UNIT 18 ATTITUDES TOWARDS ENVIRONMENT, SCIENCE AND TECHNOLOGY*

Structure

18.0 OBJECTIVES

After reading this Unit, you will learn about:

- the attitudes towards conservation and preservation of environment in ancient India;
- the various developments and achievements in the fields of Indian mathematics, astronomy, medicine, engineering, building, metallurgy in the past; and
- hydraulic engineering skills of ancient Indians.

18.1 INTRODUCTION

Human interaction with environment has been continuous since the time man set foot on earth. In this section we will be discussing human relationship with nature/ environment and its validation by available resources of knowledge and society's cumulative wisdom. Later in this Unit we will be learning about the achievements in science and technology that ancient Indians accomplished. The time period is from the earliest times to 200 BCE.

Since the beginning, concern for environment has been an integral part of the Indian intellectual and popular traditions. This sensibility was not developed as a result of contact and borrowings from the west but came into existence

* Dr Suchi Dayal, Academic Consultant, Faculty of History, SOSS, IGNOU, New Delhi

indigenously. It is apparent in the cultural patterns, religious practices, and social norms. The wisdom embodied in the popular and the classical traditions focussed on the preservation and conservation of environment.

18.2 INDIAN PHILOSOPHY AND ITS VISION OF ENVIRONMENT

In ancient Indian philosophical traditions, a harmonious relationship with environment was advocated. The environment was perceived as an organic living entity. It was acknowledged that man was the most intelligent of all creatures. Man was understood as being a small part of the environment. Upon his death, he dissolved into it. On a physical plane, man had a close relationship with all the living and non living beings. On a spiritual plane, man had to abide by a set of rules of conduct which specified the duties and obligations towards other living species. There was an acknowledgement of the fact that environment should not be endangered and destroyed.

Ancient Indian thought conceived of the relationship with nature in terms of balance and cooperation. In Indian thought the universe is conceived of as *Srsti*. It denoted the entire universe comprising *Pasu*, *Pakshi* and *Vanaspati*. The creation of *srsti* was traced to *Hiranyagarbha*, the golden egg, which finally led to Creation. Since both humans and *srsti* were created through the agency of God, both were required to maintain cordial relations with each other.

Earth and all that it entailed were regarded with utmost respect and reverence. The Earth, last of the *Panch Tattva* (sky, water, air, fire and earth), was treated as the mother of all living beings. It is said that she should be worshipped as it bore the material base of man's sustenance. In the *Vedas*, prayers were offered for the continuance of earth's resources and its bounties. It is said that they were not the sole belonging of the humans but were meant to be shared by all.

Ancient Indian wisdom treated all living beings with respect. Animals and birds were attributed with special powers and intelligence. They had the power to predict future, climatic or atmospheric changes and ability to foretell good or bad events. Killing of animals was prohibited and it was believed that doing so was a crime. This respect for animals and the fact that animals were sacrosanct is evident from the way certain animals were made the *vahanas* of individual gods and goddesses. They were as much worthy of worship as the Gods themselves. For example, Indra rode an elephant, Siva had bull as his *vahana*, Saraswati travelled on swan, Ganesha sat on a mouse and Visnu preferred Garuda. Even kings in the past acknowledged that non killing of animals was an important aspect of the policy of *ahimsa* and should be abided by. For instance, in the fifth Pillar edict, Ashoka outlined his policy of non-violence with respect to animals. In the list of animals which were prohibited from killing were parrots, mainas, red-headed ducks, akravaka-geese, swans, nandi-mukhas, pigeons, bats, ants, tortoises, boneless fish, goats, sows and many more animals. This edict may be taken as one of the earliest historical records focussing on conservation practices to be followed by people in general. (Mayank Kumar, MHI-08, Block 5, Unit 16, p. 24-25).

If we trace this benevolent attitude towards nature to an earlier time, we find that in the *Rigvedic* period different elements of nature were personified by the sages

and worshipped. They prayed for blessings from the Sun, Agni, Earth etc. Songs of praise or 'rik' were chanted in their glory.

How nature was thought as one with divinity is best exemplified by the figure of Nataraja or Dancing Siva. 'His emblems are Agni and deer. His locks are the forests. He hides within himself Ganga. His hair adorns the sun and the moon. His garlands are the snakes. He wears the tiger skin. He brings to this world the cosmic rhythm of his *damaru* in the incessant process of cyclic creation, degeneration and regeneration and finally of enlightenment. His energy is Sakti. Without her he is incomplete. She herself, the daughter of the Himalayas, must undergo penance and austerities" (Mayank Kumar, MHI-08, Block 5, Unit 15 Pg. 17)

Thus, ancient thought conceived of everything — animate and inanimate, human and non human, as part of a whole. All beings were incomplete without the other. This kind of wisdom required everything to be respected and protected for the universe to function in an orderly fashion.

