History of science and Technology:
Unit: IV

Space research: It is scientific study carried out in outer space, and by studying outer space. From the use of space technology to the observable universe, space.

Everyday benefits of space exploration

- Improving our understanding of the human body. ...
- Talking on cellular phones. ...
- Satellites in our everyday lives. ...
- Creating jobs in technology. ...
- Taking action on climate change. ...
- Making scientific discoveries. ...
- Performing risky surgical procedures. ...
- Getting young people interested in **science**

Importance of space research:

In the past four decades, **space science** and technology freed human beings from the confines of Earth. ... The peaceful uses of outer **space** provided a powerful tool for bringing about global cooperation and furthering of the well-being of humanity and the Earth's environment.
Rockets: The United states and the soviet union created their own missile programs. The space research field evolved as scientific investigation based on advancing rocket technology.

In 1948–1949 detectors on **V-2 rocket** flights detected **x-rays** from the Sun. **Sounding rockets**helped show us the structure of the **upper atmosphere**. As higher altitudes were reached, **space physics** emerged as a field of research with studies of Earths **aurora, ionosphere** and **magnetosphere.**

Artificial satellites

The first artificial **satellite**, Russian **Sputnik 1,** launched on October 4, 1957, four months before the United States first, **Explorer 1.** The major discovery of **satellite** research was in 1958, when Explorer 1 detected the **Van Allen radiation belts. Planetology** reached a new stage with the Russian **Luna programme** between 1959 and 1976, a series of **lunar probes** which gave us evidence of the Moons chemical composition, gravity, temperature, soil samples, the first photographs of the far side of the Moon by LUNA 3, and the first remotely controlled robots (**Lunokhod** to land on another **planetary body.**

International co-operation

The early space researchers obtained an important international forum with the establishment of the **Committee on Space Research**(COSPAR) in 1958, which achieved an exchange of scientific information between east and west during the cold war, despite the military origin of the rocket technology underlying the research field.[2]

Astronauts

On April 12, 1961, Russian Lieutenant **Yuri Gagarin** was the first human to orbit Earth, in **Vostok 1** In 1961, US astronaut **Alan Shepard** was the first American in space. And on July 20, 1969, astronaut **Neil Armstrong** was the first human on the **Moon.**

On April 19, 1971, the Soviet Union launched the **Salyut 1 t**he first space station of substantial duration, a successful 23 day mission, sadly ruined by transport disasters. On May 14, 1973, **Skylab** the first American space station launched, on a modified **Saturn V rocket**. Skylab was occupied for 24 weeks.[3]

Interstellar

The **Voyager 1** probe launched on 5 September 1977, and flew beyond the edge of our solar system in August 2012 to the **interstellar medium** The farthest human object from the Earth, predictions include collision, an **Oort cloud**, and destiny, "perhaps eternally—to wander the Milky Way."

Voyager 2 launched on 20 August 1977 travelling slower than Voyager 1 and reached interstellar medium by the end of 2018. Voyager 2 is the only Earth probe to have visited the **ice giants of Neptuneor Uranus**

Neither Voyager is aimed at a particular visible object, but both continue to send research data to **NASA Deep Space Network** as of 2019.

Two Pioneer probes and the **New Horizons** probe are expected to enter interstellar medium in the near future, but these three are expected to have depleted available power before then, so the point of exit cannot be confirmed precisely. Predicting probes speed is imprecise as they pass through the variable **heliosphere. Pioneer 10** is roughly at the outer edge of the heliosphere in 2019. New Horizons should reach it by 2040, and **Pioneer 11by** 2060.

NASA's 10 Greatest Science Missions

- **Viking**.
- Chandra. ...
- **Cassini-Huygens**. ...
- Spirit & Opportunity. ...
- Spitzer. ...
- **WMAP**. ...
- **Voyager**. ...

