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UP-PSC WALLAH

SCIENCE AND TECHNOLOGY

COMPREHENSIVE LEARNING SERIES FOR PRELIMS AND MAINS

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1 Science and Technology in Everyday Life

INTRODUCTION

In the dynamic landscape of India, the realm of science and technology has not just been a field of academic interest and professional pursuit but has deeply influenced the everyday order. From the age of Aryabhatta to the IT sector boom of the 21st century, India has been a front-runner in technology revolutions. Studying the scientific and technological developments of India reveals a legacy of contributions that have influenced not only the country but the world at large. Recent initiatives like Digital India, UPI, the JAM Trinity, etc have become the envy of the entire globe, showcasing India's prowess in Science and Technology.

SCIENCE AND TECHNOLOGY

Science and technology are closely related fields. Science uses observation and experimentation to study the natural world systematically, while technology uses scientific knowledge for practical applications. This symbiotic relationship means advancements in science often lead to technological innovations, and vice versa.

SCIENCE AND TECHNOLOGY IN INDIA: A HISTORICAL EVOLUTION

India's rich and varied intellectual heritage is demonstrated by the country's historical advancements in science and technology. This evolution showcases a profound journey from ancient innovations to contributions that have shaped global scientific and technological landscapes.

ANCIENT INDIA

Ancient India was a **cradle of profound intellectual and cultural development.** This era witnessed the emergence of significant advancements in various fields such as **mathematics, astronomy hydrology, architecture, and medicine,** laying the foundational stones for future scientific and philosophical endeavours.

Mathematics and Astronomy

Decimal System, Zero, and Aryabhata's Aryabhatiya: Ancient India made groundbreaking contributions to mathematics, notably the development of the **decimal system** and the **concept of zero (Bakhshali manuscript),** which revolutionised **numerical computation. Aryabhata,** a renowned Indian mathematician and astronomer, authored the **"Aryabhatiya,"** a significant work that presented numerous mathematical and astronomical theories, including the **approximation of pi** and the **idea of the Earth rotating on its axis.**

- **Mathematical Models, Varahamihira's Panchasiddhantika: Varahamihira**, another eminent scholar, compiled the **"Panchasiddhantika,"** a comprehensive treatise on astronomy. This work summarised several older astronomical models and included his own observations and mathematical calculations, contributing significantly to the field of astronomy.

Hydrology and Irrigation

The Indus Valley Civilization, had a well-organized system of canals and water management structures in cities like Mohenjo-Daro and Harappa. Similarly The Kallanai Dam (Grand Anicut) in Tamil Nadu, built across the Kaveri River by the Chola king Karikalan in the 2nd century CE, is one of the oldest functional dams in the world.

Architecture and Planning

Grid Pattern of Town Planning, covered sewers attached to houses, standardised bricks, public baths and water reservoirs etc across most of the Mature Harappan Sites points to well developed knowledge of civil engineering according to its time.

Medicine

Ayurveda, Charaka Samhita, and Sushruta Samhita: Ayurveda, the ancient Indian system of medicine, is one of the world's oldest holistic healing systems. It was systematized and recorded in texts like the **"Charaka Samhita"** and the **"Sushruta Samhita."** The **"Charaka Samhita"** is a foundational text on internal medicine, while the "**Sushruta Samhita**" is considered a crucial text on surgery, including descriptions of surgical techniques and instruments.

Bhela, Atreya are other important early contributors of Ayurveda while Dhanvantari in mythology is considered as physician of Devas. Further in South India Siddha system of medicine was developed which is considered among the oldest known medicine systems.

MEDIEVAL INDIA

India made significant contributions in a number of disciplines during the medieval period, which saw a surge in scientific and mathematical knowledge.

Advancements in Mathematics and Astronomy

Trigonometry, Algebra, and Siddhanta Siromani: This period saw remarkable developments in trigonometry and algebra. **Bhaskara II,** an eminent mathematician and astronomer, authored **"Siddhanta Siromani,"** a comprehensive treatise that included innovative work in these fields. His contributions to calculus and his understanding of the number system were particularly noteworthy.

- **Continued Contributions: Brahmagupta,** another influential **mathematician and astronomer,** wrote **"Brahmasphutasiddhanta."** This text is significant for its introduction of **zero** as a number and its rules for arithmetic operations involving zero and negative numbers. Brahmagupta also made substantial contributions to algebra and proposed methods for solving **quadratic equations.**
- **Nilakantha Jyotirvida compiled Tajik**, introducing a large number of Persian technical terms.

Unani Medicine

- **Introduction of Unani Medicine:** The medieval period in India also saw the introduction and development of **Unani medicine**. It is a system of healing and health maintenance.
- The origins of Unani medicine are found in the doctrines of the **ancient Greek physicians Hippocrates and Galen.**
- It was brought to India by **Persian and Arab traders and scholars.** Unani medicine integrated Greek and Arab medical knowledge, emphasizing the balance of bodily fluids and using herbal remedies, dietary practices, and surgical procedures.

MUGHAL ERA

The Mughal Era saw significant advancements in **architecture, metallurgy, and textiles,** which were a reflection of the empire's wealth, artistic ingenuity, and technological prowess.

Architectural and Material Advances

Taj Mahal, Fatehpur Sikri Complex:

- The Taj Mahal, an iconic symbol of India, epitomizes the architectural sophistication of the **Mughal era.** It is renowned for its intricate marble inlay work and harmonious proportions.
- **Fatehpur Sikri**, another architectural marvel, was the short-lived capital of the Mughal Empire under **Emperor Akbar.** It is celebrated for its **fusion of Indian and Persian architectural styles** and the use of red sandstone.

- **Metallurgy Advancements in Smelting and Refining:**
  - The Mughal period saw significant advancements in metallurgy. Techniques in smelting and refining were refined, leading to the production of **high-quality steel.**
  - This period is noted for the production of the famous **Damascus steel,** known for its durability and distinctive pattern, used in weaponry and armour.
- **Innovations in Textiles (Weaving and Dyeing):**
  - The Mughal era was also a golden age for textiles. Innovations in weaving and dyeing led to the creation of luxurious fabrics like **muslin, silk, and brocade.**
  - The Mughals were known for their intricate **embroidery** and the use of vibrant colors, which were sought after both domestically and internationally.

MODERN INDIA

Scientific development in India underwent significant transformations during the colonial period and after independence. During **colonial times,** the British introduced **Western scientific methods** and education, led to the establishment of research institutions and universities. This period saw the emergence of notable Indian scientists like **Jagadish Chandra Bose and C.V. Raman.**

Post-independence, India prioritized **self-reliance in science and technology,** leading to remarkable advancements in fields such as space research, nuclear technology, and information technology. The establishment of organizations like **ISRO and DRDO** marked India's commitment to indigenous scientific progress and global recognition in various scientific domains.

COLONIAL ERA

During the Colonial Era in India, there were significant developments in education, infrastructure, and communication, driven largely by the needs and policies of the British colonial administration.

Educational and Infrastructural Growth

Establishment of Educational Institutions: The British established several educational institutions in India, aiming to educate a class of people who could assist in administration. Notable institutions like the **University of Calcutta, the University of Bombay, and the University**

of Madras were founded during this period. These institutions introduced **Western-style education** and curricula in India.

- **Introduction of Transportation (Railways and Automobiles):** The British introduced railways in India, transforming the country's transportation landscape. The first railway line in India was opened in **1853, running from Bombay (now Mumbai) to Thane.** This development revolutionized travel and trade within the country. The era also saw the introduction of automobiles, further changing the dynamics of transportation.
- **Communication Developments (Telegraph and Telephone Services):** The telegraph was introduced in India in the **early 1850s,** providing a new means of rapid communication across vast distances. The introduction of telephone services came next, further enhancing both domestic and international communication capabilities.

INDEPENDENCE ERA

In the post-independence era, India has made significant strides in technological development, particularly in **space technology, information technology, and renewable energy.**

Technological Prowess

- **Space Technology:** The **Indian Space Research Organisation (ISRO), established in 1969 (evolved from INCOSPAR (founded in 1962)),** symbolises India's ambitious foray into space technology. ISRO has achieved numerous milestones, including the development of indigenous satellites and launch vehicles and notable missions like **Chandrayaan and Mangalyaan.**
- **Information Technology:** India has emerged as a global leader in the information technology sector. The IT industry has become a **major contributor** to the country's economy, with Indian IT firms and professionals gaining worldwide recognition for their expertise and innovation.
- **Renewable Energy:** India has set ambitious targets for **renewable energy**, aiming to install 500 GW of renewable energy capacity by 2030. This included a significant focus on solar and wind energy, reflecting the country's commitment to sustainable development and addressing climate change. According to the Central Electricity Authority, India was able to achieve 43.82% of total energy production through non-fossil sources.
- **Nuclear Technology:** India has made significant advances in peaceful use of nuclear science in field of energy production, cancer treatment and diagnosis, nuclear medicine, irradiation and its defence needs (as deterrence). Indias three stage nuclear energy programme to use spent fuel and thorium to produce energy is one of its kind in the world.

THE CONTRIBUTIONS OF INDIAN SCIENTISTS

Indian scientists have made remarkable contributions across various fields, significantly advancing **global knowledge and innovation.** Their pioneering work, ranging from mathematics and physics to biology and space technology, has not only enhanced **scientific understanding** but also played a crucial role in **societal development and technological progress,** both within India and internationally. These contributions reflect India's rich scientific heritage and ongoing commitment to research and development.

Srinivasa Ramanujan Aiyangar (1887–1920)

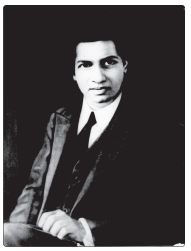

Fig. 1.1: Srinivasa Ramanujan

- **Field:** Mathematics
- **Contributions:**
  - Ramanujan is celebrated for his pioneering contributions in the fields of **mathematical analysis, number theory, and infinite series.**
  - Despite lacking formal training, his intuition and originality led him to derive over 3,000 mathematical results, including properties of highly composite numbers, the **Ramanujan prime, the Ramanujan theta function, and partition formulae.**
  - In 1911, he published a brilliant research paper on **Bernoulli** numbers. This got him recognition, and he became well-known as a mathematical genius.
  - He achieved the distinction of being the second Indian elected as a Fellow of the Royal Society of London and the first Indian elected as a Fellow of **Trinity College.**
- **Legacy:** The **Ramanujan Journal** is devoted to areas of mathematics where his work has had an impact. His work has inspired a significant amount of additional mathematical research.

