Chapter-2

Development of Science and Technology (S&T) - Historical Perspective
2.1 Science & Technology (S&T): Concept & Definitions

Civilization, as we know it today, would be impossible without science at least when its material aspects are concerned. Science, a human creation arises from the need to make sense of the world. It is a progressive activity that constitutes a worldview and permeates almost every aspect of modern life. The spread of scientific ideas has been a decisive factor in re-moulding the whole pattern of human thought. It is a systematic method of describing and controlling the material world. Today we find in the conflicts and aspirations of our time a continual and growing involvement of science.

The march of events brings before us, ever more insistently, problems about science such as: the proper use of science in society, the militarization of science; the relations of science to governments’ scientific secrecy, the freedom of science, its place in education & general culture. Whether for good or ill, its importance today needs no emphasizing. It is the means by which the whole of our civilization is rapidly being transformed. The pace of the growth of science is more rapid now than compared to the past.

The word science is derived from Latin word ‘scientia’ meaning ‘knowledge’. This encompasses the knowledge of nature and universe.

Definitions: -Some standard definitions of the word “science” are given as follows: -

“Science is the study of nature and natural phenomena characterized by the possibility of making precise statements which are susceptible of some sort

“Science is the systematic and unbiased study of the world, including everything that can be seen or detected in nature, man and society, and the knowledge that grows out of such study”. (New Standard Encyclopaedia, 1983, p. T81-82).

“Science is the study of truth, the common principles of which are supposed to be known and separated so that the individual truths even though some or all may be clear in themselves, have a guarantee that they could have been discovered and known, either with certainty or with such probability as the subject admits of, by other means than their own evidence”. (Encyclopedic Dictionary of Art. literature & Science, 1989. p.1089)

“Science is a human creation, which arises from the need to make sense of the world. It is a progressive activity that constitutes a world view and permeates almost every aspect of modern life”. (Collier’s Encyclopedia, 1987, p.498A)

“Science is that branch of study in which facts are absorbed and classified and usually quantitative laws are formulated and verified, involves the application of mathematical reasoning and data analysis to natural phenomena”. (McGraw-Hill Dictionary of Scientific & Technical Terms, 1983, p.1426).

“‘The state of knowing knowledge, as distinguished from ignorance or misunderstanding”. (Merriam-Webster’s Collegiate Dictionary, 2001, p.1042).
Similarly, technology came to be used from 17th century to describe a systematic study of the Arts. It seeks to find practical ways to use scientific discoveries profitably, ways of turning scientific language into utilitarian processes and devices. The history of technology can be said to be older than man himself, for the hominids that preceded Homo erectus and Homo sapiens were the first to use tools. It is the means to improve one’s surroundings. Technology is the product of science and capital; it is also specialization and division of labour. It is the only way to solve economic scarcity. It has evolved from utilization of materials, exploitation and transformation of energy, understanding and application of scientific principles and information processing. The World is witnessing bewildering changes on account of the development of technology. It has a pervasive multifaceted and dynamic impact on society and brings about tremendous changes. In recent years technological change has been so rapid that more than half the items produced in the U.S. today did not exist 20 years ago. It broadens the horizons for society to change its environment and enables it to use technological instruments for moulding its own future. It also complicates society and its problems; with the result that finding the intellectual solution is extremely difficult. The word technology comes from a Greek term “Tekhnologia” meaning a systematic treatment.

Definitions: -Some of the standard definitions of technology are as follows: -

“*The use of scientific knowledge to develop and produce goods and services useful to man is technology. It is sometimes called as “applied science”.*


“Technology is a systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity”. (Concise Encyclopedia Of Science and Technology, 1994, p.1661).


“Technology is a systematic treatment of an art, the practical application of knowledge especially in a particular area”. (Merriam-Webster’s Collegiate Dictionary, 2001, p.1206).

“Technology is a science of mechanical and industrial arts as contrasted with fine arts”. (New Webster’s Dictionary & Thesaurus, 1991, p.388).

2.2 History of S&T

Science has been shaped and reshaped over the years. An ancient civilization going back to more than 5000 years, which evolved with an amazing continuity, could not have been uninfluenced by science. Different civilizations played their important role in the development of various fields of science. Science, which was in primitive form then, made their lives comfortable.
2.2.1 Old Stone Age – Primitive life

During this stage man was a food gatherer, thus led a nomadic life. But slowly he learnt better methods of getting food and protection than he could achieve while staying in isolation. He learnt the use of tools. Through the use of tool making and tool using, men learned the mechanical properties of many natural products and thus laid basis of Physical Sciences. Tools made their hunting easier and shaping of materials of wood and stone.

Man started using hides and skins of animals to cover himself and slowly learnt stitching of clothes. Fire was discovered accidentally which laid basis of Chemical Science. He started taking cooked food. By the end of Old Stone Age, man started using clay pottery and used containers, which could hold liquids for longer duration without fermenting them. Rational chemistry thus came into being.

