Chapter 5 Science, Technology and India's National Security

In Chapter I of this Book you have learnt, that to protect national security, a nation requires to develop National Power. You had also learnt about the various elements of national power. One of these elements is science and technology. Let us see the role of science and technology in national security.

Relationship between Science, Technology and Engineering

Technology is often developed from the basic knowledge of science combined with engineering. For example, science might study the flow of electrons in electrical conductors by using already-existing tools and knowledge. This new-found knowledge may then be used by engineers to manufacture new tools and machines such as semiconductors, computers, and other forms of advanced technology. In this sense, scientists and engineers may both be considered as technologists. Therefore the three fields i.e. Science, technology and engineering are often considered as one for the purposes of research and development. The definition of each given below will enable better understanding of the relationship of three terminologies :-

1. **Science :** Science is an intellectual and practical activity. It does a systematic study of the structure and behaviour of the physical and natural world, through observation and experiment. The purpose of this study is to gain knowledge.
2. **Technology :** It is the application of practical sciences to industry or commerce. Technology refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes. A modern example is the rise of Information Technology (IT) which is the combined application of computer science and electronics.
3. **Dual-Use Technology :** It is that technology which can satisfy more than one goal at any given time. Thus, expensive technologies which would otherwise serve military purposes are also used to benefit civilian interests. Examples: Global Positioning System; Technology for Satellite launch rockets can also be used for manufacturing long range missiles; Nuclear reactors produce electricity, as also produce plutonium for making nuclear bombs.
4. **Engineering :** It is the application of various kinds of knowledge to invent, innovate, design, manufacture, various components.
5. **Manufacturing :** It is the process of converting raw materials, components, or parts into finished goods. Technology is an essential component of manufacturing.
6. **Industry :** It is a group of manufacturers or businesses that produce goods or services. In the modern world, industries form the backbone of a nation's economy.

Did you know ?

The Industrial Revolution led to the development of factories for large-scale production with consequent changes in society. Originally the factories were steam-powered, but later transitioned to electricity. The mechanized assembly line was introduced, with individual workers performing specific steps during the process. This led to significant increases in efficiency, lowering the cost of the end product. Later automation was increasingly used to replace human operators. This process has accelerated with the development of the computer and the robot.

Scientific, Technological and Industrial Development in India

India was the cradle of knowledge in many fields such as medicine, mathematics and astronomy since ancient times. Textiles and Ship building industry was well advanced in medieval India. HMS Trincomalee was a 38 gun frigate built at Bombay (Mumbai) for the British navy. The designer was Jamsetjee Bomanjee. The ship's keel was laid down in 1816 and launched in October 1817.

Thus until the 17th century India was technologically, economically and militarily at par with the European nations. In 1780 Tipu Sultan surprised the British forces by using rockets against them; the British copied these rockets and used them against Napoleon in Europe in 1812. The Industrial revolution commenced in England around 1760 and spread to Europe. Unfortunately, the Indian subcontinent fell behind the Europeans in various fields such as textiles, metallurgy, explosives, machinery for mass production and transport systems. The subjugation of India by the British in the 18th century, led to the dismantlement of India's indigenous industries such as textiles and shipbuilding.

Under British rule, the education system also suffered; there was very little encouragement in establishing institutions of learning, research and for development of science and technology. After independence in 1947, the government encouraged scientific-technical research through the establishment of several national research laboratories and institutions for higher education and research in pure and applied sciences and technologies. These efforts resulted in rapid strides in science and technology with achievements in many fields. These include agriculture, textiles, health-care, pharmaceuticals, info-tech, space, nuclear and defence technology.

All of these scientific and technological achievements, including those in a purely non military field, also have tremendous significance from the strategic and national security angle. For example, the green and white revolution in agriculture and dairy farming ushered in through efforts of Dr. Swaminathan and Dr. Verghese Kurien respectively, has resulted in India becoming self sufficient in production of food grains for its population. Unfortunately, the spread and speed of industrial development in the field of manufacturing did not match up to that required for rapid development of the nation.