Advantages of Nuclear Energy

- Switching from Fossil Fuels to **Nuclear Power** can Slow Global Warming. ...
- **Nuclear Power** is much better for Air Quality than Fossil Fuel Sources. ...
- Part of the Community. ...
- Technology continues to improve safety and decrease risk of accidents. ...
- We won't run out of **nuclear** fuel any time soon. ...
- Resources.

The Atomic Energy Commission :

India is the only developing country, that has achieved self-reliance in the sphere of nuclear fuel cycle activities, amidst several international technology control regimes. With the enactment of the Atomic Energy Bill in 1948, the Atomic Energy Commission was established on 10 August 1948 with Dr. Homi J. Bhabha as its first chairman. The commission was entrusted with the formulation and implementation of the policy of the Government in all matters concerning atomic energy. Subsequently in 1956, the Department of Atomic Energy (DAE) was established with the following mandate :

- Generation of safe, economically competitive electricity from nuclear energy by exploiting the natural resources of uranium and thorium available in the country;
- Building of research reactors and utilisation of radioisotopes produced in them for applications in medicine, agriculture and industry;
- Development of advanced technology in areas such as accelerators, lasers, biotechnology, information technology and materials including development of non-nuclear and strategic materials like titanium;
- Encouraging technology transfers and interaction with industry in areas of its strength, contributing to the industrial development;
- Providing support to basic research in nuclear energy and related frontier areas of science, and interaction with universities and academic institutions to improve the quality of education and research, and providing research grants to them;
- Encouraging international cooperation in advanced areas of research and in mega science projects to realise the benefits of state-of-the-art science and technologies, and
- Contributing to national security.

The Department of Atomic Energy (DAE), while performing a key role in the scientific and technological scenario of the country, has also been vital to the overall nation-building exercise. The Department has fostered the nuclear technology in the country to a perfect state of self - reliance fulfilling the aims of the planners, marked by overall balanced developments and growth in all the spheres of its activities. The strategy adopted has placed India in an advantageous position to formulate its own energy policy with confidence, matching its energy needs with its natural resources, especially in the context of several restrictive technology control regimes that are being adopted by developed nations.

Equipped with highly trained multi-disciplinary scientific manpower and impressive facilities, the high technologies generated in the various units of the DAE, besides raising nuclear technology to global standards, form part of national scientific and technology missions. These a super computing system, *Anupam*, based on parallel processing techniques with a computing speed faster than any other indigenous system available in the country, has demonstrated several number crunching complex scientific applications.

The three stage Indian nuclear power program, charted by Dr H. J. Bhabha, aimed at establishing nuclear power with resources comprises the following guidelines : a) First stage - use of natural uranium in pressurised heavy water reactors (PHWR) and production of power and plutonium; b) Second stage - use of plutonium produced in fast breeder reactors (FBR) and production of additional plutonium/u-233 and power; and c) Third stage - use of thorium u-233 in an advanced fuel cycle and reactor system (under development).

Progressive indigenisation has been achieved from Rajasthan Atomic Power Station to Kakrapar Atomic Power Station and also a high level of indigenisation exists in the related nuclear fuel cycle. DAE has also comprehensive capability to design, construct, operate and maintain related fuel cycle facilities, and many such facilities are operational all over the country.
Today DAE has under its aegis –