Chandrasekhara Venkata Raman (1888–1970)

Fig. 1.2. C.V. Raman

- **Field:** Physics
- **Contributions:**
  - C.V. Raman is best known for his work on the **scattering of light** and the discovery of the **Raman effect,** which demonstrated that **light quanta have particle-like properties** in addition to **wave-like properties.** His discovery was instrumental in the development of quantum physics.
  - Due to his deep love of music, he worked on musical instruments like the veena, violin, tabla, and mridangam.
  - In 1921, he read a paper on the theory of stringed instruments before the Royal Society of London. In 1924, he was made a Fellow of the Royal Society.
- **Legacy:** He was awarded the **Nobel Prize in Physics in 1930** for his discovery. He was the first Asian to receive this award. The Raman effect is now the basis for Raman spectroscopy, a tool widely used in chemical analysis and research.

Jagdish Chandra Bose (1858–1937)

Fig. 1.3. Jagdish Chandra Bose

- **Field:** Physics, Biophysics, and Botany
- **Contributions:**
  - In recognition of his work on "The Electromagnetic Radiation and Polarisation of Electric Rays," he was knighted in 1917 and became a Fellow of the Royal Society of London in 1920. This distinguished him as the initial Indian physicist to achieve this honour in the field of physics.
  - Bose is credited with making significant contributions to the field of **radio and microwave optics.** He pioneered the investigation of **radio and microwave optics,** and he significantly contributed to plant science by experimenting with plant stimuli.
  - He also invented the **crescograph,** an instrument that measures plant growth.
- **Legacy:** Bose is considered a pioneer in biophysics and is also regarded as one of the fathers of radio science

Homi Jehangir Bhabha (1909–1966)

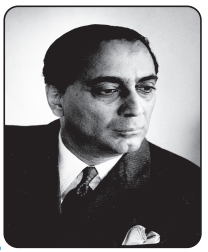

Fig. 1.4. Homi Jehangir Bhabha

- **Field:** Nuclear Physics
- **Contributions:**
  - During his tenure as a physics professor at the Indian Institute of Science, he conceived the notion of establishing a research institute focused on emerging areas of physics. This vision materialised with the inception of the Tata Institute of Fundamental Research (TIFR) in 1945.
  - Bhabha is known as the **father of the Indian nuclear programme.** He was the founding director of the **Tata Institute of Fundamental Research and the Trombay Atomic Energy Establishment (now Bhabha Atomic Research Centre).**
- **Legacy:** His major contributions include **research on cosmic rays and quantum theory.** He also played a key role in developing **nuclear weapons for India.**

Vikram Ambalal Sarabhai (1919–1971)

Fig. 1.5. Vikram Sarabhai

- **Field:** Space Science
- **Contributions:**
  - Dr. Vikram Ambalal Sarabhai, a prominent figure in modern India, was the **founder of the Indian Space Research Organisation (ISRO),** and he also spearheaded the launch of India's inaugural satellite, Aryabhatta.

- Under the mentorship of Dr. C.V. Raman, he delved into the study of **cosmic rays,** culminating in a Ph.D. from Cambridge University. His research on cosmic rays revealed their origin as energetic particles from outer space, undergoing alterations influenced by the sun, the Earth's atmosphere, and magnetic forces during their journey to Earth.
- He was instrumental in establishing the **Physical Research Laboratory (PRL) in Ahmedabad** and initiating space research and satellite communication in India.
- Dr. Sarabhai significantly contributed to cost savings for India by initiating the domestic production of military hardware and essential medical supplies like antibiotics and penicillin, formerly imported from overseas.

- **Legacy:** Known as the **father of the Indian space programme,** Sarabhai's vision was to harness space technology for national development.

Verghese Kurien (1921–2012)

Fig. 1.6. Varghese Kurien

- **Field:** Dairy Farming, White Revolution
- **Contributions:**
  - Known as the **'Father of the White Revolution'** in India, Dr. Kurien was instrumental in transforming India's dairy industry.
  - He pioneered the **Anand model** of dairy cooperatives and played a key role in setting up the **National Dairy Development Board (NDDB)** and the **Gujarat Cooperative Milk Marketing Federation (GCMMF),** which manages the **Amul brand.**
- **Legacy:** His work led to Operation Flood, the world's largest agricultural dairy development programme, making India one of the largest milk producers globally.

Satyendra Nath Bose (1894–1974)

Fig. 1.7. Satyendra Nath Bose

- **Field:** Physics
- **Contributions:**
  - He was a renowned **Indian physicist** known for his work in **quantum mechanics** in the early 1920s. His most significant contribution was the development of **Bose-Einstein statistics** and the theory of the **Bose-Einstein condensate,** a state of matter for a **dilute gas of bosons** cooled to temperatures very close to **absolute zero.**
  - This work laid the foundation for the discovery of the Bose-Einstein condensate phenomenon, a pivotal concept in **quantum physics.** Bose's collaboration with Albert Einstein led to the development of Bose-Einstein statistics, which describe the statistical distribution of identical particles with integer spin, known as bosons, named in his honour.
- **Legacy:** The class of particles 'bosons' in quantum mechanics is named after him.

Subrahmanyan Chandrasekhar (1910–1995)

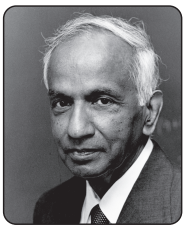

Fig. 1.8. Subrahmanyan Chandrasekhar

- **Field:** Astrophysics
- **Contributions:** Subrahmanyan Chandrasekhar was a distinguished astrophysicist whose contributions significantly advanced the understanding of **stellar evolution.** He is best known for his theoretical work on the physical processes important to the structure and evolution of stars, including his formulation of the **Chandrasekhar limit.** This limit describes the maximum mass of a stable white dwarf star, beyond which it would collapse, leading to significant insights into the later evolutionary stages of massive stars. For his profound contributions to the field of astrophysics, **Chandrasekhar was awarded the Nobel Prize in Physics in 1983,** sharing it with William A. Fowler.
- **Legacy:** He received the **Nobel Prize in Physics in 1983** for his theoretical studies of the physical processes of importance to the structure and evolution of stars.

Har Gobind Khorana (1922–2011)

Fig. 1.9. Har Gobind Khorana

- **Field:** Space
- **Contributions:**
- He served as the Project Director of India's first indigenous satellite launch vehicle (SLV-III), which successfully deployed the Rohini satellite in orbit in 1980.
- Dr. Kalam played a crucial role in the development of India's ballistic missile and space launch vehicle programs.
- Dr. Kalam played a key role in India's Pokhran-II nuclear tests in 1998, providing technical expertise and leadership in the design and testing of nuclear weapons.
- As an educator, Dr. Kalam emphasized the importance of research, innovation, and education in driving scientific and technological progress.
- **Legacy:** As the "Missile Man of India," he spearheaded advancements in aerospace and defense technology, while his presidency focused on fostering scientific temper and education. His vision continues to inspire generations, urging individuals to pursue excellence, embrace creativity, and contribute to the progress of society.

IMPACT OF SCIENCE AND TECHNOLOGY ON EVERYDAY LIFE IN INDIA

Science and technology have significantly **transformed** everyday life in India, bringing remarkable changes across various sectors. The widespread use of mobile technology and the internet has revolutionised communication, making information readily accessible. In **healthcare,** advancements have led to better diagnostics and treatments, improving public health. **Education** has been redefined with digital learning, breaking traditional barriers and enhancing accessibility. In **agriculture**, technological innovations have boosted crop production, which is crucial for India's predominantly agrarian economy. These changes reflect the pivotal role of science and technology in driving India's social and economic progress.

APPLICATIONS IN EVERYDAY LIFE

Science and technology have profoundly transformed daily life, reshaping communication through smartphones and social media. **Wearable technology** and telemedicine have revolutionised health monitoring and consultations. **Smart home technologies** and **GPS-based apps** have simplified living and transportation. Additionally, advancements in **environmental technology** have promoted sustainability. These innovations not only ease everyday tasks but also address global challenges, underscoring the vital role of science and technology in contemporary life.

Agriculture and Healthcare

- **Soil Testing, Crop Rotation, and Biotechnology**
  - In agriculture, **soil testing** has become indispensable for **optimising crop health and yield.** By analysing soil properties, farmers can make **informed decisions** about fertilisation and irrigation, leading to more efficient and sustainable farming practices.
  - **Crop rotation,** a practice of growing different types of crops in the same area across different seasons, helps in maintaining soil fertility and controlling pests and diseases.
  - **Biotechnology** has revolutionised agriculture in India, with **genetically modified crops** offering higher yields and better resistance to pests and environmental stresses.
  - **Example:** Companies like Agrocares and Soil Cares provide farmers with portable soil testing devices, enabling them to get immediate insights into soil health. Crop rotation practices, such as alternating rice with legumes, are common in Indian agriculture to maintain soil fertility. BT cotton is a widely adopted biotech crop in India, known for its pest resistance.
- **Medical Advancements, Including COVID-19 Vaccines**
  - The healthcare sector in India has witnessed significant advancements, particularly in the development and distribution of **COVID-19 vaccines.**
  - India has established itself successfully as a major pharmaceutical producer who provides quality medicines at cheap prices. Further India has emerged as a major Medical Tourism destination due to the quality of its services. Successful eradication of Polio, quality universal immunization programme are testament to India's advances in health sector. Recently leveraging Big Data, AI, Cloud computing etc India is trying to provide a first of its kind single unique digital identity which allows patients to store their health records and get better access to services and quality care under National Digital Health Mission.

- Indian pharmaceutical companies, such as the **Serum Institute of India,** played a pivotal role in producing vaccines at scale, contributing to global vaccination efforts.
- **Example:** The Covaxin vaccine, developed by Bharat Biotech, is a prominent example of India's contribution to the global fight against COVID-19. Telemedicine platforms like Practo have become household names, offering online consultations and healthcare services.

Transportation and Communication

- **Integration of GPS, Traffic Management, and Hydrogen Fuel Cars**
  - The integration of GPS technology in transportation has **greatly improved navigation and traffic management in India.** Real-time traffic updates and route optimisation have eased congestion in urban areas.
  - The exploration of **hydrogen-powered cars** represents India's commitment to sustainable and eco-friendly transportation solutions, aiming to reduce dependence on fossil fuels and lower carbon emissions.
  - **Example:** GPS-based apps like Google Maps are widely used for navigation across Indian cities. Traffic management systems in cities like Bengaluru use GPS data to optimise traffic flow. Companies like Tata Motors and Mahindra are exploring hydrogen fuel cell vehicles as future transportation solutions.
- **Mobile Phones, Internet, and Advancements in 5G Technology**
  - The widespread adoption of mobile phones and the internet has transformed communication in India.
  - The upcoming rollout of 5G technology promises to further revolutionise connectivity with **faster internet speeds, lower latency, and the ability to connect more devices simultaneously.** This advancement is expected to have a significant impact on various sectors, including healthcare, education, and industry.
  - India has successfully used its expertise and human resources in IT sector to produce Digital Public goods like Aadhaar, UPI etc allowing for financial inclusion and reaching last mile beneficiary.
  - **Example:** The widespread use of smartphones and affordable data plans by providers like Jio and Airtel has revolutionised internet access in India.