In 1991 major economic reforms took place in India. Private participation in the industrial sector increased. However, India is yet to become self-sufficient in some high technology manufacturing sectors including weapons technology. Indian scientists and engineers like Dr. Homi Bhabha Dr. Vikram Sarabhai, Dr. Abdul Kalam, Dr. Vijay Bhatkar, Dr. Swaminathan, Dr. Verghese Kurien, and others have helped India achieve notable success in a number of fields of military, non-military and dual use technologies. For example :

1. **Military Technology :** In the field of Military Technology Dr. Abdul Kalam was instrumental in making India capable of building all types of missiles required for its armed forces.

2. **Nuclear Technology :** Dr. Homi Bhabha pioneered India's nuclear development program, both for peaceful and military purposes. Besides being a nuclear weapon state, India has built its own nuclear reactors to generate electricity.

3. **Space Technology :** Dr. Vikram Sarabhai, Dr. Kasturirangan and many others scientists of the Indian Space Research Organisation (ISRO), have made the nation self-sufficient in building and launching rockets, spacecraft and satellites. Satellites are invaluable in providing the nation with communication, navigation and surveillance facilities for military as well as civilian purposes.

4. **Agriculture :** Dr. M.S. Swaminathan an agricultural scientist and Dr. Kurien Verghese an engineer by education, made a success of the green and white revolution respectively. Consequently India is now a leading producer in the world for food grains, fruits, vegetables, milk and poultry. Even this purely non-military development has a tremendous significance from the strategic and national security point of view.

5. **Information Technology :**

   Dr. Vijay Bhatkar, led a group of young engineers to build India's first super computer. A number of young Indian engineers and entrepreneurs like Dr. Narayan Murthy made India a leading power in Information Technology.

Science, Technology, Manufacturing and National Security

India needs to develop science and technology to rapidly develop the economy, achieve prosperity and ensure the economic and social welfare of the citizens. India's size, geopolitical status, security threats and need to protect national interests makes it necessary for India to become capable of developing and making the necessary weapons and allied systems for its armed forces.

The Government of India has spelt out various policies and plans to tackle the challenges that cover practically all possible fields to include economic, social, scientific and technological aspects concerning the nation. However in this chapter, we shall restrict ourselves to the brief study of the following fields of science and

technology which have a major impact on national security.

i) Space.

ii) Nuclear.

iii) Electronics.

iv) Military.

Indian Space Program

Dr. Vikram Ambalal Sarabhai (1919-1971)

Dr. Sarabhai is considered as the Father of the Indian space program. The establishment of the Indian Space Research Organization (ISRO) was one of his greatest achievements.

The Indian National Committee for Space Research (INCOSPAR) was set up under the leadership of Dr. Vikram Sarabhai and Dr. Ramanathan in 1962. Later, INCOSPAR was transformed into the Indian Space Research Organisation (ISRO) on August 15, 1969

ISRO's Vision Statement :

'Harness space technology for national development, while pursuing space science research and planetary exploration'.

Today, India is among the top five space powers in the world. India is self-sufficient in building and launching rockets, spacecraft and satellites. It has started space exploration, through the success of the Chandrayaan 1 mission to the Moon and the Mangalyaan mission to Mars.

The Indian space programme has the following three distinct elements :

(1) Launchers : ISRO made a humble beginning by launching indigenously made sounding rockets from 1965. There after it has built a series of satellite launch vehicles.

(2) Spacecraft : ISRO has developed and launched a large number of satellites for sensing, interplanetary exploration and navigation.

(3) Application Programmes : These are satellite-based programs ranging from education, health, remote sensing, mapping, navigation and military purposes.

Space has always been considered to be an important aspect of scientific research and development. Technological inventions in areas of metallurgy, super conductivity, Nano technology and cryogenics are dual use technologies. ISRO developed Lithium Ion Batteries to power its satellites; they also have several military applications, one of them being their use in submarines.

Did you know ?

Sounding rockets are one or two stage solid propellant rockets used for probing the upper atmospheric regions and for space research. They also serve as easily affordable platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites.

