With an estimated total active force of 1,325,000 personnel, India maintains the world's third-largest armed forces after China and the United States.

Army Operations	Year	Purpose
First Kashmir War	1947	In retaliation to Pakistan's attack on Kashmir on the request of King Hari Singh of Kashmir.
Operation Polo	1948	Ended the rule of Nizam of Hyderabad with its inclusion in Indian Union.
Operation Vijay	1961	Capture of Goa, Daman and Diu and AnjidivIslands from the Portuguese colonial holding.
Operation Steeplechase	1961	A colossal combined army and police counter insurgency operation Launched by Indira Gandhi during President's Rule against Naxalites.
Operation Blue Star	1984	To confine the Harmandir Sahib Complex.
Operation Meghdoot	1984	Indian Military's capture of the majority of Siachen Glacier.
Operation Rajiv	1987	Indian military's capture of Quaid Post/Bana Post.
Operation Pavan	1987	To take control of Jaffna from the LTTE to enforce the disarmament of the LTTE as a part of the INDO-SRILANKA Accord.
Operation Virat	1988	Indian Military's capture of the majority of Siachen Glacier.
Operation Trishul	1988	Indian military's capture of Quaid Post/Bana Post.
Operation Checkmate	1988	To take control of Jaffna from the LTTE to enforce the disarmament of the LTTE as a part of the INDO-SRILANKA Accord.
Operation Cactus	1988	Para-commandos of Indian Army and MARCOS of Indian Navy against Tamil Nationalist Mercenaries of PLOTE who instigated a coup in Male in the Maldives.

Operation Vijay	1999	To push back the Infiltrators from the KarelSector of Jammu and Kashmir.
Operation Black Tornado and Operation Cyclone	2008	To counter and kill the terrorists of Mumbai Attack 2008.
Operation Surya Hope	2013	For saving people trapped in the 2013 North India floods.
Operation All Out	2015	For flintring out Bodo Militants in Assam.
Operation Maitri	2015	India led rescue and relief mission in quake hit Nepal.
Surgical Strike in Myanmar	2015	A Cross Border Counter Insurgency raid in Myanmar.
Indian Surgical Strike 2016	29th Sep 2016	Indian Para-Commandos carried out a surgical strike 2-3 km inside Pakistan Administered Kacinnit crossing the Line of Control destroying 5-8 terror launch pads.
Operation Sahyog	2018	Indian Army launched Operation Sahyog to rescue people in flood-hit Kerala. Indian Army has deployed its men and machinery into disaster relief and rescue operations at Kannur, Kozhikode, Wayanad and Idukki after incessant rain
Navy Operations	**Year**	**Purpose**
Operation Vijay	1961	Annexation of Goa
Operation Trident	1971	Operation Trident and the follow-up Operation Python were offensive operations launched by the Indian Navy on Pakistan's port city of Karachi during the Indo-Pakistani War of 1971.
Operation Python	1971	A follow up to operation Trident launched by the Indian Navy on Pakistan's port city of Karachi during the Indo-Pakistani War of 1971.
Operation Cactus	1988	The 1988 Maldives coup d'etat was the attempt by a group of Maldivians led by Abdullah Luthufi and assisted by armed mercenaries of a Tamil secessionist organisation from Sri Lanka,the People's Liberation Organisation of Tamil Eelam(PLOTE), to overthrow the government in the island republic of Maldives. The coup d'etat failed due to the intervention of the Indian Army

Operation Restore Hope	1992-2003	The Unified Task Force (UNITAF) was a US-led, United Nations-sanctioned multinational force, which operated in Somalia to create a protected environment for conducting humanitarian operations in the southern half of the country.
Mission Sahayata&Operation MeghRahat	2014	For search, rescue, relief, relocation and humanitarian assistance to worst flood hit Jammu and Kashmir.
Operation Madad	2015	A joint effort by Army, Navy and Air Force along with national disaster management force personnel helped in evacuating thousands stranded in the floods in Tamil Nadu and Andhra Pradesh.
Operation Sea Waves	2004	Operation Sea Waves was a disaster relief operation undertaken by the Indian Armed Forces in the aftermath of the 2004 Indian Ocean tsunami. Sea Waves was focused on rescue and relief efforts on the Andaman and Nicobar Islands.
Operation Rainbow		Carried by Indian Armed Forces in Sri Lanka for rescue in the aftermath of Tsunami.
Operation Gambhir		An overseas relief operation launched by India following the December 26 tsunami disaster that has left thougarvis dead along the South and South-East Asian shores.
Operation Sukoon	2006	To evacuate Indian, Sri Lankan and Nepalese nationals as well as Lebanese Nationals with Indian Spouses form the conflict zone during the Lebanon War.
Operation Search Light		To find the missing Boieng 777 M H 17 Malaysian Flight.
Operation Raahat	2015	To evacuate Indian citizens and other foreign nationals from Yemen during 2015 military intervention by Saudi Arabia and its allies during Yemeni Crisis.
Air Operation	**Year**	**Purpose**
Bangladesh Liberation War	1971	The war began with preemptive aerial strikes on 11 Indian air stations that led to the commencement of hostilities with Pakistan and Indian entry into the war of independence in East Pakistan on the side of Bengali nationalist forces.
Meghna Hell Bridge	1971	It took place when the Indian Air Force airlifted the MuktiBahini and the DI Corps of the Indian Army from Btahmanbaria to Raipura in Narsingdiover the River Meghna, bypassing the destroyed Meghna Bride and Pakistani defences in Ashuganj.

Tangail Airdrop Operation	1971	The main objective was to capture the Poongli Bridge on the Jamuna River which would cut off the Pakistani 93m Brigade which was retreating from the north to defend Dhaka and its approaches and to link up with advancing Maratha Light Infantry.
Operation Meghdoot	1984	To capture the Siachen Glacier in the Jammu and Kachntit.
Operation Poomalai or Eagle Mission 4	1987	To air-drop supplies over the besieged town of Jaffna in Sri Lanka on 4 June 1987 in support of Tamil Tigers during the Sri Lankan Civil War.
Operation Cactus	1988	The 1988 Maldives coup d'etat was the attempt by a group of Maldivians led by Abdullah Luthufiand assisted by armed mercenaries of a Tamil secessionist organisation from Sri Lanka, the People's Liberation Organisation of Tamil Eelam (PLOTE), to overthrow the government in the island republic of Maldives. The coup d'etat failed due to the intervention of the Indian Army.
Bangladesh Liberation War	1971	The war began with preemptive aerial strikes on 11 Indian air stations that led to the commencement of hostilities with Pakistan and Indian entry into the war of independence in East Pakistan on the side of Bengali nationalist forces.
Operation SafedSagar	1999	To support Ground Troops during Kargil War aimed to flush out regular and irregular troops of the Pakistani Army along the Line of Control.
Atlantique Incident	1999	An event in which a Breguet Atlantic patrol plane of the Pakistan Navy's Naval Air Arm, with 16 people on board, was shot down by the Indian Air Force for violating Indian airspace. The episode took place in the Rain of Kutch on 10 August 1999, just a month after the Kargil War, aggravating already tense relations between India and Pakistan.
Operation Rahat	2013	Biggest IAF operation to evacuate the stranded people affected by the 2013 North Indian Flash Floods in the state of Uttarakhand and Himachal Pradesh.
Operation Maitri	2015	A rescue and relief operation in Nepal by Indian Armed Forces in the aftermath of April 2015 Nepal Earthquake.
Operation SankatMochan	2016	An operation of the Indian Air Force in view of 2016 Juba Clashes to evacuate Indian citizens and other foreign nationals from South Sudan during the South Sudanese Civil War.
Balakot Air Strike	2016	To destroy terrorist base camps and launch pads in PoK, who are responsible for Pulwamaattack.

Defence Communication Network

- **India's first integrated Defense Communication Network (DCN) has been launched by the Ministry of Defence**.
- It is **built by HCL under a nearly Rs. 600 crore project**.
- The Defence Communication Network (DCN), a strategic, highly secure and scalable system, has a pan-India reach - from Ladakh to the North East to island territories, enabling the army, air force, navy and the Special Forces Command to share situational awareness for a faster decision-making process.
- Implementation of DCN is proof of the strength of the Indian industry and has reaffirmed the emphasis of the Government on Make in India, program.
- The DCN is a major step towards ensuring Network Centricity across the three Services, Integrated Defence Staff and Strategic Forces Command.
- **The network provides converged voice, data and video services to the three Services based on a secured system with adequate redundancy**.
- This network is a step towards joint manship that the government is pushing for in the armed forces.
- It is capable of working on terrestrial as well as satellite mode of communication and has also been fixed onboard different military vehicles.
- **DCN will ensure Network Centricity across the three services, Integrated Defence Staff (IDS) and Strategic Forces Command (SFC).** It was developed as a part of the armed forces pursuit of modernising military communications system.
- **Significance:**
  - It will **help the armed forces and the Special Forces Command to share situational awareness for a faster decision-making process.** Hence, it will help in improving the prompt response time due to integrated technology.
  - It will help in bolstering the prowess of the defence forces during critical operations and rescue missions.
  - It acts as proof of the strength of the Indian industry. Initially, it was planned to import the system.
  - With the indigenous development, it has reaffirmed the capability of the Indian industries and acts as a boost to the Make in India Programme.

Missiles of India

	Name of the Missile	Type of Missile	Operational Range	Speed
Air-to-air missiles	MICA	Air-to-Air Missiles	500 m to 80 km	Mach 4
	Astra Missile	Air-to-Air Missiles	80-110 km	Mach 4.5 +
	Novator K-100	Medium Range air-to-air missile	300–400 km	Mach 3.3
Surface-To-Air Missiles	Trishul	Short-Range surface to air missile	9 km	
	Akash Missile	Medium-range surface-to-air missile	30-35km	Mach 2.5 to 3.5
	Barak 8	Long-Range Surface to Air Missile	100 km	Mach 2

Surface-to-surface Missiles	Agni-I	Medium-range ballistic missile	700-1250 km	Mach 7.5
	Agni-II	Intermediate-range ballistic missile	2,000–3,000 km	Mach 12
	Agni-III	Intermediate-range ballistic missile	3,500 km – 5,000 km	5–6 km/s
	Agni-IV	Intermediate-range ballistic missile	3,000 – 4,000 km	Mach 7
	Agni-V	Intercontinental ballistic missile	5000 – 8000 Km	Mach 24
	Prithvi I	Short-Range Ballistic Missile	150 km	–
	Prithvi II	Short-Range Ballistic Missile	350 km	–
	Dhanush	Short-Range Ballistic Missile	350 – 600 km	–
	Shaurya	Medium-Range Ballistic Missile	750 to 1,900 km	–
	Prahaar	Short-Range Ballistic Missile	150 km	–
Cruise Missiles	BrahMos	Supersonic cruise missile	290 km	Mach 2.8 to 3 Mach
	BrahMos II	Hypersonic cruise missile	300km	Mach 7
	Nirbhay	Subsonic cruise missile	1,000 -1500 km	Mach 0.8
Submarine Launched Ballistic Missiles	Ashwin	Ballistic Missile	150-200km	Mach 4.5
	Sagarika	Ballistic Missile	700 – 1900 Km	
	K-4	Ballistic Missile	3,500–5,000 km	
	K-5	Ballistic Missile	6,000 km	
Anti-Tank Missile	Amogha	Anti-Tank Guided Missile	2.8 km	
	Nag	Anti-Tank Guided Missile	4km	230 m/s
	Helina	Anti-Tank Guided Missile	7-8km	

Nuclear Triad

- A **nuclear triad is a three-pronged military force structure that consists of land-launched nuclear missiles, nuclear-missile-armed submarines and strategic aircraft with nuclear bombs and missiles**.

