3

Legacy of Science and Technology

3.1. INTRODUCTION

The tradition to know the unknown, accompanied with experimentation and observation, has always generated scientific temper. This has led to the assumption that truth lay in the real world with all its diversity and complexities besides superficial thinking. It has been the responsibility of scientists to unravel the mystery behind the truth and utilise available resources for the progress of humanity.

Ancient Indians have given a lot of useful discoveries to the modern world. Many scientific concepts are evolved from our traditions, which could not be proven at that time but as time passed and our traditions tarnished due to invaders, those few works of science are only claimable to Indians. Of course, these few works are also in varied fields of science, such as mathematics, physics, chemistry, biology, medical science, geography, astronomy, agriculture, technology etc.

It is obvious that some of the works of those days have provided foundation to develop the science and technology to its new height. Albert Einstein also writes about ancient Indian contribution saying that, "We owe a lot to the ancient Indians, teaching us how to count. Without which, the most modern scientific discoveries would never have been possible."

Being the land of sages and seers, India always remained the country of great scholars of various fields. Research has shown that from making the best steel in the world to teaching the world to count, India was actively contributed to the field of science and technology centuries long before modern laboratories were set up. Many theories and techniques, discovered by the ancient Indians have created and strengthened the fundamentals of modern science and technology. While some of these ground breaking contributions have been acknowledged, some are still unknown to the most. The proceeding paragraphs will bring out the essence of Indian traditions in the field of science and technology.

3.2. SCIENCE

Science is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe. Scientific methodology includes the following: objective, observation, measurement and data, validating those data to claim some results which is universally accepted by science community. Science has helped us to understand the environment, the world around us, our past, our future, our comforts, diseases, viruses, microorganism, surgeries, satellites, gravitation, light, computer, software etc. The achievements of science are innumerable. The Indian contribution in field of (*a*) Mathematics, (*b*) Physics, (*c*) Chemistry, (*d*) Botany, (*e*) zoology (*f*) geography (*g*) astronomy etc. are laid down is proceeding paragraphs.

3.3. MATHEMATICS

The town planning of Harappa shows that the people possessed a good knowledge of measurement and geometry since 1700 BCE. Seidenberg (1978) concluded that Pythagoras from India can be found in rituals and development of modern geometry can be traced back of those days. The mathematicians of ancient India were so advanced that they could explore the motion of planets. In the early medieval period, the two outstanding works in mathematics were *Ganitasara* by *Sridhara* and *Lilavati* by *Bhaskara*. *Ganitasara* deals with multiplication, division, numbers, cubes, square roots, and mensuration. Sulabhasutra was written by Indian scholars, which consisted of formulae to solve complex mathematical problems. In the classical period of Indian mathematics (400 AD to 1200 AD), important contributions were made by scholars like Aryabhata, Brahmagupta, Bhaskara II, and *Varāhamihira*. Indian mathematicians made early contributions to the study of the concept of zero as a number, negative numbers, arithmetic, and algebra.

3.3.1. The Idea of Zero

The **zero** is seen as one of the greatest innovations in human history. Brahmgupta introduced negative numbers and operations on zero into mathematics. It also appears that the symbol for zero was derived from the fish sign that stood for ten" in Brahmi and this occurred around 50 B.C.E.- 50 C.E. (Kak 1994b). He showed that mathematical operations like addition and subtraction started using the digit - zero. The concept of zero and its integration into the place-value system also enabled the mathematicians to write any large number. An inscription on a temple wall in Gwalior, India, dating

back to the ninth century, has been considered the oldest recorded example of a zero, according to the University of Oxford.

3.3.2. Decimal System

India gave indigenous method of expressing all numbers by means of ten symbols —the decimal system in 400 CE. In this system, each symbol received a value of position as well as an absolute value. Due to the simplicity of the decimal notation, which facilitated calculation, this system made the use of arithmetic much easier and faster.

3.3.3. Numeral Notations

Indians, as early as 500 BCE, had devised a system of different symbols for every number from one to nine i.e. 1, 2, 3,4,5,6,7,8,9. This notation system was adopted by the Arabs known as Hindu Numbers. Centuries later, this notation system was adopted by the western world who called them the Arabic numerals as it reached there through the Arabic Traders.