ISRO SATELLITE LAUNCH VEHICLES

SLV-3

Height : 22.7m
Lift-off weight : 17t
Propulsion : All Solid
Payload mass : 40 kg
Orbit : Low Earth Orbit

ASLV

Height : 23.5m
Lift-off weight :39t
Propulsion : All Solid
Payload mass : 150 kg
Orbit : Low Earth Orbit

PSLV-XL

Height : 44m
Lift-off weight : 320t
Propulsion : Solid & Liquid
Payload mass : 1860 kg
Orbit : 475 km
Sun Synchronous
Polar Orbit
(1300 kg in
Geosynchronous
Transfer Orbit)
Payload mass

GSLV Mk II

Height : 49m
Lift-off weight : 414t
Propulsion : Solid, Liquid & Cryogenic
Payload mass : 2200 kg
Orbit : Geosynchronous
Transfer Orbit

GSLV Mk III

Height : 43.43m
Lift-off weight : 640t
Propulsion : Solid, Liquid & Cryogenic
Payload mass : 4000 kg
Orbit : Geosynchronous
Transfer Orbit

For details see : https://www.isro.gov.in/applications

Nuclear Programme

India began its nuclear programme soon after independence. The Atomic Energy Commission (AEC) was established to advise the government on nuclear issues. The main purpose of the nuclear programme had been to use nuclear energy for civilian power reactors to produce electricity. Dr. Homi Bhabha and Meghanand Saha played an extraordinary role in the nuclear field. In 1954 the Department of Atomic Energy was created under the leadership of Dr. Homi Bhabha.

Nuclear energy is going to play an increasingly important role in India's energy security and sustainable development plans. India has the largest Thorium ore resources in the world and therefore, Thorium can be used as the basic fuel for nuclear power reactors. Though Thorium itself is not a fissile material, and thus cannot undergo fission, yet it can be transmuted to uranium-233 in a reactor fuelled by natural uranium or plutonium. This would reduce India's dependence on fossil fuels. To achieve this, Dr. Homi Bhabha had in the 1950s, conceived of the three-stage nuclear programme, as a way to develop indigenous nuclear energy to overcome the problem of India's limited source of Uranium through Thorium.

Dr. Homi Jehangir Bhabha (1909-1966)

Dr. Bhabha was a scientist, visionary and institution builder. He was instrumental for the formation of Atomic Energy Commission in 1948 and the Department of Atomic Energy in 1954. He was such a visionary that he had realized the importance of nuclear power programme way back in 1950s and enunciated a three stage nuclear programme so as to meet the energy security of the nation.

Do you know ?

Strategy for Nuclear Energy : India's nuclear programme aims at tapping nuclear energy for power generation. This is based on the use of Uranium and Thorium as nuclear fuel.

The estimated deposits of these are as follows :

Natural Uranium deposits: 70,000 tonnes.

Natural Thorium deposits: 3,60 000 tonnes.

India's Three Stage Nuclear programme is as follows :

Stage 1: Building Pressurised Heavy Water Nuclear Reactors using Uranium Oxide (UO2) and Heavy Water. This phase also includes building Reprocessing Plants for reprocessing spent fuel.

Stage 2: Building Fast Breeder Reactors that would use Plutonium 239 generated from the First Stage to transmute thorium to Uranium 223 as also generate electricity.

Stage 3 : Using Fast Breeder Reactors using Uranium 233. to primarily generate electricity.

(For details see : Bhabha Atomic Research Centre, http://www.barc.gov.in/about anushakti_sne.html).

The government has taken considerable diplomatic measures to accelerate the nuclear program, these include signing nuclear cooperation agreements with the USA, France and Russia, to seek technology and build nuclear reactors as also to become a member of the exclusive Nuclear Suppliers Group (NSG).

Nuclear Suppliers Group(NSG) -

NSG is a multilateral export control regime of a group of nuclear supplier countries that seek to prevent nuclear proliferation by controlling the export of materials, equipment and technology that can be used to manufacture nuclear weapons.