Primitive man keenly observed plants and animals in his surroundings. He started thinking about nature and this gave rise to the biological sciences of today. He did posses some knowledge about art already and thus, probably, started drawing pictures mostly of caves and animals. Also some representations of human organs like those of heart and bones have been found, which laid the basis of Anatomy. By using implements he transformed nature, which gave rise to Mechanics. There were some medicine men or shamans who had concern with health.

2.2.2 New Stone Age

Then came the period between the first invention of Agriculture and the founding of cities, which is usually known as New Stone Age or Neolithic age.
During this age ground and polished stone implements were used in place of chipped instruments of the Old Stone Age. It lasted for approximately 8000-3000 BC. There began a revolution in food production. The difficulties that man faced in searching food led to the invention of techniques of Agriculture. New techniques in Agriculture were introduced which gave rise to new mathematical and mechanical concepts.

Mostly civilizations originated from river valleys, where cultivation by natural flow irrigation canals could be practiced. Early civilizations were accordingly limited to a number of favoured areas, the main ones known to us being those of Mesopotamia, Egypt and of the Indus valley. The major technical advancements that took place, were the discovery & use of metals like Copper & Bronze. The lever and inclined plane, used in great constructions of temples and pyramids strengthened the foundation of Mechanics. The transport by cart and ship to known sources of valuable materials, led to the deliberate exploration and to the beginning of Geography.

Then raised the consciousness among the people to keep records. They started using some signs/symbols and thus came Mesopotamian Cuneiform or Egyptian hieroglyphics into existence. The final simplification of true alphabet did not occur till Iron Age. Mathematics came even before writing. First they used ten fingers of two hands for counting. For complicated counting, stones were used. Then they replaced it by beads arranged on wires-Abacus.

The practice of building gave rise to Geometry and also to conceptions of
areas and volumes of figures. The calculation of volume of pyramid was highest flight of Egyptian Mathematics. Early civilizations like those of Sumerians and Mesopotamians paid lot of attention to sun, moon and stars and regular phenomenon of day and night which gave rise to Astronomy. They tackled the difficult task of reconciling the lunar and solar calendars. The Egyptians thought sky as a flat cover, resting on hills. The Babylonians pictured it as a vast four-square tent. Chinese Astronomy started with the idea of rotation of a wheel. Medicine was considered as an upper caste profession. The doctor could only deal with wounds, dislocations and fractures and tried to save patient’s life. The South American Indians had discovered Quinine for curing malaria. This gave rise to the science of Botany. During Bronze Age & till the end of Iron Age, Chemistry never rose to the rank of a recognized science.

The technical innovation that came with the beginning of city life of river valleys of Mesopotamia, Egypt, India & China did not last for more than a few centuries. It was followed by cultural and political stagnation. There were eruptions of barbarians and even barbarian dynasties. The successors of original administrators, who improved agricultural techniques before, turned exploiters. The virtual enslavement of peasants and urban craftsmen, led to the conflicts and thus city-states got weakened and ultimately put a stop to their intellectual and technical progress.

2.2.3 The Iron Age

From the middle of the 2nd millennium B.C. some technical, political and
economic factors brought transformation of the civilizations of few river basins into which embraced the major cultivable areas of Asia, northern Africa & Europe. The Iron Age improved tools and machines but did not make remarkable change in material technique. The advances it made were more widespread among the social classes. During this period, Greeks assembled and developed out of the technical experience of the older empires.

2.2.3.1 The Greeks

The most successful in the exploitation of the new conditions of the Iron Age were the Greeks. Almost unconsciously and without acknowledgement, Greeks took most part of the learning, which was still available, centuries after the destructive warfare.

Greek science was of different character from that of early civilizations. Greeks esteemed most Mathematics, especially Geometry. The technical developments in early Iron Age and especially by Greeks before Alexandrian period were not as fundamental as those of Bronze Age.

Of the chemical inventions the most important was that of blown glass first made in Egypt. Metal using technique started in 6th century B.C. Architecture in Greek times advanced to the level of citizens’ profession. Greek science developed in a more general and independent way but lacked experience. The history of Greek science underwent through four phases-Ionian, Athenian, Alexandrian or Hellenistic and Roman phases.

Greek science is believed to originate in the Ionian cities of Asia Minor in
6th century B.C. It is associated with the legendary figures of Thales & Pythagoras. Thales is believed to have predicted the solar eclipse in 585 B.C. and invented formal study of Geometry. Hellenic science based on Thales and Pythagoras reached its zenith by the works of Aristotle and Archimedes. Aristotle made his framework in Biological Sciences while Archimedes made greatest contribution in Mathematical Physics.

The Greeks made great progress in the field of medicine. Pre-Greek medicine was entirely confined to religion and ritual. Hippocrates and his school insisted that disease was natural and not supernatural. In the museum of Alexandria a research institute was set where various human organs like heart, brain etc were investigated. These researches led the base for Physiology. But medical practice remained eclectic and a matter of physician’s choice.