- Specifically, these components are land-based intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and strategic bombers.
- The purpose of having this three-branched nuclear capability is to significantly reduce the possibility that an enemy could destroy all of a nation's nuclear forces in a first-strike attack. This, in turn, ensures a credible threat of a second strike, and thus increases a nation's nuclear deterrence.
- It includes the following components:
  - **Bomber aircraft:** Aircraft carrying nuclear bombs, or nuclear-armed cruise missiles, for use against ground or sea targets.
  - **Land-based missiles (MRBMs or ICBMs):** Delivery vehicles powered by a liquid or solid-fueled rocket that primarily travel in a ballistic (free-fall) trajectory.
  - **Ballistic missile submarines (SSBNs):** Nuclear missiles launched from ships or submarines. They are classified under an umbrella of vessels and submarines that are capable of launching a ballistic missile.
- **India's Nuclear Triad**
  - **India's nuclear weapons policy is that of "no first use" and "minimum credible deterrence**," which means that the country will not use nuclear weapons unless they are attacked first, but the country does have the capability to induce the second strike.
  - **India completed its nuclear triad with the commissioning of INS Arihant in August 2016, which was India's first submarine built indigenously**.
  - **INS Arihant is a nuclear-powered ballistic missile submarine armed with 12 K-15 missiles with a range of 750 km**, which will later be **upgraded K-4 missiles with an extended range of 3500 km**.
  - In November 2017, it tested the **BrahMos missile from the Sukhoi-30 MKI platform**. The INS Arihant was the first SSBN to be completed under India's program.
  - The **INS Arighat is currently under construction and close to completion**. This would be the second SSBN of the three underway to be finished.
  - After the INS Arihant was completed, India now contained air-launched nuclear missiles, nuclear-missile-armed submarines and strategic aircraft with nuclear bombs and missiles. This allows the country to join the nuclear triad.

Telecommunication Technology: IT and Computer

- The telecom services have been recognized the world-over as an important tool for socio-economic development for a nation.
- It is one of the prime support services needed for rapid growth and modernization of various sectors of the economy.
- **The two telecom technologies are:**

GSM

- GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Europe and other parts of the world.
- GSM uses a variation of time division multiple access (TDMA) and frequency division multiple access (FDMA).
- GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot.
- It operates at either the 900 MHz or 1800 MHz frequency band.
- The key advantage of GSM systems to consumers has been higher digital voice quality and low cost alternatives to making calls, such as the Short message service (SMS, also called "text messaging")

CDMA

- Code-Division Multiple Access is a digital cellular technology that uses spread-spectrum techniques.
- Individual conversations are encoded with a pseudo-random digital sequence. CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements.
- The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code.
- CDMA consistently provides better capacity for voice and data communications than other commercial mobile technologies, allowing more subscribers to connect at any given time.
- The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands.

Different Telecom Technologies

- **VOIP (Voice over Internet Protocol)**
  - VOIP is IP enabled voice calling technology over internet. Example: Skype, Yahoo messenger, MSN messenger.
  - It requires broadband connectivity to make a call along with IP enables devices like Computers, Smartphone etc.
  - The voice is converted into digital packets and transmitted to destination over packet switched network.
- **IPTV**
  - IPTV is new generation TV that communicates over Internet protocol in the form of packets rather than signals in normal TV's.
  - It has 3 components: IPTV where content is encoded and decoded; Delivery Network over which information in the form of packets is transmitted; Setup Box which is communication link between operator's broadband modem and customer's TV. Also packets delivered are reassembled here.
  - IPTV enables two-way interactivity, in contrast to traditional one way cable or satellite broadcast network. The two-way IPTV network means viewers have more options to personalize interact and control their viewing experience.
  - Because IPTV is based on internet protocol, it is sensitive to packet loss and delays if the IPTV connection is not fast enough.
- **Near Field Communication (NFC)**
  - It's a new standard of wireless communication.
  - It enables users to transmit radio frequency wave over a very short distance just about few centimeters.
  - Since it's a very short range communication, power consumption is very negligible or no power consumption.
  - It can transfer low amount of data between devices enabled with NFC.
  - No need of pairing the devices, its ready to use at just a click or swipe.
  - NFC-based wallet, Mobo Money launched- Tech Mahindra, the Tech & Software development arm of Mahindra Group, announced launch of Mobo-Money, a NFC based, contactless digital payment ecosystem.
  - Mobo Money will be the first commercial roll-out of NFC (Near Field Communication) for an ecosystem. The company aims to get about one million merchants including local kirana shop owners on board.

- **Li-Fi**
  - Li-Fi means light fidelity.
  - Li-Fi is a wireless communication, high speed and bidirectional.
  - It's similar to WiFi but not a radio frequency wave communication.
  - It's a visual light communication where visible light has the capacity to transmit the data.
  - A dedicated LED light so developed emits a visible range light. The reach of light is the range of Li-Fi communication.
  - Internet connectivity would become more simple and high bandwidth of Li-Fi can render cost effective and efficient data communication.
  - Most importantly Li-Fi is high security benefits. Light communication can't be intercepted unlike electromagnetic waves. Hence its secure mode of communication.
  - Since light can't pass through obstacles like walls and barriers, Li- Fi can't work beyond it. It limited to visible range of light.
  - It provides one point solution to signal solution. In offices a merely LED bulb can work as network generator.
- **Bluetooth technology**
  - Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions in the ISM band from 2400-2480 MHz) from fixed and mobile devices, creating Personal Area Networks (PANs) with high levels of security.
- **List of applications**
  - Wireless control of and communication between a mobile phone and a hands free headset
  - Wireless Bluetooth headset and Intercom.
  - Wireless networking between PCs in a confined space and where little bandwidth is required.
  - Wireless communication with PC input and output devices, the most common being the mouse, keyboard and printer.
  - Transfer of files, contact details, calendar appointments, and reminders between devices with OBEX.
- **Wi-Fi technology**
  - Wi-Fi is a mechanism for wirelessly connecting electronic devices.
  - A device such as a personal computer, video game console, smartphone, or digital audio player, when enabled with WiFi, can connect to the Internet via a wireless network access point.
  - Wi-Fi works with no physical wired connection.
  - It uses radio frequency (RF) technology, RF being a frequency within the electromagnetic spectrum associated with radio wave propagation.
  - Wi-Fi is supported by many applications and devices including video game consoles, home networks, PDAs, mobile phones, major operating systems, and other types of consumer electronics.
  - Wi-Fi allows cheaper deployment of local Area Networks (LANs). Products designated as "Wi-Fi Certified" by the Wi-Fi Alliance are backward compatible. Unlike mobile phones, any standard Wi-Fi device will work anywhere in the world.
- **WiMax technology**
  - WiMax (Worldwide Interoperability for Microwave Access) is a wireless broadband technology, which supports point to multi-point (PMP) broadband wireless access.
  - WiMax can provide Broadband Wireless Access (BWA) up to 30 miles (50 km) for fixed stations, and 3 – 10 miles (5 – 15 km) for mobile stations.
- **Uses of WiMax technology are:**
  - Providing portable mobile broadband connectivity across cities and countries through a variety of devices.

- Providing a wireless alternative to cable and DSL for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services (triple play).
- Providing a source of Internet connectivity as part of a business continuity plan.

- **AMOLED Display**
  - **AMOLED (active-matrix organic light-emitting diode)** is a display technology for use in mobile devices and televisions.
  - OLED describes a specific type of thin-film-display technology in which organic compounds form the electroluminescent material, and active matrix refers to the technology behind the addressing of pixels.
  - **AMOLED technology** is used in mobile phones, media players and digital cameras, and continues to make progress toward low-power, low-cost and large-size (for example, 40-inch) applications.
  - The greatest advantage of **AMOLED display** is fast pixel switching response time that makes the display fit and efficient for animation.
- **4G LTE Vs 4G WiMAX**
  - LTE stands for Long Term Evolution. It's a first generation 4G technology termed as **"true 4G".**
  - WiMAX stands for Worldwide Interoperability for Microwave Access.
  - They differ in their bandwidth; LTE has higher bandwidth than WiMAX.
  - LTE is compatible with existing network but for WiMAX we need altogether new network.
  - The cost of installation of LTE is more than WiMAX.
  - Overall LTE is gaining popularity and hopes to existing 4G technology in coming years.
- **LTE – Long Term Evolution**
  - LTE (Long Term Evolution) is a wireless broadband technology designed to support roaming Internet access via cell phones and handheld devices.
  - With its architecture based on Internet Protocol (IP) unlike many other cellular Internet protocols, Long Term Evolution supports browsing Web sites, VoIP and other IP-based services well.
  - LTE can theoretically support downloads at 300 Megabits per second (Mbps) or more based on experimental trials.
- **WiBro**
  - **WiBro (Wireless Broadband)** is a wireless broadband Internet technology developed by the South Korean telecoms industry.
  - **WiBro (Wireless Broadband)** communication technique uses radio waves (frequency of 2.3 GHz) and allows a maximum theoretical speed of 30 megabits per second over a range between 1 and 5 kilometers.
  - **WiBro** is a wireless point to point communication technique, tailored to serve low-cost sparsely populated areas where the fiber is not an option.

- **GPRS**
  - General Packet Radio Services (GPRS) is a packet-based wireless communication service that promises data rates from 56 up to 114 Kbps and continuous connection to the Internet for mobile phone and computer users.
  - GPRS facilitates instant connections whereby information can be sent or received immediately as the need arises, subject to radio coverage. No dial-up modem connection is necessary. This is why GPRS users are sometimes referred to be as being "always connected".
  - GPRS packet-based services cost users less than circuit-switched services since communication channels are being used on a shared-use, as-packets-are-needed basis rather than dedicated to only one user at a time.

- Packet switching means that GPRS radio resources are used only when users are actually sending or receiving data. Rather than dedicating a radio channel to a mobile data user for a fixed period of time, the available radio resource can be concurrently shared between several users.
- This efficient use of scarce radio resources means that large numbers of GPRS users can potentially share the same bandwidth and be served from a single cell.

- **WAP**
  - **Wireless Application Protocol (WAP)** is a secure specification that allows users to access information instantly via handheld wireless devices such as mobile phones, pagers, two-way radios, smartphones and communicators.
  - WAP is supported by all operating systems WAPs that use displays and access the Internet are called micro-browsers i.e. browsers with small file sizes that can accommodate the low memory constraints of handheld devices and the low-bandwidth constraints of a wireless-handheld network.
  - Although WAP supports HTML and XML, the WML language (Wireless Markup Language) is specifically devised for small screens and one-hand navigation without a keyboard.

