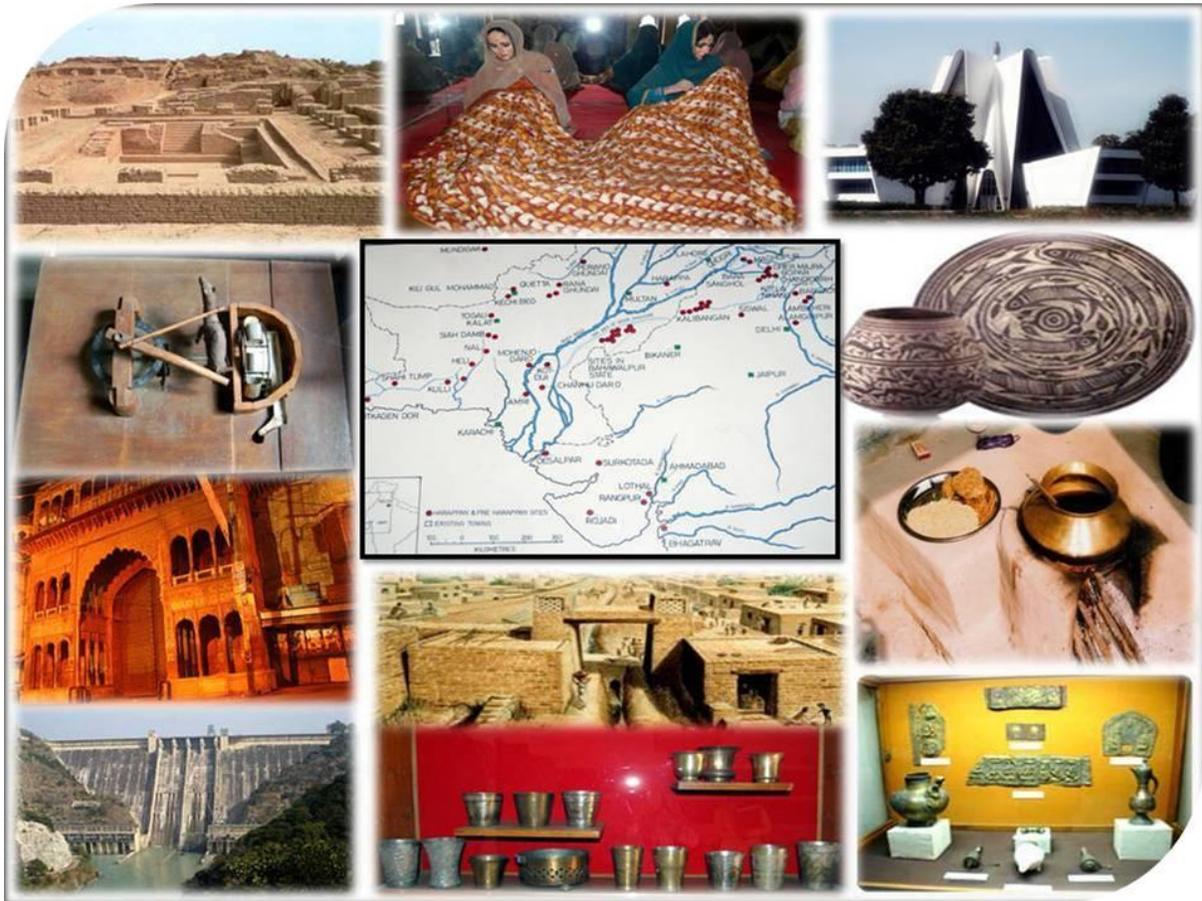


History of Science and Technology in Punjab



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Punjab State Council for Science & Technology, Chandigarh

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EXECUTIVE SUMMARY

History of Punjab – A Brief

Punjab in Persian literally means "five" (panj) "waters" (āb), i.e., the Land of Five Rivers namely Jhelum, Chenab, Ravi, Sutlej & Beas, referring to the rivers which flow through it. Punjab has a long history and rich cultural heritage. Punjab is the land where spiritual aspirations arose. This heroic land bore numerous invasions, and after all its suffering, did not entirely lose its glory and its strength and has been considered as one of the most enlightened and prosperous regions in the world.

Life in the region of Punjab existed prior to 4,00,000 years as suggested by the stone tools found in the Jhelum district. The history in Punjab begins with pre-historic activity of Mehrgarh. Incipient agriculture appears to have emerged towards the end of the Stone Age. Archaeological discoveries at Mehrgarh in present-day Baluchistan indicate that human inhabited villages existed in the region as early as 7000 BCE. Microlithic tools have been discovered in Punjab in the valleys of Beas and Satluj. By about 3000 BCE, the small communities in and around the Indus River basin had evolved and expanded giving rise to the Indus Valley Civilization, one of the earliest in human history. At its height, it boasted of large cities like Harappa (near Sahiwal in West Punjab) and Mohenjo Daro (in Sindh). The size and prosperity of this civilization grew due to the innovations which eventually led to more planned settlements having sophisticated irrigation and water storage systems including artificial reservoirs. This glorious civilization declined rapidly after the 19th century BCE, for reasons that are still largely unknown.

The next one thousand years of the history of Punjab (c.1500-500 BCE) was dominated by the Aryans that emerged from their cultural development in the Asian subcontinent. The Rig-Veda, perhaps the oldest scripture in India, was composed in the erstwhile Punjab sometime around 1500 BCE. During 550 BCE-600 CE, Buddhism remained prevalent in Punjab and in between during 550-515 BCE, Persian Invasion took place to the west of Indus River. Alexander invaded Punjab in 326 BCE. From 322-298 BCE, Chandra Gupta Maurya ruled the region followed by Asoka's rule from 273-232 BCE. Beyond this, the period of 125-160 BCE is known as the period of Rise of the Sakas or Scythians, who were the ancestors of Rajputs. The Kushanas ruled the region from 45-180 CE, followed by the rule of the Gupta Empire from 320-550 CE. In 500 CE, the Hunnic invasion took place after which the rule of Vardhana Empire was established from 510-650 CE. Rajput rulers governed the region between 647-1192 CE and the

period of 713-1300 CE is known as the period of Muslim Invaders (Arabs, then Turks) like Mohammed Ghori and Mahmud Ghazni. Mughal Rule was established during 1450-1700 CE during which the ten Sikh Gurus also arrived on the scene.

Under the Mughals, the province enjoyed a period of peace and prosperity for more than 200 years. The Mughal Rule declined after the death of Aurangzeb in 1707 CE and Banda Singh Bahadur established the first Sikh kingdom in Punjab from 1708- 1715 CE. After his martyrdom, from 1716-1759 CE, the Sikh struggle against Mughal Governors continued. In 1739 CE, Nadir Shah of Iran invaded Punjab while Ahmed Shah Abdali (Durrani) intruded the region nine times between 1748-1769 CE. As a result of these invasions, the region of Punjab suffered heavily on all social and cultural fronts due to political instability and socio-religious disturbances and all developments were affected adversely throughout the 18th century.

After the death of Abdali, the Sikh Misls ruled different parts of Punjab from 1764-1799 CE. The region came under the strong rule of Maharaja Ranjit Singh from 1799-1839 CE, who also united Punjab for the first time. After his death, the British Empire annexed Punjab during 1845-49 CE, after the First and Second Anglo-Sikh Wars and ruled Punjab from 1849-1947. In 1947 CE, India became independent and partition of India took place. Punjab was divided into two parts. The Eastern part became the Indian Punjab and the Western part, the Pakistan Punjab. In 1966, Punjab in India was further divided into three parts on linguistic basis - Haryana, Himachal Pradesh and Punjabi Suba (the present Punjab).