2.2.3.2 Science in Rome and Christianity

The rise of Greek science coincided with that of Roman power in the Mediterranean. Science and Philosophy under Romans was either ignored or relegated to rather low status. The spirit of independent research was quite foreign to the Romans, so scientific innovation ground to a halt. The scientific legacy of Greece was condensed and corrupted into Roman encyclopaedias.

One religious sect, which proved more significant than the rest, was Christianity. The early Christians approached the worldly wisdom of their time. The lamp of ancient learning was burning very feebly even after the fall of Roman Empire.
2.2.3.3 Science in Islam

In the 7th century the Arabs, inspired by their new religion, burst out of the Arabian Peninsula and laid foundations of an Islamic empire, which eventually rivaled that of ancient Rome. To the Arabs, ancient science was a precious treasure. Quran, the sacred book of Islam, praised medicine as an art close to God. Astronomy and Astrology were believed to be one way of glimpsing what God willed for mankind. Contact with Hindu Mathematics and the requirements of Astronomy stimulated study of numbers and of geometry. The writings of Hellenes were thus, eagerly sought and translated and thus much of the science of antiquity passed into Islamic culture. Greek Medicine, Astronomy, Astrology and Mathematics and works of Plato & Aristotle, were assimilated in Islam by the end of 9th century. The numbers fascinated Islamic thinkers, which gave rise to Algebra.

2.2.4 Medieval Science

During medieval age there were little scientific investigations undertaken almost exclusively for religious ends by clerics, priests and monks. The men of Middle Ages were perfectly competent in reasoning and in design and carrying out experiments. But their experiments remained isolated. The sum total of the medieval achievements in natural sciences include a few notes on natural history and minerals by St. Albert.

Mathematics during medieval age did not make any serious advancement till Renaissance. In Astronomy Ptolemy’s ‘Almagest’ was translated from
Arabic. In observational Astronomy, the science where accurate observation, calculation and prediction were necessary, Islamic predominance lasted longer than in any other branch of science. The medieval astronomers showed themselves capable of making some improvements in detail in astronomical calculations. They also made contributions to Trigonometry and construction of instruments.

Architecture was the greatest and most characteristic expression of medieval technique and thought. Medieval architecture contributed little, directly or indirectly, to the advancement of science.

2.2.4.1 Technical advances from the East & China

The technical advances of Middle Ages were made possible by exploitation and development of inventions, which were to give Europeans greater powers of controlling and understanding the world. The major inventions like clocks, compass, etc., have come from the East and most of them ultimately from China. Many inventions appearing in 10th century or later in Europe were fully described in China in the 1st century.

The two technical introductions from the East, which were fated to have a far greater effect in the West than in their land of origin, were the linked inventions of paper and printing. The process of papermaking was originally developed in China. It was introduced to Europe via the Arabs in the 12th century.

Printing with movable wooden type was originally a Chinese invention of
the 11th century. The Koreans first used movable metal types in the 14th century. It was introduced into Europe in the mid 15th century. Later still, largely in the 16th century, printing was to be the medium for great technical and scientific changes.

2.2.5 Rise of Modern Science

The careful observation of nature, increasing familiarity with mechanical representations of the heavens and attempts to represent natural events mathematically, were ingredients in the rise of modern science whose roots are found in Middle Ages. The rediscovery of Hermetic Corpus of writings on natural magic encouraged the study of nature and the printing press, made possible the growth of science as public knowledge. During 16th and 17th century people were not able to make distinction between science and its applications. The printing press was part of new technologies and science became an instrument of national power and progress for most of the European nations, which induced change rapidly. These changes were evident in Astronomy followed by Mathematics, Physics, Biology, Chemistry, etc. Some of the scientists who did outstanding work in various fields of science were Copernicus, Kepler, Galileo, Robert Boyle, William Harvey and Lavoisier.

During the 19th century unprecedented development of science took place. There were few opportunities for education and careers in sciences. Science and industry began to find common ground and make common cause. Science became a growing force for change in the material and intellectual climate of the
19th century. Eminent scientists of this century were Faraday, Joule, Ampere, Thomas Young and Charles Darwin etc. All of them and many others contributed to the various inventions.

The 20th century saw even more rapid and extensive advances in science than its predecessor. Many subjects like Physics, Chemistry etc revolutionized more than once since the turn of the century. An enormous output of agrochemicals boosted the crop yield. Organic chemistry tackled the synthesis of vital molecules like haemoglobin and structural Organic chemistry, in breaking the code of deoxyribonucleic acid (DNA), paved way to understand the chemical basis of inheritance. Organic chemistry merged with new sciences of Molecular Biology and Biochemistry. Laser Spectroscopy made it possible to study the chemical processes occurring in less than billionth of a second.

Physics also experienced a great revolution. Einstein’s ‘relativity theory’ made an end to Newtonian Physics. The structure of matter was particles of matter had profound implications for cosmology and nuclear power.