18.3 POLLUTION (*PRADUSHANA*) IN TRADITIONAL CONTEXT

The violation of the peaceful coexistence among the creatures and the material world was considered as *pradushan*. Non-adherence to norms of cleanliness, and violation of *maryada* led to pollution. The cause of pollution was human greed and selfishness. Polluted *Srsti* had been described in the following terms,

> *"It seems that all stars, planets, moon, sun, air, agni and nature of directions have been polluted. Seasons also appear to work against the nature, Prithvi in spite of being full of virtues has lost its rasa in all medicinal plants. When such pollution will occur, human beings will suffer from diseases. Due to pollution of seasons, several types of diseases will crop up and they will ruin the country. Therefore, collect the medicinal plants before the beginning of terrible disease and change the nature of Prithvi".*

(*Charaka Samhita*, Vimansthan, 3.2 as cited in MHI-08, Block 5, Unit 15, p.18)

18.4 DEIFICATION OF NATURE

Indian civilization has always respected nature and environmental diversity. In Indian consideration, environment is not a physical and lifeless being, but a very living and active mechanism and human beings are just one among the various other creatures that inhabit the earth. Through deification of nature, ancient Indians were successful in inculcating respect for environment. This is best exemplified through the example of sacred groves. Sacred groves or *Deo-rahati* from time immemorial have been established to venerate local, indigenous deities. They have been in existence since the Vedic period. Today the number of sacred groves has declined. Some are still preserved though. However, in ancient times, sacred groves were maintained by a large number of cities. The cities of Champa, Kushinagara and Vaishali had sacred groves.

In ancient literature of India, we come across various categories of forests. One is *Aranyaka* in which ancient sages lived peacefully. A special part of the forest

which was reserved for meditation was called *Tapovana*. Both *aranyaka* and *tapovana* were *abhayaranya* or sanctuaries which were visited by kings, princes, and commoners to seek the wisdom, blessings and guidance of the sages. Not only forests but also pools, ponds and rivers were considered sacred and worshipped by the ancients. Even today, such symbols of nature are considered to be sacred remnants of the past.

There was an inherent concern for forests and other forms of life in ancient India. There is a text called *Vrikshayurveda* by Parashara dated to 400 BCE which is devoted to the science of plants. It is noteworthy that such kind of specialized knowledge existed in the ancient past. It mentions different types of forests such as *atavi, bipana, gahana, kanana, vana, maharanya*, and *aranyani*. The classification of forests was also done according to regions. Thus, there was a desire to learn about forests as well as an acknowledgement of the fact that forests played an important role in the day-to-day lives of the people. Information was systematically gathered and classified which shows that not only the *janapada* but also the *aranya* associated with it formed an important component of daily life.

Indians had a deep association with nature right from the very beginning. Nearly all the rituals and ceremonies concerned with various stages of one's life underline the intimate relationship with fire, wood and water. The ancient literature of India, the *Vedas* talk about the sanctity of rivers, mountains and the earth. The *Dharmasutras* extol the virtues of being kind towards one and all. Additionally, there are many texts which speak of the joyous harmonious relationship with nature. Ancient Indian wisdom as encapsulated in texts approached the sanctity of life in all forms in various ways. Destruction of animal and plant life brought up images of doomsday. It was said that after the passing of the *Treta Yuga* the people would exert all possessing power over rivers, fields, mountains, clumps of trees and shrubs. The fourth eon would even be worse. All living entities like plants, trees and animals would be killed. The *dharma* would decline. The death of *Dharma* (from *dhr*, which means that which sustains; righteousness, justice, duty) would take place when the nature was despoiled (Narayanan, Vasudha, p. 181).

In most Hindu traditions, the earth is considered sacred. She is addressed *as Bhu, Bhumi, Prthvi, Vasudha, Vasundhara, Avni*. She is worshipped along with Lord Vishnu as his consort. It is said in Manusmriti that, "*Impure objects like urine, faeces, spit; or anything which has these elements or poison should not be cast into water*" (*Manusmriti* 4: 56, as cited in Narayanan, 2001).

Prakriti (nature) just does not personify nature but also stands for cosmic matter. It possesses divine power and along with *purusha* is responsible for creation. All the constituent elements of nature such as water, earth, fire, ether/space and air are considered sacred.