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NUCLEAR TECHNOLOGY

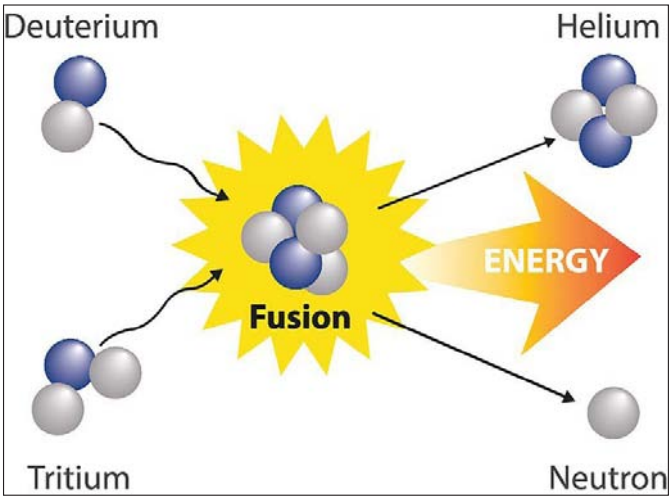
Nuclear technology is "the technology that involves the reactions of atomic nuclei". It has found applications from smoke detectors to nuclear reactors and from gun sights to nuclear weapons.

Currently, approximately 17% of electricity worldwide is produced by nuclear power plants, but in some countries, like France, over 75% of their electricity is produced by nuclear power. The United States, on the other hand, only produces about 15% of the electricity from nuclear power.

Nuclear fusion refers to the "union of atomic nuclei to form heavier nuclei resulting in the release of enormous amounts of energy".

Fusion takes place when two low-mass isotopes, typically isotopes of hydrogen, unite under conditions of extreme pressure and temperature. Fusion is what powers the sun. Atoms of Tritium and Deuterium (isotopes of hydrogen, Hydrogen-3 and Hydrogen-2, respectively) unite under extreme pressure and temperature to produce a neutron and a helium isotope. Along with this, an enormous amount of energy is released, which is several times the amount produced from fission.

Scientists continue to work on controlling nuclear fusion in an effort to make a fusion reactor to produce electricity. Some scientists believe there are opportunities with such a power source since fusion creates less radioactive material than fission and has a nearly unlimited fuel supply. However, progress is slow due to challenges with understanding how to control the reaction in a contained space.



The word fission means "a splitting or breaking up into parts". Nuclear fission releases heat energy by splitting atoms. The surprising discovery that it was possible to make a nucleus divide was based on Albert Einstein's prediction that mass could be changed into energy. In 1939, scientist began experiments, and one year later Enrico Fermi built the first nuclear reactor.

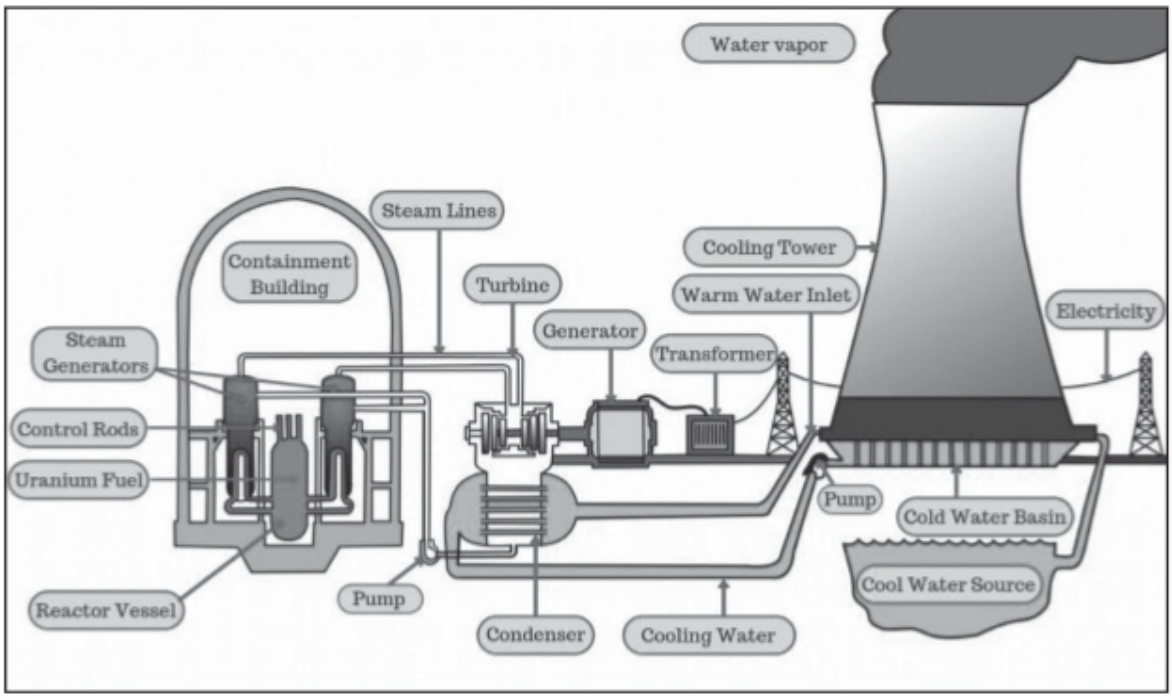
Nuclear power plants use pellets to fuel the plants. A pellet contains approximately 3% U-235 that is encased in a ceramic matrix.

Working:

- Nuclear fission produces heat, and this heat is used to heat water and make steam. The steam powers turbines which turn generators.
- The generators produce electricity. Nuclear power generates electricity much like coal- or diesel-powered plants. What is different from the other two, is that nuclear doesn't produce greenhouse gases like the burning of fossil fuels. It does produce spent nuclear fuel that is radioactive, and this has disposal problems.
- The two main types of reactors in use today are the pressurized water reactor (PWR) and boiling water reactor (BWR). In the pressurized water reactor the water is heated by the nuclear reactions,

but because the water is pressurized, it doesn't boil. The water in the reactor heats the water in the steam generator side, but it is on a different loop so they do not mix. In the boiling water reactor, the water comes to a boil due to the heat produced by nuclear fission. The water from the reactor powers the turbine. In both systems, the water is reused.

- There are several components common to all types of reactors:
  - **Fuel:**Usually pellets of uranium oxide (UO_2) arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core.
  - **Moderator:**This is material which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite.
  - **Control rods:**These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it. (Secondary shutdown systems involve adding other neutron absorbers, usually as a fluid, to the system.)
  - **Coolant:**A liquid or gas circulating through the core so as to transfer the heat from it. In light water reactors the moderator functions also as coolant.
  - **Pressure vessel or pressure tubes:**Usually a robust steel vessel containing the reactor core and moderator/coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the moderator.
  - **Steam generator:**Part of the cooling system where the heat from the reactor is used to make steam for the turbine.
  - **Containment system:**The structure around the reactor core which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any malfunction inside. It is typically a meter-thick concrete and steel structure.



- Today, nuclear science is responsible for many technological advances that we enjoy as part of daily life. Nuclear science and technology promote sustainable development by improving health and the quality of life. This is done through varied applications such as nuclear medicine, food preservation and safety, industrial materials and processes, basic scientific research, environmental studies, and the generation of electrical power with minimal environmental impact.
  - **Health and Medicine:**An estimated 16 million nuclear medicine imaging and therapeutic procedures are performed each year in the India. Nuclear technology also helps treat cancer, test drugs and to sterilize surgical instruments and medical supplies.

- **Agriculture and Food Safety:**One-third to one-half of the food produced in the world is lost due to spoilage and infestation. Nuclear technologies can prevent much of this loss by delaying spoilage. Food irradiation technology kills illness-causing microorganisms, such as Salmonella, ampylobacter, and E. Coli, which frequently contaminate fresh meat and poultry.
- **Consumer Products:**Nuclear technology is essential to many products that contribute to every-day health and safety, such as smoke-alarms, radial tires and fail-safe lighting sources that require no energy supply. Every day products such as cosmetics, hair products and contact lens solutions are sterilized with radiation.
- **Scientific Research:**Entire areas of research and development in chemistry, metallurgy, genetics, biotechnology, hydrology and many other fields of science and engineering exist because of nuclear technologies. Radioisotopes are essential to biomedical research on AIDS, cancers and Alzheimer's disease. Deep space exploration would be impossible without small nuclear powered generators. Radionuclides are essential tools for genetic research and determining the structure of DNA. Radioisotopic measurement techniques are the only way for accurately dating many historical and archeological artifacts and geologic formations.
- **Environmental Protection:**Nuclear technology is not limited to research; it is also used to solve problems while eliminating harmful environmental impacts. Radioisotope techniques are essential to climatological investigations related to climate change. Radionuclides are helpful in determining plant and sea assimilation of greenhouse gases, and measuring carbon dioxide releases from industrial areas. Radioisotope techniques are used to study the chronology of contaminated river and lake sediments. Rather than using toxic chemicals, solid wastes and sewage can be treated with radiation techniques.

India's Three-Stage Nuclear Power Programme

- India's three-stage nuclear power programme was formulated by HomiBhabha in the 1950s to secure the country's long term energy independence, through the use of uranium and thorium reserves found in the monazite sands of coastal regions of South India.
- The ultimate focus of the programme is on enabling the thorium reserves of India to be utilized in meeting the country's energy requirements.
- Thorium is particularly attractive for India, as it has only around 1–2% of the global uranium reserves, but one of the largest shares of global thorium reserves.
- However, at present thorium is not economically viable because global uranium prices are much lower.
- The recent Indo-US Nuclear Deal and the NSG waiver, which ended more than three decades of international isolation of the Indian civil nuclear programme, have created many hitherto unexplored alternatives for the success of the three-stage nuclear power programme.
- Thorium itself is not a fissile material, and thus cannot undergo fission to produce energy.
- Instead, it must be transmuted to uranium-233 in a reactor fueled by other fissile materials [plutonium239 or uranium-235].
- The first two stages, natural uranium-fueled heavy water reactors and plutonium-fueled fast breeder reactors, are intended to generate sufficient fissile material from India's limited uranium resources, so that all its vast thorium reserves can be fully utilized in the third stage of thermal breeder reactors.

Stage I – Pressurized Heavy Water Reactor (PHWR)

- In the first stage of the programme, natural uranium fuelled pressurized heavy water reactors (PHWR) produce electricity while generating plutonium-239 as by-product.
- PHWRs was a natural choice for implementing the first stage because it had the most efficient reactor design [uranium enrichment not required] in terms of uranium utilization.
- India correctly calculated that it would be easier to create heavy water production facilities (required for PHWRs) than uranium enrichment facilities (required for LWRs).

- Almost the entire existing base of Indian nuclear power (4780 MW) is composed of first stage PHWRs, with the exception of the two Boiling Water Reactor (BWR) units at Tarapur Atomic Power Station.