India's Nuclear policy

India's Nuclear policy, revolved around two principles: promotion of research and development for harnessing nuclear energy for peaceful purpose, and attainment of self-sufficiency in the nuclear programme. Pandit Jawaharlal Nehru had publicly opposed the development of nuclear weapons. He maintained that atomic energy for peaceful purposes was more useful for India.

The first change in India's nuclear programme came after the Chinese nuclear tests of 1964. India, under the leadership of Prime Minister Lal Bahadur Shastri announced that India would be willing to consider the use of nuclear blasts for peaceful purposes. This was for the first time that India considered developing nuclear explosives.

India conducted its first nuclear test in 1974 at Pokhran. Following the test Prime Minister Mrs. Indira Gandhi stated that the nuclear test was an experiment conducted as part of research and development for using nuclear energy for peaceful purposes. India had demonstrated to the world that India was capable of developing nuclear weapons, but did not have the intention of doing so.

In 1998 India carried out several nuclear tests again at Pokhran. India declared that it was now a nuclear weapon state. Prime Minister Atal Behari Vajpayee's statement after the nuclear test gives us the main aspects of India's nuclear policy :

1. The security situation deteriorated in the 1980s and 1990s because of the spread of nuclear weapons and missiles in India's neighbourhood.
2. India has been the victim of externally aided and abetted terrorism, militancy and clandestine war.
3. At a global level, we see no evidence on the part of the nuclear-weapon States to take steps in moving towards a nuclear-weapon-free-world.
4. The Nuclear Non-proliferation Treaty was extended indefinitely perpetuating the existence of nuclear weapons in the hands of the five countries.
5. India does not intend to use these weapons for aggression; these are weapons of self-defence.

Nuclear Non-proliferation Treaty (NPT) :

The NPT is an international treaty whose objective is to prevent the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament. This treaty was signed in 1968. India did not join this treaty. The treaty prohibits those countries that do not have nuclear weapons to produce nuclear weapons. But it does not place any restrictions on those countries that have nuclear weapons. This is discriminatory. Therefore India refused to join the agreement.

Pokharan Test Site

Countries having nuclear weapons

According to the Stockholm International Peace Research Institute (SIPRI) the following countries have nuclear weapons: the United States, Russia, the United Kingdom, France, China, India, Pakistan, Israel and North Korea. (SIPRI information of January 2016)

Find Out :

Which countries are members of the Nuclear Suppliers Group.

Electronics

सी डैक
CDAC
CENTER FOR DEVELOPMENT OF ADVANCED COMPUTING

PARAM SUPER COMPUTER

The Government of India's National Policy on Electronics (NPE) 2011 seeks to promote Electronics System Design & Manufacturing (ESDM) in the country. One of the important objectives of this policy is to develop a partnership between ESDM

and the core sectors of the economy like Defence, Atomic Energy and Space. It also plans to create a complete secure cyber eco-system in the country to secure Information and communication technology (ICT) infrastructure and cyber space of the country.

Electronics is an important part of India's defence preparedness. It is used in communications by satellite phones; radars; guided missiles, electronic circuits in various equipment etc. India started a program to develop indigenous supercomputers and supercomputing technologies. These supercomputers are also capable of assisting in the development of Nuclear Weapons. PARAM 800 was the first super computer developed by the Centre for Development of Advanced Computing (C-DAC).

The coming together of multiple technologies with the internet and the growth of social networking has added a new dimension to discussions on cyber security. The use of internet is enormous. People use the web and social networking sites every day. It is impossible to carry out surveillance of all that happens in cyberspace. The rapid advancement in technologies has led to new forms of threats which need to be understood and tackled. Cyber security threats today have become increasingly sophisticated and complex. There can be attacks on such basic social necessities as power supplies, banking, railways, air traffic control, etc. Hackers can target government ministries, banks, utilities, other key infrastructure, and companies nationwide, demanding ransom. These acts are not a traditional law and order problem. Therefore it would be difficult to deal with them. To tackle this problem the Indian government has introduced the National Cyber Security Policy in 2013 to provide an umbrella framework for defining and guiding actions related to cyber security.