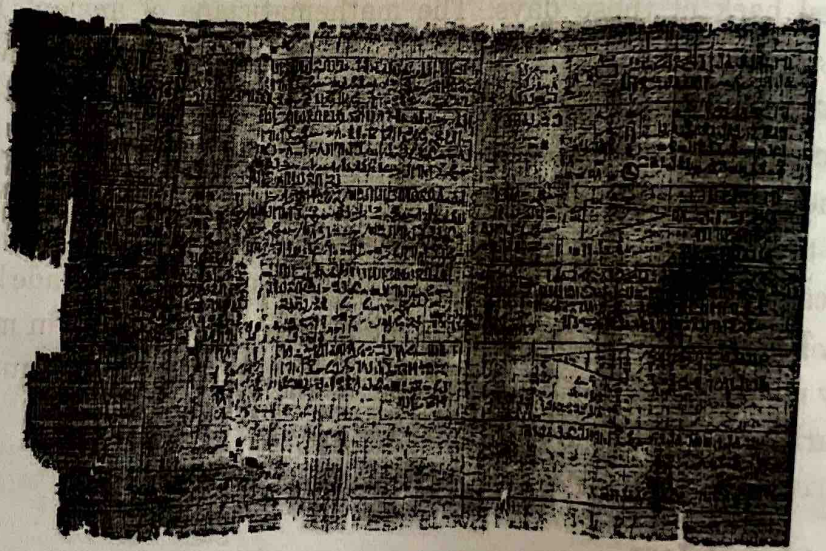

Fig.3.1. Numerals representation of ancient India (500 CE)

3.3.4. The Fibonacci Numbers

The Fibonacci sequence can be explained like this: each number in the sequence is the sum of the two previous numbers in the sequence. Therefore, the sequence begins with 0, and then continues on like this: 1, 1, 2, 3, 5, 8, 13, and 21 etc. The Fibonacci sequence was invented by the Italian **Leonardo Pisano Bigollo** (1180-1250) but

Fibonacci numbers and their sequence were first introduced in Indian mathematics by Pingala in connection with the Sanskrit tradition of prosody. Later on, the methods for the formation of these numbers were given by mathematicians Virahanka, Gopala and Hemacandra, much before the Italian mathematician Fibonacci introduced the fascinating sequence to Western European Mathematics.

3.3.5. Binary Numbers

Binary numbers is the basic language in which computer programs are written. Binary basically refers to a set of two numbers, 1 and 0, the combinations of which are called bits and bytes. The binary number system was first described by the Vedic scholar Rishi Pingala, in his book Chandahshastra in 2nd Century BCE. Rishi Pingala (in Chandahshastra 8.23) has assigned the following combinations of zero and one to represent various numbers, much in the same way as the present day computer programming procedures.

0 0 0 0 numerical value = 1

1 0 0 0 numerical value = 2

0 1 0 0 numerical value = 3

1 1 0 0 numerical value = 4

0 0 1 0 numerical value = 5

1 0 1 0 numerical value = 6

0 1 1 0 numerical value = 7

1 1 1 0 numerical value = 8 etc.

Rishi Pingala is credited with using binary numbers in the form of short and long syllables (the latter equal in length to two short syllables), a notation similar to Morse code. Pingala used the Sanskrit word śūnya explicitly to refer to zero.

3.3.6. Chakravala method of Algorithms

This method for obtaining integer solutions was developed by Brahmagupta. It is a method of cyclic algorithm to solve indeterminate quadratic equations. Another mathematician, Jayadeva later generalized this method for a wider range of equations, which was further refined by Bhaskara II in his book "Bijaganita".

3.3.7. Ruler Measurements

Excavations at Harappan sites have yielded rulers or linear measures made from ivory and shell. Marked out in minute subdivisions with amazing accuracy, the calibrations correspond closely with the Hasta increments of 1 3/8 inches, traditionally used in the ancient architecture of South India. Ancient bricks found at the excavation sites have dimensions that correspond to the units on these rulers. This ruler has been taken as reference of today's scaling system.