Trees have been attributed a place of reverence in the Indian tradition. It is part of *Vanaspati* and equivalent to humans. Ancient wisdom believed that every tree had a *Vriksh Devata*. It was offered water in the morning which ensured continuous care of the trees. In *Narasimha Purana* tree was personified as God (Brahma) itself. Atharvaveda considered *Peepal* tree as abode of various Gods. Various trees and their association with Gods and Goddesses are:

Asoka tree	Buddha, Indra, Visnu, Aditi
Peepal	Vishnu, Laxmi, Vana Durga
Tulsi	Visnu, Krishna, Jagannath, Laxmi
Kadamba	Krisna
Ber	Shiva, Durga, Surya, Lakshmi
Vata	Brahma, Visnu, Shiv, Kal, Kubera, Krishna

(Mayank Kumar , MHI 08, Block 5, Unit 16, p. 24)

In *Matsya Purana* there is a passage where Parvati gives instruction about the planting of trees. Once Parvati plants an Ashoka sapling and takes great care of it. The Gods and divine beings come to her and say—

> *"O Goddess! ... almost everyone wants children. When people see their children and grandchildren, they feel they have been successful. What do you achieve by creating and rearing trees like sons…?" Parvati replied: "One who digs a well where there is little water lives in heaven for as many years as there are drops of water in it. One large reservoir of water is worth ten wells. One son is like ten reservoirs and one tree is equal to ten sons (dasa putra samo druma). This is my standard and I will protect the universe to safeguard it…"*

(*Matsya Puranam*, chap. 154, 506-512. Adopted from Narayana, Vasudha, 2001, pp. 187)

Repeatedly, it is mentioned in the texts that trees and especially fruit trees are sacrosanct and great misfortune befalls those who destroy them. For example, in the *Ramayana*, when faced with calamity, the demon king Ravana speaks as follows, "…I have not cut down any Fig tree in the month of Vaisakh, why does this calamity befall me".

Extolling the virtues of trees, *Vishnu Purana* says that one who plants five mango trees does not go to hell and *Vishnu Dharmottara* says that one who plants a tree does not fall into hell. The *Dharmasutras* as well as Kautilya's *Arthashastra* condemn the felling of trees. Kautilya prescribes varying levels of punishment for those who destroy trees, groves and forests. The different grades of punishments as described below show how destruction of natural flora was considered to be a crime. Kautilya says that for cutting off the tender sprouts of fruit trees or flower trees or shady trees in the parks near a city, a fine of 6 *panas* shall be imposed; for cutting off the minor branches of the same trees, 12 *panas*, and for cutting off the big branches, *24 panas* shall be levied. Cutting off the trunks of the same shall be punished with a fine between 48-96 *panas*; and felling of the same shall be punished with a fine between 200-500 *panas*. For similar offenses committed in connection with the trees which mark boundaries, or which are worshipped, double the above fines shall be levied (Kautilya *Arthashastra* as cited in Narayanan, Vasudha, 2001, p. 188).

The *Arthashastra* suggests the need to develop *Abhayaranya* or *Abhayavana* which were forest or animal sanctuaries where trees and animals would reside free from the fear of slaughter. There was also a Forest Suprintendent who took care of the forests and penalties were prescribed for poaching and killing of

animals. Capital punishment was prescribed for those who entrapped, killed or molested elephants, deer, bison, birds, fish, amongst other animals.

Rivers in India are also considered sacred. They are believed to wash away the sins or *papa* of those who take a dip in their waters. The rivers of India are considered nurturing and life giving. In south India, in the plains of Tamilnadu, the river Kaveri after the monsoons is perceived as having become pregnant and tradition says that locals offer her food in order to satisfy her pregnancy food cravings *(macakkai*). According to an oral tradition and local *Sthala Puranas*, bathing in the river Kaveri during Tamil month of Aippasi, October 15- November 14, washes away one's sins and gives a human being supreme liberation.

The close relationship people have with nature in the past and even today is exemplified by the fact that coconut tree is worshipped, coconut fruit is considered auspicious; mango leaves are used as festoons during *yajna* sacrifices or during ritual occasions; mango tree and its wood is used as *samidha* in yajna; Lotus and the Tulsi plant are considered ritually pure.

Manusmriti, a treatise on jurisprudence according to Sayan Bhattacharya, encapsulates in certain sections a reflection of ecological awareness (2014: 37)

1) All living forms are broadly described as *Chara* (movable living world) and *Achara* (immovable: plant kingdom), thus representing a notion of biodiversity.

2) The spoilage of the five gross elements by unethical activity may be taken to mean pollution.

3) Any action against wholesomeness (*Soucha*) may be taken to mean contamination.

4) Storage organs of plants like tuberous roots and underground stems, leafy vegetables, beautiful flowers, tasteful fruits, timber yielding trees, crops etc. were considered precious and various punishments are prescribed for causing injury to these.

5) Importance was given for conserving and domesticating animals, biodiversity protection, and vegetarianism. According to Manu, agriculture caused injury to animals, specially the insects and germs in the soil.

6) For biodiversity protection, he mentioned that fishes of all types should not be killed for food purpose; one hoofed animals, village pigs, solitary moving animals and unknown beasts should be protected; carnivorous birds, birds of village habitat, web footed birds, diving birds feeding on fishes, birds with striking beaks should not be killed for the purpose of eating. He stated that killing of *Khara* (ass), *asva* (horse), *ustra* (camel), *mrga* (deer), *ibha* (elephant), *aja* (goat), *ahi* (snake), *ahisa* (buffalo) is a sin.