The radio telescopes, orbiting laboratories and lunar and planetary probes transformed astronomy and cosmology beyond recognition. In 1970’s man landed on moon, and unmanned landings were made on Mars and Venus. The Voyager spacecraft revealed more clear pictures of planets and recognized the rings around Saturn more distinctly. The X-ray astronomy and gamma-ray astronomy unfolded the life histories of stars.

In Biology, advancement occurred in evolutionary theory. Artificial
selection transformed agriculture more rapidly than before Darwin’s theory on natural selection and Gregor Mendel’s inherited characteristics produced understanding of inheritance and Molecular Biology unlocked the genetic code. In 1980’s the first mammals were cloned.

In medicine the development of penicillin and sulfonamides, discovery of vaccines for polio and smallpox and other similar advances helped in making progress in health. By 1970’s small pox was internationally eradicated.

The information technology revolutionized the working environment across the globe. The invention of the analytical engine by Charles Babbage in 1833 brought a revolution in the electronic media. After over a century in 1937 the first mechanical computer Mark-1 was developed by Howard Aiken in which transistors were used, this reduced the physical size and increased speed of the computers. Since then measurable developments have taken place in the field of IT that ultimately increased the capability for sharing information, knowledge and experience without physical proximity through networks. It has enhanced the perceptual and physical understanding of the whole world.

Science was a key to victory in war. By 1950’s, the role of science in warfare, the horror of atomic weapons and threat of chemical and bacteriological warfare, changed attitudes. Deforestation and growth of agriculture has caused imbalance of the atmosphere. Acid rain, formed due to industrial pollution, became a concerning issue. Such developments rose to the need for greater public understanding of science.
2.3 History of Science and Technology in India

2.3.1 Early Civilization

From food gathering stage to one of food production and settled life was a purposeful event in the Indian subcontinent as elsewhere. Between the periods 3000-1500 BC humans got settled. Around 2500 BC Indus Valley Civilization—the largest of ancient civilizations got settled. Its major cities Mohenjadaro and Harappa (now in Pakistan), Kalibangan (in Rajasthan) & Lothal (in Gujarat) were famous for town planning, wheeled carts & copper-bronze craftsmanship. The fertile alluvial soil, monsoon rainfall and the water of the Indus were conducive to develop an agriculture-based economy and a settled life for arts and crafts. The technological goals had, then as now, social overtones and the technicians understandably could well have enjoyed a significant status in that society.

Indian astronomical and mathematical achievements were well known to the Arab compeers. Brahmagupta’s work was translated into Arabic in late 8th century. The 11th century scholar Al-Biruni was remarkable transmitter and synthesizer of Indian astronomy and mathematics. Through the path of transmission of Arabic Scientific knowledge, the Indian ideas passed into Latin Europe in the 12th & 13th century.

Likewise, the Indian medical knowledge and surgical practices were known not only in Arabic world but also in South-East Asia, Tibet and China. Indian medical knowledge was translated into Latin.
India was specially noted for metallurgy. Iron Pillar of Delhi was an excellent metallurgical achievement of 6th century A.D. India’s geographical position enabled it to play a definite role in the dynamics of scientific ideas and techniques. Her geological settings too provided the necessary stimuli for varied endeavours.

2.3.2 S&T Upto 1800 A.D.

Around 1500 BC Vedic Aryans heralded the dawn of new intellectual and technical endeavours. The Vedic and Post-Vedic literature provided a rare insight into some of their lofty conception and breadth of mathematical vision. The Vedic priests were keen observers of the sky and were well aware of the sun’s path, motion of the moon, eclipses and also developed lunisolar calendars with methods of intercalation.

The classical age of India and the succeeding centuries up to 12th century AD experienced springtime efflorescence and an intellectual unfolding in the realism of Mathematics, Astronomy and Medicine. There appeared a large number of scientific texts with accurate terminology; the mode of precise and stylish presentation of scientific ideas was standardized.

2.3.2.1 Mathematics

In Vedic period, number-reckoning on an ascending decimal scale was developed along with Arithmetical and Geometrical series. There were leading mathematicians like Aryabhata-I (5th century AD), Bhaskara-I, Brahmagupta (7th century), Mahavira (9th century), Aryabhata-II, Sridhara and Sripati (10th-
11th century) and Bhaskaracharya-II (12th century). Aryabhata-I gave the approximate value of pi (π) as 3.1416, which is in use till date. Indian mathematicians had blazed new trails in Algebra, Trigonometry and Geometry.

2.3.2.2 Astronomy

Many Indian mathematicians were also astronomers, well versed in observing the movements of luminaries of the sky. The Indian astronomers dealt with time-reckoning rising, setting and conjunction of planets, eclipses. Earlier in 5th century, Aryabhata I, through his classic, the ‘Aryabhatiya’ heralded the new mathematics-based Astronomy. He conceived the rotation of the earth about its own axis.