The term 'Punjab' emerged during the Mughal period when the province of Lahore was enlarged to cover the whole of the Bist Jalandhar Doab and the upper portions of the remaining four doabs. During their regime, the province of Lahore was known as the province of 'panj-aab'. The boundaries of Punjab changed several times thereafter, under Maharaja Ranjit Singh, the British and in independent India. Punjab since the very beginning has been exposed to political upheavals due to incessant chain of invasions. First Aryans, then Persians, then Greeks followed by Arabs, Turks, Afghans and Mughals, over the last millennium. Its rulers from the 11th to the 14th century were Turks. They were followed by the Afghans in the 15th and 16th centuries, and by the Mughals till the mid 18th century. The Sikhs ruled over Punjab for over eighty years before the advent of British rule in 1849. The policies of the Turko-Afghan, Mughal, Sikh and British rulers; the religious movements as well as the freedom movement had important effects on the economic, social and cultural life of the province including the development of Science & Technology.

Science based Technology: Domestic & Agriculture in Punjab – Early Years

The history of Science and Technology in Punjab began with prehistoric human activity at Mehrgarh, in present-day Pakistan, and continued through the Indus Valley Civilization. Irrigation based on technology was developed in the Indus Valley Civilization by around 4500 BCE. The size and prosperity of the Indus civilization grew as a result of this scientific innovation, which eventually led to more planned settlements making use of drainage and sewerage. As the people possessed scientific knowledge & culture, sophisticated irrigation and water storage systems were developed, including artificial reservoirs at Girnar dated to 3000 BCE and an early canal irrigation system from circa 2600 BCE. Technological interventions in Agriculture were also being made in this region. Cotton was cultivated in the region by the 5th millennium-4th millennium BCE. Sugarcane cultivation was originally imported from tropical South and Southeast Asia. Different species originated in different locations with *Saccharum barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea. The Indus Valley people were remarkably advanced in sanitation and drainage technology. By 2800 BCE, private bathrooms, located on the ground floor, were found in many houses of the Indus civilization. Pottery pipes in walls allowed drainage of water and there was, in some cases, provision of a crib for sitting in toilets. 'Western-style' toilets were also made from bricks and used wooden toilet seats on top. The waste was then transmitted to drainage systems. Large scale sanitary sewer systems were in place by 2700 BCE. The drains were 7-10 feet wide and 2 feet below ground level. The sewage was then led into cesspools, built at the intersection of two drains, which had stairs leading to them for periodic cleaning. Plumbing using earthenware plumbing pipes with broad flanges for easy joining with asphalt to stop leaks was in place by 2700 BCE. In the field of metallurgy, the Harappans manufactured copper, bronze and some precious metals too.

The inhabitants of the Indus Valley Civilization had advanced knowledge of mathematics. They developed a system of standardization, using weights and measures, as evident from the excavations made at the Indus valley sites. This technical standardization enabled gauging devices to be effectively used in angular measurement and measurement for construction. Calibration was also found in measuring devices. Some of the devices even had multiple subdivisions. The world's first dock at Lothal (2400 BCE), near Sabarmati was located away from the main current to avoid deposition of silt. Modern oceanographers have observed that the Harappans must have possessed knowledge relating to tides in order to build such a dock, as well as exemplary hydrography and maritime engineering. This was the earliest known dock found in the world, equipped to berth and service ships.

Excavations at Balakot (2500-1900 BCE), present day Pakistan, have yielded industrial technological evidence. An early furnace have been found. The furnace was most likely

used for the manufacturing of ceramic objects. Ovens, dating back to the civilization's mature phase (2500-1900 BCE), were also excavated at Balakot. The Kalibangan archeological site further yields evidence of pot-shaped hearths, which at one site have been found both on ground and underground. Kilns with fire and kiln chambers have also been found at the Kalibangan site.

Based on archaeological and textual evidence, Joseph E. Schwartzberg (2008), a University of Minnesota professor emeritus of geography- traces the origins of Indian cartography to the Indus Valley Civilization (2500-1900 BCE). The use of large scale constructional plans, cosmological drawings, and cartographic material was known in India with some regularity since the Vedic period (1st millennium BCE). Climatic conditions were responsible for the destruction of most of the evidence, however, a number of excavated surveying instruments and measuring rods have yielded convincing evidence of early cartographic activity. Schwartzberg on the subject of surviving maps—further holds that: 'Though not numerous, a number of map-like graffiti appear among the thousands of Stone Age Indian cave paintings; and at least one complex Mesolithic diagram is believed to be a representation of the cosmos.'

The first hand propelled wheel cart dates back to Indus Valley Civilization. Archeological evidence of an animal-drawn plough dates back to 2500 BCE in the Indus Valley Civilization. The earliest available swords of copper discovered from the Harappan sites date back to 2300 BCE. Swords have been recovered in archaeological findings throughout the Ganges–Jamuna Doab region of India, consisting of bronze but more commonly copper indicating their advanced awareness on metallurgy.

The Vedic and Post-Vedic Periods- The Indus Valley Civilization declined rapidly after the 19th century BCE. The next one thousand years of the history of the Punjab (1500-500 BCE) is dominated by the migrating Aryans under the influence of whom the culture that emerged then spread around among the inhabitants of the region. The Rig-Veda, one of the older texts in South Asia, is generally thought to have been composed in the Greater Punjab. The Aryans were a pantheistic people, following their tribal chieftain or raja, engaging in wars with each other or with other alien ethnic groups, slowly settled down as agriculturalists thereby consolidating territories and acquiring agricultural based occupations. Their skills in using horse-drawn chariots and their knowledge of astronomy and mathematics made them a group of people capable of defending themselves with technological advantage that led others on this account to follow their social customs and religious beliefs clearly indicate their scientific knowledge and outlook.

The Vedic period extended into the 6th and 1st millennia BCE, continuing up to the 2nd century BCE when it began to be transformed into classical forms of Hinduism. In its

late phase (from 200 BCE), it saw the rise of the Mahajanapadas, and was succeeded by the golden age of Hinduism and classical Sanskrit literature, the Mauryan Empire (from 320 BCE). Upto this period, there were many S&T developments including the emergence of Gandhara school of art, technology for good quality weapons (spears, swords, longbow), advancements in medical sciences (ayurveda, medicine & construction of hospitals), metallurgy (coinage of copper & silver, glass moulding), mathematical calculations using zero and decimal including first positional base 10 numeral systems in the world, several advancements in integral system and trigonometry and use of indigo as a dye.

Buddhism and Mauryan Empire were followed by the rule of Turks, when Darius of Persia expanded the Persian Empire beyond the Indus River (Punjab and Sind) in 521 BCE. There were many social changes as a result of Turkish rule. Traditional society so far dominated by a rigid caste system in which the relative positions, duties and disadvantages of its different segments were determined by birth, began to significantly transform itself during the Turko-Afghan, Mughal, Sikh and British periods. The ruling class, or Rajputs, lost their status to newer elites and the Brahmins too lost State patronage. The upper castes, including Brahmins (priests) and Kshatriyas (rulers) were thus forced into other occupations. The former took to secular occupations; and the latter became, at best, chaudharis, collecting revenue from a group of villages. Others became cultivators, traders and shopkeepers. As a result of the hierarchical order being weakened by the Turko-Afghans and the Mughals, much greater social mobility became possible. Artisans and service-providing groups increased in size and numbers, due to a spurt in craft production and trade. The extension of cultivation led to the emergence of new towns in the well cultivated upper doabs of Punjab. Merchants of Multan and Lahore began to play a crucial role in domestic and external trade.