Thus, the ancient Indian tradition took care of nature and environment. In fact, the ancient way of living encapsulated living harmoniously with nature. This beautiful eco-balance was disrupted only with the coming of the British in India. Today, we feel the relevance of such ties more than ever before.

Check Your Progress Exercise 1

1) Give some examples from the ancient Indian texts which show ancient Indian's concern for the environment.

.....

.....

.....

.....

.....

2) Give some instances which show that Indians deified nature. How did it lead to conservation of nature?

.....

.....

.....

.....

.....

18.5 SCIENCE AND TECHNOLOGY IN ANCIENT INDIA

India, right from the earliest period had achieved immense heights in the field of science and technology. In this part of the Unit we will be learning about the various facets of Indian science and technology from the earliest period.

18.5.1 Hydrology in Ancient India

In past, hydraulic techniques were introduced by the political authority and even by the locals in order to meet the needs of agriculture. They represent highly advanced techniques of water harvesting and these indigenous methods are valued even today.

The availability of water resources usually guided the location of habitation in the past. In those areas where there were scarce water bodies all efforts were made with the help of science and technology to harness the meagre resources available to humankind. Many advances were made in the field of hydraulic engineering.

Harappan Civilization

The Indus Valley civilization is the earliest civilized, urban culture that has survived in the Indian subcontinent. Its various features indicate the high level of technology that was implemented by the Harappan people. One example is the Great Bath which has been found from Mohenjodaro. It is a tank which was accessed by steps on both sides. The side walls and the base of the tank were made waterproof through the use of gypsum mixed in the mortar material. The sides were double walled and the intervening space between the walls was filled with bitumen coating and earth filling to ensure total waterproofing. The tank was connected with a well which supplied water to it. The well was situated in

one of the rooms fronting the open courtyard of the building complex. Used water was carried away by a corbelled baked brick drain in the south western portion. The way the tank had been constructed and the techniques used for water proofing indicate high level of hydraulic engineering skills.

At Lothal a Dockyard has been unearthed. It is a testimony to the engineering skill of the Harappans. This dockyard is the first ever artificial basin constructed for sluicing ships at high tide. It surpasses the docks made by the Romans and Phoenecians in conception. Its embankment walls measure 212.4 m. on the west, 36.4 m. on the north, 209.3 m. on the east, and 34.7 m. on the south. It is a lined structure with evidence for channels for inlet and outlet of water. Towards the southern part of the eastern wall of this dockyard is a 7 m wide gap which functioned as a spill channel. This connected the Lothal Dockyard with the Bhogavo river and thence to the Gulf of Cambay. The entire structure has been made in such a way that during high tide, water would swell the channel's natural flow and push the extra water upstream. The boats used the high tide to dock at the yard. The boats made a return journey when the tide ebbed. Extra water was discharged through a water spill channel which was built in the southern wall of the dockyard. A wooden sluice fitted across the spill channel was used to regulate the water flow. The wharf, measuring 260 m. ran along the western wall of the dock. From the wharf goods could be taken to the warehouse adjacent to it. The warehouse had a floor area of 1,930 sq. m., larger than the granaries of Mohenjodaro and Harappa. The structure stood on a 4- metre high platform on which were raised sixty- four blocks of mud bricks, each block 3.6 m. square and 1 m. high. The blocks were interspersed with 1- metre wide passages to allow ventilation and easy access to the goods. On top of the blocks a superstructure of timber was raised.

Similarly, at Dholavira, in the Rann of Kutch, various rock cut reservoirs were constructed to harvest rain water. Dholavira is located in an area which faced acute scarcity of water. The Harappans devised very ingenious methods to divert the rain water that flowed into the two rivers close to the settlement of Dholavira to some 16 reservoirs for later use. The two seasonal rivulets called Manhar and Mandsar were used to collect rain water from the catchment areas. Stone bunds were erected across the rivers at suitable points to dam up the water. The monsoon runoff was carried to the reservoirs, excavated in the rocky sloping areas between the inner and the outer walls of the settlement, with the help of inlet channels. These water reservoirs were separated from each other by bund-cum-causeways which also facilitated access to the different divisions of the settlement. Besides this, storm water collection drains were made criss- crossing the citadel area. These drains were made of stone and brick and were not used for sullage at all but to collect the rain water. Similarly, house drains were linked to soak-pits in Dholavira. Thus, every effort was made to harvest rain water judiciously with the help of technology.

Water management at other Harappan sites of Kalibangan, Surkotada, Chanhudaro also reveal the application of scientific techniques to everyday purpose. Wells both public and private have been found. The drains from well constructed bathrooms were connected to drains in the streets which were provided with manholes at regular intervals for easy cleaning. The drains were constructed with kiln baked bricks and covered with tiles. This shows that the drainage and sewerage system at Harappan sites was of a most developed kind and became a defining feature of this urban, highly advanced civilization.