During 14th–17th centuries, there appeared a number of astronomical works, a majority of which was in the nature of commentaries on earlier works. There were families of astronomers especially in Kerala & Maharashtra. Indian astronomers, in consonance with the general ethos of the people, had open-mindedness and a scientific attitude for assimilating all rational ideas. Later in the 18th century Sawai Jai Singh-II, the rare Maharaja imbibed with a scientific zeal, erected huge observatories in Jaipur, Delhi, Ujjain, Mathura & Banaras.

2.3.2.3 Medicine

The science of life, body and mind was and still is as important as science of heavens. With its origin in the healing art of the Vedic times, the Ayurveda emerged as the medical science par excellence by about the 6th century BC. The outstanding feats of the ancient Indian surgery were related to laparotomy,
lithotomy and plastic operations with efficient pre- & post-operative treatments.

Indian medical knowledge and surgical practices influenced in no small measure in Greece and specially West Asia. The Unani medicine began to take its roots in 13th – 14th centuries in India under the Islamic rulers from Perso-Arabic culture. It gained its popularity with the advent of the Mughals. The Muslim rulers encouraged both the Ayurveda and Unani Tibb & Hakims and Vaidyas worked together in hospitals and medical schools.

2.3.2.4 Biology

In Biological Sciences, there is ample evidence to indicate that Indians had appreciable knowledge of Histology, Physiology, Pathology and Reproduction of various plants, besides systematic classification. The medieval period witnessed not a few developments in respect of the introduction of new plants, especially by the Portuguese and the Moghuls-tobacco, pineapple, chilies, coffee, cinchona, eucalyptus and the like which began to take roots in India from the 16th century AD onwards. The Moghuls gave encouragement to horticulture. Akbar who was passionately fond of animals from Central Asia and Kashmir was a great breeder of domestic animals including superior horses. Jahangir was the greatest naturalist among the Moghuls. He left behind a fine record of his keen observations of a wide variety of birds and animals, their ecology, behavior and the like.

2.3.2.5 Technology and Agriculture

As to technological endeavours, the Vedic period and the succeeding
centuries witnessed certain new trends in agriculture which revealed themselves through the effective use of plough, cultivation of rice and other new grains, and also supported an economy which had its own social implications. Along side, iron made its appearance (around 1000 BC) and began to assert itself as a metal of great utility in domestic, agricultural and self-defense activities. A number of techniques and the associated professionalism in respect of metalworking, wood, leather, textiles and the like became specialized fields of craftsmanship.

From about 6th century BC the technical skills began to display signs of excellence in terms of near mastery in Iron metallurgy and steel, copper bronze working, ceramics, cosmetics & perfumery. The most important technology, was that of Agriculture around which, revolved the socio-religious life of the times. Agriculture and the associated systems received a far greater attention. In view of the importance of agriculture for the material well being of all classes of people, and its dependence, by and large, on the seasonal rainfall, the necessity arose of making plausible forecasts and determining the quantities of rainfall.

The technology of agricultural implements received a new fillip, the village carpenters and blacksmiths assuming an important role in this venture. They were interwoven into the land economy with certain shares in the agricultural products. Iron emerged as the most important metal of common man.

The advent of paper in the 12th or 13th century AD, possibly from Central Asia and also of the new linguistic influences, notably Arabic and Persian
resulted in a spate of manuscripts, artistic calligraphy and elegant presentation. There were a number of paper-production centers of excellent quality in different parts of India. The new writing material also facilitated commerce and credit operations. The spinning wheel, which began to be used widely from 14th century, provided a fillip to the textile industry.

During the medieval period, technology of Engineering and Architecture assumed new dimensions. A striking feature was that the craftsmen, irrespective of their religious persuasion, worked together. In the history of human progress, one would observe that the scientific and technological developments - their innovations and their usefulness to the society at large were noted for their innate capacity for bringing about certain changes in the socio-economic structures and even in the value systems. The Indian culture area experienced such changes, in the ancient and medieval periods. The scientific knowledge was assumed to be just a part of the totality of knowledge including man and his environment.

Some socio-economic factors like rigid caste system, little or no interaction among the thinkers, political instability and absence of middle class support overpowered the innovators. With the result that India continued to plough its weary way until the Europeans especially the British, who came to trade at first and later to govern the country, introduced Western science.

2.3.3 Western Science in India Till Independence

By the end of the 15th century arrival of Portuguese was witnessed. As
they remained confined on the Western Coast, their influence on the scientific and technological efforts was limited. The Portuguese physician Gracia da Orta (1479-1570 AD) who came to Goa in 1534 developed a botanical garden in which he nursed many medicinal plants, at the same time studying scientifically the flora of the region. The three great European trading companies namely, the East India Company, The United East India Company of Netherlands and the French East India Company and the people who came with them, the missionaries, naturalists, medical men, engineers and other technical men were greatly responsible for introducing Western Science in India. Besides East India's administrative policies, the curiosity to understand and make use of the natural environment, stimulated diffusion of Western S&T in the country. This diffusion took place in 3 different phases.