Stage II – Fast Breeder Reactor

- In the second stage, fast breeder reactors (FBRs) [moderators not required] would use plutonium-239, recovered by reprocessing spent fuel from the first stage, and natural uranium.
- **In FBRs, plutonium-239 undergoes fission to produce energy, while the uranium-238 present in the fuel transmutes to additional plutonium-239.**

Why should Uranium-238 be transmuted to Plutonium-239?

- Uranium-235 and Plutonium-239 can sustain a chain reaction. But Uranium-238 cannot sustain a chain reaction. So it is transmuted to Plutonium-239.

Why U-238 and not U-235?

- Natural uranium contains only 0.7% of the fissile isotope uranium-235. Most of the remaining 99.3% is uranium-238.
- Thus, the Stage II FBRs are designed to "breed" more fuel than they consume.
- Once the inventory of plutonium-239 is built up thorium can be introduced as a blanket material in the reactor and transmuted to uranium-233 for use in the third stage.
- The surplus plutonium bred in each fast reactor can be used to set up more such reactors, and might thus grow the Indian civil nuclear power capacity till the point where the third stage reactors using thorium as fuel can be brought online.

Stage III – Thorium Based Reactors

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

Prototype Fast Breeder Reactor at Kalpakkam

- The Prototype Fast Breeder Reactor (PFBR) is a 500 MWe fast breeder nuclear reactor established at the Madras Atomic Power Station in Kalpakkam, India.
- The Indira Gandhi Centre for Atomic Research (IGCAR) is responsible for the design of this reactor
- The Kalpakkam PFBR is using uranium-238 not thorium, to breed new fissile material, in a sodiumcooled fast reactor design.
- The surplus plutonium or uranium-233 for thorium reactors [U-238 transmutes into plutonium] from each fast reactor can be used to set up more such reactors and grow the nuclear capacity in tune with India's needs for power.
- The fact that PFBR will be cooled by liquid sodium creates additional safety requirements to isolate the coolant from the environment, since sodium explodes if it comes into contact with water and burns when in contact with air.

What Hinders Deployment of Thorium-Fuelled Reactors In India?

- Most people would assume that it is a limitation of technology. But instead, it is due to shortage of uranium fuel that is needed to convert fertile fuel [thorium] into fissile [fuel that can undergo sustained chain reaction].
- Scientists at the Bhabha Atomic Research Centre have successfully tested all relevant thorium-related technologies in the laboratory.
- In fact, if pressed, India could probably begin full-scale deployment of thorium reactors in ten years.

- The single greatest hurdle, to answer the original question, is the critical shortage of fissile material.

What is a fissile material?

- A fissile material is one that can sustain a chain reaction upon bombardment by neutrons.
- Thorium is by itself fertile, meaning that it can transmute into a fissile radioisotope [U-233] but cannot itself keep a chain reaction going.
- In a thorium reactor, a fissile material like uranium or plutonium is blanketed by thorium.
- The fissile material, also called a driver in this case, drives the chain reaction to produce energy while simultaneously transmuting the fertile material into fissile material.
- India has very modest deposits of uranium and some of the world's largest sources of thorium. It was keeping this in mind that in 1954, HomiBhabha envisioned India's nuclear power programme in three stages to suit the country's resource profile.
- In the first stage, heavy water reactors fuelled by natural uranium would produce plutonium [U-238 will be transmuted to Plutonium 239 in PHWR];
- The second stage would initially be fuelled by a mix of the plutonium from the first stage and natural uranium. This uranium would transmute into more plutonium and once sufficient stocks have been built up, thorium would be introduced into the fuel cycle to convert it into uranium 233 for the third stage [thorium will be transmuted to U-233 with the help plutonium 239].
- In the final stage, a mix of thorium and uranium fuels the reactors. The thorium transmutes to U-233 which powers the reactor. Fresh thorium can replace the depleted thorium [can be totally done away with uranium which is very scares in India] in the reactor core, making it essentially a thorium-fuelled reactor [thorium keeps transmuting into U-233. It is U-233 that generates the energy].

Present State of India's Three-Stage Nuclear Power Programme

- After decades of operating pressurized heavy-water reactors (PHWR), India is finally ready to start the second stage.
- A 500 MW Prototype Fast Breeder Reactor (PFBR) at Kalpakkam is set to achieve criticality any day now and four more fast breeder reactors have been sanctioned, two at the same site and two elsewhere.
- However, experts estimate that it would take India many more FBRs and at least another four decades before it has built up a sufficient fissile material inventory to launch the third stage.

Solution to India's Fissile Shortage Problem – Procuring Fissile Material Plutonium

- The obvious solution to India's shortage of fissile material is to procure it from the international market

Favorable Conditions for Plutonium Trade

- As yet, there exists no commerce in plutonium though there is no law that expressly forbids it.
- In fact, most nuclear treaties such as the Convention on the Physical Protection of Nuclear Material address only U-235 and U-233.
- This is because Plutonium has so far not been considered a material suited for peaceful purposes.
- The Non-Proliferation Treaty (NPT) merely mandates that special fissionable material — which includes plutonium — if transferred, be done so under safeguards.
- Thus, the legal rubric for safeguarded sale of plutonium and safety procedures for moving radioactive spent fuel and plutonium already exists but it is not too complicated as in case Uranium.
- Japan and the U.K. who are looking to reduce their stockpile of plutonium will certainly be happy to sell it to India.

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INTERNATIONAL MISSIONS

1. International Space Station

- The International Space Station (ISS) is a space station (habitable artificial satellite) in low Earth orbit.
- The ISS programme is a joint project between five participating space agencies: NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada).
- The ownership and use of the space station is established by intergovernmental treaties and agreements.
- The ISS serves as a microgravity and space environment research laboratory in which crew members conduct experiments in biology, human biology, physics, astronomy, meteorology, and other fields.
- The station is suited for the testing of spacecraft systems and equipment required for missions to the Moon and Mars.
- The ISS maintains an orbit with an average altitude of 400 kilometres (250 mi) by means of reboost manoeuvres using the engines of the Zvezda module or visiting spacecraft. It circles the Earth in roughly 92 minutes and completes 15.5 orbits per day.

2. Hubble Space Telescope

- The Hubble Space Telescope (often referred to as HST or Hubble) is a space telescope that was launched into low Earth orbit in 1990 and remains in operation.
- It was not the first space telescope but it is one of the largest and most versatile, well known both as a vital research tool and as a public relations boon for astronomy.
- The Hubble telescope is named after astronomer Edwin Hubble and is one of NASA's Great Observatories, along with the Compton Gamma Ray Observatory, the Chandra X-ray Observatory, and the Spitzer Space Telescope.
- Hubble features a 2.4-meter (7.9 ft) mirror, and its four main instruments observe in the ultraviolet, visible, and near infrared regions of the electromagnetic spectrum.
- Hubble's orbit outside the distortion of Earth's atmosphere allows it to capture extremely high-resolution images with substantially lower background light than ground-based telescopes.
- It has recorded some of the most detailed visible light images, allowing a deep view into space.
- Many Hubble observations have led to breakthroughs in astrophysics, such as determining the rate of expansion of the universe.
- The Hubble telescope was built by the United States space agency NASA with contributions from the European Space Agency.
- The Space Telescope Science Institute (STScI) selects Hubble's targets and processes the resulting data, while the Goddard Space Flight Center controls the spacecraft.
- Space telescopes were proposed as early as 1923.

- Hubble was funded in the 1970s with a proposed launch in 1983, but the project was beset by technical delays, budget problems, and the 1986 Challenger disaster.
- It was finally launched by Space Shuttle Discovery in 1990, but its main mirror had been ground incorrectly, resulting in spherical aberration that compromised the telescope's capabilities.
- The optics were corrected to their intended quality by a servicing mission in 1993.

3. Juno: Mission at Jupiter

- Juno is a NASA space probe orbiting the planet Jupiter.
- It was built by Lockheed Martin and is operated by NASA's Jet Propulsion Laboratory.
- The spacecraft was launched from Cape Canaveral Air Force Station on August 5, 2011 (UTC), as part of the New Frontiers program.
- Juno entered a polar orbit of Jupiter on July 5, 2016, to begin a scientific investigation of the planet.
- After completing its mission, Juno will be intentionally deorbited into Jupiter's atmosphere.
- Juno's mission is to measure Jupiter's composition, gravity field, magnetic field, and polar magnetosphere.
- It will also search for clues about how the planet formed, including whether it has a rocky core, the amount of water present within the deep atmosphere, mass distribution, and its deep winds, which can reach speeds up to 618 kilometres per hour (384 mph).
- Juno is the second spacecraft to orbit Jupiter, after the nuclear powered Galileo orbiter, which orbited from 1995 to 2003.
- Unlike all earlier spacecraft sent to the outer planets, Juno is powered by solar arrays, commonly used by satellites orbiting Earth and working in the inner Solar System, whereas radioisotope thermoelectric generators are commonly used for missions to the outer Solar System and beyond.
- For Juno, however, the three largest solar array wings ever deployed on a planetary probe play an integral role in stabilizing the spacecraft as well as generating power.

4. Artemis Program

- The Artemis program is an ongoing crewed spaceflight program carried out predominantly by NASA, U.S. commercial spaceflight companies, and international partners such as the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), Canadian Space Agency (CSA) and the Australian Space Agency (ASA) with the goal of landing "the first woman and the next man" on the Moon, specifically at the lunar south pole region by 2024.
- NASA sees Artemis as the next step towards the long-term goal of establishing a sustainable presence on the Moon, laying the foundation for private companies to build a lunar economy, and eventually sending humans to Mars.
- In December 2017, Space Policy Directive was signed authorizing the lunar campaign.
- Artemis draws upon ongoing spacecraft programs including Orion, the Lunar Gateway, and Commercial Lunar Payload Services, and adds an undeveloped crewed lander.
- The Space Launch System will serve as the primary launch vehicle for Orion, while commercial launch vehicles are planned for use to launch various other elements of the campaign.

5. BepiColombo

- BepiColombo is a joint mission of the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA) to the planet Mercury.
- The mission comprises two satellites launched together: the Mercury Planetary Orbiter (MPO) and Mio (Mercury Magnetospheric Orbiter, MMO).
- The mission will perform a comprehensive study of Mercury, including characterization of its magnetic field, magnetosphere, and both interior and surface structure.

- It was launched on an Ariane 5 rocket on 20 October 2018, with an arrival at Mercury planned for December 2025, after a flyby of Earth, two flybys of Venus, and six flybys of Mercury.
- The mission was approved in November 2009, after years in proposal and planning as part of the European Space Agency's Horizon 2000+ programme; it is the last mission of the programme to be launched.