For details see :

National Cyber Security Policy-2013 (NCSP-2013)

Ministry of Electronics and Information Technology of the Indian Government

http://meity.gov.in/writereaddata/files/National_cyber_security_policy-2013_0.pdf

Military Technology Including Research, Development and Manufacturing

Defence Research and Development Organisation :

Military technology is the application of technology for use in warfare. It draws on the knowledge of several traditional engineering disciplines, including mechanical engineering, electrical engineering, mechatronics, electro-optics, aerospace engineering, materials engineering, and chemical engineering.

The Defence Research and Development Organisation (DRDO) was created in 1958 to provide scientific and technological advice to the Ministry of Defence. Its mission is to establish a world class science and technology base and provide the Defence Services the most advanced systems and solutions. It also evaluates defence equipment and provides technological knowledge to defence industries. Today, DRDO has more than 50 laboratories which are engaged in developing defence technologies covering various disciplines. These include aeronautics, armaments, electronics, combat vehicles,

engineering systems, instrumentation, missiles, advanced computing and simulation, special materials, naval systems, life sciences, training, information systems and agriculture.

The DRDO has been successful in developing many weapon systems these include, Tejas Light Combat Aircraft, Arjun Main Battle Tank, the INDRA Radar and Pinaka Multi Barrel Rocket System. The most successful program of the DRDO has been the Integrated Guided Missile Development Program (IGMDP) headed by Dr. Abdul Kalam, which commenced in 1983. It comprised development of five different missiles, they are : Agni, an Intermediate Range Ballistic Missile, Trishul, a low-level quick reaction surface to air missile (SAM); Akash, a medium to high altitude SAM; Prithvi, a tactical surface to surface missile (SSM); and Nag, a third generation anti-tank missile.

The Integrated Guided Missile Development Program laid down the foundation of missile technology in India. Development of a number of types of missiles with improved technology and capability followed. These included the Prithvi II & III Short Range Surface to Surface Ballistic Missiles, Agni III and Agni IV Surface to Surface Intermediate Range Ballistic Missiles, Agni V Surface to Surface Intercontinental Ballistic Missiles, the Brahmos Supersonic Cruise Missile, the Nirbhay Subsonic Cruise Missile, Submarine launched K4 and K15 Ballistic Missiles, the Pradyuman and Prithvi Air Defence Surface to Air Missiles and the Astra Air to Air Missile.

Dr. APJ Abdul Kalam (1931 – 2015)

Dr. Kalam was responsible for the evolution of ISRO's launch vehicle programme. He took up the responsibility of developing Indigenous Guided Missiles at Defence Research and Development Organisation as the Chief Executive of Integrated Guided Missile Programme. He is popularly known as India's Missile Man. Dr. Kalam became the 11th President of India on 25th July 2002.

Classification of Missiles

A combination of factors is generally used to classify a missile. Range is one of the important factor in classification.

- Tactical Missile : Approximate range : 150 kms to 300 kms (For example Prithvi I)
- Short Range Ballistic Missile : Approximate range : 300 kms to 1000 kms (For example Agni 1).
- Medium Range Ballistic Missile : Approximate range : 1000 kms. to 3500 kms (For example Agni 2 and K4 Sagarika)
- Intermediate Range Ballistic Missile : Approximate range : 3550 kms to 5500 kms (For example Agni 3 and Agni 4)
- Intercontinental Ballistic Missile : Approximate range : More than 5500 kms (For example Agni 5.)

Prithvi Missile

Agni Missile

Akash Missile

Trishul Missile

Nag Missile

Brahmos Missile

DRDO Products

Futuristic Game Changer Technologies in the Field of Defence

While India is still to play catch up with the weapons of the advanced nations such as USA, Russia, Japan and France, India must look into jumping ahead in frontier technologies such as

- Artificial Intelligence and Robotics.
- Particle beam or laser beam weapons.
- Electromagnetic propulsion.
- Light weight Super alloys and composites having high strength and heat resistance.
- Miniaturisation of systems.
- Stealth technology which can defeat detection by radars.

Do you know ?