In the 1st phase, the Europeans for commercial or political reasons came in direct contact with the new land and became deeply involved in the study of latter's flora and fauna, minerals and other areas in which they had experienced systematic new knowledge earlier.

In the 2nd phase, the scientific organizations and institutions as established by the Company & the British rulers widened the scope of scientific studies in the country.

In the 3rd phase, the scientific climate thus created in the earlier two phases gave impetus and attracted the Indian intellectuals to come forward, established some scientific institutions and conducted researches with great zeal.
In this way the foundation of modern science in India was laid. The European experts who came to India with trading enterprise were drawn to these areas:

2.3.3.1 Botany

The turning point in the history of botanical horticultural investigations in India was the coming into being of the Royal Botanic Garden in 1787 at Sibpur on the West Bank of river Hooghly. It emerged to be an important world center for botanical studies. The botanical researches received a new fillip with the establishment of teaching and research departments in the Universities, especially from 1920 onwards. S.N. Ghosh (Punjab University), Y. Bhardwaj (Banaras Hindu University) M.S. Sampath Kumar (Mysore University) and others made significant contributions.

2.3.3.2 Zoology

Like the flora, the wide and varied fauna of India had an enchanting appeal to the European naturalists. At the beginning of the 19th century, Governor-General Wellesley took the initiative in establishing a college at Fort William with a natural history department located at Barrackpore. In 1883 the ‘Bombay Natural History Society’ came into being. The zoological studies assumed new dimension with the establishment of the Zoological Survey of India in 1916. A notable feature was that the accumulating zoological knowledge was of immense help in understanding the intricate problems of several diseases.
2.3.3.3 Geology

The mineral wealth of India was indeed a source of attraction and inspiration for many of the Europeans who, in addition to their own fields of employment, soon set about exploring the Deccan, Central and North India, and the Himalayas.

The need for ensuring adequate supplies of coal for the steamers led the government in 1835 to set up a committee for the investigations of coal and other mineral resources of India. In 1846 the coalfields in Raniganj, Jharia, Taldange, Dhanbad and Karampura areas were explored.

2.3.3.4 Meteorology and Astronomy

The meteorological and allied observations became widespread in several parts of the country. In 1848 the first attempt to record the maximum and minimum temperatures was made. The study of law of storms was started and H. Piddington coined the term ‘Cyclone’. The natural calamities forced the need for strengthening the meteorological observations in a planned manner. Between 1865 and 1871, a number of observatories were established. Their work included the collection and recording of the atmospheric data, issuance of cyclone warnings, tidal observations, and astronomical and magnetic studies.

As to the astronomical studies, even in the last decade of the 18th century, the Governor of Madras, Charles Oakeley had established the Madras Observatory for promoting the knowledge of Astronomy, Geography and Navigation in India. With regards to the geomagnetic studies, India participated
in the global study of the earth’s magnetism as early as 1834.

2.3.3.5 Archaeology

William Jones encouraged the antiquarian studies in the classical texts and epigraphs, monuments and other architectural remains of India. The first systematic investigations on Archeology started in 1863 with the collection of tools, pebbles, etc

It was Lord Curzon who endeavoured to place the archaeological survey on an all India footing. Under John Marshall, the Director General of Archaeology, excavations were conducted at Taxilla, Pataliputra, Sanchi and Besnagar, Nalanda and above all, at the Indus Valley civilization sites- Mohenjodaro & Harappa (1922-23). A number of site museum devoted to Archaeology also came up, and the preservation of monuments was undertaken on scientific lines. Significant investigations were also conducted in the fields of epigraphy and numismatics.

2.3.3.6 Agriculture

The early phase of the British in India was characterized by the lack of a deliberate policy to improve Agriculture. The area under cultivation was increased; irrigation facilities were improved in the major river deltas.

Veterinary research also found place in the colonial system, as it was to take care of the health of military animals, particularly horses. In the first decade of this century, interest in agricultural research and education was shown in a
greater measure. Irrigations and famine commissions' recommendations further
directed attention to Agriculture, including Forestry.

The World War II caused disruption in what was achieved so far. Under a
situation of food scarcity, some food policy distribution and an integrated policy
of agricultural development were laid down as interim measures. It is found that
food grains production was almost stagnant between 1900 & 1930, although
cultivation area had increased. Lack of technology improvement and investment
in farming are the probable causes. The period between 1931 and 1947 is
marked by ups and downs.

2.3.3.7 Medical Sciences

A few British medical men started research work in Medical Sciences on
their own. The important fields studied by these scientists were the role of
Anopheles mosquitoes in the transmission of malaria by Ronald Ross, the
development of a vaccine for the prevention of plague by Haffikine etc. A string
of Pasteur institutes began to be established from 1900 onwards.