By the early 17th century, Punjab had an active commercial life, involving a wide range of traders, peddlers, brokers. The cash nexus was fairly well established under the Mughals, and interdependence between towns and the countryside increased considerably by the end of the 17th century. The technological interventions in the field of irrigation led to the introduction of the 'Persian Wheel', which facilitated artificial irrigation, resulting in considerable increase in agricultural production. A certain degree of commercialization of agriculture was in evidence during the early 17th century. The spinning wheel, carding-bow and improved wooden loom brought a major change in weaving technology and resulted in rapid growth in the textile industry under the Mughals. The introduction of lime mortar as cementing material and the abundance of lime (chuna) in Punjab facilitated brick-and-stone construction and gave impetus to the building industry. After the Turks introduced the manufacturing of paper, Sialkot emerged as an important centre of paper manufacture. Artisanal production, on the whole, continued to be carried on with elementary technology and simple tools in a

system of production which was rooted in the caste society and based on the family as a unit of production. Minute specialization by each occupational sub-caste created a vested interest in static labor-intensive technology. Since production of necessities like textiles, metal articles, leather goods and agro-manufactures was highly localized, mass production and technological innovation became relatively difficult. Islamic Law was introduced for the administration of justice under Turko-Afghan and Mughal rule.

A Period of change in thought process - By the 16th century, many new ideas began to emerge. Sufism and the Sikh Panth gained considerable ground and popularity amongst the masses. Guru Nanak initiated the development of a new script- the Gurmukhi and gave sermons on the origin of universe, vastness of universe, conservation of nature and natural resources etc. The ideology of Guru Nanak and his successors had a special appeal for laboring sections. Day laborers, craftsmen, agriculturists, traders and shopkeepers were electrified by the radical new doctrine. Their voluntary contributions to the common funds of the community enabled the Gurus to establish religious centers and establish new towns, which became centers of production and exchange. The financial independence of the community and its organizational networks spread all over the Mughal Empire, making the Sikh Panth a sort of state within the Mughal Empire. The egalitarian nature of the Sikh Panth was reinforced by the institution of the Khalsa in 1699. In addition to equality in congregational worship and the community meal, the Khalsa encouraged equality in social and political life. The scientific and rational vision of the great Gurus further helped the people to get rid of superstitions, caste system, unscientific rituals, pseudo-religious ceremonies, idol worship etc. and helped create scientific thinking based on principles of faith, justice, equality and mutual respect. Sikhism advocated the pursuit of salvation through disciplined, personal meditation on the name and message of God.

In addition to the development of scientific temper, technologies to build forts, laying of gardens, construction of bowlis (for water storage) and manufacture of arms were encouraged during the Sikh rule. Ranjit Singh was the first ruler in the Punjab who thought of large scale utilization of canal water for the irrigation of the crops. Both the perennial and inundation canals were excavated and expanded in the early nineteenth century. Under the Kingdom of Lahore, inundation canals were excavated particularly in the south-west, in Multan and Derajat, both by the State and the private individuals with the help of the State. Cultivation of a variety of crops was also encouraged during the Sikh rule.

Preliminary scientific parleys and socio-political changes during the British Rule

British annexed Punjab during 1845-49 CE, after the First and Second Anglo-Sikh Wars, and ruled the province from 1849 to 1947. The British era in Punjab introduced new institutions and technologies. The colonial state subscribed to the values of humanism, rationalism and progress. Yet the state was geared towards using its technological and industrial superiority to perpetuate its own domination and maximize its economic advantages. There was a substantial increase in agrarian production. The network of perennial canals built by the new state combined with new agricultural techniques, implements and seeds, made Punjab agriculturally the best-developed region of India. The bulk of its agricultural surplus entered foreign trade. The commercialization of agriculture transformed the large peasant proprietor in the upper doabs and the canal colonies into a producer for the world market. As machine-made goods became available, the traditional artisan was faced with a shrinking market. As his incomes fell he began to look for opportunities outside the village community. An increasing number of artisans thus became skilled and unskilled laborers on construction sites, railway tracks and railway workshops. Some migrated to the British colonies in Africa, Latin America and South-east Asia in search of work. However, others took to the new education and became professionals like teachers, lawyers and engineers. Some turned to petty trading and jobs related to industry; others joined the police, army and civil administration. The colonial state took two policy decisions regarding education: one that it was the responsibility of the state to impart education to the people, and two, that it should focus mainly on Western knowledge (based on S&T) and English language. The system of education, thus, was aimed primarily to provide manpower for the administrative, technical and military requirements of the colonial state. The content of education developed by the government was totally secular, consisting of natural and social sciences, languages and literature. Christian missionaries were not only allowed but were also encouraged to undertake educational projects. Often, the evangelical content of their educational program motivated English-educated Punjabis to devise their own programs of education. By 1900, several educational institutions came up in the Punjab under the aegis of the Arya Samajis, Singh Sabhas and Islamic Anjumans. The 20th century saw the extension of private enterprise in education along with an enlargement of the educational responsibilities of local bodies, particularly through municipalities. The principle of free elementary education for boys was conceded in 1919 and for girls in 1940.

A similar tendency was evident in the sphere of medicine and health. By the time the British annexed Punjab, the idea of regular Western-style hospitals for Europeans and soldiers was well established. Within the first two decades of British rule in Punjab, civil hospitals and dispensaries of different grades were established mainly at the district and tehsil headquarters, and a medical school was set up in 1860 at Lahore. Dispensaries and hospitals were also run by the missionaries and charitable institutions, which

received some assistance in the form of grants-in-aid. Municipalities were formed to take care of sanitation.

Impact of Changes - Social and Religious reform was to a significant extent spurred by Christian missionaries. A reaction and interface with Western Christian thought resulted in many educated Punjabis organizing themselves into such organizations such as the Anjuman-i-Islamia, Lahore (1869), the Lahore Brahmo Samaj (1863), the Singh Sabha, Amritsar (1873) and the Arya Samaj, Lahore (1877). These spread themselves throughout Punjab by the end of the century. Religion became the dominant concern of the reformers. Their other major concern was the spread of education. They were deeply interested in the upliftment of women through education, establishing a higher age of marriage and reforming customs related to marriage and death. Other organizations taking an interest in religious and social reform of some kind were the Namdharis and Nirankaris among Sikhs; the Dev Samaj and the Sanatan Dharm among Hindus; and the Ahmadiyahs among Muslims. To sum up, the British Raj greatly transformed Punjab. Different sub-regions of the province and different sections of its population were differently affected by a century of colonial rule. Economically, scientifically and in terms of urbanization, the upper doabs and canal colonies were better developed than the south-eastern districts comprising the Haryana area. Hindus and Sikhs were better off, compared to Muslims. Specifically, the segments that did well as the collaborators of the colonial state were the professional middle classes, large landholders and traders. Those artisans who diversified from their traditional vocations also benefitted.

Advancements in S&T in Punjab after Independence

In 1947, 13 out of 29 British districts of Punjab in undivided India came to East Punjab, which was renamed Punjab (India) on 26th January, 1950. In 1948, the former princely states were organized separately as Himachal Pradesh and PEPSU (Patiala and East Punjab States Union), the latter merging with Punjab in 1956. Following the Akali agitation for a Punjabi-speaking state, and the Re-organization Act of 1956, the territory of Punjab was bifurcated into the linguistic states of Punjab and Haryana, with the remaining hill areas going to Himachal Pradesh. Post-bifurcation, Punjab came to have an area of 50,362 sq. kilometers which was one-seventh of its size before independence. The new state was divided into eleven districts, including Rup Nagar, created as part of the re-organization. Structurally, the development blocks which were introduced in 1952 presented the only new feature up to this period. At present (2013), Punjab has 22 districts.