Energy and Environment

- **Development of Renewable Sources and Energy-Efficient Technologies**
  - India's focus on renewable energy sources, such as **solar and wind power,** is part of its commitment to sustainable development.
  - This includes the promotion of **LED lighting, energy-efficient appliances, and green building practices.**
  - **Example:** Solar panels installed on rooftops are becoming a common sight in Indian cities and villages. Energy-efficient LED bulbs, promoted by government schemes like UJALA, have replaced traditional incandescent bulbs in many households.
- **Science-Based Solutions for Waste Management and Pollution Control:**
  - Effective waste management and pollution control are critical for environmental sustainability in India.
  - Science-based approaches, such as **waste segregation, recycling, and the use of biodegradable materials,** are being implemented to tackle the challenge of waste disposal.
  - Pollution control measures, including air quality monitoring and the promotion of cleaner fuels, are helping to reduce environmental pollution.
  - **Example:** The Swachh Bharat Mission, focusing on effective waste management, has led to the widespread adoption of waste segregation at the source. Air purifiers and pollution monitoring apps like AQI India have become essential in urban areas to combat air pollution.

Defence and Industry

- **Contributions of CSIR and DRDO**
  - **The Council of Scientific and Industrial Research (CSIR) and the Defence Research and Development Organisation (DRDO)** have made significant contributions to India's defence and industrial sectors. CSIR's research in diverse fields, such as **aerospace, biotechnology, and electronics,** has bolstered India's industrial capabilities.
  - **DRDO's Contributions:** DRDO has been instrumental in the indigenization of defence technology in India. It has made significant advancements in developing small arms, mortars, rocket-propelled grenades (RPGs), disposable rocket launchers (RLs), mines, bombs, and ammunition.

- **CSIR's Contributions:** CSIR has been a pioneer in scientific and industrial research in India. It has made significant strides in various fields of science and technology, contributing to the nation's industrial and economic development.
- CSIR's work spans a wide range of areas, including aerospace engineering, structural engineering, ocean sciences, life sciences, metallurgy, chemicals, mining, food, petroleum, leather, and environmental science. CSIR designed and developed **HANSA-NG,** India's first all-composite aircraft; it also established the world's first **'Traditional Knowledge Digital Library',** a groundbreaking initiative to document and protect traditional and indigenous knowledge, especially in medicine.
- **Example:** DRDO's development of the **Prithvi and Agni missiles is a testament** to India's capabilities in defence technology. CSIR's research has led to innovations like the indigenously developed **Rotavirus vaccine,** enhancing public health.

INTEGRATING SCIENCE AND SOCIETY

The integration of science and society is crucial to shaping a sustainable and progressive future. This synergy involves harmonising scientific advancements with societal needs, ensuring that technological progress benefits all segments of society. It underscores the importance of sustainable practices, the fusion of traditional wisdom with modern science, and the crucial role of public engagement and policy in driving collective solutions.

Shift Towards Sustainable Practices

- Sustainable practices in science and society focus on balancing environmental, societal, and economic needs.
- This involves adopting methods that are environmentally friendly and socially responsible.
- For instance, the use of renewable energy sources and green technologies are key examples of sustainable practices.
- These approaches ensure that current needs are met without compromising the ability of future generations to meet their own needs.
- **Example:** The Indian government's initiative to install 500 GW of renewable energy capacity by 2030, focusing on solar and wind energy, is a prime example of sustainable practices. This move aims to reduce carbon emissions and promote sustainable energy sources.

Collaboration Between Modern Technical Science and Indigenous Wisdom

- Integrating modern science with indigenous wisdom, such as traditional medicine and **AYUSH (Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homoeopathy),** can lead to more holistic and culturally sensitive approaches to healthcare and environmental management.
- **Example:**
  - The Government of India is actively promoting AYUSH (Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homoeopathy) through initiatives like the **National AYUSH Mission (NAM) and the AYUSH Oushadhi Gunvatta Evam Uttpadan Samvardhan Yojana (AOGUSY),** aimed at enhancing services, quality, and visibility of AYUSH products.
  - Additionally, the Ministry of AYUSH's efforts in awareness, research, and education, along with the establishment of the **AYUSH Export Promotion Council (AYUSHEXCIL)**, are focused on expanding the global presence of AYUSH medicines and practices.

Engagement of Scientists with Policymakers and the Public

- Scientists engaging with **policymakers** and the public is crucial for developing collective solutions to societal challenges.
- In India, several programmes and initiatives are designed to enhance engagement between scientists, policymakers, and the public, fostering collective solutions to societal challenges. Here are some notable initiatives:
  - **India Alliance's Public Engagement Initiatives:** The DBT/Wellcome Trust India Alliance supports programmes that bridge the gap between the scientific community and the public. These initiatives aim to make science more accessible and encourage public participation in scientific discourse.
  - **Science Communication, Outreach, and Public Engagement (SCOPE) by the Department of Atomic Energy:** This programme organises activities for science communication, societal outreach, and public engagement, aiming to enhance the visibility and understanding of the Department of Atomic Energy's work.
  - **India Science, Technology, and Innovation (ISTI) Portal:** This portal acts as a comprehensive repository of information on ongoing and completed research projects, technologies, and scientific advancements in India, promoting public engagement with science and technology.
- **Example:** The **'Science, Technology, and Innovation Policy 2020'** by the Government of India aims to bring scientists closer to policymaking and encourage public engagement.

Scientific Development and India's Progress

- **Essential for a Nation's Growth**
  - Scientific development is vital for India's growth, fostering innovation and new ideas. It plays a key role in addressing societal challenges and improving the quality of life.
  - **Example:** The development of the NavIC system by ISRO, India's own regional satellite navigation system, is a significant achievement in scientific development. It demonstrates India's capabilities in advanced space technology.

- **Emphasis on Science and Technology for National Development**
  - India's focus on science and technology, as seen in initiatives like **"Make in India,"** is crucial for national development.
  - This emphasis aims to transform India into a global manufacturing hub and foster technological advancements.
  - **Example:** The 'Digital India' initiative, launched by the Government of India, aims to transform India into a digitally empowered society and knowledge economy. It focuses on digital infrastructure as a utility to every citizen, governance, services on demand, and digital empowerment of citizens.

Challenges and Opportunities

Challenges Faced by India in Science and Technology

- **Inadequate Research Funding:** One of the primary challenges is the relatively low level of funding for research and development (R&D). Compared to leading countries in S&T, India's investment in R&D as a percentage of GDP is lower. This impacts the scale and scope of research activities.
- **Infrastructure Constraints:** There is a need for better Infrastructure in terms of state-of-the-art laboratories, research facilities, and technological resources. The lack of advanced infrastructure hampers high-end research and innovation.
- **Human Resource Development:** While India produces a large number of graduates in science and engineering, there is a gap in the quality and employabllity of these graduates. The challenge lies in improving the quality of education and training to produce world-class scientists and engineers.
- **Brain Drain:** Many of India's highly skilled professionals and students in the field of science and technology migrate to other countries for better opportunities. This brain drain Is a significant challenge in retaining talent and expertise within the country.
- **Innovation Ecosystem:** Although Improving, India's innovation ecosystem needs further development This includes aspects like industry-academia collaboration, startup support. Intellectual property rights (IPR) protection, and commercialization of research.
- **Regulatory and Bureaucratic Hurdles:** The regulatory framework and bureaucratic processes in India can sometimes be cumbersome and time-consuming, affecting the pace of scientific research and techno logical innovation.
- **International Collaboration:** While there are partnerships and collaborations with International Institutions, there is scope for expanding and deepening these relationships to leverage global knowledge and resources.
- **Focus on Applied Research:** There is a need for a greater focus on applied research that can be translated into practical solutions and products, which is crucial for enhancing global competitiveness.

GLOBAL CHALLENGES AND NECESSITY

- **Economic Disparity:** Globalisation can widen the wealth gap, both within and between nations. While it offers growth opportunities, the benefits are often unevenly distributed, leading to significant disparities.
- **Cultural Erosion:** The spread of a dominant global culture can lead to the erosion of local cultures and traditions.
- **Environmental Impact:** Globalisation can exacerbate environmental degradation through increased industrial activity and consumption patterns that are not sustainable.
- **Vulnerability to Global Economic Trends:** Economies become more interconnected, making them more susceptible to global economic fluctuations.
- The 2008 global financial crisis demonstrated how interconnected economies could rapidly transmit financial shocks across borders.

Resource Depletion

- **Definition:** This is the **consumption of a resource faster than it can be replenished.**
- Natural resources are separated into two categories: renewable sources and non-renewable sources. The depletion of both types of resources poses challenges for sustainability.

- The National Mission for a Green India, part of the National Action Plan on Climate Change, aims to address resource depletion by increasing forest cover in India.

Challenges in Resource Depletion

- **Sustainability Concerns:** The rapid depletion of natural resources, such as fossil fuels, water, and minerals, poses a significant threat to sustainability.
- **Environmental Degradation:** Overexploitation of resources leads to environmental issues like deforestation, loss of biodiversity, and soil erosion.
- **Economic Impact:** Resource depletion can have far-reaching economic consequences, particularly for industries and communities dependent on these resources.
- **Global Conflicts:** Competition over scarce resources can lead to conflicts and geopolitical tensions.
- The **Aral Sea crisis,** where extensive irrigation projects caused one of the world's largest lakes to shrink dramatically, is a stark example of resource depletion.

Intellectual Property Protection

- **Definition:** Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs, symbols, names, and images used in commerce. IP protection is critical for fostering innovation and creativity.
- The Indian Patent Act, which has been amended multiple times to meet international standards, reflects India's commitment to protecting intellectual property.

Challenges in Intellectual Property Protection

- **Balancing Rights and Access:** Ensuring that IP protection does not hinder access to essential services, such as medicines and education, is a critical challenge.
- **Piracy and Counterfeiting:** Despite stringent laws, piracy and counterfeiting remain rampant, undermining the benefits of IP protection.
- **Innovation vs. Monopoly:** Overly strict IP laws can stifle innovation and lead to monopolistic practices.
- **Global Enforcement:** The enforcement of IP rights across different jurisdictions with varying laws and standards is complex. The ongoing debates around patent laws in the pharmaceutical industry, especially regarding COVID-19 vaccines, highlight the challenges in balancing IP rights and public health needs.