In 1911, the Government of India created the Indian Research Fund
Association to promote scientific medical research in India. This Association for
over 30 years sponsored schemes of research. The work of the Association was
taken over by the Indian Council of Medical Research (ICMR) in 1949. Work on
many of the communicable diseases, whether by bacteria, virus, protozoa or
parasite was mostly limited to survey.
2.3.3.8 Physiology

Independent chairs on Physiology and Pharmacology were first created around 1920 in the Calcutta Medical College and Physiology began to be taught as a distinct non-medical discipline in a Calcutta Science College around this time. Since the resources were inadequate and heavy teaching load was there, so investigative work could not be done.

2.3.3.9 Psychology

Scientific Psychology got started in India in 1915 in the University of Calcutta. Later development of Psychology in India followed more or less the pattern of the Western World. While the policies and the involvement of the foreign government in scientific and technical education of the Indians, as could be expected, in furtherance of their own interests, some Indian intellectuals and men of vision, who were themselves the product of such an education, provided new leadership for country's development. The last quarter of the 19th century witnessed eminent personalities like M.L. Sircar, Ashutosh Mukherjee, Jagdish Chandra Bose, Shrinivas Ramaiyam, C.V.Raman, Meghnand Saha, Birbal Sahani, Homi Jahangir Bhaba and P.C. Ray who were instrumental in heralding Western science teaching and research into India.

In 1876 M.L. Sircar founded Indian Association for the cultivation of Science similar to the Royal Institution of London. His motto behind this establishment was to provide an opportunity for Indian scholars for training by Indian teachers in physical and biological sciences.
Ashutosh Mukherjee, who was a mathematician, played significant role extending universities into institutions of higher learning and original research. J.C. Bose was the first Indian to contribute in Physics and Plant Physiology. In 1923, he established Bose Institute in Calcutta. He acted as a source of inspiration for new scientific pursuits.

The first half of the 20th century witnessed newer efforts in the direction of widening the base for scientific education and research, which were marked by increasing participation of enlightened Indians. Some of the Indian researchers devoted themselves to reach great heights and achieve excellence. Some of them like C.V. Raman was elected a Fellow of the Royal Society of London in 1924 and received Nobel Prize in 1930 for his outstanding work in Physics.

Some other mathematicians like Ganesh Prasad, N.R.Sen, Anand Rao, B.N.Prasad etc. made significant contributions in various branches of Mathematics. In 1931, P.C. Mahalanobis established Indian Statistical Institute at Calcutta. Thus Statistics gained importance and began to be applied in Agriculture, Public health, Economics etc. In Physical Chemistry N.R.Dhar, J.C.Ghosh, J.N.Mukherjee and S.S.Bhatnagar initiated researches. Thereafter the endeavours showed signs of decay largely due to the traditional compulsions and political vicissitudes. Thus the country as a whole remained educationally and scientifically backward until the emergence of independence in 1947. Not only was there initially a big gap to be bridged, but the developed countries had also
been in the mean time making advances in S&T at a tremendous pace (with a
doubling period of about 8-10 years), thus enhancing the gap even further.

Being aware of the importance of S&T, Mahatma Gandhi emphasized the
importance of village industries and self-sufficiency of the village community.
He was aware of the fact that despite vast resources, majority of Indians were
very poor, mainly because of the lack of education & stagnant technology.
Knowing that modern technology is capital intensive and will be difficult for a
newly developed democracy like India, he propagated the ideas of manual
labour.

The World War I exposed India’s weakness in the spheres of economy,
transport and communications and defence. It exposed her industrial
backwardness and dangerous dependence on foreign countries for various
esential commodities like medicines, chemicals, dyes etc. Until World War-II
there was still a gap between S&T. At the end of the World War-II, investments
in R&D in India was stepped up steeply, as also on higher education which is
essential to produce trained manpower in S&T.

2.3.4 S&T After Independence

Since its independence, India laid a strong foundation in S&T. For its
development, India’s first Prime Minister, Pt. Jawaharlal Nehru contributed a lot.
He involved scientists in decision-making process, explained applications of
S&T and set Department of Science and Natural Resources. Considering the
importance he moved in the Parliament the “Scientific Policy Resolution” on 4th
March 1958, which declared India’s faith in adopting Science, Technology and scientific method as the means of industrial and economic progress. In addition to the financial support, the Indian Parliament was probably one of the first in the world to adopt it. The development of the country was undertaken by means of the 5-year Plans.

The 1st Plan (1951-56) aimed at setting up of new national laboratories and research institutions training of personnel for manning the research institutions and running industries. The exploration and survey of resources was also emphasized. For making use of scientific and technical information on a large scale, GOI made efforts for setting a national scientific documentation center with the technical assistance of UNESCO under this plan. Thus Indian National Scientific Documentation Center (INSDOC), now known as National Institute of Science Communication and Information Resources (NISCAIR) came into being which became operational in 1952.

During 2nd Plan (1956-61) efforts were made to strengthen research facilities, coordinate research programs in various national laboratories and institutions with the requirement of national planning. It also intended to link up research work at the national level with the work carried out at the regional and state level and train and generate scientific manpower in sufficient numbers and ensure its proper utilization, link research and industrial needs.