- five Research Centers
    - Bhabha Atomic Research Centre (BARC)- Mumbai
    - Indira Gandhi Centre for Atomic Research (IGCAR)-Kalpakkam (Tamil Nadu)
    - Centre for Advanced Technology (CAT)- Indore (Madhya Pradesh)
    - Variable Energy Cyclotron Centre (VECC)-Calcutta
    - Atomic Minerals Directorate for Exploration & Research (AMD)- Hyderabad
- three Industrial Organisations
    - Heavy Water Board (HWB)-Mumbai
    - Nuclear Fuel Complex (NFC)- Hyderabad
    - Board of Radiation & Isotope Technology (BRIT)-Mumbai
- four Public Sector Undertakings
    - Nuclear Power Corporation of India Ltd. (NPCIL)-Mumbai
    - Uranium Corporation of India Ltd. (UCIL)-Jaduguda (Bihar)
    - Indian Rare Earth Ltd. (IRE)-Mumbai
    - Electronics Corporation of India Ltd. (ECIL)-Hyderabad
- four Service Organisations
    - Directorate of Purchase & Stores (DPS)-Mumbai
    - Construction, Services & Estate Management Group (CS&EMG)-Mumbai
    - General Services Organisation (GSO)-Kalpakkam (Tamil Nadu)
    - Atomic Energy Education Society (AEES)-Mumbai
- DAE also financially supports seven autonomous Research Institutes
    - Tata Institute of Fundamental Research (TIFR)- Mumbai
    - Tata Memorial Centre (TMC)-Mumbai
    - Saha Institute of Nuclear Physics (SINP)-Calcutta
    - Institute of Physics (IOP)- Bhubaneshwar
    - Mehta Research Institute of Mathematics & Mathematical Physics (MRI)-Allahabad
    - Institute of Mathematical Sciences (IMSc)-Chennai
    - Institute for Plasma Research (IPR)-Ahmedabad

AEES also gets financial support from DAE.

Indian Rare Earths Limited (IREL), a public sector undertaking [PSU] unit of DAE, process minerals to products which are not only of value to the Department, but also useful to other users in the country and outside. Nuclear Fuel Complex (NFC), Hyderabad fabricates fuel and structural components for all operating power reactors, thorium blankets and structural components for FBTR. In the recent past, NFC developed special alloys for use in the space programme for the country - a major milestone in import substitution. NFC alongwith IRE has succeeded in producing pure zirconia crystal, popularly known as American diamonds.

The Heavy Water Board designs, builds, operates its own heavy water plants which not only meet the country's requirements but have given India an export capability.

Electronics Corporation of India Limited (ECIL) was established to cater to the nuclear, radiological, instrumentation and control requirements for country's nuclear power programme. This was the first window of DAE for technology transfer in commercial and industrial electronics. At present 80 per cent of the products of this commercial venture serve core sectors of the nation like telecommunication, defence, space, steel, petrochemical and thermal power plants for their instrumentation and control computer application needs. ECIL has received the award for excellence in Strategic Electronics in 1994 from the Department of Electronics.

The activities of the Department of Atomic Energy under Industry & Minerals sector of the in the Ninth Plan [] pertain to the requirement of heavy water, nuclear fuel, instruments and controls, spent fuel recovery and waste disposal for the nuclear power reactors. The Uranium Corporation of India Ltd. (UCIL) completed its project of uranium Mining and Mill at Narwapahar, Bihar.

The Nuclear Fuel Complex (NFC) took up five new projects for implementation in the Eighth Five Year Plan (1992-1997) for meeting fuel requirnment of the new nuclear power reactors. Three of the NFC's projects namely, New Zircaloy Fabrication Plant, New Uranium Oxide Plant and New Fuel Assembly Plant are at advanced stages of completion. The two remaining projects namely Zirconium Sponge Plant and Titanium Sponge Plant are yet to start. However, due to the scaling down of the nuclear power target, the delay has not caused any problem in meeting the fuel demand of the existing reactors.

The Department of Atomic Energy has taken up the development of fast breeder reactors which enable utilising Thorium as fuel for power reactors. Simultaneously, it is proposed to set up high flux research reactors to develop new fuel designs in order to economise on the use of nuclear fuels. For augmenting uranium capacity, UCIL will develop a new uranium mine at Domiasat in Meghalaya in the Ninth Plan.

No new heavy water plant will be set up in the Ninth Five Year Plan (1997 - 2002) but a new spent fuel re-processing plant in addition to revamping of the old plant at Trombay, will be set up in the Ninth Plan.