The Arithmatics

Jain Guru Mahaviracharya wrote Ganit Sara Sangraha in 850 A.D., which is the first textbook on arithmetic in present day. The current method of solving Least Common Multiple (LCM) of given numbers was also described by him. Thus, long before John Napier introduced it to the world, it was already known to Indians.

3.4. Physics

"Ancient Indian theories were brilliant imaginative explanations of the physical structure of the world, and in a large measure, agreed with the discoveries of modern physics".

"A.L.Basham, Australian Indologist

It would be surprising for many Indians today to know that the concepts of atom (Anu, Parmanu) and relativity (Sapekshavada) were explicitly stated by an Indian philosopher nearly 600 years before the birth of Christ. According to this philosophy, all matters are composed of smallest articles called *Anu*, which is called Atom in modern science.

3.4.1. The Theory of Matter

From the Vedic times, around 1500 B.C.E to 600 B.C.E, Indians (Aryans) had classified the material world into four elements viz. Earth (*Prithvi*), fire (*Agni*), air (*Maya*) and water (*Apa*). To these four elements was added a fifth one viz. ether or *Akasha*. According to some scholars these five elements or *Pancha Mahabhootas* were identified with the various human senses of perception i.e. earth with smell, air with feeling, fire with vision, water with taste and ether/ *Aakash* (sky) with sound. Whatever the validity behind this interpretation, it is true that since very ancient times, Indians had perceived the material world as comprising of these 5 elements.

The Buddhist philosophers who came later, rejected ether as an element and replaced it with life, joy and sorrow.

3.4.2. Theory of Atom

We all know that concept modern of atom was first given by Dalton in 1810 AD. But it was known to the Indian scholars of ancient time (much before Dalton's time). Maharshi Kannad first gave the concept of *anu* or *paramanu*. It is often thought by western scholar that both are same, which proved wrong later on. *Anu* is molecule and *Paramanu* is an atom. Although, he misinterpreted atoms in inertial frame of reference, *Upanishad* gives an idea of Heisenberg's uncertainty principle. It is also stated that "Anu" can have two states; absolute rest and a state of motion. He further held that atoms of same substance combined with each other in a specific and synchronized manner to produce "Dvyanuka" (diatomic molecules) and "trianuka" (triatomic molecules).

3.4.3. Mass-energy Equivalence

The ancient Indian scholars proposed the concept of mass-energy equivalence as well. In Upanishads *God/Brahamana* has been compared with an energy that controls the universe. *Atman* has been considered an individual soul which is nothing but energy derived after cremation of a body. Hence it says that a mortal being (mass) is converted into energy that becomes a part of *Brahmand/ u*niverse. In *Bhagavad Gita*, this energy or *atman* has been proposed as indestructible and immortal (*nainam chidanti sastrani / nainam dahati pavakah / na cainam kledaintya apo / na sosayati marutah*). It means *Atma* neither can be cut by weapons nor can be burnt in fire or dried by air. That means, *Atma* is universal and immortal. The *atma* and body have been compared with concept of balance of mass-energy. Mass-energy equivalence states that mass is concentrated energy. In his theory of special relativity, Einstein formulated the equation $E = mc^2$. As per him there is a tremendous amount of energy in mass. The Indian scripture has stated creatures body as mass and the same is converted into energy once a human die in form of fine elements.

3.4.4. Concept of big bang

In 1927, an astronomer named **Georges Lemaître** had a big bang idea. He said that a very long time ago, the universe started as just a single point. He said the universe stretched and expanded to get as big as it is now, and that it could keep

on stretching. This philosophy has been mentioned in Indian Scripture, stating that there is one *Shakti* in this universe, which is very large and all energy is flowing from it. This has been called as the Goddess *Durga*. The *Shaktivada* or Shakti philosophy solely emphasises on essence of energy. The Goddess has many *rupas* or forms which are the manifestation of different forms of energy. Again we all know that Aryabhatta invented the use of zero but do we know how he was inspired? He was inspired by *Shunyavada* (of Nagarjuna Buddha) that says that universe expanded from a *shunya* or zero. This is also an indication that the Indians were aware of concept of Entropy.