Various dynasties are known for having constructed irrigation channels, reservoirs, embankments and wells for the purposes of water harvesting. The Mauryan rulers not only dug wells for public use alongside roads but also document the construction of irrigation devices for newly settled villages. Kautilya's *Arthashastra* is known for giving details about irrigation techniques, rainfall regimes and water harvesting methods.

A tank constructed at the site of Sringaverapura near Allahabad of 1st century BCE, is a remarkable example of hydraulic engineering. It is a huge tank more than 250m long. It has been built by damming the river Ganga which, during the monsoon period spills into an adjoining stream (*nullah*) from where 11m wide and 5m deep canal carries water to this tank. But first the water is channelled to a settling chamber where all the silt and debris collects at the bottom and the clean water then fills up the tank. This water is used for ritual and bathing purposes. The tank never goes dry because of underground wells at the base which draw water from ground level. Here mention may be made of another reservoir which was an impressive edifice called the Sudarshana lake. It is dated to 3rd century BCE and was located in Girnar area of Gujarat. This was first excavated by a functionary called Pusyagupta during the reign of emperor Chandragupta Maurya. During the reign of Ashoka, supplementary channels were added by Yavanraja Tushaspha. After a span of four centuries, the lake was repaired by the Shaka king, Mahakshatrapa Rudradaman of Ujjain. This has been recorded in the Junagadh Inscription of the Girnar of 150 CE. The lake continued to exist even in later times as attested by an inscription of 455 CE of the reign of Skanda Gupta. The record mentions local city governor Chakrapalit, son of Skanda Gupta's provincial governor, Parnadatta, who repaired the lake when the embankment broke. During this time the lake's embankment at the base was a huge 100 ft thick. The lake finally breached in the 9th century CE after which it was not repaired. From the lake, water was lifted by counterpoised 'sweeps' or other devices and fed into smaller channels.

18.5.2 Mathematics

In the field of science and Mathematics, the ancient people of India acquired a good measure of command. The two subjects which developed as a result of the Vedic people's interest in sacrifices were geometry and astronomy. The altar where the sacrifice was to be performed was to be of prescribed size and shape. That is how the science of geometry originated. The study of astronomy developed out of the need to fix the proper time for sacrifice. The term *ganita*, which means the science of calculation, occurs in the Vedic literature. The *Chandogya Upanisad* mentions among other sciences, the science of numbers. *Ganita* at this time included astronomy, arithmetic and algebra, but not geometry. Geometry then belonged to a different group of sciences known as *kalpa*. In India, in the post Vedic period, bulk of mathematics developed as an adjunct to astronomy. This class of astronomical works are called *Siddhantas*. Just a few centuries before and after the Common Era mathematics developed to adequately express, describe and account for astronomical ideas and phenomena.

In early Jainism, the priests encouraged the development of mathematics. They devoted one of the four branches of *Anuyoga* (religious literature) to the elucidation of *ganitanuyoga* (mathematical principles), *samkhyana* (science of

calculation) and *jyotisha* (astronomy). A Jaina priest was supposed to have knowledge in all three. The ideas present in the mathematical works of *Ganitasara-sangraha* of Mahavira (850 CE) and *Ganitatilaka* of Sripati (999 CE) may be traced back to a passage in the *Sthananga- sutra* (1st century BCE). This passage enumerates: *parikarma* (fundamental operations), *vyavahara* (determination), *rajju* (geometry), *kalasavarna* (fraction), *yavat- tavat* (linear equation), *varga* (quadratic equation), *ghana* (cubic equation), *vargavarga* (biquadratic equation), and *vikalpa* (permutations and combinations). At this time *ganita* included all three branches — arithmetic, algebra, and geometry (Satpathy, B.B., not dated)

In the field of Arithmetic, the system with zero developed in India and then travelled to the other parts of the world. The Hindu term for zero- *Sunya,* meaning –void, passed over into Arabic as *sifr*. There is evidence to corroborate the existence of decimal place value notation with zero. In a Gwalior inscription of the reign of Bhojadeva verses are numbered from 1-26 in decimal figures. Not only this, but a circular symbol for zero also appears in this inscription.

Thus, Indian mathematics was very developed and complex with a variety of ideas from number theory to second-order algebraic equations and the concept of limiting value.

18.5.3 Astronomy

Though astronomy originated in the Vedic period, it's clear development as a separate science occurred in the *Brahmanas*. It came to be called *nakshatra vidya* (science of stars). An astronomer was called *nakshatra-daria* (star observer) or *ganaka* (calculator).

According to the *Rigveda*, the universe comprises *prthivi* (earth), *antariksa* (sky, literally meaning the region below the stars), and *div* or *dyaus* (heaven). The universe was deemed as infinite. According to *Shatapatha Brahmana* the earth is described as *parimandala* (globe or spherical). *Rigveda* mentions that the axial rotation and annual revolution are caused by the sun. There is only one Sun which causes day and night, twilight, month, year, seasons. It has seven rays which clearly are the seven colours of the Sun's rays. The *Rigveda* mentions the inclinations of the ecliptic with the equator and the axis of the earth.