Objectives

The main objectives of the mission are:

- Study the origin and evolution of a planet close to its parent star
- Study Mercury's form, interior, structure, geology, composition and craters
- Investigate Mercury's exosphere, composition and dynamics, including generation and escape
- Study Mercury's magnetised envelope (magnetosphere) - structure and dynamics
- Investigate the origin of Mercury's magnetic field
- Verify Einstein's theory of general relativity by measuring the parameters gamma and beta of the parameterized post-Newtonian formalism with high accuracy

6. Habitable Zone Planet Finder

- A new astronomical spectrograph built by a Penn State-led team of scientists provides the highest precision measurements to date of infrared signals from nearby stars, allowing astronomers to detect planets capable of having liquid water on their surfaces that orbit cool stars outside our Solar System.
- The Habitable Zone Planet Finder (HPF) allows precise measurement of a star's radial velocity, measured by the subtle change in the color of the star's spectra as it is tugged by an orbiting planet, which is critical information in the discovery and confirmation of new planets.
- The HPF, located at McDonald Observatory at the University of Texas at Austin, targets low-mass planets around cool nearby M dwarf stars in Habitable Zones, regions where liquid water might exist on a planet's surface.
- M dwarf stars are known to host rocky planets, but these stars are faint due to their size and their magnetic activity manifests as spots and flares, which pose problems for existing visible light instruments.
- The HPF, coupled to the 10-meter Hobby Eberly Telescope, instead uses near-infrared light a type of invisible infrared light closest in wavelength to the visible spectrum -- to observe these stars at wavelengths where they are brighter and less active.

7. Perseverance

- NASA's Perseverance mission will send an advanced roving laboratory to Jezero crater on Mars, the site of an ancient lake and river delta.
- There, the rover will study rocks that formed in habitable environments and may preserve signs of past microbial life.
- Throughout the mission, it will collect soil and rock samples and leave them on the surface for collection by a future Earth return mission.
- Only when the samples are returned to Earth will scientists be able to determine whether definitive signs of ancient life are present.
- Perseverance is similar in structure and appearance to NASA's Curiosity rover.
- The components it will use to land on Mars are nearly identical to those used for Curiosity, but there are some upgrades, and the science instruments are entirely different.
- The Planetary Society is an education and public outreach partner for the Mastcam-Z camera system, which will produce stunning color images of the surface.

8. Chang'e-4

- China's Chang'e-4 mission delivered a landing platform and a rover named Yutu-2 to the Moon's far side—the first mission there by any country.
- Chang'e-4 landed in Von Kármán crater, within the Moon's South Pole-Aitken basin, in December 2018.
- An ancient lunar impact there may have exposed the Moon's mantle.
- By studying this region directly, scientists will learn more about the early solar system and Earth.
- The mission also demonstrates the feasibility of future human and robotic far side missions.
- The Moon's quiet, airless far side makes it one of the best places in the inner solar system for science applications like radio astronomy.
- But missions there require a relay satellite, since the far side never faces Earth.
- China launched the Queqiao relay satellite with two SmallSats, Longjiang-1 and 2, in May 2018.
- Chang'e-4 and Yutu-2 are continuing to conduct science operations.
- Both vehicles power down during the 2-week lunar night, when temperatures plummet to -173 degrees Celsius (280 degrees Fahrenheit), to avoid damanging their instruments.
- They must also sleep when the Sun is directly overhead to avoid overheating.

9. OSIRIS-Rex

- OSIRIS-REx is a mission to retrieve a sample from near-Earth asteroid 101955 Bennu.
- By returning pristine carbon-bearing rocky material from the surface of an asteroid, the science team seeks to understand how primitive asteroids contributed to the origin of planets, and what role they may have played in the origin of life on Earth.
- The mission will map Bennu and its composition in 3D and ground-truth earlier astronomical surveys.
- It will also study how Bennu's orbit changes when it gets heated by sunlight and radiates the heat away in a different direction at night, a phenomenon known as the Yarkovsky effect.

Past milestones

- **25 May 2011:** NASA selects OSIRIS-REx as next New Frontiers mission, The Planetary Society will participate in a contest to name target asteroid 1999 RQ38 August 2019: OSIRIS-REx enters 1.7-kilometer-altitude orbit, beginning Orbital C phase
- **12 June 2019:** OSIRIS-REx enters 680-meter-altitude orbit, beginning Orbital B phase
- **22 April 2019:** OSIRIS-REx begins Detailed Survey: Equatorial Stations phase (PDF diagram)
- 28 February 2019: OSIRIS-REx completes Orbital A phase, moves on to Detailed Survey: Baseball Diamond phase (PDF diagram)
- **19 January 2019:** OSIRIS-REx observes Bennu to be an active asteroid
- **31 December 2018:** OSIRIS-REx enters 2,000-meter-altitude orbit, ending Preliminary Survey phase and beginning Orbital A phase
- **10 December 2018:** OSIRIS-REx finds water on Bennu
- **3 December 2018:** Bennu arrival, beginning Preliminary Survey phase (PDF diagram)
- **16 November 2018:** TAGSAM successfully tested
- **17 August 2018:** OSIRIS-REx sees Bennu from a distance of 2.2 million kilometers
- **22 September 2017:** Earth flyby; read Vicky Hamilton's article for The Planetary Report on how the flyby tested OSIRIS-REx's instruments
- **8 September 2016:** Launch
- **20 May 2016:** OSIRIS-REx ships to Cape Canaveral, Florida
- **5 June 2014:** Construction begins
- **1 May 2013:** The Planetary Society announces naming contest results; 1999 RQ3 will be named after Egyptian god Bennu

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SUPERCOMPUTER AND ITS APPLICATIONS

Supercomputer

- A type of computer which is used in areas that requires large mathematical and difficult calculations at frontline of processing capacity is known as Super computer.
- The computing performance of a supercomputer is measured in FLOPS (that is floating-point operations per second) instead of MIPS (Million Instruments Per Second).
- The supercomputer consists of tens of thousands of processors which can perform billions and trillions of calculations per second, or you can say that supercomputers can deliver up to nearly a hundred quadrillions of FLOPS.
- They have evolved from grid to cluster system of massively parallel computing.
- Cluster system computing means that machine uses multiple processors in one system instead of arrays of separate computers in a network.
- These computers are most massive size. A most powerful supercomputer can occupy few feet to hundreds of feet.

Characteristics of Supercomputer

- They can support more than a hundred users at a time.
- These machines are capable of handling the massive amount of calculations that are beyond the human capabilities, i.e., the human is unable to solve such extensive calculations.
- Many individuals can access supercomputers at the same time.
- These are the most expensive computers that can ever be made.

Features of Supercomputer

- They have more than 1 CPU (Central Processing Unit) which contains instructions so that it can interpret instructions and execute arithmetic and logical operations.
- The supercomputer can support extremely high computation speed of CPUs.
- They can operate on pairs of lists of numbers instead of pairs of numbers.
- They were used initially in applications related to national security, nuclear weapon design, and ! cryptography. But nowadays they are also employed by the aerospace, automotive and petroleum industries.

Uses of Supercomputer

Supercomputers are not used for everyday tasks because of their superiority. Supercomputer handles those applications, which required the real-time processing. The uses are as follows:

- They're used for scientific simulations and research such as weather forecasting, meteorology, nuclear energy research, physics, and chemistry, as well as for extremely complex animated graphics.

- They are also used to interpret new diseases and predict illness behaviour and treatment.
- The military uses supercomputers for testing new aircrafts, tanks, and weapons.
- They also use them to understand the effect on soldiers and wars. These machines are also used for encrypting the data.
- Scientists use them to test the impact of nuclear weapon detonation.
- In entertainment, supercomputers are used for online gaming and creation of animation.
- Supercomputers help in stabilizing the game performance when a lot of users are playing the game.

The potential applications of supercomputers

- **Recreating the Big Bang:** The "Big Bang" or the initial expansion of all energy and matter in the universe, happened more than 13 billion years ago in trillion-degree Celsius temperatures, but supercomputer simulations make it possible to observe what went on during the universe's birth. Researchers can run models that require upward of a thousand trillion calculations per second, allowing for the most realistic models of these cosmic mysteries yet.
- **Understanding earthquakes:** By modeling the three-dimensional structure of the Earth, researchers can predict how earthquake waves will travel both locally and globally. The resulting techniques can be used to map the subsurface for oil exploration or carbon sequestration, and can help researchers understand the processes occurring deep in the Earth's mantle and core.
- **Modeling swine flu:** Potential pandemics like the H1N1 swine fl u require a fast response on two fronts: First, researchers have to fi gure out how the virus is spreading. Second, they have to fi nd drugs to stop it. Supercomputers can help with both. During the recent H1N1 outbreak, researchers at Virginia Polytechnic Institute and State University in Blacksburg, used an advanced model of disease spread called EpiSimdemics to predict the transmission of the fl u.
- **Testing nuclear weapons:** Computer simulations to ensure that the country's cache of nuclear weapons is functional and safe. The real aim is to create better simulations of nuclear explosions and to do away with real-world nuke testing for good.
- **Predicting climate change:** The challenge of predicting global climate is immense. There are hundreds of variables. Dealing with these variables requires supercomputing capabilities. The resulting simulations both map out the past and look into the future. Models of the ancient past can be matched with fossil data to check for reliability, making future predictions stronger. New variables, such as the effect of cloud cover on climate, can be explored.
- **Making possible more scientific advances:** Supercomputing is needed for processing sophisticated computational models able to simulate the cellular structure and functionalities of the brain. This should enable us to better understand how our brain works and how we can cope with diseases such as those linked to ageing.
- **More reliable decision-making:** The world faces an increasing number of challenges at the local level as well as at the planetary scale. The convergence of HPC, Big Data and Cloud technologies will allow new applications and services in an increasingly complex scenario where decision-making processes have to be fast and precise to avoid catastrophes. Supercomputers are in the front line for developing essential public policies, from homeland security to climate action.

Different types of supercomputers are:

- **Tianhe-2 – China**
  - The Tianhe-2 (Milky Way-2), built by China's National University of Defence Technology (NUDT) for the National Supercomputer Center in Guangzho. It's the most powerful computer in the world and performs at 33.86 petaflop/s (Pflop/s) on the Linpack benchmark.
  - The system has 3,120,000 computing cores made up from 16,000 computer nodes, each comprising two Intel Ivy Bridge Xeon processors and three Xeon Phi coprocessor chips.