Following the re-organization, Punjab took centre stage in the Green Revolution launched by the Government of India and the states. Much of what has happened in

Punjab in the field of Science & Technology subsequently owes its origins, nature and impact in some direct or indirect way to the Green Revolution.

The Green Revolution

India has gone from a food-deficit to a food surplus country largely because of the agricultural transformation of Punjab. The economic transformation of rural Punjab is basically a story of agricultural or scientific transformation. During the 1960s a fundamental change occurred in the institutional and economic infrastructure due to massive public investment. There was irrigation and power development, agricultural research and extension services, and the strengthening of the co-operative credit structure. Already, consolidation of holdings and the predominance of owner farmers had created crucial pre-requisites for the Green Revolution. Punjab led the country's Green Revolution of the 1960s and earned for itself the distinction of becoming India's 'bread basket'. The Green Revolution introduced a new technology of production in agriculture. The hard working farmers of the state readily adopted the technology consisting of a package of inputs, such as, high-yielding varieties of seeds, chemical fertilizers, pesticides, insecticides, weedicides, agricultural implements like tillers, tractors, threshers, pumpsets/ motors, combine harvesters/ reapers and others. Punjab was also a major beneficiary of British investment in irrigation works and development of canal colonies where peasants from the east and central Punjab were resettled. In the post-Independence period, canal irrigation was further developed by the state. By 1960-61 the net sown area irrigated in Punjab had gone up to 54 percent. During the British period, agriculture in Punjab, particularly in the canal colonies was largely commercialized. The peasants who migrated to Indian Punjab from western Punjab in 1947-48 during Partition were experienced in and geared towards commercial agricultural production. Thus, even before the availability of the Green Revolution Technology, Punjab was showing signs of rapid agricultural development. From 1953-55 to 1963-65, the index of agricultural production of all crops experienced a growth rate of 4 percent compared to 2.2 percent at the all India level. These conditions in Punjab were accompanied by an official policy of strengthening and promoting agricultural research and extension. The College of Agriculture at Ludhiana was converted into the Punjab Agricultural University (PAU) in 1962. PAU was put in charge of agricultural research and education in the state and played a pivotal role. It is renowned for its work on high yielding varieties of seeds and technical innovations like fertilizer drills and threshers. Simultaneously, the government invested massively in rural development, ranging from irrigation works, drainage of rain water, and reclamation of land to solve the problem of land salinity. The impact was dramatic from 1965-66 and 1970-71 the per hectare yield of wheat doubled, from 1104 kg per hectare in 1965-66 to 2238 kg in 1970-71. Following the success of the new technology in wheat in the mid-1970s, a breakthrough was achieved in dwarf high-yielding varieties of paddy. After wheat, paddy provided a major push to agricultural prosperity in the state. By the mid-1980s, except

for the southern parts of Punjab, the state began to follow a 'wheat-paddy rotation' pattern in cultivation, and, as a consequence Punjab became the food bowl of the country. It became the largest contributor to the central pool of procurement of food grains both for food security, as well as for running the public distribution system of food grains. The Green Revolution has been the backbone of Punjab's development. It increased cropping intensity from 126 percent in 1960-62 to 185 percent in 1996-97, and the net sown area as a percentage of the geographical area rose from 75 to 85 during this period. The number of tractors rose from 10,646 in 1962-65 to 234,006 in 1990-93 and pumps sets from 45,900 to 721,220. Fertilizer (NPK) consumption increased from 30,060 tonnes in 1962-65 to 1212,570 tonnes in 1990-93. Consumption of chemical inputs also increased. The Green Revolution also brought changes in lifestyle. Aspirations increased—there was demand for better education for children, better housing and better consumer goods.

The impact of the Green Revolution differed through the regions of Punjab. The Doaba region saw a sizeable immigration of Sikhs to England, United States and Canada. Money remittances from overseas communities were used by the Jat Sikh farmers in the Doaba to improve their houses, increase lands and to buy machines. Recruitment in the army has always been an important adjunct to the agricultural economy. However, the trend of supplementing agricultural income from other sources was unevenly spread through the different regions. The Doaba region was foremost in this trend, followed by Majha and, only a part of the Malwa region, like the districts of Ludhiana and Patiala. One area where the impact of the Green Revolution was least felt was the so-called Kandi region (the area of the Himalayan foothills). Until today, the Kandi belt continues to remain relatively backward socially and economically.

The Green Revolution Technology worked very well until the beginning of the 1980s. But subsequently, agriculture began to show signs of fatigue. Productivity slowed, and stagnation set in. PAU estimates show that on an average the Punjab farmer achieved 75 percent of the achievable potential yields of rice and wheat with the currently available technology (PAU, 1998). As union and state government support to agriculture has declined, the present cropping pattern and production system seems to be economically unsustainable. Additionally, the Green Revolution Technology has put great pressure on the ecological system, leading to a fall in the level of the ground water table, and soil depletion. Thus, the initial prosperity that the peasantry achieved is at this time diminishing at a very rapid rate. Punjab now requires new technology to make the present crops more profitable, as well as ecologically sustainable.

The state is witnessing serious consequences of intensive farming using chemicals and pesticide. A comprehensive study conducted by Post Graduate Institute of Medical Education and Research (PGIMER) has underlined the direct relationship between

indiscriminate use of these chemicals and increased incidence of cancer in this region. Increase in the number of cancer cases has been reported in several villages including Jhariwala, Koharwala, Puckka, Bhimawali, Khara. Environmental activist, Vandana Shiva has written extensively about the social, political and economic impacts of the Green Revolution in Punjab. She claims that the Green Revolution's reliance on heavy use of chemical inputs and monocultures has resulted in water scarcity, vulnerability to pests, and incidence of violent conflict and social marginalization. In 2009, under a Greenpeace Research Laboratories investigation, Dr. Reyes Tirado, from the University of Exeter, UK conducted the study in 50 villages in Muktsar, Bathinda and Ludhiana districts revealed chemical, radiation and biological toxicity rampant in Punjab. 20% of the sampled wells showed nitrate levels above the safety limit of 50 mg/l, established by WHO, the study connected it with high use of synthetic nitrogen fertilizers.

To mitigate the negative effects of green revolution, the state government has initiated a number of measures in recent years. These include package of agricultural practices, extension services directed towards the diversification of agriculture in Punjab from crop production to other subsectors such as dairy, animal husbandry and horticulture, alternative crops, new improved varieties of crops etc. These efforts have started showing results and the state is again on its way to the path of rapid development and progress based on scientific & technological interventions.

Sector Wise Developments of S&T in Punjab

Following is the summary of Punjab's contribution in the field of Science & Technology in various sectors during the course of history:

Agricultural Science & Technology

The history of Agriculture in Punjab dates back to Neolithic age around 4000 BCE. The southern and north-western parts of Punjab were marked by human settlement which had a notable advanced agriculture and use of the two-wheel ox-cart. During the Indus Valley Civilization, the area witnessed technical advancements in agriculture which provided surplus food. In the Vedic period, agriculture was an important vocation with four main agricultural operations of ploughing, sowing, reaping and threshing. Many indigenous agricultural implements were used and Vedic farmers also knew the method of improving the fertility of soil by crop rotation method, selection & treatment of seeds, seasons and sowing and harvesting, manuring etc. Monarchs like Chandragupta Maurya, Ashok, Chandra Gupta-I, Samudragupta and Harshavardhan were great leaders who gave a new lead to the march of culture and agriculture in the region of Punjab. Agricultural production and traditional agricultural techniques further grew during the Mughal and Sikh rules and with the arrival of British, the scientific and

technological innovations and mechanization of agriculture transformed the medieval character of agriculture in the Punjab into a modern one.