Emphasis on Application-Oriented R&D, Human Resource Development, and S&T Integration

- **Application-Oriented R&D:** This refers to research and development that is aimed at **practical applications and outcomes.** It's about translating research findings into products, processes, and services that can be commercialised.
  - As the **COVID-19 pandemic** unfolded, there was an urgent global need for effective vaccines. **Bharat Biotech,** in collaboration with **ICMR and NIV**, quickly initiated the development of **Covaxin.** This rapid response demonstrated the ability to swiftly pivot research focus in response to global health needs.
- **Human Resource Development:** This involves developing the **skills and abilities** of people, particularly in science and technology, to meet the challenges of the modern world and drive innovation.
  - **IITs and IISERs** are known for their strong research cultures. They have state-of-the-art laboratories and research facilities that enable students and faculty to engage in cutting-edge research. Many of these institutions are involved in significant research projects in areas like **nanotechnology, biotechnology, renewable energy, and information technology.**
- **S&T Integration in National Activities:** This is about embedding science and technology into various national activities, including **economic development, healthcare, education, and infrastructure.**
  - The Digital India initiative, which aims to transform India into a digitally empowered society and knowledge economy. Under it, the **BharatNet Project** aims to connect rural areas with high-speed internet. It involves laying optical fibre cables to reach remote villages, thereby bridging the digital divide between urban and rural India. This technological advancement enables rural populations to access a wide range of online services, including education, healthcare, and government services.

Challenges in Application-Oriented R&D and S&T Integration

- **Funding and Investment:** Securing adequate funding for research and development is a significant challenge, especially in developing countries.
- **Bridging the Gap Between Research and Market:** Translating research into marketable products and

2 Overview of India's Science & Technology Sector

INTRODUCTION

This chapter explores the diverse landscape of Ministries and Departments for Science and Technology under the Central Government in India. Delving into key entities such as the **Department of Science and Technology (DST), Department of Atomic Energy (DAE),** and more, it examines their roles, programs, and resource allocations. The chapter also sheds light on the research ecosystem's evolution in India, addressing challenges and government initiatives. The focus spans from historical contexts to current statistics, offering a comprehensive overview of the nation's scientific and technological pursuits.

MINISTRY AND DEPARTMENTS FOR SCIENCE AND TECHNOLOGY UNDER CENTRAL GOVERNMENT

1. Department of Science and Technology (DST)

The **Department of Science and Technology was founded in May 1971**, primarily with the intention of advancing novel fields of science and technology. It serves as the nation's nodal department for organisation coordination and the advancement of science and technology-related initiatives.

- The Department has major responsibilities for specific projects and programmes which are as follows:
  1. Formulation of policies relating to Science and Technology.
  2. Matters relating to the **Scientific Advisory Committee of the Cabinet (SACC).**
  3. Promotion of new areas of Science and Technology with special emphasis on emerging areas.
     (a) Research and Development through its research institutions or laboratories for the development of indigenous technologies concerning bio-fuel production, processing, standardisation and applications, in coordination with the concerned Ministry or Department;
     (b) Research and Development activities to promote utilisation of by-products to develop value added chemicals.
  4. Coordination and integration of areas of Science & Technology having cross-sectoral linkages in which a number of institutions and departments have interest and capabilities.

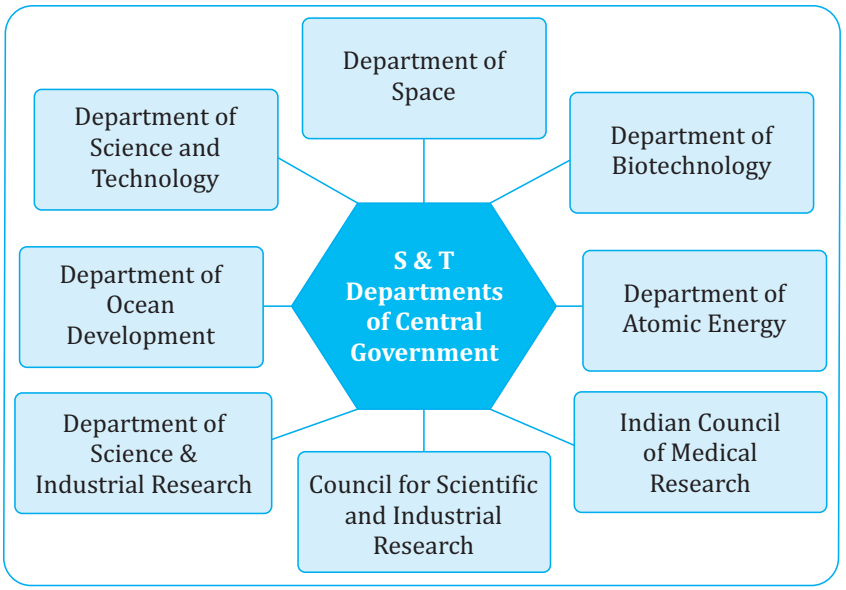

Fig. 2.1. Department of Science and Technology

5. Undertaking or **financially sponsoring** scientific and technological surveys, research design and development, where necessary.
6. Support and **Grants-in-aid to Scientific Research Institutions**, Scientific Associations and Bodies.
7. **All matters concerning:**
   (a) Science and Engineering Research Council.
   (b) **Technology Development Board** and related Acts such as the **Research and Development Cess Act, 1986 and the Technology Development Board Act, 1995.**
   (c) **National Council for Science and Technology Communication;**
   (d) National Science and Technology Entrepreneurship Development Board;
   (e) **International Science and Technology Cooperation** including appointment of scientific attaches abroad (These functions shall be exercised in close cooperation with the Ministry of External Affairs);
   (f) Autonomous Science and Technology Institutions relating to the subject under the Department of Science and Technology including **Institute of Astro-physics, and Institute of Geo-magnetism.**
   (g) Professional Science Academies promoted and funded by the Department of Science and Technology.
   (h) The Survey of India, and National Atlas and Thematic Mapping Organisation.
   (i) National Spatial Data Infrastructure and promotion of G.I.S.
   (j) The National Innovation Foundation, Ahmedabad.
8. Matters commonly affecting Scientific and technological departments/organisations/ institutions e.g. financial, personnel, purchase and import policies and practices.
9. Management Information Systems for Science and Technology and coordination thereof.
10. Matters regarding Inter-Agency/Inter-Departmental coordination for evolving science and technology missions.
11. **Matters concerning domestic technology** particularly the promotion of ventures involving the commercialization of such technology other than those under the Department of Scientific and Industrial Research.
12. All other measures needed for the promotion of science and technology and their application to the development and security of the nation.
13. Matters relating to institutional Science and Technology capacity building including setting up of new institutions and institutional infrastructure.
14. Promotion of Science and Technology at the State, District, and Village level for grassroots development through State Science and Technology Councils and other mechanisms.
15. Application of Science and Technology for weaker sections, women and other disadvantaged sections of Society.

Key Initiatives of Department of Science and Technology

The Department of Science and Technology (DST) in India launches numerous programs and projects across diverse areas of science and technology.