On 27 March 2019 India a successfully launched an anti-satellite missile. India was only the fourth country to test an anti-satellite weapon that is used to attack enemy satellites or intercept ballistic missiles. Besides India only United States, China and Russia have tested such a weapon.

Promotion of Science and Technology through Education

Various scientific educational and research facilities have been established and are functioning to meet the needs of the nation. Some of these are under the control of various ministries of the government, some others are autonomous, details regarding a few which are important for students interested to become scientists and technologists are given below. Detailed information on these can be accessed on the links to various ministries in the website of the government of India at https://india.gov.in/. A consolidated list is also availabe on the internet at https://en.wikipedia.org/wiki/List_of_institutes_funded_by_the_Central_Government_of_India.

Prominent Educational Institutions for Students

- The Indian Institutes of Science Education and Research (IISERs
- The Indian Institutes of Technology (IITs)

Prominent Research Organisations

- The Department of Atomic Energy (DAE).
- Indian Space Research Organisation (ISRO).
- Council of Scientific and Industrial Research (CSIR)
- Centre for Development of Advanced Computing (C-DAC).
- Indian Institute of Science (IISc).
- Tata Institute of Fundamental Research (TIFR)

Defence Oriented Research and Development Establishments

- Defence Research and Development Organisation (DRDO).

(https://www.drdo.gov.in/)Those students who are interested in making a career as a scientist with DRDO can log on to https://rac.gov.in/ for further details.

Please see the following websites for further information :

1. Bhabha Atomic Research Centre : Strategy for Nuclear Energy
   http://www.barc.gov.in/about/anushakti_sne.html
2. Cyber Security : Dr VK Saraswat, Member NITI Aayog
   http://www.niti.gov.in/writereaddata/files/document_publication/CyberSecurityConclaveAtVigyanBhavanDelhi_1.pdf
3. Ministry of Home Affairs, Government of India. Cyber and Information Security (C&IS) Division (Division deals with matters relating to Cyber Security, Cyber Crime, National Information Security Policy & Guidelines (NISPG) and implementation of NISPG, NATGRID etc.)
   https://mha.gov.in/division_of_mha/cyber-and-information-security-cis-division
4. Shri Atal Bihari Vajpayee laid a paper entitled "Evolution of India's Nuclear Policy". PAPERS LAID ON THE TABLE XII Lok Sabha Debates, Session II, (Budget) Wednesday, May 27, 1998 / Jyaistha 6, 1920 (Saka)
   https://parliamentofindia.nic.in/ls/lsdeb/ls12/ses2/0527059801.htm

EXERCISE

Q. 1 (A) Choose the correct alternative and complete the following statements.

i. India declared itself to be a nuclear weapon power in _____

a. 1974 b. 1978

c. 1998 d. 2000

ii. GPS is an example of ____

a. Dual use technology

b. Internet revolution

c. Nuclear research

d. Electronics revolution

(B) Complete the following sentence by using appropriate reason.

India did not join the Nuclear Non-proliferation Treaty

(C) Identify the incorrect pair in every set, correct it and rewrite it.

i. Dr. Homi Bhabha : Nuclear Science

ii. Dr. Vikram Sarabhai : Space Science

iii. Dr. Abdul Kalam : Information Technology

(D) Find the odd word from the given set.

Tejas, Agni, Trishul, Prithvi,

Q. 2 Observe the map and answer the following questions.

On a map of India point out the location of the following :

Pokhran

Q.3 State whether the following statements are true or false with reasons.

i. The Integrated Guided Missile Development Program laid down the foundation of missile technology in India.

ii. India's nuclear energy programme is Uranium based.

Q.4 Explain the correlation between the following.

Science and Technology

Q.5 Observe the given image and write about it in brief :

Q.6. Express your opinion on the following

Should India develop nuclear weapons?

Q.7. Answer the following.

i. What is the role of the Defence Research and Development Organisation (DRDO) ?

ii. What are the Futuristic Game Changer Technologies in the Field of Defence.

Activity :

Give examples of Cyber Crime. What is cyber security? Why is it important? Discuss in the classroom.