After independence, Punjab took centre stage in the Green Revolution launched by the Government of India and earned for itself the distinction of becoming India's 'bread basket'. The Green Revolution introduced a new technology of production in agriculture. The technology consisted of a package of inputs, such as, high-yielding varieties of seeds, chemical fertilizers, pesticides, insecticides, weedicides, and machines like tractors, threshers, pumpsets/motors, combine harvesters / reapers and others.

Today also, Agriculture is the mainstay of Punjab's economy. Nearly 86 per cent of the total geographical area of the State is under cultivation. Punjab with only 1.53 per cent geographical area of the Country alone contributes 60 percent wheat 58 percent of rice to the central pool. Besides wheat and rice, other main crops are maize, gram, sugarcane, potato, fruits, vegetables and pulses. Processed agro-products like mushrooms, honey, chillies, potato chips and tomato paste are exported from Punjab. The State has achieved great success in allied agricultural professions like animal husbandry, dairy farming, poultry, horticulture, vegetable production etc. The state has also been on the forefront of white and blue revolutions in the country.

Water Management and Irrigation System

The construction of dams and bridges using plaited bamboo iron chairs gets a mention in the Arthshastra of Kautilya. Use of suspension bridges is visible in about the 4th century. Technologies to manage water resources were highly advanced in the region from Harappan times onwards. Punjab being an agricultural region evolved indigenous water management technologies and always accorded importance to irrigation schemes. The Rig-Vedic farmers constructed channels for carrying water from the wells and from rivers even. The Maurya monarchs also took keen interest in irrigation schemes. Artificial means of irrigation in Punjab based on technology were gradually developed. Irrigation by wells with the water wheel (*gharat*) called Persian Wheel became increasingly important in the upper portions of the Punjab from the thirteenth century onwards, particularly between the river Chanab and the river Yamuna. The use of water wheel (*gharat*) for grinding flour also became popular in the region. Firoz Shah Tughluq, introduced canal irrigation in the 14th century. In the 17th century, Shah Jahan constructed the famous Shah Nahr in the upper Bari Doab, and the Yamuna Canal for Yamuna-Satluj divide. Irrigation by canals and wells was well maintained by the Sikh rulers. The British brought more area under cultivation through a network of canals. Irrigation works of great magnitude with permanent head- works, head regulators, well defined courses and extensive systems of distributaries were constructed. Punjab Irrigation Department was set up in the year 1849. The construction of Upper Bari Doab

Canal from river Ravi at Madhopur, Sirhind Canal from river Sutlej at Ropar, Eastern Canal & Bikaner Canal from river Sutlej at Hussainiwala Headworks date back to the British era. After independence, monumental multipurpose projects like Bhakra Dam on river Sutlej, Pong Dam on river Beas, Beas Sutlej Link Project and Ranjit Sagar Dam on river Ravi have been undertaken in addition to construction of Nangal Hydrel Channel, Anandpur Sahib Hydrel Channel, Bhakra Canal System, Mukerian Hydrel Channel, Shah Nehar Barrage, Harike Barrage etc., which has made Punjab the best irrigated state in the country.

Town Planning, Civil Engineering and Architecture

The Harappan or Indus- Valley Civilization was the world's first civilization to build planned towns with underground drainage, civil sanitation, hydraulic engineering, and air-cooling architecture based on technology. Weights and linguistic symbols were standardized across this vast geography. Oven-baked bricks were invented and archaeologists have found geometric compasses and linear scales made of ivory. Their townships were laid out with geometric precision. All construction was done in burnt bricks. There were rows of comfortable houses using only two or three standard sizes and designs providing court-yards, bathrooms and kitchen. There were grids of paved wide and straight roads and covered drains with man-holes, and flood protection walls. Every city had a citadel, a lower section of town for commoners, public bathrooms with change rooms, big tanks and a room having a water well, a set of big granaries with working areas and labourer's barracks. Some of the cities had a stadium as well. They had jetties on the riverside for loading / unloading goods, perhaps grains. The roads, buildings, forts, gardens and places of worship in the region developed gradually during the Mauryan, Mughal, Sikh and British periods with distinctive style and architecture. Post independence, Chandigarh, planned by the famous French architect, Le Corbusier, is one of the best experiments in urban planning and modern architecture in the twentieth century in India.

Metallurgy, Industry, Power and Transportation

Iron could have likely originated in Vedic India because copper was a well-known technology in many parts of ancient India. Rust-free steel was an Indian invention, and remained an Indian skill for centuries. Delhi's famous iron pillar, dated 402 CE, is considered a metallurgical marvel and shows minimal signs of rust. Another important contribution to metallurgy in the region was in the isolation, distillation and use of zinc. Brass in Taxila has been dated from 3rd century BCE to 5th century CE. The construction of dams and bridges using plated bamboos and iron chains gets mentioned in the Arthshastra of Kautilya. Brass utensils and bangles belonging to the Kushana period have been discovered in the region of Punjab. Alloys that exceed 10 per cent

zinc are found earliest in Taxila in the 4th century BCE. Use of suspension bridge is reported in the 4th century. North Indians were expert in extracting metals and forming alloys. Another famous series of seamless celestial globes was produced using a lost-wax casting method in the Mughal Empire in 1070 AH (1659–1960 CE) by Muhammad Salih Tahtawi with Arabic and Persian inscriptions. It is considered a major feat in metallurgy. These Mughal metallurgists pioneered the method of wax casting while producing these seamless globes. Metal Currency was in circulation before 5th century BC with coinage of silver & copper in 400 BCE-100 CE which had animals and plants as symbols on them.

Village and small scale industry originated in the region from the Harappan times and evolved during the Vedic Period, Mauryan Era and Post-Mauryan Period. During the Mughal rule, the introduction of the 'Persian Wheel' facilitated artificial irrigation. The spinning wheel, carding-bow and improved wooden loom brought a major change in weaving technology and resulted in rapid growth in the textile industry under the Mughals. Weaving and spinning of cotton, making of unrefined sugar, pottery, different kind of scents, oils and spirits, shoe-making became popular cottage industries. Manufacture of agricultural implements and brass & gold work attained importance. The introduction of lime mortar gave impetus to the building industry. With the arrival of British, changes came all over with the introduction of electronic telegraph, steam engine and sophisticated railways. The railway network contributed to the commercialization of agriculture and encouraged the development of agro-processing and agro-input machinery industries. Lahore, Amritsar, Dhariwal, Sialkot, Wazirabad, Batala, and a few other towns emerged as important industrial centers and industries that existed in the form of woolen mills, iron foundries in Batala and Mandi Gobindgarh and a couple of sugar mills. Post independence, there was an explosion in the number of small scale units. Growth centered on Ludhiana, Jalandhar, Amritsar and Goraya. Most of these units produced bicycles, sewing machines, agricultural implements, medical instruments, hosiery, machine tools and sports goods or parts for these goods. At present, there are 1.99 lakh small scale industrial units in the state producing bicycle parts, sewing machines, hand tools, machine tools, auto parts, electronic items, sports goods, surgical and leather goods, hosiery, knitwear, nuts and bolts, textiles, sugar, vegetable oil etc giving employment to about 8.80 lakh persons. An information technology park is also being setup at Mohali which will provide built-up space for software and hardware industry. As on 2010-11, there are 168000 small scale and 425 large and medium scale industries. The Industrial production has more than doubled in both, small scale industries (from Rs.183.24 billion in 2001 to Rs. 418.96 billion in 2010) as well as medium and large scale industries (from Rs. 265.76 billion in 2001 to Rs. 583.12 billion in 2010) providing employment to about 2.50 lakh persons.