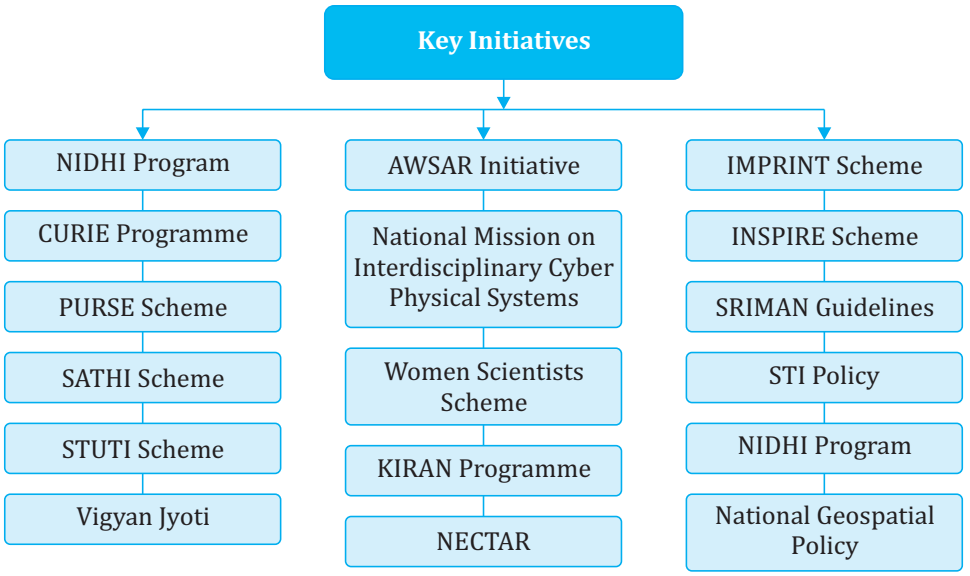

Fig. 2.2. Key initiative in the Field of Science and Technology

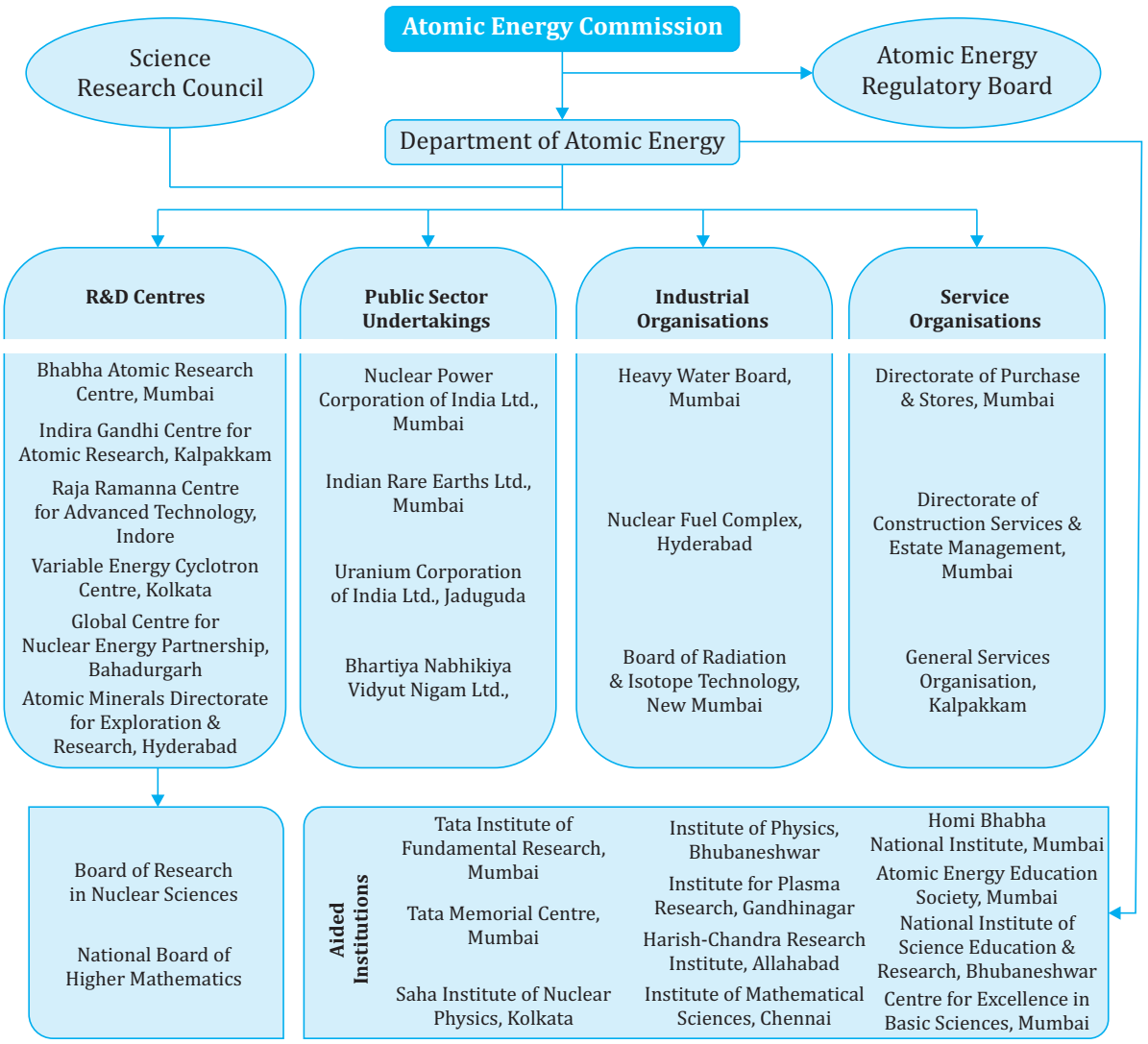

Fig. 2.3. Organisational Structure of Atomic Energy Commision

- **Mandate:** The mandate of the Department, on which its programmes are based, covers:
  - **Increasing share of nuclear power** through deployment of indigenous and other proven technologies, along with development of fast breeder reactors and thorium reactors with associated fuel cycle facilities;
  - **Building and operation of research reactors** for production of radioisotopes and carrying out radiation technology applications in the field of medicine, agriculture and industry, cancer care, water related technologies, waste management etc.;
  - **Developing advanced technologies** such as accelerators, lasers, supercomputers, advanced materials and instrumentation, and encouraging transfer of technology to industry;
  - **Support to basic research** in nuclear energy and related frontier areas of science; interaction with universities and academic institutions; **Support to research and development projects** having a bearing in DAE's programmes, and international cooperation in related advanced areas of research, and,
  - **Contribution to national security.**
- **Activities**
  - The Department is engaged in th**e design, construction and operation of nuclear power research reactors and the supporting nuclear fuel cycle** technologies covering exploration, mining and processing of nuclear minerals, production of heavy water, nuclear fuel fabrication, fuel reprocessing and nuclear waste management.
  - The department not only advances technology but also aids national prosperity by **fostering skilled human resources a**nd supporting the Indian industry.

- Spearheaded by the Department of Atomic Energy, **the National Cancer Grid** aims to transform cancer care across India. **Launched in 2012,** it connects a vast network of:
  - **Hospitals:** Providing specialised cancer treatment and advanced diagnostics.
  - **Research Institutes:** Fueling advancements in cancer prevention, diagnosis, and treatment.
  - **Experts:** Sharing knowledge and expertise through telemedicine consultations and online education.
- The Department is also **developing better crop varieties, techniques for control/eradication of insects thus protecting the crops,** radiation based post harvest technologies, radiation based techniques **for diagnosis and therapy of disease particularly cancer,** technologies for safe drinking water, better environment and robust industry.

4. Department of Space

- The **Department of Space (DOS)** has the primary **objective** of promoting development and application of space science and technology to assist in all-round development of the nation. Towards this, **DOS has evolved the following programmes:**
  1. **Launch Vehicle programme** having indigenous capability for launching spacecraft.
  2. **INSAT Programme** for telecommunications, broadcasting, meteorology, development of education, etc.
  3. **Remote Sensing Programme** for application of satellite imagery for various developmental purposes.
  4. **Research and Development in Space Sciences and Technology** for serving the end of applying them for national development.
- With the setting up of the **Indian National Committee for Space Research (INCOSPAR) in 1962,** space activities in the country were initiated. In the same year, the work on the Thumba Equatorial Rocket Launching Station (TERLS) near Thiruvananthapuram was also started.
- **Indian Space Research Organisation (ISRO)** was established in August 1969. The Government of India constituted the **Space Commission and established the Department of Space (DOS) in June 1972 and brought ISRO under DOS in September 1972**.

Activities

The Department of Space has evolved the following programmes with the objective of promoting & developing application of space science and space technology:

- **Launch Vehicle programme** having indigenous capability for launching the satellites.
- Programme for telecommunications, broadcasting, meteorology, development of education etc.
- **Remote Sensing Programme** for application of satellite imagery for various developmental purposes.
- **NavIC system** for satellite based navigation.

Services Provided by the Department of Space

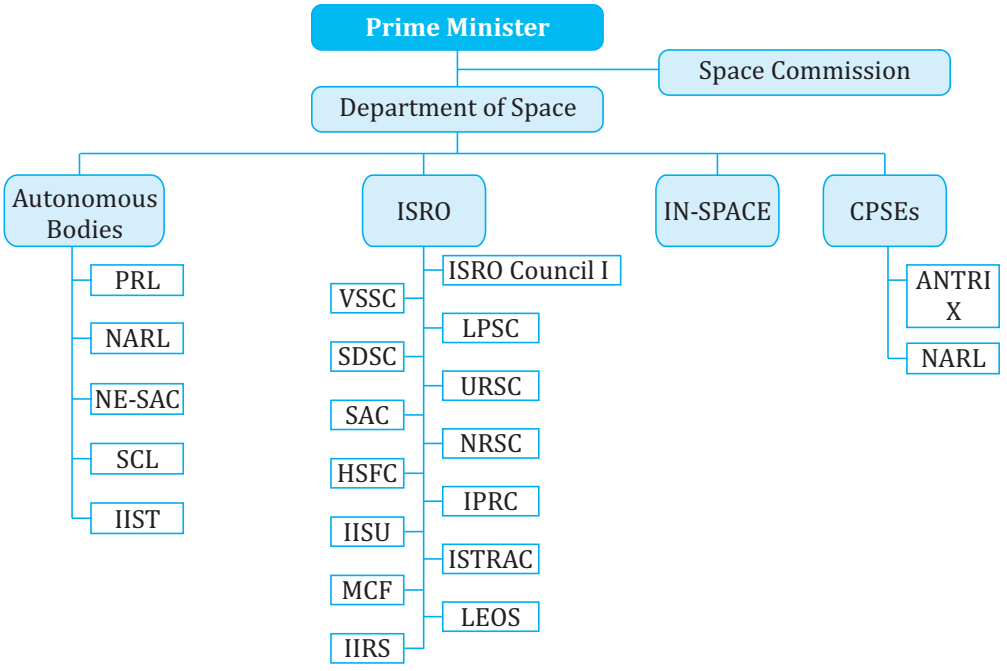

Fig. 2.4. Organisational Structure of Department of Space

- Provide **national space infrastructure** for the telecommunication needs of the country.
- Provide **satellite services** required for weather forecasting, monitoring etc.
- Provide satellite imagery required for the developmental and security needs of the country.
- Provide satellite imagery and specific products and services required for application of space science and technology for developmental purposes to the Central Government, State Governments, Quasi Governmental Organisations, NGOs and the private sector.
- **Provide space based navigation system.**
- Provide launch services, satellite or sub-systems, launch support, mission support, ground system support and disaster management.
- **Transfer of technologies for technological, industrial and societal applications.**
- Promote Research & Development in space sciences and technology.

Antrix Corporation Limited

- Antrix Corporation Limited (ACL), Bengaluru is a **wholly owned Government of India Company** under the administrative control of the Department of Space.
- Antrix Corporation Limited was incorporated as a **private limited company owned by the Government of India** in September 1992 as a **Marketing arm of ISRO for promotion** and commercial exploitation of space products, technical consultancy services and transfer of technologies developed by ISRO. Another major objective is to facilitate development of space related industrial capabilities in India.
- As the commercial and marketing arm of ISRO, Antrix is engaged in **providing Space products and services to international customers worldwide.**
- Antrix provides **end-to-end solution** for many of the space products, ranging from supply of hardware and software including simple subsystems to a complex spacecraft, for varied applications covering communications, earth observation and scientific missions; space related services including remote sensing data service, Transponder lease service; Launch services through the operational launch vehicles (PSLV and GSLV); Mission support services; and a host of consultancy and training services.

The Devas-ISRO's Antrix Corporation Deal: A Saga of Controversy

In 2005, a deal between Antrix Corporation, the commercial arm of the Indian Space Research Organisation (ISRO), and Devas Multimedia, a Bengaluru-based startup, sparked substantial controversy and extended legal battles. Let's delve into the key aspects of this complex saga:

The Deal:

- Antrix leased two communication satellites, GSAT-6 and GSAT-6A, to Devas for 12 years at a significantly lower price than market value.
- Devas planned to use the S-band spectrum on these satellites to provide multimedia services across India.

Allegations of Corruption:

- Critics argued that the deal undervalued the spectrum, causing a potential loss of billions of dollars to the Indian exchequer.
- The low lease price and Devas's connections to influential politicians raised suspicions of corruption and cronyism.

Cancellation and Legal Battles:

- In 2011, the UPA government cancelled the deal citing national security concerns and the need for the S-band spectrum for defence purposes.
- Devas challenged the cancellation through international arbitration, winning a $1.2 billion compensation award in 2015.
- Indian courts overturned the arbitration award, but legal battles continue with further appeals pending.

Current Status:

- The Supreme Court of India is yet to hear the final appeal against the Devas-Antrix deal.
- The controversy continues to raise questions about transparency and decision-making in India's space program.