3.4.5. Theory of Relativity

Time has been proposed as a relative event. In Hindu scriptures, one can find that time in heaven runs slower than that on earth and if one travels from heaven to earth, centuries would pass. So this is how time has been said to be relative.

3.4.6. The Heliocentric Theory

The heliocentric theory argues that the Sun is the central body of the solar system. It is very big in this universe. Everything else (planets and their satellites, asteroids, comets, etc.) revolves around it. The first evidence of this theory is found in the writings of ancient Greece. But in 499 A.D., the mathematician-astronomer Aryabhata propounded a detailed model of the heliocentric solar system of gravitation.

Fig.3.2. The great Scientist and mathematician Aryabhata

Mathematicians of ancient India often applied their mathematical knowledge to make accurate astronomical predictions. The most significant among them was Aryabhatta whose book, "Aryabhatiya" represented the pinnacle of astronomical knowledge at the time. He correctly propounded that the Earth is round, rotates on its own axis and revolves around the Sun i.e. the heliocentric theory. He also made predictions about the solar and lunar eclipses, duration of the day and night along with distance between earth and moon.

3.5. CHEMISTRY

Ancient India's development in chemistry was not confined to an abstract level like physics, but found development in a variety of practical activities. Some of examples are laid down.

Writing paper

Before the introduction of writing paper, ancient literature was preserved generally on palm leaves in South India and birch-bark (*bhoj-patra*) in Kashmir and other northern regions of the country. Use of paper began during the medieval period. Kashmir, Sialkot, Zafarabad, Patna, Murshidabad, Ahmedabad, Aurangabad, Mysore were well-known centres of paper production. During Tipu's time, Mysore possessed a paper-making factory, producing a special type of paper that had a gold surface. The paper making technique was more or less the same throughout the country, differing only in preparation of the pulp from different raw materials.

Chemical Products

Rig Veda mentions the tanning of leather and dyeing of cotton in those periods. The major chemical products of this period were glass, paper, soap, dyeing, cosmetics, perfumes, alcoholic lacquers, pharmaceuticals, gun powder and salt peter. The two great chemical experts of ancient India were Nagarjuna (metallurgist) and Kanada. Indian and Persian army used arrows tipped with iron. In the Gupta age, metallurgical operations were found. *Nataraja* statue, the god of dance, is made of five metals also known as *Pancha-Dhatu* and Iron Pillar, the standing example of fine metallurgical knowledge and craftsmanship, can be seen in Delhi as a silent witness to Ashoka pillars. Paintings found on walls of Ajanta and Ellora caves also testify to the high level of chemistry knowledge in ancient India.

Chemistry was called 'Rasayan Shastra' which produced many chemists in the past, who wrote the books on various subject, such as;

- Nagarjuna- Ras Ratnakar, Kakshaputtantra, Arogya Manjari, Yog Saar, Yoasthak
- Vaagbhatt- Rasratna Samuchchay
- Govindacharya- Rasarnava
- Yashodhar- Ras Prakash Sudhakar
- Ramchandra- Rasendra Chintamani
- Somdev- Rasendra Chudamani

Ras Chemistry

The following chemicals has been mentioned as main chemicals in the 'Vaagbhatt. Rasratna Samuchchay book mentions ten types of Ras/ juice

1. Maharas
2. Upras
3. Samanya Ras
4. Ratna
5. Dhatu
6. Vish
7. kshar
8. Aml
9. Lavan
10. Lohbhasm.

This book has also described 10 types of poisons which could also be used for medicinal purposes. More than 32 instruments were used in it, the main ones are-

1. Dol Yantra
2. Swedani Yantra
3. Patan Yantra
4. Adhaspadan Yantra
5. Dheki Yantra
6. Baluk Yantra
7. Triyak Patan Yantra
8. Vidhyadhar Yantra

9. Dhup Yantra
10. Koshthi Yantra
11. Kachchap Yantra
12. Damru Yantra.

Nagarjuna has done several experiments based on mercury. In India, 'Para' (Mercury) was considered to be *Shiva* element and 'Gandhak' as *Parvati* element and when both of them were joined with 'Hingul', it was called *Rassindur*, which was considered as a life-enhancing essence.