The apparent annual course of the Sun is divided into two halves, the *uttarayana* when the Sun goes northwards and the *daksinayana* when it goes southwards. The sun is called by different names at the various parts of the zodiac, and thus has originated the doctrine of twelve *adityas* or suns. The *Rigveda* says that the moon shines by the borrowed light of the Sun.

Thus, although scientific Indian astronomy is dated much later than the time of Ptolemy, its constants and methods were all original. Indian astronomy was both accurate and pragmatic. They created the first sine and cosine tables and early trigonometry. Aryabhata's encyclopaedic work on astronomical calculations to Varahamihira's defining of syllabus for astronomy and clarification of various concepts, the achievements of Indian astronomical texts are astounding. Eclipse and planetary conjunctions: *Mahurats*, *tithis*, calendar, eclipses, and planetary conjunctions were an important part of Indian astronomy and *panchang*-making.

18.5.4 Medicine

Ayurveda, the traditional system of Indian medicine deals with both mind and body. This is evident from the word '*Ayurveda*' itself. It is composed of two words — *dyus* and *veda. Dyus* means life and the latter knowledge or science. According to *Caraka Samhita*, *dyus* comprises *sukha* (happiness), *dukha* (sorrow), *hita* (good) and *anhita* (bad). A happy life is one which is free from physical and mental disease, full of vigour, strength and energy. Conversely, an unhappy life is full of sorrow and disease.

Ayurveda deals with the mental, physical and spiritual life of an individual in the course of his interaction with the environment. It has two streams — surgery and medicine. Ayurveda contains much that can be dated to the pre-Aryan or Aryan times. Its speculations, philosophy, logic and aetiology of diseases is said to have been borrowed from the Nyaya-Vaisesika and Sankhya philosophical schools. *Ayurveda* enjoys a high place along with the *Vedas*. It is called the *Upanga* of *Atharvaveda* and *Upaveda* associated with *Rigveda*. There is close similarity between the medical portions of the *Atharvaveda* and *Ayurveda*. The *Mahabharata* mentions that *Ayurveda* was composed by Krsnatreya.

The history of *Ayurveda* may be divided into:

1) The beginning period (*idevakala*)
2) The period of compilation (*rsikala* or *samhitakala*)
3) The period of epitomes (*sangrahakala*)
4) The period of decline.

The early treatises of *Ayurveda* are lost. It included the *Brahma-samhita* composed of one lakh *Mokas*. These works are all lost. Important among them were the *Brahma-samhita*, *Prajapati-samhita*, *Alvi-samhita*, and *Balabhit-samhita*. During the time period of 500 BCE to 500 CE, various works related to *ayurveda* were compiled by founder writers. The eight parts of *Ayurveda* include *Kayacikitsa* (therapeutics), *Salya-tantra* (major surgery), *Salakya - tantra* (minor surgery), *Bhutavidya* (demonology), *Kaumarabhrtya-tantra* (pediatrics), *Agada - tantra* (toxicology), *Rasayana-tantra* (geriatrics), and *Vajikarana - tantra* (virilification).

Ayurveda had deep influence on Greek medicine and its concepts occur in Hippocratic manuals. The medical treatment of eye diseases of elephants referred to by Megasthenes (c. fourth century BCE) is found to have been based on ideas borrowed from the *Hastyayurveda* of Palakapya. Conversely, some ideas associated with Greek medicine might have been incorporated in *Ayurveda*. Ayurvedic texts were translated into Arabic and from Arabic to Persian. The *Susruta Samhita* was translated by an emigrant Indian physician

Some renowned Ayurvedic texts were translated into Arabic and from Arabic into Persian. The Ayurvedic concepts spread to Iran, Central Asia, Tibet, Indo-China, Indonesia, and Cambodia.

Ayurveda encapsulates a novel and holistic approach to health and wellness. It comprises of self discipline, exercise and plant-based medicine approach to health and illness. Its concepts are analytical, rational and practical. It has influenced modern day medicine too, especially in the field of plastic surgery.

18.5.5 Architecture

The earliest civilization of the Indian subcontinent, Harappan civilization, was of a most developed and urban kind. Its cities and towns such as Harappa, Mohenjodaro, Lothal, Kalibangan, Dholavira, Rakhigarhi boast of a detailed layout and well constructed roads and houses. They are witness to the highly developed technical skill of the ancient Indians. In terms of city construction, Mohenjodaro's largest buildings were more than 73m x34m in dimensions. The roads were well made and ran from north to south and east to west and cut each other at right angles in a chessboard pattern. The roads width varied from 10m. to 5.48 m. and some of the roads were paved.