Impact:

- The Devas-Antrix deal casts a shadow on India's image as a reliable partner in international space collaborations.
- It highlighted the need for robust regulatory frameworks and due diligence in commercial agreements involving strategic assets.

NewSpace India Limited (NSIL)

- NewSpace India Limited (NSIL), incorporated on 6 March 2019 **(under the Companies Act, 2013) is a wholly owned Government of India company,** under the administrative control of Department of Space (DOS).
- NSIL is the commercial arm of Indian Space Research Organisation (ISRO) with the primary responsibility of **enabling Indian industries to take up high technology space related activities and is also responsible for promotion and commercial exploitation of the products and services** emanating from the Indian space programme.
- To satisfy the needs of its customers, NSIL draws upon the proven heritage of the Indian Space Program and ISRO's vast experience in diverse branches of Space Technology.
- **The major business areas of NSIL include:**
  (a) **Production of Polar Satellite Launch Vehicle (PSLV) and Small Satellite Launch Vehicle (SSLV) through industry;**
  (b) Production and marketing of space-based services, including launch services and space-based applications like transponder leasing, remote sensing and mission support services.
  (c) **Building of Satellites** (both Communication and Earth Observation) as per user requirements.
  (d) **Transfer of technology** developed by ISRO centres/ units and constituent institutions of Dept. of Space.
  (e) **Marketing spin off technologies** and products/ services emanating out of ISRO activities

Indian National Space Promotion and Authorization Center (IN-SPACe)

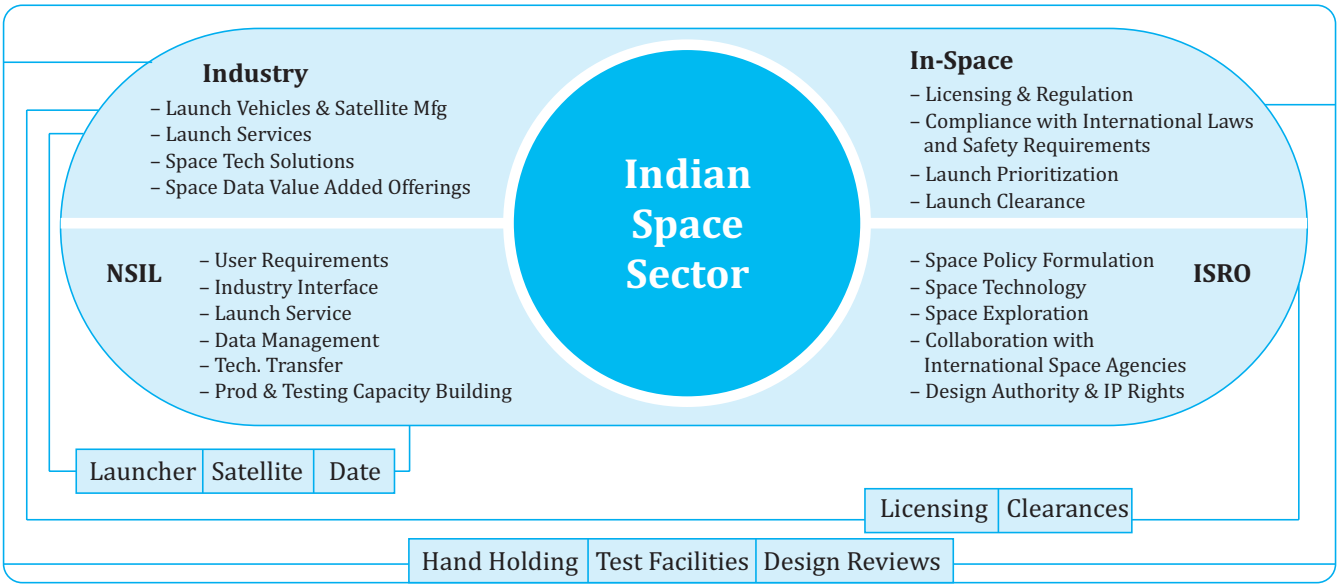

Fig. 2.5. Overview of Indian Space Sector

- Indian National Space Promotion and Authorisation Centre (IN-SPACe) is a **single-window, independent, nodal agency** that functions as an **autonomous agency in the Department of Space (DOS).**
- It is formed following the Space sector reforms to enable and facilitate the participation of private players.
- IN-SPACe is **responsible to promote, enable, authorise and supervise various space activities of non-governmental entities** including building launch vehicles & satellites and providing space-based services; sharing space infrastructure and premises under the control of DOS/ISRO; and establishing of new space infrastructure and facilities.
- The agency acts as an interface between ISRO and Non-Governmental Entities (NGEs) and **assesses how to utilise India's space resources better and increase space-based activities**. It also assesses the needs and demands of private players, including educational and research institutions, and explores ways to accommodate these requirements in consultation with ISRO.

5. Department of Biotechnology

Historical background

- In 1986, then-Prime Minister Rajiv Gandhi recognized India's need for a dedicated Department of

Biotechnology (DBT) within the Ministry of Science and Technology. This visionary move addressed macro-economic growth challenges tied to scientific development.

- Formed in 1982, the National Biotechnology Board laid the groundwork, and the 1986-established DBT pioneered biotechnology in India.
- Dr. S Ramachandran became the first Secretary, overseeing a ten-member Scientific Advisory Committee (SAC).

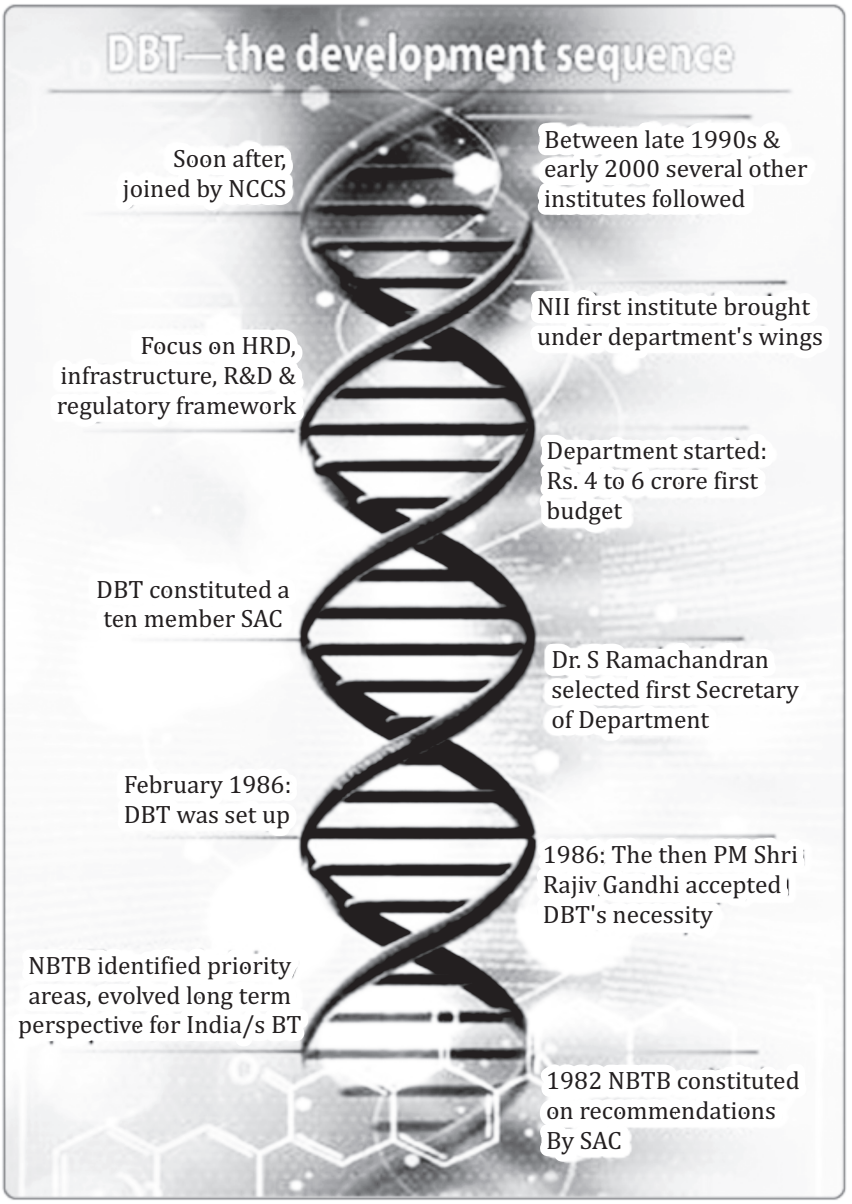

Fig. 2.6. Development sequence of the Department of Biotechnology

- The DBT incorporated the **National Institute of Immunology** and fostered institutes like the **National Centre for Cell Science, National Institute for Plant Genome Research, and National Brain Research Centre.**
- Throughout the **late 1990s and early 2000s**, new institutions emerged, emphasising areas like biomedicine, stem cell research, and agricultural biotechnology.
- The DBT's focus expanded to encompass health care, food, agriculture, energy, and environmental security. Strategic international collaborations and industry partnerships grew.
- Notably, the DBT prioritised **Young India through grants**, funds, and awards, committing to enhance funding mechanisms for efficient project assessment and fund disbursement.
- This journey underscores India's transformative progress in biotechnology and its commitment to addressing societal challenges through advanced scientific and technological interventions.

Vision

- "Attaining new heights in biotechnology research, shaping biotechnology into a premier precision tool of the future for creation of wealth and ensuring social justice – specially for the welfare of the poor."

Mission

- The Department shall devote wholly to **achieve excellence in the promotion of biotechnology in the country**.
- The Department shall provide services in the areas of research, infrastructure, generation of human resource, popularisation of biotechnology, promotion of industries, creation of centres of excellence, implementation of biosafety guidelines for genetically modified organisms and recombinant DNA products and biotechnology-based programs for societal benefits.
- **Bioinformatics** is a major mission to establish an information network for the scientific community, nationally and internationally. Their mission is:
  - Realising full potential of biotechnology
  - A well directed effort, a significant investment for the generation of products, processes and technologies.