The Indian Rare Earths (IRE) will take up joint ventures for beach sand processing in Tamil Nadu, Kerala, etc. in the Ninth Plan.

DRDO: It was established in 1958 by amalgamating the Defence Science Organisation and some of the technical development establishments. A separate Department of Defence Research and Development was formed in 1980 which later on administered DRDO and its 50 laboratories/establishments. Most of the time the Defence Research Development Organisation was treated as if it was a vendor and the Army Headquarters or the Air Headquarters were the customers. Because the Army and the **Air Force**themselves did not have any design or construction responsibility, they tended to treat the designer or Indian industry at par with their corresponding designer in the world market. If they could get **a MiG-21** from the world market, they wanted a MiG-21 from DRDO.[8]

DRDO started its first major project in **surface-to-air missiles**(SAM) known as **Project Indigo** in the 1960s. Indigo was discontinued in later years without achieving full success. Project Indigo led to **Project Devil** along with Project Valiant, to develop short-range SAM and **ICBM** in the 1970s. Project Devil itself led to the later development of the **Prithvi** missile under the **Integrated Guided Missile Development Programme** (IGMDP) in the 1980s. IGMDP was an Indian **Ministry of Defence** programme between the early 1980s and 2007 for the development of a comprehensive range of missiles, including the **Agni missile** Prithvi ballistic missile, **Akash missile, Trishul missile and Nag Missile**. In 2010, defence minister **A. K. Antony**ordered the restructuring of the DRDO to give 'a major boost to defence research in the country and to ensure effective participation of the private sector in defence technology'. The key measures to make DRDO effective in its functioning include the establishment of a Defence Technology Commission with the defence minister as its chairman.The programmes which were largely managed by DRDO have seen considerable success with many of the systems seeing rapid deployment as well as yielding significant technological benefits. Since its establishment, DRDO has created other major systems and critical technologies such as aircraft avionics, small arms, artillery systems, EW Systems, tanks and armoured vehicles, sonar systems, command and control systems and missile systems.

Antartic Mission:

The **Indian Antarctic Program** is a multi-disciplinary, multi-institutional program under the control of **the National Centre for Polar and Ocean Research, Ministry of Earth Sciences, Government of India**. It was initiated in 1981 with the first Indian expedition to **Antarctica** The program gained global acceptance with India's signing of **the Antarctic Treaty** and subsequent construction of the **Dakshin Gangotri** Antarctic research base in 1983,[1] superseded by the **Maitri** base from 1989. The newest base commissioned in 2012 is **Bharati** constructed out of 134 shipping containers. Under the program, **atmospheric, biological, earth, chemical** and **medical sciences** are studied by India, which has carried out 30 scientific expeditions to the Antarctic as of 14 October 2010.

The origin of the Indian missions to the Antarctic are traced to the **joint Indian Space Research Organisation** – **Hydrometeorological Centre of Russia** agreements, which led to Indians, such as Dr. Paramjit Singh Sehra, joining the 17th Soviet Antarctic expedition of 1971–1973.

India officially acceded to the **Antarctic Treaty System** on 1 August 1983. On 12 September 1983, the country became the fifteenth Consultative Member of the Antarctic Treaty.[3]

The National Centre for Polar and Ocean Research—a **research and development b**ody functioning under the Ministry of Earth Sciences, **Government of India**—controls the Indian Antarctic program.[4] The NCPOR and the Department of Ocean Development select the members for India's Antarctic expeditions.[2] After medical tests and subsequent acclimatization training at the Himalayas, these selected members are also trained in survival, environment ethics, firefighting and operating in a group.