The construction of Bhakra Nangal Complex, including Bhakra Dam, Bhakra Main Line, Nangal Hydrel Channel, Ganguwal and Kotla Power House, Harike Barrage, Sirhind Feeder, remodeling of Madhopur Headworks into Barrage etc have been some of the major hydroelectric projects which have played a significant role in considerably enhancing the irrigation and power potential of the state. Presently, the Punjab State Power Corporation Ltd. (PSPCL) has 2,677 MW of installed capacity from its own thermal power plants. In 2013, two new Thermal Power Plants with private partnership have been commissioned in Punjab at Talwandi Sabo (1980 MW) Mansa and Rajpura (1400 MW). Another thermal plant with the capacity of 540 MW is being developed at Goindwal Sahib in Tarn Taran district. The state has also started the exploitation of non-conventional energy sources in a big way e.g. rice straw thermal power plant at Jalkheri is the first of its kind in India with a generating capacity of 10 MW. The State is also generating energy from biogas, biomass, small hydro and other non-conventional sources. There is 100 per cent electrification in Punjab.

Transportation facilities have existed in the region from ancient times. The Grand Trunk road has existed in the region for more than two millennia. With the advent of the British, revival of ancient routes and renovation was initiated. Modern system of transportation began with the introduction of railways. At present, the road length in Punjab is 44,076 km out of which provincial roads are 42,589 km while national highways are 1,487 km. All villages of the state have been linked with metalled road. The length of the rail routes passing through the state is around 3,726.06 km. Rail communication with Pakistan also emanates from Punjab (Amritsar). Punjab has been declared one of the best States in India in terms of rail, road and transport network as per National Council of Applied Economic Research (NCAER), 2007.

Today transportation in Punjab is provided by buses, railways, air and other local means like taxis and auto-rickshaws. The state has a large network of multimodal transportation system. Air transportation in Punjab is through airports at Ludhiana, Patiala, Pathankot, and Mohali. Sri Guru Ram Dass International Airport in Amritsar is operational while another International Airport in Mohali is coming up at a project cost of Rs. 910 crore and is likely to be fully operational by 2015. With this, Punjab is geared to be one of the finest and easily accessible tourist as well as business destinations in South Asia.

Mathematics, Geometry, Algebra, Physics, Chemistry, Astronomy and Cosmology

Mathematics- The use of large numbers uniform system of weights & measurements were adopted by the people of Indus Civilization. The religious texts of the Vedic Period provided evidence that for the use of large numbers. In this age, highly significant mathematical concepts like Pythagorus is found in the Satapatha Brahmana as well as

the Sulba Sutra, the Indian mathematical treatise. The Decimal system based on powers of ten, where the remainder is carried over to the next column, was first mentioned in the Taittiriya Samhita of the Black Yajurveda; The Concept of infinity; Binary number system, essential for computers, was used in Vedic verse meters. It has been admitted worldwide that the Indians (perhaps Panjabis) were the inventors of the numerals and they were the first to have started counting by tens. This revolutionized the counting of very large numbers. An example of this system is found in "Panch Sidhantka" written by Varha Mehar in the 5th century. Aryabhata, Brahmagupta, and Bhaskaracharya were the greatest mathematicians of India and had some connection with the Panjab. Brahma Gupta's main claim to fame is the set of rules he devised to calculate the volume of a prism and of four sided figures inscribed within and around circles. He is also the first person to have summed up the series. The oldest extant mathematical manuscript 'Bakhshali' was used in the region of Punjab in 8th-12th CE.

Geometry- The Satpatha Brahmana, a component of the religious text of Vedic Period contained rules for ritual geometric constructions. 'Pythagoras Theorem' was known to the Hindu mathematicians two centuries earlier than Pythagoras (580BC-500BCE). This is also confirmed by Mr. V. Schroeder when he states that "the Greek philosopher owed inspiration to India" (History of Hindu Chemistry Vol.1). The usual belief has been that the T-ratios like sine and cosine etc were invented by the Arabs but Edinburgh Encyclopedia tells us that the Arabs received this knowledge from India. "Hindu mathematicians knew the relationship between the diagonal of a square and its sides; in other words they were familiar with the Pythagorean relationship between the sides of a right angled triangle. It is claimed too that they knew about binomial expressions and the coefficient that arose, and were also able to write these down, using long and short syllables as early as 3rd century BC. It is therefore sometimes said that they knew the Pascal's triangle as early as this." In Ain-e-Akbari (commissioned by Emperor Akbar of Delhi), we find references to the calculation of circumference of a circle as calculated by the ancient Hindu mathematicians of Taxila. Here we find the ratio of diameter to the circumference as 1250 to 3929 which turns out to be the ratio 'Pie' used today and valued at 3.143. According to Mr. Colin A. Ronan the value of 'pie' was first calculated by Aryabhata (born 476 BCE) up to four decimal places. The circumference of the earth was calculated by the Indian mathematicians as 4,967 Yojanas. If a Yojna is taken as equal to five English miles, then the circumference of the earth calculated by the Indian mathematicians turns out to be 24,835 miles. (Modern calculations give us the circumference as 24857 miles)

Algebra- The Buddhist carvings and statues created near Taxila around the 1st century CE onwards (known as Gandhara Art) captivate the westerners even today. The fact is that Algebra had been taught in India since 500 BCE. It has also been discovered that

the great mathematician Bhaskaracharya was the first to have used Differential Calculus in his problems of astronomy.

Physics- Although laws of motion and theory of gravity are said to have been discovered by Newton in 1687 CE, but we find references to gravity, laws of motion, inertia and momentum (impetus) in the Indian writings of antiquity and this fact is now acknowledged by the western scientists.

Cosmology- The Rig-Veda divides universe into earth, firmament and heaven. The Rig-Veda versus also bring out clearly the important part played by Sun, the Moon and the Earth. The Rig-Veda also described the constellation system and solar eclipse. Guru Nanak (1469 CE) who founded the Sikh religion told about the distance to the moon which is exactly what the scientists tell us today. He also disclosed that there are universes upon universes, and spheres upon spheres and many planets had existence like ours.

Astronomy- Astronomy was practiced in north India as early as 2780 BCE. We find the mention of movements of the earth and the other planets mentioned in the old Indian literature. The Sanskrit Uccha for (apex of an orbit) appears to have become Aux in the west. According to Professor Wilson, "The science of astronomy exhibits many proofs of accurate observation and deduction, highly creditable to the science of Hindu astronomers. Although there are some remarkable coincidences between the Hindu and other systems, their methods are their own." Dr. Robertson writes, "It is highly probable that the knowledge of the twelve signs of zodiacs were derived from India." The earliest astronomical text was Vedanga Jyotisa whose astronomical attributes were generally applied to timing of social and religious events. The greatest astronomer of India was Aryabhata who wrote a lot about the motions of the planets and the solar and lunar eclipses. His works Aryabhatika, Dasa Gitika and Aryashtasata had become world famous. Another great astronomer named Parasara is supposed to have lived around 1400 BCE. He was followed by Varahmihira, the author of 'Brihat Samhita' about which Mrs. Manning writes, "Richness of detail constitutes the chief attraction of Brihat Samhita, a merit which was appreciated by the Arab astrologer, Alberuni, as it will be for geography, architecture, sculpture etc, is unequalled by any Sanskrit work yet published." Brahmagupta, another mathematician set forth the Hindu astronomical system in verse form, including events such as lunar and solar eclipses, planetary conjunctions, and the positions of the planets. The Indian astronomer to have worked out laws of gravity was the great mathematician Bhaskaracharya who lived around 1200 BCE.