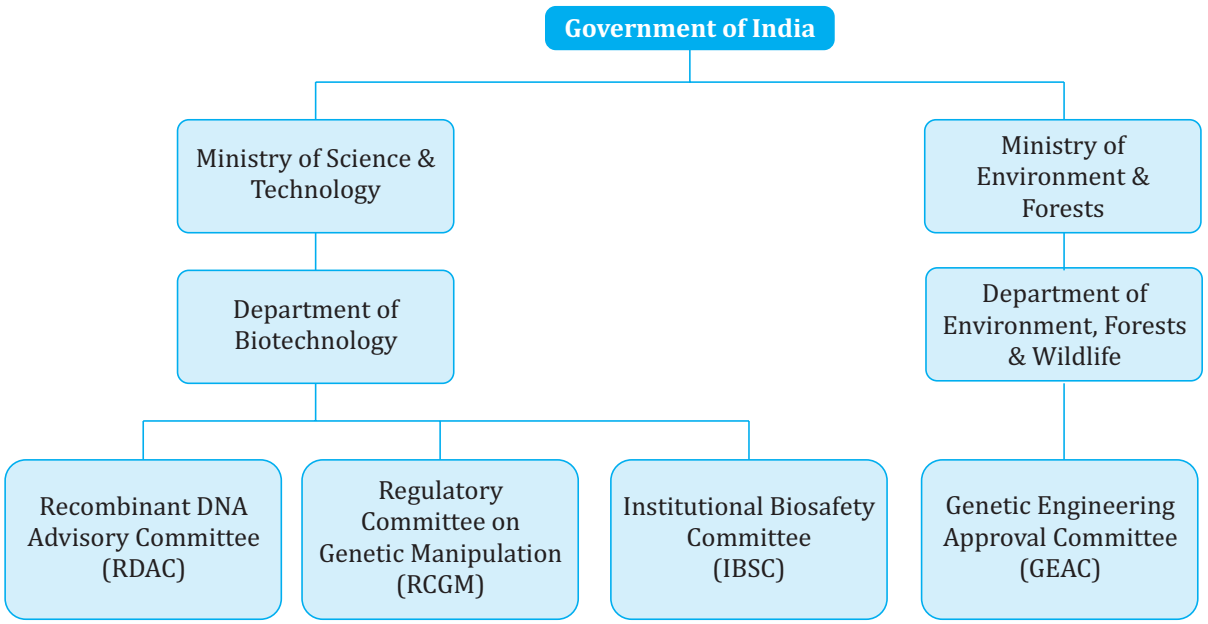

Fig. 2.7. Overview of Government Departments Related to Biotechnology and Environment

  - Enhance efficiency and productivity and cost-effectiveness of agriculture, nutritional security, molecular medicine, environmentally sustainable technologies, scientific and technological empowerment of human resource, a strong infrastructure for research and commercialization, enhance the knowledge base, nurturing the leads of potential utility, and bring the bio-products to the marketplace.
  - Socio-economic development/applicants of biotech for Upliftment of women, rural, SC & ST population.

National Biotechnology Development Strategy (2015-2020)

- The Department of Biotechnology (DBT), Government of India, announced the First National Biotechnology Development Strategy in September 2007.
- In 2015, DBT announced "**The National Biotechnology Development Strategy-2015-2020"** (hereinafter referred to as 'Strategy-II'), which was framed after a wider consultation with stakeholders. Strategy-II would seamlessly build on the earlier Strategy to accelerate the pace of growth of the biotechnology sector at par with global requirements.
- NBDS 2020-2025 (Draft) aims to make India a global leader in biotechnology research, innovation, and industrial growth. It has a mission to establish a $150 billion bio-economy by 2025 by building on successes of NBDS (2015-2020).

Guiding Principles that Will Drive the Strategy

Consultations with stakeholders have identified the **following 10 guiding principles that shall drive the renewed mission through Strategy-II.**

1. Building a Skilled Workforce and Leadership
2. Revitalising the Knowledge Environment at par with the Growing Bio-economy
3. Encourage Use-inspired Discovery Research
4. Focus on Biotechnology Tools for Inclusive Development

5. Commercialization of Technology – Nurturing Innovation, Translational Capacity and Entrepreneurship
6. Biotechnology and Society – Ensuring a Transparent, Efficient and Globally Best Regulatory System and Communication Strategy
7. Biotechnology Cooperation – Fostering Global and National Alliances
8. Strengthen Institutional Capacity with Redesigned Governance Models
9. Create a Matrix of Measurement of Processes as well as Outcome.
10. Enhance Research opportunities in basic, disciplinary and inter-disciplinary sciences.

Sectoral Priorities

The Department has identified the following sectors to accelerate the pace of growth of the biotechnology sector at par with global requirements.

1. Human Resource
2. Building Knowledge Environment
3. Research Opportunities: human genome research, vaccines, infectious & chronic disease biology, stem cells & regenerative medicine, basic research, translation research, human developmental and disease biology – maternal & child health, bio-engineering and bio-design
4. Agriculture, Animal Health and productivity
5. Medicinal and Aromatic Plants
6. Food fortification and biofortification
7. Bioprospecting, value-added biomass & products
8. Marine biotechnology & biodiversity
9. Environmental management, Clean bio-energy
10. Nurturing Entrepreneurship – IP Landscaping, Technology Transfer, Incubators, Entrepreneurship, SME Support Systems
11. Biotechnology and society
12. Biotechnology Cooperation

Major Initiatives of the National Biotechnology Development Strategy 2015-2020

- Launch **four major missions in healthcare, food and nutrition, clean energy and education.**
- Create a technology development and translation network across India with global partnerships, including 5 new clusters, 40 biotech incubators, 150 TTOs, and 20 bio-connect centres.
- Ensure strategic and focused investment in building human capital by setting up a Life Sciences and Biotechnology Education Council

6. Ministry of Earth Sciences/Department of Ocean Development

- The Ministry of Earth Sciences (MoES), under the Government of India, is mandated to provide services for weather, climate, ocean and coastal state, hydrology, seismology, and natural hazards; to explore and harness marine living and non-living resources in a sustainable manner for the country and to explore the three poles of the Earth (Arctic, Antarctic and Himalayas).
- **MoES was formerly the Department of Ocean Development (DOD)**, which was created in July 1981 as a part of the Cabinet Secretariat directly under the charge of the Prime Minister of India. It came into existence as a separate department in March 1982.
  - The erstwhile DOD functioned as a nodal institution for organising, coordinating and promoting ocean development activities in the country. The Government of India notified DOD as the Ministry of Ocean Development in February 2006.
- **In July 2006,** the Ministry of Ocean Development was **reorganised by the Government of India with Presidential notification into the new Ministry of Earth Sciences (MoES).**
  - This brought the **Indian Meteorological Department (IMD)**, Delhi, the **Indian Institute of Tropical Meteorology (IITM)**, Pune, and **National Centre for Medium Range Weather Forecasting (NCMRWF),** Noida under the purview of MoES administration.
  - The Government also approved the setting up of **Earth Commission** on the pattern of **Space Commission (government department responsible for administration of the Indian space program) and Atomic Energy Commission (governing body of the Department of Atomic Energy).**

Major Initiative Under MoES

1. **National Centre for Coastal Research (NCCR):** NCCR focuses on understanding and addressing coastal processes and issues in India. They conduct research on topics like coastal erosion, sea level rise, storm surges, and coastal ecosystems.
2. **India Meteorological Department (IMD):** IMD, founded in 1875, is India's national meteorological service. They provide weather forecasts, warnings for cyclones and other extreme weather events, and climate information. IMD plays a crucial role in disaster preparedness and mitigation across the country.
3. **Indian National Centre for Ocean Information Services (INCOIS)**: INCOIS, established **in 1999,** focuses on providing oceanographic data and information services to various stakeholders. They

monitor oceanographic parameters like currents, waves, sea level, and marine weather. INCOIS's data and services are used for fisheries management, maritime safety, coastal zone management, and scientific research.

4. **National Centre for Polar and Ocean Research (NCPOR):** NCPOR, established in 1981, is India's premier research institute for polar and marine sciences. They conduct research on the Arctic, Antarctic, and Indian Ocean, focusing on topics like ocean circulation, climate change, marine ecosystems, and polar biology. NCPOR plays a vital role in India's polar research program and contributes to international research efforts.
5. **Earthquake Risk Evaluation Centre (EREC):** EREC, established in 2009, falls under the Atmospheric Sciences and Seismology sector of the MoES. They focus on assessing earthquake risks across India and developing earthquake preparedness strategies. EREC conducts research on earthquake hazards, vulnerability, and mitigation, and provides information and expertise to government agencies and other stakeholders.
6. **Indian Tsunami Early Warning Centre (ITEWC): ITEWC, established in 2007,** provides tsunami warnings and advisories to the Indian coast. They monitor real-time data from seismic stations and tide gauges to detect tsunamis and disseminate warnings quickly and effectively. ITEWC plays a crucial role in saving lives and minimizing damage from tsunamis in India.
7. **National Center for Earth System Sciences (NCESS): NCESS, established in 1978,** focuses on research on the Earth system, including the atmosphere, oceans, land, and cryosphere. They conduct research on climate change, air quality, monsoon dynamics, and natural hazards. NCESS's research contributes to improved understanding of the Earth system and informs policy decisions on environmental issues.

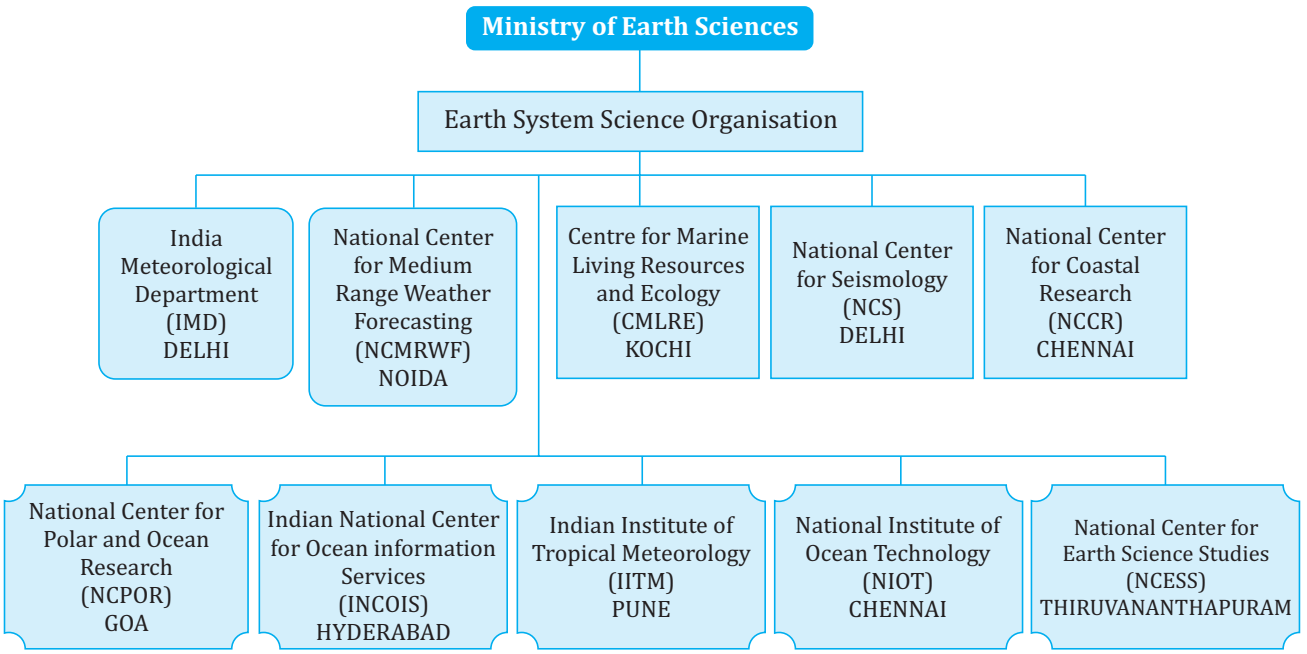

Fig. 2.8. Earth System Science Organisation (MoES)