The houses were spacious and well made. They were made of burnt bricks which were uniform in the ratio of 1:2:3 or 1:2:4. Many of the houses had more than one storey and as such they may have acquired the expertise in the principles of load distribution. A typical house consisted of a central courtyard besides a room containing a well, paved bathroom and a number of drains. A sewer pipe was laid below the floor meant to carry dirty water to the drains in the street. In a similar fashion, vertical pipes positioned vertically along the walls were meant to carry sewage from the upper floor. There was also a well-equipped system to draw water from the wells with a pulley.

At Kalibangan copper axes have been found which indicate that beginnings of copper metallurgy as early as 2450 BCE. The drainage system, roads, granaries, houses, weights and measures, seals all show a high degree of skill and mastery over material. The weights found at Mohenjodaro and Lothal are of cut and polished chert material. Finds of graduated scales made of shell at Mohenjodaro, of bronze rod at Harappa, and of ivory at Lothal indicate their knowledge of practical geometry and land surveying. The average distance between the successive divisions of the scales is 6.70 mm., 9.34 mm., and 1.70 mm. respectively. Terracotta plumb-bobs and an instrument made of shell for measuring angles of 45°, 90°, and 180° were also found at Lothal.

In the historial period, construction of religious buildings such as stupas and *caitya grhas* also indicate the technological skill of the Buddhists. Rock cut *caitya* or *vihara*'s design was first planned by a master craftsman or an architect. In choosing a suitable site he had to take into account such factors as the type of rock and whether it was free of faults, the existence of a suitable ledge from where the cave excavation could be started, and the proximity of spring or river water for drinking and bathing. Detailed plans must have been made since it was important to know the exact position and size of stone blocks to be left standing for the construction to proceed.

18.5.6 Developments in Metallurgy

The metallurgical tradition goes back 7000 years in India. India has a rich history of stone-working, agriculture, animal husbandry, pottery, metallurgy, textile manufacture, bead-making, wood-carving, cart- making, boat-making and sailing.

The first evidence of copper comes from the site of Mehrgarh in 6000 BCE in the form of a copper bead. However, this was a form of native copper and was not smelted out of an ore. It was after 1500 years that settlements started experimenting with the smelting of copper which a few centuries later developed

further with the Harappans. The Harappans obtained copper ore from the Aravalli hills, Baluchistan and beyond. They soon discovered that adding tin to copper produced bronze which was harder than copper but easier to cast. They also found that the impurities present in the ore such as nickel, arsenic and lead hardened bronze even more and it could be used to dress stones. Shaping copper or bronze involved techniques of fabrication such as forging, sinking, raising, cold work, annealing, riveting, lapping and joining. The Harappans produced spearheads, arrowheads, axes, chisels, sickles, blades (for knives as well as razors), needles, hooks, and vessels such as jars, pots and pans, besides objects of toiletry such as bronze mirrors; those were slightly oval, with their face raised, and one side was highly polished. The Harappan craftsmen also invented the true saw, with teeth and the adjoining part of the blade set alternatively from side to side, a type of saw unknown elsewhere until Roman times. Besides they have given us the famous 'Dancing girl', and figurines of animals like rams, deer, bulls etc made with the lost wax process.

Gold and silver ornaments have been found from Harappan site of Mohenjodaro (circa 3000 BCE). Gold was manufactured by panning alluvial sands from placer deposits. The ancient mines (carbon dates from 1st millennium BCE) of Maski in Karnataka are the deepest in the world. Herodotus mentions about the gold-digging ants from India. This could refer to the activities of marmot, a type of rodent found in Afghanistan, who digs up the river sand which could then have been panned for gold by the inhabitants. Surface tension was used to turn melted gold filings into spheres.

By the Later Vedic period use of iron was known in north India. Earlier, *Rigveda* mentions *ayas* which referred to copper or bronze. In the subsequent period, mention has been made of *krisnayas, kalayasa* or *syamayas* (dark metal) which clearly meant iron. The development of copper-bronze and iron metallurgy were independent developments in India. Two highly advanced forms of iron were manufactured in India. This indicates that in the field of innovation India was way ahead of other countries. Wootz steel goes back to 300 BCE in south India. It was iron carburized under controlled conditions. It was exported from the Deccan to Syria where it was shaped into Damascus swords which were known for their sharpness and toughness. The Indian steel was called 'the wonder material of the Orient'. According to a Roman historian, Quintius Curtius, Alexander the Great received from Porus of Taxila (in 326 BCE) the gift of two-and-a- half tons of wootz steel. Wootz steel was more prized than gold or jewels. Wootz steel is primarily iron containing a high proportion of carbon (1.0- 1.9%). Thus, the term wootz applies to a high-carbon alloy produced by crucible process.