Medicine & Health

As far as recorded knowledge goes, the earlier instances of rational medical knowledge have been found in the Rig-Veda. The Rig-Veda contained information and observations on ailments, skin diseases, urinary diseases, eye diseases and many other diseases of the human body. The idea of rejuvenation is also found in Rig-Veda. The fundamental concepts of medicine were later collected together and comprehensive treatises were also written during the Buddhist and Jain periods. Study of medicine was a subject in Taxila. Most of the information during this period is contained in Charak Samhita, written during the Kushan period, which contains detailed information on the science of medicine. The centre of medicine in Punjab was Taxila where research in medicine was conducted by the topmost physicians like Jivka. It was also taught as a subject. The system known as Ayurveda is fully explained in Susruta and Charaka. According to Susruta, expertise in dissection was compulsory for students of medicine. The stress in training was always on knowledge gained through observation and practical experience. The cataract surgery was known to Susruta which was performed with a curved needle (Jabamukhi Salaka) to loosen the lens and push the cataract out of the field of vision.

In modern era, the Mughal rulers patronized Unani system of medicine. The coming of the British in the territory marked the entry of allopathic medicine system, medical research and opening of modern hospitals and dispensaries. Post independence, the state gave priority to health services and modern medical infrastructure. In modern day Punjab, a wide network of Health Institution consisting of hospitals, Community Health Centers, Primary Health Centers and Subsidiary Health Centers/Dispensaries to cater to the health needs of the rural and urban population through well trained medical and paramedical staff have been established in the State.

Education

In Ancient Punjab, literary education was generally the monopoly of the upper castes. Vedic learning was confined to the Savarnas; and even among Brahmins, only a section had the right to study the Vedas and priesthood. The medium of instruction was Sanskrit. Other classes were gradually accepted for education. An early center of learning in the region dating back to the 5th century BC was at Taxila. It was an important Vedic/Hindu and Buddhist centre of learning from the 6th century BCE to the 5th century CE. Higher education imparted at Taxila included arts and sciences consisting of rituals, grammar, astronomy, mathematics, medicine, military science and political science. Kautilya, the greatest political thinker of India, was also associated with the Taxila University. With the advent of Islam in India the traditional methods of education increasingly came under Islamic influence. Pre-Mughal rulers such as Qutub-din Aibak and other Muslim rulers initiated institutions which imparted religious knowledge. Muslim scholars such as Nizamuddin Auliya and Moinuddin Chishti

established Islamic Monasteries. During the Sikh regime, the maktabas or Persian schools, run by Maulvis were open to all communities irrespective of caste, color or creed. Besides, there were madrasas which imparted advanced education in Muslim sciences and philosophy. Then, there were schools, popularly known as chatshalas, conducted by Pandhas. These schools imparted education, to the mercantile and trading communities in the various graphic forms of lande (for shopkeepers), mahajani (for merchants) and sarafi (for bankers). In addition, there were pathshalas for learning Sanskrit. Gurmukhi schools were run either by the village gurdwaras or dharmshalas. There were schools imparting education in Hindu scriptures. The British introduced secular schools which imparted education in Urdu, elementary arithmetic, history and geography. Urdu was introduced and made the official language for use at the lower rung of administration. After their foothold the western system of education was introduced and content of education underwent significant changes. Modern educational institutes were opened for spread of modern science. The evangelical content of educational program motivated educated Punjabis to devise their own programs of education. By 1900, several educational institutions came up in the Punjab under the aegis of the Arya-Samajis, Singh Sabhas and Islamic Anjumans. Presently, the state is well served by higher level educational and professional institutions. The state has sixteen universities, more than 100 engineering colleges, ten medical colleges and several R&D institutes.

Traditional Technologies

The region of Punjab is well known for the traditional technologies which have evolved over the years. Traditional agricultural practices of the region could be classified and categorized into different subject matter areas like crop production, application of fertilizers and manures, cropping patterns, grading, selection and treatment of seeds, harvesting, post-harvest practices, grain storage, soil conservation, soil management, water management, weed control, insect-pest control, weather forecast, agricultural engineering, home management, clothing and textile, animal husbandry (Animal nutrition, livestock production, veterinary medicine) etc. Other than these, traditional implements, embroidery, weaving, handicrafts, phulkari, dresses, parandhis, pidhis, cooking stoves etc. are unique to the region of Punjab.

Environment & Ecology

Punjab has maintained its resources of environment from the ancient times. It was a vast region of diverse ecosystems including mountain, riverine forests, open scrub woodlands, grasslands, wetlands and freshwater aquatic ecosystems such as rivers, canals and choes (seasonal rivulets). Punjab has been endowed with natural wetlands from the ancient times. There have been a number of nature conservation programs in Punjab by the Bishnois, to whom the preservation of animal and vegetable life was a

religion so from the early 15th century. Later Sikh Gurus has also mentioned about the preservation of the environment in their verses. The diverse habitats co-existed largely unspoilt until the region lost its independence in 1849. After independence, the Green Revolution of the 1960s brought a dramatic increase in the use of intensive irrigation, chemical fertilizers, pesticides and herbicides that decisive environmental degradation set in. At present, only limited varieties/species of plants and animals are being promoted in the domestic sector over the diverse fauna and flora once abundant in the state. At the same time, life styles of people have become highly energy and resource intensive. Hence, the state is facing a wide spectrum of environmental problems.

Literature, Art, Spirituality, Religion & Scientific Thought

Art- The Kushan rule is credited with coins and seals, art and culture of Gandhara, specially the images of Buddha. The region is also home to famous Mughal Architecture witnessed in the Forts, Mausoleums, Gardens, and Mosques etc. The Sikh architecture combined the fineness of both Hindu and Muslim style of buildings. Landmark architecture includes Sri Harmandar Sahib (Golden Temple) at Amritsar.

Literature- The ancient script- Rig-Veda, was composed in the region of Punjab, between 1700–1100 BCE and is divided into ten books in classical Sanskrit. The famous Ayurvedic Treatise, the Charaka Samhita, was composed by Charaka during the reign of Kanishka. The evolution of Gurmukhi script is another major achievement of the region. The sacred Sikh Scripture, Guru Granth Sahib, comprising a voluminous text of 1430 angas, was compiled and composed during the period of Sikh gurus, from 1469 to 1708 CE.

Religion, Politics and Spirituality- Right from the period of the dravids, the people of the Punjab have been religious in nature. It is well known that most Buddhist scholars developed Buddhism in the region of Punjab at Taxila. Taxila University provided education in politics and jurisprudence where Kautilya (also known as Chanakaya), the world famous writer of Arthshashtra was a discourser on this subject. Most of the Hindu religious literature (including Vedas and “Gita”) was written in the region of Punjab. The Vedic literature mentions the names of seven Rishis (Religious scholars). They are Vashisht, Kashyap, Atry, Vishwamittar, Gautam, Jamdagan, and Bhardwaj. At least five of them were in one way or the other associated with Punjab. Sikhism, a new doctrine, evolved in the region about 500 years ago. It is now the fifth largest, modern and organized religion in the world and one of the fastest-growing.