STEPS TAKEN- POLICIES AND SCHEMES BY THE GOVERNMENT FOR PROMOTION OF SCIENCE AND TECHNOLOGY

Policies

- Science, Technology and Innovation (STI) plays a significant role in fostering socio-economic and political development globally and benefitting all the sectors through scientific and technological advances. STI acts as a key determinant in addressing socio-economic challenges related to critical sectors such as health, environment, education, food, energy, climate change, water etc.
- **Four major policies have been implemented since independence** namely, Scientific Policy Resolution (SPR1958), Technology Policy Statement 1983 (TPS1983), Science and Technology Policy 2003 (STP2003), and Science Technology Innovation Policy 2013 (STIP2013). These policies guided the evolution of India's STI ecosystem.

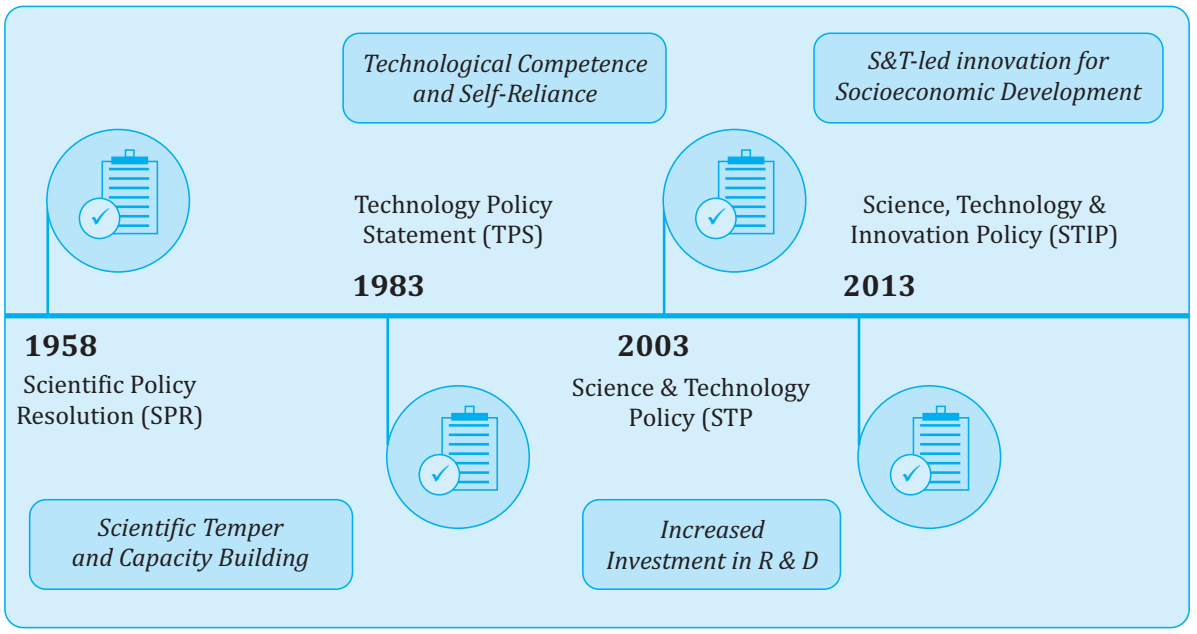

Fig. 2.9. Timeline of Science Policies

1. **Scientific Policy Resolution 1958(SPR 1958)**
   - In 1958, the Indian government, led by Prime Minister Jawaharlal Nehru, formulated its inaugural science policy, SPR 1958.
   - This policy aimed at industrialization to provide citizens with economic, social, and cultural benefits.
2. **Science and Technology Policy of the 1983**

1958

MOTIVATION	SALIENT FEATURES	IMPACT
Nurturing scientific enterprise/scientific temper. S &T seen as an instrument of socio-economic transformation and nation building.	Cultivation of scientific enterprise in pure and applied science research and capacity building. Opportunities for scientific activity, discovery and dissemination of new knowledge.	Emergence of several scientific organizations and national laboratories. Strong foundation in R & D and higher education.

Fig. 2.10. Science Technology and Policy 1983

1983

MOTIVATION	SALIENT FEATURES	IMPACT
Technology seen to influence lives and bolster societal expectations. Focus on meeting people's aspirations through technological development.	Maximize utilization of local (human and material Resources. Strengthen technological self-reliance in new sectors: Information, electronics, and biotechnology.	Establishment of Technology Development Fund (TDB). Establishment of Technology, Information Forecasting and Assessment Council (TIFAC).

Fig. 2.11. Science Technology and Policy 1983

- **Technological self-reliance** through the development and promotion of indigenous technologies was the main focus of TPS 1983. Adopting local technology would increase the use of available resources (both human and material) and lessen vulnerabilities in important areas.

3. Science and Technology Policy of the 2003

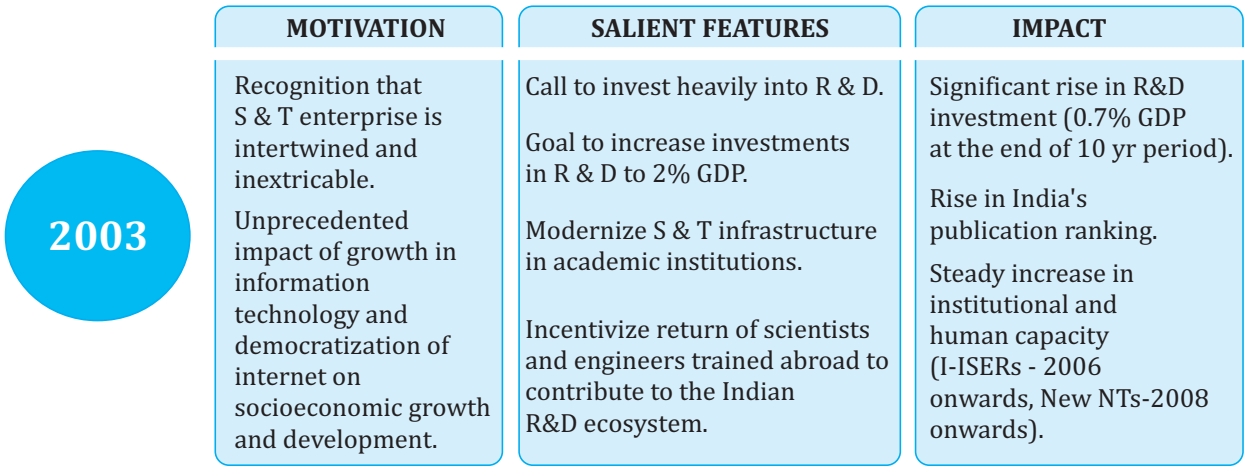

Fig. 2.12. Science and Policy 2003

- **An important aspect of STP2003** was a call to **heavily invest in R&D** with the goal of **raising investment to 2% of GDP,** as well as a process to create mechanisms within ministries and agencies to solicit input from scientists and technologists regarding planning and policymaking. It also advocated creation of intellectual property regimes and fusion of industry and science.

4. Science, Technology And Innovation Policy 2013

- India needed to integrate science, technology, and innovation in order to rank among the world's top five scientific powers. The fourth policy, the STIP2013, was put into effect with this goal in mind. As the name implies, the term **"innovation"** was a crucially new addition to this policy document.

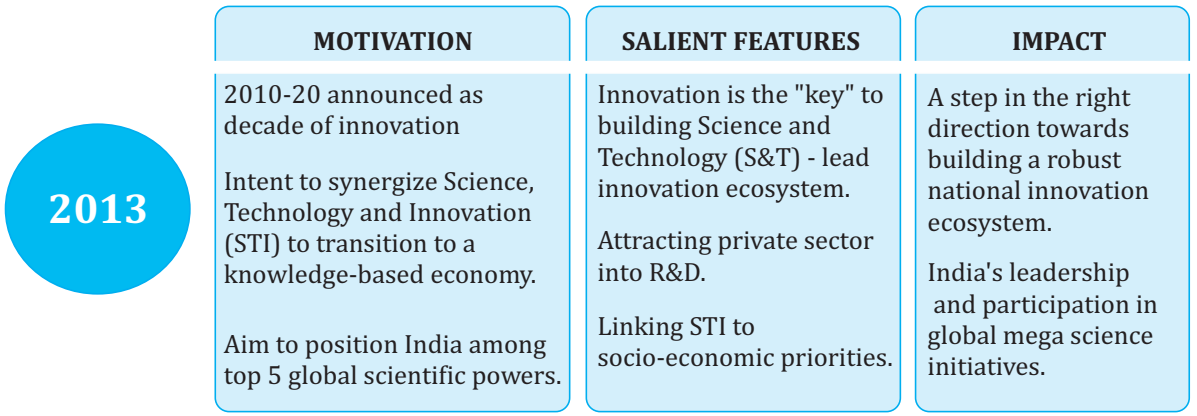

Fig. 2.13. Science Technology and Innovation Policy 2013

- Among the main objectives of STIP 2013 were fostering an ecosystem of innovation led by science and technology in the nation and broadly connecting science, technology, and innovation to socio-economic priorities.

Features:

- **Focus on faster, sustainable and inclusive development:** The policy aimed to leverage science, technology, and innovation (STI) for the betterment of all sections of society, fostering economic growth, social inclusivity, and environmental sustainability.
- **Strengthening STI ecosystem:** The policy aimed to strengthen various aspects of the STI ecosystem, including R&D infrastructure, human resources, funding mechanisms, and institutional linkages.
- **Prioritising critical R&D areas:** The policy identified specific areas of national importance for R&D investment, such as agriculture, healthcare, energy, water, and environment.

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