Rasa-Shastri used to perform various purification processes to remove the harmful properties of metals and minerals. The mercury had to undergo eighteen types of the purification processes. The abrasion of mercury with juice and spices of medicinal herbs and combining it with asbestos and some alkalis are important in these processes. Ancient chemistry experts believed that after passing through seventeen purification processes, all the possibilities of transformation (in the form of gold or silver) in mercury should be examined. If it comes out desirable in the test, then it should be applied in the process of the eighteenth purification. Similarly, there were many methods of treating metals in India.

3.6. Astronomy

Astronomy is the branch of science which deals with celestial objects, space, and the physical universe as a whole. Ancient India was highly interested in celestial bodies like planets, stars, etc. and their movement. Indian scriptures are full of story of sun, moon, nine planets, stars, etc. Astronomy has made great progress too since ancient time. *Jyotish-vedanga* texts established systematic categories in astronomy. It is a concise text containing 121 verses and separate sections on astronomical definitions, methods of determining the true position of the planets, description of the movement of the sun and the moon and the calculation of the eclipses. The reason he gave for eclipse was that the earth was a sphere and rotated on its axis and when the shadow of the earth fell on the moon, it caused lunar eclipse and when the shadow of the moon fell on the earth, it caused solar eclipse. On the contrary, the orthodox theory explained it as a process where the demon swallowed the planet. All these observations have been described by *Varahamihira* in *Panch Siddhantika* which gives the summary of five schools of astronomy present in his time. Aryabhata deviated from Vedic astronomy and gave it a scientific outlook which became a guideline for upcoming astronomers. Astrology and horoscope were studied in ancient India too. Aryabhata's theories removed the misconceptions about celestial events and made astrology a kind of scientific explorations.

Geology

Geology is a scientific exploration study of earth concerned with liquid and solid such as sea rock, plants construction etc. Varahamihira made great contributions in the fields of hydrology, geology and ecology. He was one of the first scientists to claim that termites and plants could be the indicators of the presence of underground water. He gave a list of six animals and thirty plants, which could indicate the presence of water. He gave very important information regarding termites (Deemak or insects that destroy wood), that they go very deep to the surface of water level to bring water to keep their houses (bambis) wet. Another theory, which has attracted the world of science is the earthquake cloud theory given by Varahmihira in his Brhat Samhita. The thirty second chapter of this samhita is devoted to signs of earthquakes. He has tried to relate earthquakes to the influence of planets, undersea activities, underground water, unusual cloud formation and abnormal behaviour of animals.

3.7. ENGINEERING & TECHNOLOGY

In the ancient India, the technological advancement first originated for religious purposes. When people got well settled and the agrarian mode of production started producing surplus food, the technological advancement gained importance. It is only in the later Vedic period, more significantly in the Christian era, that the technological advancement made some real progress. The manufacturing of utensils and arms from steel, copper, zinc, etc. was very famous in India. The production of musical Instruments, silk and cotton cloths, ornaments was picking up the pace too. Scientific techniques were used in irrigation, metallurgy, making of bricks and pottery. The artefacts found from the sites suggest that Harappans developed metallurgy of copper and bronze around 2500 B.C. The details of some technological achieves of traditional knowledge are given in proceeding paragraphs.

3.7.1 Wootz Steel

Wootz steel is the pioneering steel alloy matrix, developed in India. It is a crucible steel characterized by a pattern of bands that was known in the ancient world by many different names such as "Ukku Hindwani" and Seric Iron. This steel was used to make the famed Damascus swords of yore that could cleave a free-falling silk scarf or a block of wood with the same ease. Tamils of the Chera Dynasty Produced the finest steel of the ancient world by heating black magnetite ore in the presence of carbon in a sealed clay crucible kept inside a charcoal furnace. In the 5th century

BC, the Greek historian Herodotus has observed that Indian and the Persian army used arrows tipped with iron. Ancient Romans were using armor and cutlery made of Indian iron. Swords made of Indian wootz steel were very famous in Persian courts.