Scientific Thought - The scientific and rational vision of the great Sikh Gurus helped the people to get rid of superstitions, caste system, unscientific rituals, pseudo-religious ceremonies, etc. and helped create scientific thinking based on principles of faith,

justice, equality and mutual respect. Much of the progress made by the region of Punjab could be attributed to the vision advocated by the great Sikh Gurus.

Scientific Manpower - Punjab has contributed immensely towards science and scientific research and technology generation. It has produced some world famous scientists who are known for their work in various fields of science & technology. Although history of science in Punjab dates back to the Indus Valley Civilization, yet the modern scientific education, human resource development and research began in the region with the arrival of British in 1849. The first modern college and university in the region were established under the British Rule. Scientific research began in the beginning of 20th century, when Prof. Purn Singh conducted research in Pharmaceutical Chemistry. Other famous chemical scientists from Punjab were: Bawa Kartar Singh, Prof. Gurbaksh Singh and Dr. S.S. Bhatnagar, who became the first Director-General of the CSIR and became known as "The Father of Research Laboratories" for having established various chemical laboratories in India.

In Biology, Dr. Hargobind Khurana, an Indian American molecular biologist, was awarded the Nobel Prize in Physiology or Medicine (in 1968 for his work on the interpretation of the genetic code and its function in protein synthesis).

In the field of Physics, Prof. Piara Singh Gill conducted research on Cosmic Rays. He established the CSIO Laboratory in Chandigarh. Prof. Abdus Salam from Jhang, Punjab (Pakistan) was awarded the Noble Prize for his work in Physics of elementary particles in 1979.

In the field of Botany, Dr. Birbal Sahni was a famous paleo-botanist. Dr. Pran Nath Mehra, Shiv Ram Kashyap and Amar Chand Joshi are other well known botanists from Punjab. Dr. M.S. Randhawa, basically a botanist, is famous for his contributions in agricultural development in Punjab and landscaping of Chandigarh. Dr. G.S. Kalkat, Dr. S.S. Johal and Dr. Khem Singh Gill also contributed significantly towards agricultural science & technology.

In the field of Medicine, Dr. A.S. Paintal is famous for his research. He attained the position of Director of Indian Council of Medical Sciences. Other famous physicians of the state are Dr. Daljit Singh and Dr. Dhanwant Singh.

Dr. Amarjit Singh Piani and Dr. Narinder Singh Kapany did commendable work in electronics and optical fibres, respectively.

In Astronomy, Prof. Satish Dhawan was Head of ISRO and contributed immensely in Indian Space Program. Prof. Yash Pal has made research contributions in Astro-Physics and Science Popularization. Ruchi Ram Sahni is credited with introducing

scientific temper and culture in the Punjab with his Popular Science Lecture series. Other scientists of the state who have made contributions for popularization of science are S. Jagjit Singh and Dr. N.K. Sehgal (UNESCO Prize Winners).

Conclusions

History of Science & Technology in Punjab unfolded in accordance with the geographical dictates of the region. The S&T developments began on a very promising note during the Indus Valley Civilization when science began to emerge. This trend continued during the Vedic Aryan, Buddhist periods, Greek rule, Golden Age and Persian and Mughal rules, although on a slower rate. The region made considerable progress in the fields of agriculture, irrigation, medicine, architecture, metallurgy, traditional technologies, arts and literature, during these periods. As the region provided passage to Delhi, it was invaded constantly by Muslim and Arab invaders (during 713-1300 CE) and in the 18th century by Nadir Shah and Ahmed Shah Abdali (1739-1769 CE), as a result of which developments in all spheres suffered. However, formation of the independent Sikh state under Ranjit Singh in 1799 CE provided stability and there were all round progress mostly in the fields of cropping, irrigation, building of forts, manufacture of arms & ammunition and lying of gardens. After the death of Maharaja Ranjit Singh, Punjab was annexed by the British, who transformed the region with S&T developments in transportation, agriculture, irrigation, medicine, telecommunication etc. After Independence in 1947, Punjab was on forefront in Green and White Revolutions and is at present, a very progressive state with better economy, infrastructure, lifestyle and all modern facilities. During the last two decades, Punjab has made rapid strides in all spheres due to advancements in the field of science & technology. Punjab – The Food basket and Granary of India", has been awarded National Productivity Award for agriculture extension services for consecutively ten years from 1991-92 to 1998-99 and 2001 to 2003-04. The State at present is on its way to rapid industrialization through coordinated development of Small, Medium and Large scale industries. Punjab has been declared one of the best States in India in terms of rail, road and transport network as per National Council of Applied Economic Research (NCAER), 2007. Ludhiana (Punjab) has been adjudged as the best place for doing business in India as per the World Bank Study, 2009. With the up-gradation of Amritsar International Airport & another International Airport coming up in Mohali, Punjab is geared to be one of the finest and easily accessible tourist as well as business destinations in South Asia. State Government has undertaken setting up of new power projects at to make Punjab a power surplus state by 2014-15. Punjab is already home to many large Indian Companies & MNCs like Ranbaxy, Hero Group, Avon Cycles, Gujarat Ambuja, Trident Group, Rail Coach Factory (Kapurthala), Sonalika, M&M, Godrej, Phillips, Oswal Woolen Mills, HCL, Nestle, Smithkline Beecham, ICI, Quark, Dell, IDS Infotech, etc. to

name a few. Many new Science & Technology institutes, Universities, Medical colleges, Engineering, Pharmacy and Management colleges have are established/ upcoming in the state, the prominent being PGIMER, CSIO, IMTECH (all in Chandigarh), IIT (Ropar) NIPER, C-DAC, and the Knowledge City in Mohali which houses NABI, BT Park, PBTI, Indian School of Business and Nano Technology Institute.

Eminent Punjab Scientists & Engineers are counted among the international luminaries in the field of science & technology.

In Retrospect

The study of history of science & technology is an important source of information on the development of the state and lessons learnt could be useful for future all round development of the State. The land of Punjab has been a major contributor to the process of nation building. The rich tradition of the land has made this part of India a laboratory of the process of economic, social and cultural transformation. The achievements of Punjab in Science & Technology have been manifold. There have, however, been a number of lessons to be learnt from the history of S&T and especially from the Green Revolution. At present, Punjab needs full-fledged development based on scientific & technological interventions. There are plenty of problems and imminent challenges such as tackling environmental degradation, loss of biodiversity and declining human health. The ever-growing numbers of people have no recourse to sufficiently clean water to drink and clean air to breathe. Adding further to this plight is the contamination of food products. Humans of the state are increasingly suffering from cancer and heart ailments and other life style diseases. Punjab has shown only frustrating interest in its rivers and water reservoirs. These are mostly employed as means of waste disposal. They have to be managed differently for recharging our underground water reserves, as sources of clean freshwater fulfilling various human needs and as source of earning livelihood, besides subsidising energy budget.

In view of this, it is better that we soon set on demographically declining transition and work diligently for cleaner environment while discouraging, with all our might, the fierceness with which the above pandemics are assaulting us. This shall not be possible without arming ourselves with scientifically explored facts on all these fronts. Sophisticated projects can be perceived and executed in the fields of environment and human health.

The enduring strength of the spiritual and cultural heritage of Punjab is not only the pride of its people, but also of the people of India. The ultimate vision of Punjab is of an integrated, peaceful society, well set on the path of once again leading the nation towards new levels of quality of life of its people. A state which interacts creatively and

productively with its neighbors and works with the rest of the people of the country as a whole, to build a new India which can face the world with economic strength, political stability, self confidence and pride.