One expedition costs up to ₹200 million Logistical support to the various activities of the Indian Antarctic program is provided by the relevant branches of the Indian armed forces.[4] The launching point of Indian expeditions has varied from Goa in India to Cape Town in South Africa on 19th expedition during the time of NCAOR Founding Director Dr. P C Pandey in December 1999.[2] Over 70 institutes in India contributed to its Antarctic program as of 2007.[2]

The Indian Antarctic program is bound by the rules of the Antarctic Treaty System, which India signed in 1983.[4] Pandey (2007) outlines the various international activities that India has undertaken as a part of its Antarctic program:

On 12 September 1983, India achieved the status of Consultative Party, on 1 October became a **member** of **Scientific Committee on Antarctic Research**(SCAR), and in 1986 became a member of the **Convention for the Conservation of Antarctic Marine Living Resources(**CCAMLR). In 1997 India also ratified the Protocol on Environmental Protection to the Antarctic Treaty thus reaffirming India's commitment to protecting the Antarctic environment. India hosted the eleventh COMNAP/SCALOP (Standing Committee on Antarctic Logistics and Operations) meeting in Goa in 1999, and the working group meeting on eco-system monitoring and management of CCAMLR in August 1998 at Cochin. India occupied the CCAMLR chair beginning in November 1998 for a period of 2 years.[2]

India also collaborates with the international community as a member of the **Intergovernmental Oceanographic Commission,** Regional Committee of Intergovernmental Oceanographic Commission in Coastal Indian Ocean (IOCINDIO), **International Seabed Authority** (ISBA), and the State Parties of the United Nations Convention on the Law of the Seas (UNCLOS).

Antarctica holds scientific interest for global research projects due to a number of reasons: 'Origin of continents, climate change, meteorology and pollution' are among the reasons cited by S.D. Gad (2008).[4] Mrinalini G. Walawalkar (2005) holds that: 'ice–ocean interaction and the global processes; paleoenvironment and paleoclimatic studies; geological evolution of earth and **Gondwanaland** reconstruction; Antarctic ecosystems, biodiversity and environment physiology; solar terrestrial processes and their coupling; medical physiology, adaptation techniques and human psychology; environment impact assessment and monitoring; enabling low temperature technology development; and studies on earthquakes' are among the areas of study under the Indian Antarctic program.[6]

Close to 1,300 Indians had been to the continent as of 2001 as a part of the country's Antarctic program. Indian expeditions to the Antarctic also study the fauna and the molecular biodiversity of the region. A total of 120 new microbes had been discovered as a result of international scientific effort in the Antarctic by 2005.[6] 30 of these microbes had been discovered by Indian scientists.[6] India has also published over 300 research publications based on Antarctic studies as of 2007.[2]

The 'ice cores' retrieved by drilling holes in Antarctic's vast ice-sheets yield information 'on the and eco-history of the earth as records of wind-blown dust, **volcanic ash or radioactivity a**re preserved in the ice as it gets accumulated over time'. The NCAOR developed a polar research & development laboratory with a 'low-temperature laboratory complex at −20 °C for preservation and analysis of ice core and snow samples' according to S.D. Gad (2008).[4] The 'ice core' samples are held, processed, and analyzed in containment units designed by such technology.[4] Storage cases made of poly propylene also ensure that the samples do not alter characteristics and are preserved for analysis in the form that they were recovered.[4]

Dakshin Gangotri

The first permanent settlement was built in 1983 and named **Dakshin Gangotri.** In 1989 it was excavated and is being used again as supply base and transit camp.

Maitri

The second permanent settlement, was put up in 1989 on the **Schirmacher** Oasis and has been conducting experiments in geology, geography and medicine. India built this station close to a freshwater lake around Maitri known as **Lake Priyadarshini.** Maitri accomplished the mission of geomorphologic mapping of Schirmacher Oasis.

Bharati

Located beside Larsmann Hill at 69°S, 76°E, **Bharati** is established in 2015. This newest research station for oceanographic research will collect evidence of continental breakup to reveal the 120-million-year-old ancient history of the Indian subcontinent. In news sources this station was variously spelled "Bharathi", "Bharti" and "Bharati".