Fig.3.3. Ancient India tools inventions

A pillar at Qutub Minar, World heritage site, in Delhi, is believed to be casted in the Gupta period around 500 AD. The pillar is 7.32 meters tall, tapering from a diameter of 40 cm at the base to 30 cm at the top and is estimated to weigh 6 tonnes. It has been standing in the open for last 1500 years, withstanding the wind, heat and weather, but still has not rusted, except very minor natural erosion. This kind of rust-proof iron was not available till iron and steel were discovered.

3.7.2. Smelting of Zinc

India was the first to smelt zinc by the distillation process, an advanced technique derived from a long experience of ancient alchemy. The ancient Persians had also attempted to reduce zinc oxide in an open furnace but had failed. Zawar in the Tiri valley of Rajasthan is the world's first known ancient zinc smelting site. The distillation technique of zinc production goes back to the 12th Century AD and is very important in Indian manufacturing achievements.

Once zinc had separated into a pure metal, alloys could be made with the required zinc component to provide the required properties. For instance, strength and durability increase with higher zinc component. In addition, copper alloys look like gold when the zinc component is higher than 28 per cent. Most early brass objects

found in other countries, had less than 10 per cent zinc component, and therefore these were not based on zinc distillation technology.

Copper work

Bronze can be found in use in the Indian subcontinent at quite an early phase and became a distinctive feature of the Indus Valley culture around 1800 BCE (represented by Harappa, Mohenjodaro, Chanhudaro and other sites). The Harappan, the Chalcolithic and the Copper Hoards cultures were the three main copper using cultures. D. P. Agrawal and Manju Pant, in their article "Bronze Age Technology", analyse the Bronze Age technology through archaeological and chemical evidences. India has the oldest material technology like, metals, ceramics, glass, gems and minerals, etc. Ancient metallurgy of gold, silver, lead, copper and alloys of these were well developed and is gift to the world. Brass in Takshashila, has been dated from third century BCE to fifth century CE. Copper is mentioned in many places in kautilya's Arth shashtra (3rd BCE), which was used to make coin. The utensils of copper have been found in excavation, which were used Aurveda era.