The 3rd Plan (1961-66) aimed to strengthen the existing research institutions and expand facilities for research, encourage basic research and
research in engineering and technology with a view to developing and manufacturing scientific and industrial instruments. To train scientific manpower and expand the programs of research fellowship and scholarship, coordinate research work carried out by various national laboratories, universities, technical institutions, laboratories of scientific associations and research wings of government departments and utilize the results of research were also its objectives.

The 4th Plan (1969-74) emphasized on purposeful research and developmental programs. The laboratories were to provide experimental and pilot plant data to entrepreneurs. Engineering consultancy firms were to be engaged in Design Engineering and presenting feasibility reports. The plan aimed at avoiding duplication in the research work of different laboratories, stressed the desirability of increasing the utilization of indigenous expertise and materials in the nuclear power projects.

Under this plan in 1971, the Department of Science and Technology (DST) was established. Its main functions aimed at promoting and identifying frontline and priority areas of R&D in various disciplines of S&T, international scientific and technological affairs and development of S&T entrepreneurship. Besides it also aimed in the coordination of S&T activities in the country in which a number of institutions/departments/ministries have interests and capabilities and utilization of S&T for different sectors of society and industry. DST also provides financial and administrative support to some academic and
professional bodies engaged in the promotion of S&T in India.

The 5th Plan (1974-79) attempted to restructure the research programs. Plans were also finalized to make a beginning in the field of dissemination of scientific information by setting up of National Information System on S&T (NISSAT) under the DST.

The 6th Plan (1980-85) regarded science both as an outlook and as a value system and therefore it was felt that the “task of creating scientific temper is a vital necessity for the growth of science and its utilization in the developmental process”. A close nexus between S&T and education was envisaged.

The Plan also aimed at creating instruments relating to policy formulation and implementation of S&T creating necessary structures to transfer the benefits of S&T to rural areas. The “Technology Policy Statement (1983)” was a major enunciation of government policy during the 6th Plan Period.

The 7th Plan (1985-90) continued to emphasize on “growth, self reliance, improved efficiency and productivity”. It recognized new areas in S&T emerging on world scene, like microelectronics, informatics and telematics etc. Special emphasis was called for concerning S&T efforts to enhance productivity in the various major socio-economic sectors.

In the 8th Plan (1992-97) emphasis was laid on integration of S&T in the socio-economic sectors. Stress was also laid on specified four thrust areas of major significance, which was - Basic research in frontline areas, Innovative
research in exploitable areas of S&T, Allocation in S&T to atomic energy and space. It also emphasized on research and developmental activities in emerging technologies that provide India an opportunity for securing a position of leadership and self-reliance, diffusion of appropriate technology and integration of S&T in socio-economic and rural sectors.

The 9th Plan (1997-2002) was launched in the 50th year of India’s Independence. Its specific objectives were to give priority to productive employment, ensuring food and nutritional security for all, participation and mobilization of people at all levels and strengthening efforts to build self-reliance.

The 10th Plan (2002-07) was approved by National Development Council on 21st Dec.2002. It aims at creating 50 million job opportunities during the period. The ultimate idea of the plan is to bring all sections of society to the mainstream of socio-economic development.

2.4 Strategy of S&T in the National Development

The basic strategy of S&T effort includes:

i) Policies related to the provision and satisfaction of the basic minimum needs of the population.

ii) Policies concerning the achievement of self-reliance.

iii) Policies connected with the import of technology and those involved in deriving maximum social and economic benefit from the scientific and technical resources.
iv) Issues pertaining to the supply of S&T from scientific and technological institutions and educational establishments.

v) Range of policy matters associated with the problem of matching the demand for technology with its supply.

2.5 Urgency to Promote S&T World-Wide

In the world moving rapidly towards the knowledge-based economies of the 21st century, capacity building in S&T is necessary everywhere. “Inventing a better future” is a call for global movement to build S&T capacities in all nations. The growing sense of cooperation among scientific and technological communities of different countries and regions is highlighted as especially important in making these ideas and paths more practical now than ever before. Yet the global reality is that many innovations fail to accrue to those who need them most; and benefits are not at all shared equitably around the planet.

The international community has given inadequate attention to the needs of capacity building in S&T as the engine that drives knowledge-based development. Universities have an essential role to play in building S&T capacities. The universities must orchestrate the brainpower of the faculty, take responsibility for training new generations of talent and participate in the transformation of the nation on S&T base.

Stronger S&T capacity in the developing nations is not a luxury but an absolute necessity if these nations are to participate as full partners in the fast forming and knowledge-based world economy. Because S&T capacity building
is demanding and far-reaching, and necessarily tailored to each country and in particular situation, it will require the involvement of all pertinent actors in its implementation. There is much that national governments and other groups of social actors like local governments, non-governmental organizations, private sectors, international & regional organizations and media can do to change the course of events so that the benefits of S&T flow more equitably to all the members of the human family.
References