- **Titan – United States**
  - The Titan computer is a Cray XK7 system used by the United States Department of Energy at their Oak Ridge National Laboratory. The former top-ranked Jaguar supercomputer was upgraded in 2012 to become the then most powerful computer (until the Tianhe machine overtook it).
  - The system performs at 17.59 Pflop/s using 261,632 NVIDIA K20x cores.
- **Sequoia – United States**
  - The Sequoia computer is based on the now unsupported IBM BlueGene framework. It has been used to make key advances in climate, astronomy and energy application areas.
  - Located in California's Lawrence Livermore National Laboratory, the Sequoia platform has achieved 17.17 Pflop/s and uses 1,572,864 cores.
- **K Computer – Japan**
  - The K computer was manufactured by Fujitsu at the RIKEN Advanced Institute for Computational Science (AICS) in Kobe, Japan.
  - This system hit 10.51 Pflop/s and uses 705,024 SPARC64 processing cores.
- **Mira – Unites States**
  - Also built around the BlueGene architecture, the Mira is one of the older computers on the list. Primarily used by the Unites States Department of Energy (and now housed at the Argonne National Laboratory outside Chicago), it is being succeeded by the upcoming Aurora supercomputer.
  - The Mira computer has peaked at 8.59 Pflop/s and uses 786,432 cores.
- **Piz Daint – Switzerland**
  - The Piz Daint, a Cray XC30 system, is the most powerful computer in Europe. It's installed at the Swiss National Supercomputing Centre (CSCS) in Lugano, Switzerland.
  - Piz Daint achieved 6.27 Pflop/s on the Linpack benchmark, using 73,808 NVIDIA K20x accelerator cores.
- **Shaheen II – Saudi Arabia**
  - The Shaheen II is the newest computer in the top 10 list. Based around a Cray XC40 system, it went live in 2015 and is the only computer from the region in the top 10. It's located at the King Abdullah University of Science and Technology.
  - The platform has performed at 5.536 PFlop/s and uses 196,608 Intel Xeon E5-2698v3 cores.
- **Stampede – United States**
  - The Stampede computer is a Dell PowerEdge C8220 system based around interlinked powerful desktop computers.
  - It's based at the Texas Advanced Computing Center and has reached 5.17 Pflop/s.
- **Juqueen – Germany**
  - The only other Europe-based computer, housed at the Forschungszentrum Juelich in Germany, is based on the older BlueGene architecture from IBM. It has reached 5.01 Pflop/s.
- **Vulcan – United States**
  - The Vulcan computer is another IBM BlueGene and is installed at Lawrence Livermore National Laboratory, along with No 3, the Sequoia. It has reached a speed of 4.29 Pflop/s.

Recent Advancement

- **BullSequana Supercomputer**
  - France-based European Information Technology Corporation Atos and C-DAC (Centre for Development and Advanced Computing) of India have entered into agreement for designing, building and installing BullSequana Supercomputer in India.
  - BullSequana Supercomputer will create a network of 70 high-performance supercomputing facilities for various academic and research institutions across India. Spanning over a period of seven years.

- **Application:**
  - Strengthening academic and research institutions in India
  - Recreating the Big Bang
  - Understanding earthquakes, cosmos and subatomic particle
  - Intelligence Agencies Mapping the blood stream
  - Modelling swine flu, other deadly diseases
  - Testing nuclear weapons
  - Predicting climate change/ Weather Forecasting/ hurricanes
  - Building artificial human brain
- **Shakti – India's first indigenous Microprocessor**
  - Indian Institute of Technology Madras (IIT Madras) researchers have designed India's fi rst indigenous microprocessor called 'Shakti'.
- Significance
  - 'Shakti' will reduce dependency on imported microchips and the risk of cyber attacks.
  - 'Shakti' will be ideal for communication and defence sectors.
  - The team is now ready with 'Parashakti', an advanced microprocessor for super computers

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DAY - 67

PLANETARY SYSTEM

■ Study of the solar system

- The solar system took shape 4.57 billion years ago, when it condensed within a large cloud of gas and dust.
- Gravitational attraction holds the planets in their elliptical orbits around the Sun. In addition to Earth, five major planets (Mercury, Venus, Mars, Jupiter, and Saturn) have been known from ancient times.
- Since then only two more have been discovered: Uranus by accident in 1781 and Neptune in 1846 after a deliberate search following a theoretical prediction based on observed irregularities in the orbit of Uranus.
- Pluto, discovered in 1930 after a search for a planet predicted to lie beyond Neptune, was considered a major planet until 2006, when it was redesignated a dwarf planet by the International Astronomical Union.
- The average Earth-Sun distance, which originally defined the astronomical unit (AU), provides a convenient measure for distances within the solar system.
- The astronomical unit was originally defined by observations of the mean radius of Earth's orbit but is now defined as 149,597,870.7 km (about 93 million miles).
- Mercury, at 0.4 AU, is the closest planet to the Sun, while Neptune, at 30.1 AU, is the farthest.
- Pluto's orbit, with a mean radius of 39.5 AU, is sufficiently eccentric that at times it is closer to the Sun than is Neptune.
- The planes of the planetary orbits are all within a few degrees of the ecliptic, the plane that contains Earth's orbit around the Sun.
- As viewed from far above Earth's North Pole, all planets move in the same (counterclockwise) direction in their orbits.
- Most of the mass of the solar system is concentrated in the Sun, with its 1.99 × 1033 grams.
- Together, all of the planets amount to 2.7 × 1030 grams (i.e., about one-thousandth of the Sun's mass), and Jupiter alone accounts for 71 percent of this amount.
- The solar system also contains five known objects of intermediate size classified as dwarf planets and a very large number of much smaller objects collectively called small bodies.
- The small bodies, roughly in order of decreasing size, are the asteroids, or minor planets; comets, including Kuiper belt, Centaur, and Oort cloud objects; meteoroids; and interplanetary dust particles.
- Because of their starlike appearance when discovered, the largest of these bodies were termed asteroids, and that name is widely used, but, now that the rocky nature of these bodies is understood, their more descriptive name is minor planets.
- The four inner, terrestrial planets—Mercury, Venus, Earth, and Mars—along with the Moon have average densities in the range of 3.9–5.5 grams per cubic cm, setting them apart from the four outer, giant planets—Jupiter, Saturn, Uranus, and Neptune—whose densities are all close to 1 gram per cubic cm, the density of water.

- The compositions of these two groups of planets must therefore be significantly different. This dissimilarity is thought to be attributable to conditions that prevailed during the early development of the solar system (see below Theories of origin).
- Planetary temperatures now range from around 170 °C (330 °F, 440 K) on Mercury's surface through the typical 15 °C (60 °F, 290 K) on Earth to −135 °C (−210 °F, 140 K) on Jupiter near its cloud tops and down to −210 °C (−350 °F, 60 K) near Neptune's cloud tops.
- These are average temperatures; large variations exist between dayside and nightside for planets closest to the Sun, except for Venus with its thick atmosphere.
- (Saturn and its spectacular rings, in a natural-colour composite of 126 images taken by the Cassini spacecraft on October 6, 2004. The view is directed toward Saturn's southern hemisphere, which is tipped toward the Sun. Shadows cast by the rings are visible against the bluish northern hemisphere, while the planet's shadow is projected on the rings to the left.)
- The surfaces of the terrestrial planets and many satellites show extensive cratering, produced by high-speed impacts (see meteorite crater).
- On Earth, with its large quantities of water and an active atmosphere, many of these cosmic footprints have eroded, but remnants of very large craters can be seen in aerial and spacecraft photographs of the terrestrial surface.
- On Mercury, Mars, and the Moon, the absence of water and any significant atmosphere has left the craters unchanged for billions of years, apart from disturbances produced by infrequent later impacts.
- Volcanic activity has been an important force in the shaping of the surfaces of the Moon and the terrestrial planets.
- Seismic activity on the Moon has been monitored by means of seismometers left on its surface by Apollo astronauts and by Lunokhod robotic rovers.
- Cratering on the largest scale seems to have ceased about three billion years ago, although on the Moon there is clear evidence for a continued cosmic drizzle of small particles, with the larger objects churning ("gardening") the lunar surface and the smallest producing microscopic impact pits in crystals in the lunar rocks.

Mercury

- Meteorite crater surrounded by rays of ejected material on Mercury, in a photograph taken by the Messenger probe, January 14, 2008. A chain of craters crosses the centre of the rayed crater.
- All of the planets apart from the two closest to the Sun (Mercury and Venus) have natural satellites (moons) that are very diverse in appearance, size, and structure, as revealed in close-up observations from long-range space probes.
- The four outer dwarf planets have moons; Pluto has at least five moons, including one, Charon, fully half the size of Pluto itself.
- Over 200 asteroids and 80 Kuiper belt objects also have moons. Four planets (Jupiter, Saturn, Uranus, and Neptune), one dwarf planet (Haumea), and one Centaur object (Chariklo) have rings, disklike systems of small rocks and particles that orbit their parent bodies.

Lunar exploration

- During the U.S. Apollo missions a total weight of 381.7 kg (841.5 pounds) of lunar material was collected; an additional 300 grams (0.66 pounds) was brought back by unmanned Soviet Luna vehicles.
- About 15 percent of the Apollo samples have been distributed for analysis, with the remainder stored at the NASA Johnson Space Center, Houston, Texas.
- The opportunity to employ a wide range of laboratory techniques on these lunar samples has revolutionized planetary science.
- The results of the analyses have enabled investigators to determine the composition and age of the lunar surface. Seismic observations have made it possible to probe the lunar interior.

- In addition, retroreflectors left on the Moon's surface by Apollo astronauts have allowed high-power laser beams to be sent from Earth to the Moon and back, permitting scientists to monitor the Earth-Moon distance to an accuracy of a few centimetres.
- This experiment, which has provided data used in calculations of the dynamics of the Earth-Moon system, has shown that the separation of the two bodies is increasing by 4.4 cm (1.7 inches) each year. (For additional information on lunar studies, see Moon.)

Planetary studies

- Mercury is too hot to retain an atmosphere, but Venus's brilliant white appearance is the result of its being completely enveloped in thick clouds of carbon dioxide, impenetrable at visible wavelengths.
- Below the upper clouds, Venus has a hostile atmosphere containing clouds of sulfuric acid droplets.
- The cloud cover shields the planet's surface from direct sunlight, but the energy that does filter through warms the surface, which then radiates at infrared wavelengths.
- The long-wavelength infrared radiation is trapped by the dense clouds such that an efficient greenhouse effect keeps the surface temperature near 465 °C (870 °F, 740 K).
- Radar, which can penetrate the thick Venusian clouds, has been used to map the planet's surface. In contrast, the atmosphere of Mars is very thin and is composed mostly of carbon dioxide (95 percent), with very little water vapour; the planet's surface pressure is only about 0.006 that of Earth.
- The outer planets have atmospheres composed largely of light gases, mainly hydrogen and helium.
- Each planet rotates on its axis, and nearly all of them rotate in the same direction—counterclockwise as viewed from above the ecliptic.
- The two exceptions are Venus, which rotates in the clockwise direction beneath its cloud cover, and Uranus, which has its rotation axis very nearly in the plane of the ecliptic.
- Some of the planets have magnetic fields. Earth's field extends outward until it is disturbed by the solar wind—an outward flow of protons and electrons from the Sun—which carries a magnetic field along with it.
- Through processes not yet fully understood, particles from the solar wind and galactic cosmic rays (high-speed particles from outside the solar system) populate two doughnut-shaped regions called the Van Allen radiation belts.
- The inner belt extends from about 1,000 to 5,000 km (600 to 3,000 miles) above Earth's surface, and the outer from roughly 15,000 to 25,000 km (9,300 to 15,500 miles).
- In these belts, trapped particles spiral along paths that take them around Earth while bouncing back and forth between the Northern and Southern hemispheres, with their orbits controlled by Earth's magnetic field.
- During periods of increased solar activity, these regions of trapped particles are disturbed, and some of the particles move down into Earth's atmosphere, where they collide with atoms and molecules to produce auroras.
- Jupiter has a magnetic field far stronger than Earth's and many more trapped electrons, whose synchrotron radiation (electromagnetic radiation emitted by high-speed charged particles that are forced to move in curved paths, as under the influence of a magnetic field) is detectable from Earth.
- Bursts of increased radio emission are correlated with the position of Io, the innermost of the four Galilean moons of Jupiter.
- Saturn has a magnetic field that is much weaker than Jupiter's, but it too has a region of trapped particles.
- Mercury has a weak magnetic field that is only about 1 percent as strong as Earth's and shows no evidence of trapped particles.