India was the first country to master zinc distillation in the world. Zinc has a low boiling point and vaporises while its ore is smelted. Thus, it is the most difficult metal to smelt. It is a silvery white metal which in combination with copper results is the formation of valuable brass of superior quality. There is archaeological evidence for the production of zinc in the Zawar mines of Rajasthan of 6th or 5th century BCE. Ancient Indians had mastered the art of smelting zinc with the help of a sophisticated downward distillation technique in which vapour was captured and condensed in the lower container.

Ancient texts contain many references to metallurgical tradition of ancient India. Kautilya's *Arthashastra* refers to a department of mines. The Director of mines was supposed to have an intimate knowledge of different types of metal ores,

ways to test and purify metals, create alloys, familiar with metal veins in earth, art of colouring gems. He should be able to inspect an old mine by the marks of dross, crucibles, coal and ashes, or a new mine with excessive colour and heaviness and with a strong smell and taste.

The above discussion indicates that much before the Industrial Revolution of Europe, India had achieved expertise in the field of smelting various elements, metal technology and the science behind it. It was also ahead in many innovations.

Check Your Progress Exercise 2

1) Describe how mathematics was developed in ancient India.

2) Indicate *True* or *False:*

   a) Awareness about the environment in ancient India began in the 1st century CE. ( )

   b) Indian philosophy outlines environment ethics encouraging preservation, protection and conservation of nature. ( )

   c) Ashoka has mentioned in his edicts about non killing of a number of animals. ( )

   d) Trees were indiscriminately cut down in ancient India. ( )

   e) Indians learnt everything about science and technology from the Greeks. ( )

   f) In Indian mathematics Pythagorean triplets were borrowed from the west. ( )

   g) Indian astronomy was faulty and incorrect. ( )

   h) *Mahurats, tithis*, calendar, eclipses, and planetary conjunctions were an important part of Indian astronomy and *panchang*-making. ( )

18.6 SUMMARY

It is evident from the above discussion on environment that ancient Indians were very careful about the preservation of environment and its sustainability. The ancient literature of India which includes the *Vedas, Manusmriti, Ramayana, Mahabharata* and *Puranas* is replete with references which underline the deep significance environment had for humans. Ancient Indian texts like *Arthashastra, Sathapatha Brahamana, Vedas, Manusmrti, Brhat-Samhita*, *Ramayana, Mahabharata, Rajatarangini* reflect the concepts of forest ecology and conservation in a sustainable manner.

In the field of science and technology, the ancient Indians had attained mastery over a number of arts. The Harappans fashioned huge cities like Mohenjodaro, Harappa and laid the foundations of the first urban civilization in the subcontinent. Their houses, drainage system, roads, 'granaries', dockyard, water tank etc are testimony to their engineering skills. The contributions of Aryabhatta, iron and zinc smelters are so profound that they impress many with their ingenuity. Different fields like Mathematics, Astronomy, geography, medicine were flourishing in the past in which ancient Indians have contributed a great deal. In fact, ancient Indians along with the Greeks were the only civilizations that put high premium on science and technology.

18.7 KEY WORDS

Ayurveda **:** Literally 'knowledge for longevity'.

Harappan Civilization : Also referred to as Indus Valley Civilization. It flourished in the Indo Gangetic divide and is dated to 2600-1800 BCE.

Metallurgy **:** It is the art and science of extracting metals from their ores and modifying the metals for use.

Distillation **:** It is a process where a mixture made of two or more components with different boiling points can be separated from each other.

18.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) See Section 18.2 and 18.3 for details
2) See Section 18.4

Check Your Progress Exercise 2

1) See Sub-section 18.5.2 for details
2) True or False
   a) False
   b) True
   c) True
   d) False
   e) False
   f) False
   g) False
   h) True

18.9 SUGGESTED READINGS

Bhattacharya, Sayan (2014.) Forest and Biodiversity Conservation in Ancient Indian Culture: A Review Based on Old Texts and Archaeological Evidences. *International Letters of Social and Humanistic Sciences*, 19, (2014), 35-46.

Narayanan, Vasudha (2001). Water, Wood and Wisdom: Ecological perspectives from the Hindu Traditions. *Daedalus*.Volume 130 (4),179-206.

Nipunage, D.S. and Kulkarni, D.K. (2010). Deo-rahati: An Ancient Concept of Biodiversity Conservation. *Asian Agri-History*. Volume 14(2), 185-196.

Pandey, Archana (2016). Society and Environment in Ancient India (Study of Hydrology). *International Journal of Humanities and Social Science Invention*. Volume 5(2), 26-31. ISSN (online) 2319-7722. www.ijhssi.org/

Satpathy, Binod Bihari (not dated). *History of Science and Technology in India*. DDCE/History (M.A.)/SLM/Paper.

Tanwar, Renu (2016). Environment Conservation in Ancient India. *IOSR Journal of Humanities and Social Sciences*. Volume 21(9), Ver. 11, 01-04.

Vahia, Mayank (2015). Evaluating the Claims of Ancient Indian Achievements in Science. *Current Science*. Volume 108(12), 25th June 2015, 2145-48.