- Uranus and Neptune have fields that are less than one-tenth the strength of Saturn's and appear much more complex than that of Earth. No field has been detected around Venus or Mars.

Investigations of the smaller bodies

- More than 500,000 asteroids with well-established orbits are known, and thousands of additional objects are discovered each year.
- Hundreds of thousands more have been seen, but their orbits have not been as well determined.
- It is estimated that several million asteroids exist, but most are small, and their combined mass is estimated to be less than a thousandth that of Earth.
- Most of the asteroids have orbits close to the ecliptic and move in the asteroid belt, between 2.3 and 3.3 AU from the Sun. Because some asteroids travel in orbits that can bring them close to Earth, there is a possibility of a collision that could have devastating results (see Earth impact hazard).

Comets

- Comets are considered to come from a vast reservoir, the Oort cloud, orbiting the Sun at distances of 20,000–50,000 AU or more and containing trillions of icy objects—latent comet nuclei—with the potential to become active comets.
- Many comets have been observed over the centuries. Most make only a single pass through the inner solar system, but some are deflected by Jupiter or Saturn into orbits that allow them to return at predictable times.
- Halley's Comet is the best known of these periodic comets; its next return into the inner solar system is predicted for 2061.
- Many short-period comets are thought to come from the Kuiper belt, a region lying mainly between 30 AU and 50 AU from the Sun—beyond Neptune's orbit but including part of Pluto's—and housing perhaps hundreds of millions of comet nuclei.
- Very few comet masses have been well determined, but most are probably less than 1018 grams, one-billionth the mass of Earth.
- Since the 1990s more than a thousand comet nuclei in the Kuiper belt have been observed with large telescopes; a few are about half the size of Pluto, and Pluto is the largest Kuiper belt object.
- Pluto's orbital and physical characteristics had long caused it to be regarded as an anomaly among the planets.
- However, after the discovery of numerous other Pluto-like objects beyond Neptune, Pluto was seen to be no longer unique in its "neighbourhood" but rather a giant member of the local population.
- Consequently, in 2006 astronomers at the general assembly of the International Astronomical Union elected to create the new category of dwarf planets for objects with such qualifications.
- Pluto, Eris, and Ceres, the latter being the largest member of the asteroid belt, were given this distinction. Two other Kuiper belt objects, Makemake and Haumea, were also designated as dwarf planets.
- Smaller than the observed asteroids and comets are the meteoroids, lumps of stony or metallic material believed to be mostly fragments of asteroids. Meteoroids vary from small rocks to boulders weighing a ton or more.
- A relative few have orbits that bring them into Earth's atmosphere and down to the surface as meteorites. Most meteorites that have been collected on Earth are probably from asteroids. A few have been identified as being from the Moon, Mars, or the asteroid Vesta.

Meteorites

- Meteorites are classified into three broad groups: stony (chondrites and achondrites; about 94 percent), iron (5 percent), and stony-iron (1 percent).
- Most meteoroids that enter the atmosphere heat up sufficiently to glow and appear as meteors, and the great majority of these vaporize completely or break up before they reach the surface.

- Many, perhaps most, meteors occur in showers (see meteor shower) and follow orbits that seem to be identical with those of certain comets, thus pointing to a cometary origin.
- For example, each May, when Earth crosses the orbit of Halley's Comet, the Eta Aquarid meteor shower occurs.
- Micrometeorites (interplanetary dust particles), the smallest meteoroidal particles, can be detected from Earth-orbiting satellites or collected by specially equipped aircraft flying in the stratosphere and returned for laboratory inspection.
- Since the late 1960s numerous meteorites have been found in the Antarctic on the surface of stranded ice flows (see Antarctic meteorites).
- Some meteorites contain microscopic crystals whose isotopic proportions are unique and appear to be dust grains that formed in the atmospheres of different stars.

■ Theories of origin

- The origin of Earth, the Moon, and the solar system as a whole is a problem that has not yet been settled in detail. The Sun probably formed by condensation of the central region of a large cloud of gas and dust, with the planets and other bodies of the solar system forming soon after, their composition strongly influenced by the temperature and pressure gradients in the evolving solar nebula. Less-volatile materials could condense into solids relatively close to the Sun to form the terrestrial planets. The abundant, volatile lighter elements could condense only at much greater distances to form the giant gas planets.
- In the 1990s astronomers confirmed that other stars have one or more planets revolving around them. Studies of these planetary systems have both supported and challenged astronomers' theoretical models of how Earth's solar system formed. Unlike the solar system, many extrasolar planetary systems have large gas giants like Jupiter orbiting very close to their stars, and in some cases these "hot Jupiters" are closer to their star than Mercury is to the Sun.
- That so many gas giants, which form in the outer regions of their system, end up so close to their stars suggests that gas giants migrate and that such migration may have happened in the solar system's history. According to the Grand Tack hypothesis, Jupiter may have done so within a few million years of the solar system's formation. In this scenario, Jupiter is the first giant planet to form, at about 3 AU from the Sun. Drag from the protoplanetary disk causes it to fall inward to about 1.5 AU. However, by this time, Saturn begins to form at about 3 AU and captures Jupiter in a 3:2 resonance. (That is, for every three revolutions Jupiter makes, Saturn makes two.) The two planets migrate outward and clear away any material that would have gone to making Mars bigger. Mars should be bigger than Venus or Earth, but it is only half their size. The Grand Tack, in which Jupiter moves inward and then outward, explains Mars's small size.
- About 500 million years after the Grand Tack, according to the Nice Model (named after the French city where it was first proposed), after the four giant planets—Jupiter, Saturn, Uranus, and Neptune—formed, they orbited 5–17 AU from the Sun. These planets were in a disk of smaller bodies called planetesimals and in orbital resonances with each other. About four billion years ago, gravitational interactions with the planetesimals increased the eccentricity of the planets' orbits, driving them out of resonance. Saturn, Uranus and Neptune migrated outward, and Jupiter migrated slightly inward. (Uranus and Neptune may even have switched places.) This migration scattered the disk, causing the Late Heavy Bombardment. The final remnant of the disk became the Kuiper belt.
- The origin of the planetary satellites is not entirely settled. As to the origin of the Moon, the opinion of astronomers long oscillated between theories that saw its origin and condensation as simultaneous with the formation of Earth and those that posited a separate origin for the Moon and its later capture by Earth's gravitational field. Similarities and differences in abundances of the chemical elements and their isotopes on Earth and the Moon challenged each group of theories. Finally, in the 1980s a model emerged that gained the support of most lunar scientists—that of a large impact on Earth and the expulsion of material that subsequently formed the Moon. (See Moon: Origin and evolution.) For the outer planets, with their multiple satellites, many very small and quite unlike one another, the picture is less clear. Some of these moons have relatively smooth icy surfaces, whereas others are heavily cratered; at least one, Jupiter's Io, is volcanic. Some of the moons may have formed along with their parent planets, and others may have formed elsewhere and been captured.

Study of extrasolar planetary systems

- The first extrasolar planets were discovered in 1992, and more than 4,100 such planets are now known. Over 600 of these systems have more than one planet. Because planets are much fainter than their stars, fewer than 100 have been imaged directly. Most extrasolar planets have been found through their transit, the small dimming of a star's light when a planet passes in front of it. Many of these planets are unlike those of the solar system. Hot Jupiters are large gas giants that orbit very close to their star.
- A primary goal of extrasolar planet research has been finding another planet that could support life. A useful guide for finding a life-supporting planet has been the concept of a habitable zone, the distance from a star where liquid water could survive on a planet's surface. About 20 planets have been found that are roughly Earth-sized and orbit in a habitable zone.

Star formation and evolution

- The range of physically allowable masses for stars is very narrow. If the star's mass is too small, the central temperature will be too low to sustain fusion reactions. The theoretical minimum stellar mass is about 0.08 solar mass. An upper theoretical bound called the Eddington limit, of several hundred solar masses, has been suggested, but this value is not firmly defined. Stars as massive as this will have luminosities about one million times greater than that of the Sun.
- A general model of star formation and evolution has been developed, and the major features seem to be established. A large cloud of gas and dust can contract under its own gravitational attraction if its temperature is sufficiently low. As gravitational energy is released, the contracting central material heats up until a point is reached at which the outward radiation pressure balances the inward gravitational pressure, and contraction ceases. Fusion reactions take over as the star's primary source of energy, and the star is then on the main sequence. The time to pass through these formative stages and onto the main sequence is less than 100 million years for a star with as much mass as the Sun. It takes longer for less massive stars and a much shorter time for those much more massive.
- Once a star has reached its main-sequence stage, it evolves relatively slowly, fusing hydrogen nuclei in its core to form helium nuclei. Continued fusion not only releases the energy that is radiated but also results in nucleosynthesis, the production of heavier nuclei.
- Stellar evolution has of necessity been followed through computer modeling, because the timescales for most stages are generally too extended for measurable changes to be observed, even over a period of many years. One exception is the supernova, the violently explosive finale of certain stars. Different types of supernovas can be distinguished by their spectral lines and by changes in luminosity during and after the outburst. In Type Ia, a white dwarf star attracts matter from a nearby companion; when the white dwarf's mass exceeds about 1.4 solar masses, the star implodes and is completely destroyed. Type II supernovas are not as luminous as Type Ia and are the final evolutionary stage of stars more massive than about eight solar masses. Type Ib and Ic supernovas are like Type II in that they are from the collapse of a massive star, but they do not retain their hydrogen envelope.
- The nature of the final products of stellar evolution depends on stellar mass. Some stars pass through an unstable stage in which their dimensions, temperature, and luminosity change cyclically over periods of hours or days. These so-called Cepheid variables serve as standard candles for distance measurements (see above Determining astronomical distances). Some stars blow off their outer layers to produce planetary nebulas. The expanding material can be seen glowing in a thin shell as it disperses into the interstellar medium while the remnant core, initially with a surface temperature as high as 100,000 K (180,000 °F), cools to become a white dwarf. The maximum stellar mass that can exist as a white dwarf is about 1.4 solar masses and is known as the Chandrasekhar limit. More-massive stars may end up as either neutron stars or black holes.
- The average density of a white dwarf is calculated to exceed one million grams per cubic cm. Further compression is limited by a quantum condition called degeneracy (see degenerate gas), in which only certain energies are allowed for the electrons in the star's interior. Under sufficiently great pressure, the electrons are forced to combine with protons to form neutrons. The resulting neutron star will have a density in the range of 1014–1015 grams per cubic cm, comparable to the density

within atomic nuclei. The behaviour of large masses having nuclear densities is not yet sufficiently understood to be able to set a limit on the maximum size of a neutron star, but it is thought to be less than three solar masses.

- Still more-massive remnants of stellar evolution would have smaller dimensions and would be even denser that neutron stars. Such remnants are conceived to be black holes, objects so compact that no radiation can escape from within a characteristic distance called the Schwarzschild radius. This critical dimension is defined by Rs = 2GM/c2. (Rs is the Schwarzschild radius, G is the gravitational constant, M is the object's mass, and c is the speed of light.) For an object of three solar masses, the Schwarzschild radius would be about three kilometres. Radiation emitted from beyond the Schwarzschild radius can still escape and be detected.
- Although no light can be detected coming from within a black hole, the presence of a black hole may be manifested through the effects of its gravitational field, as, for example, in a binary star system. If a black hole is paired with a normal visible star, it may pull matter from its companion toward itself. This matter is accelerated as it approaches the black hole and becomes so intensely heated that it radiates large amounts of X-rays from the periphery of the black hole before reaching the Schwarzschild radius. Some candidates for stellar black holes have been found—e.g., the X-ray source Cygnus X-1. Each of them has an estimated mass clearly exceeding that allowable for a neutron star, a factor crucial in the identification of possible black holes. Supermassive black holes that do not originate as individual stars exist at the centre of active galaxies (see below Study of other galaxies and related phenomena). One such black hole, that at the center of the galaxy M87, has a mass 6.5 billion times that of the Sun and has been directly observed.
- Whereas the existence of stellar black holes has been strongly indicated, the existence of neutron stars was confirmed in 1968 when they were identified with the then newly discovered pulsars, objects characterized by the emission of radiation at short and extremely regular intervals, generally between 1 and 1,000 pulses per second and stable to better than a part per billion. Pulsars are considered to be rotating neutron stars, remnants of some supernovas.

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DAY - 68

HEALTH DEVELOPMENT

The government is focused on ensuring affordable healthcare for all Indians as per the sustainable development goal of the United Nations Development Programme (UNDP) and science and technology forms a major tool for ensuring this.

Ministry of Science & Technology brings interventions to make healthcare accessible and affordable like low cost vaccines for disease prevention, diagnostic kits for detection and medicines for treatment of diseases. In addition to health care interventions, the Ministry also focuses on the health care delivery system with the growing engagement of the private sector, especially start-ups and small industry. The availability of a proper technology translational mechanism ensures this.

India in vaccine development & manufacture

- DBT's Indo-US Vaccine Action Programme (VAP) & the Vaccine Grand Challenge Programme (VGCP) helped develop the world's lowest cost rotavirus vaccine. The vaccine developed from Indian strain 116E is efficacious in preventing severe rotavirus diarrhea in low-resource settings in India.
- Introduced in 9 states, namely Odisha, Andhra Pradesh, Haryana, Himachal Pradesh, Assam, Tripura, Tamil Nadu, Madhya Pradesh and Rajasthan, the ROTAVAC® vaccine has received WHO prequalification in 2018 and has been included in India's Universal Immunization Program (UIP).
- Furthermore, the program is taking major strides towards vaccine for diseases like dengue, enteric diseases, influenza, malaria & tuberculosis (TB). It is estimated that one out of every six children over the world receives vaccines manufactured in India.
- **Malaria Vaccine**: International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi along with its translational research partner "Multi Vaccines Development Program" has made significant progress in the development of vaccines for P. falciparum and P. vivax malaria. Funding support through Vaccine Grand Challenge Program of Department of Biotechnology, Biotechnology Industry Research Assistance Council (BIRAC) and multiple international agencies including Malaria Vaccine Initiative (MVI), PATH and European Vaccine Initiative (EVI) has made this possible. .
- **Dengue Vaccine**: The International Centre for Genetic Engineering and Biotechnology (ICGEB) in collaboration with drug major Sun Pharma is using the recombinant EDIII-based sub-unit dengue vaccine candidate to develop an injectable vaccine that protects against all four dengue strains that are endemic to India.

Low cost diagnostic kits help timely detection of diseases

1- Day Dengue Diagnostic Kit

- The highly sensitive rapid 1- day dengue diagnostic kit detects Dengue Virus (DENV) infection from the first day of fever, with a cost of Rs 145/test to the distributors. The kit's performance was tested by Drug Controller Govt. of India and is currently being exported.

Diagnostic kits for Celiac disease

- The Celiac diagnostic kits (Celiac Microlisa & Celiac Card) were developed through collaborative, multi-institutional, inter-disciplinary efforts and are rapid, sensitive, specific, and are much cheaper in comparison to imported kits in use today.

- The participating institutions were ICGEB, New Delhi, Translational Health Science and Technology Institute (THSTI), Gurugram; All India Institute of Medical Sciences (AIIMS), New Delhi, and have been made commercially available by industrial partner.

Plasma Gelsolin Diagnostic Kit for prematurity and sepsis

- CSIR-IMTECH has developed two mass-production ready, plate-based kits to estimate plasma gelsolin levels in humans leading to early detection of pre-term birth.
- After successful clinical trials, the diagnostic kit has been transferred to an industry for commercialization.

eSkIN: An in-silico Platform for Skin Data Analysis

- A sophisticated but user-friendly software tool named "eSkIN" has been developed for skin system which enables modeling, simulations, analysis, and visualization.
- It has the ability to convert large scale high-throughput 'omics' data into biomedical knowledge.
- The software is open for use and is available at the online platform of the industry partner, Persistent Systems.

Sohum for early detection of hearing impairment in children

- Sohum is a non- invasive and safe device for screening of neonates for hearing impairment with high sensitivity and specificity.
- This product is licensed to Sohum Innovations and has been launched in India.
- The company is using seed the market strategy by providing products to various hospitals across India for eliciting feedback and adoption.

NeoBreath: Foot-operated newborn resuscitation system

- This product is a foot-operated resuscitation system that can free-up a hand of the device operator or healthcare professional faced with a baby that's not able to breathe.
- This facility, allows use of both hands for holding the mask, leading to effective sealing and better ventilation.
- NeoBreath is licensed to Windmill Health and has been commercialized in India, as well as top hospitals of South Africa, Nigeria, Kenya and Mali.
- A few sample units have also been shipped to Rwanda, Chile, Peru and Argentina and pilot sales in Africa and South America have started.
- More than 150 units have been sold by the company so far.
- The technology has been sub-licensed to Phoenix Medical systems, Chennai for market outreach and sales.

Brun: Feto-maternal Parameter Monitoring System

- This device is a safe, easy and cost-effective way to continuously monitor feto-maternal vitals of pregnant women, which helps to reduce neonatal mortality.
- The product is licensed to Brun Health.
- The company has completed design for manufacturing of the product and is validating the technology at AIIMS, New Delhi and the product is yet to be commercialized.

Sishunetra

- First-of-a-kind, low-cost wide field eye screening device for premature and term infant has been developed.
- The product has undergone extensive field trials and is ready to be launched in the Indian market by 2018.

Fetal Mom

- This device functions as a fetal electrocardiogram and monitors uterine activity through signal extraction from maternal electrocardiogram, thereby eliminating the need for use of conventional transducers.
- The product has undergone clinical validation and is ready for launch.

Soft Tissue Biopsy device for tissue sample collection with minimum skill for diagnosis

- The device provides a safer, easier and cost-effective way to perform percutaneous aspiration needle biopsy.
- It is easy to use and hence the task can be carried out by a person with limited expertise.

Mobile Lab

- The Mobile Lab is a compact portable clinical laboratory, in the form of a suitcase with a power backup facility.
- It consists of all essential instruments like Biochemistry Analyzer, Centrifuge, Incubator, Data Recorder/Mini Laptop with Patient Data Management Software, Micropipettes and other accessories.

AnuPath: Multi-analyte PoC device

- AnuPath is a point-of-care medical device for management and early prevention of complications for diabetes, chronic kidney disease, anemia and malnutrition.
- The handheld medical device utilizes dry test strips for detection of biomarkers related to the respective disease.

Oral cancer screening camera

- The product is a hand-held imaging device that uses trimodal imaging technology combining tissue fluorescence, absorption, and diffuse reflectance for screening and detection of oral cancers.

Haemoglobin (Hb) Calculator App

- An android-based smartphone app called Haemoglobin (Hb) Calculator was developed for accurate and sensitive measurement of Hb.
- The application's higher sensitivity, specificity, accuracy and reliability make it an attractive alternative for Hb estimation in resource-limited conditions.

DALI (Dyslexia Assessment in Languages of India): Kit for early detection of dyslexia

- DALI is a package developed by National Brain Research Centre, Manesar that contains screening tools for school teachers and assessment tools for psychologists in Indian languages to identify dyslexia.
- It is the first indigenously developed screening and assessment tool to be standardized and validated across a large population of nearly 4840 children.
- The tools are available in Hindi, Marathi, Kannada and English and are currently being developed in other languages as well.
- **Medicines and technological solutions bring affordable treatment**

Streptokinase

- Streptokinase is a vital, life-saver injectable protein drug that saves up to 40% of human lives after heart attacks, if given within a few hours of the onset of chest pain. CSIR-IMTECH has developed

a portfolio of streptokinase technology which includes natural streptokinase; recombinant streptokinase; clot-specific streptokinase (third generation thrombolytic molecules); and the new generation clot-buster(s) (fourth generation thrombolytic molecules).

- The technology of natural streptokinase of 'British' Pharmacopoeiac grade developed by CSIR-IMTECH was transferred to Cadila Pharmaceuticals.

Novel processes for Eribulin, Nicotine and Bedaquiline

- Serving as important drugs for health care, bench scale processes have been developed for all three molecules, for which synthesis at a large scale is necessary to serve the market demand. In all three cases, the developed routes are new and cost-effective. Eribulin (an anti-cancer drug) fragments are now made in lesser number of steps, Nicotine is made in one-step and Bedaquiline (anti-Drug Resistant TB drug) synthesis was achieved from commercially available starting materials at a low cost.

Anti-diabetes herbal drug

- CSIR has developed an anti-diabetic herbal formulation from a combination of natural extracts derived from six plant species mentioned in ancient Ayurveda texts. The drug, BGR-34, was approved by the Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) after it was tested on patients over a period of 18 months across states of Delhi, Himachal Pradesh, Haryana, Punjab and Karnataka.

Hand-cranked defibrillator

- Defibrillation is a treatment for life-threatening cardiac dysrhythmias, specifically ventricular fibrillation (VF) and non-perfusing ventricular tachycardia (VT). A defibrillator delivers a dose of electric current (often called a countershock) to the heart. The world's first electricity and hand-cranked dual powered defibrillator has been developed, serving in regions without reliable electricity such as in India, Africa, South America and Asia. Health units such as Primary Health Centres (PHCs) and Community Health Centres (CHCs) as well as emergency response units of security forces would benefit from this immensely. The price of this device would be 1/4th of the big brands, while providing similar or higher quality and reliability levels.

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