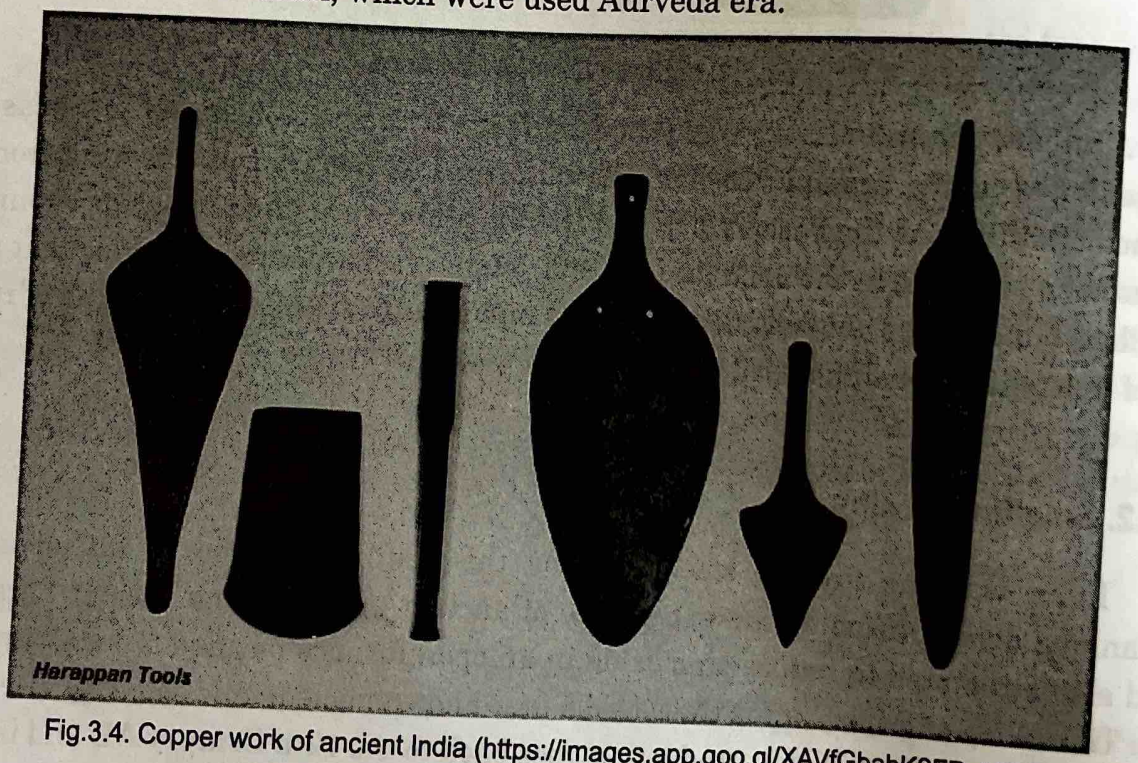

Fig.3.4. Copper work of ancient India (https://images.app.goo.gl/XAVfGbahK2FPgM3s7

3.7.3. Seamless Metal Globe

Considered one of the most remarkable feats in metallurgy, the first seamless celestial globe was made in Kashmir by Ali Kashmiri Ibn Luqman, in the reign of

the Emperor Akbar. In a major feat in metallurgy, Mughal metallurgists pioneered the method of lost-wax casting to make twenty other globe masterpieces in the reign of the Mughal Empire. Before these globes were rediscovered in the 1980s, modern metallurgists believed that it was technically impossible to produce metal without any seams.

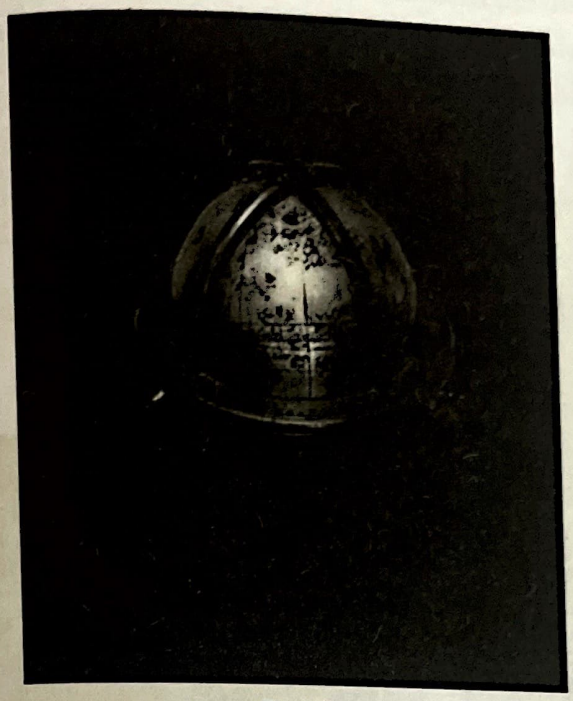

Fig.3.5.

3.7.4. Chemical works

The advance nature of ancient India's chemical science also finds expression in other fields, like distillation of perfumes and fragment ointments, manufacturing of dyes and chemicals, polishing of mirrors, preparation of pigments and colours. Paintings found on walls of Ajanta and Ellora (both World heritage sites) which look fresh even after 1000 years, also testify to the high level of chemical science achieved in ancient India.

3.7.5. Constructions Technology

Ancient Indians were aware of fire and flood control measures to protect farms and villages. A well planned irrigation systems also been designed in those times.

Larger private dwellings (flats) were built having multiple stories. Standardized fired bricks were used to build homes Separate cooking areas and toilets were built. Various public function buildings such as public baths were also been built together with grain and goods storage facilities which could be used for trade.

The Harappan civilization is said to be the world's first city to build well-planned streets with underground drainage using, hydraulic engineering, air-cooling architecture and civil sanitation. The measurements and weights were standardized. The oven-baked bricks were invented using these guidelines in India. Many improvements in civil engineering were invented in irrigation systems, drainage systems for water, water storage tanks carved from a rock, river dams, granaries with ducts and moats. Middle-class style homes, private bathrooms in homes, have been.

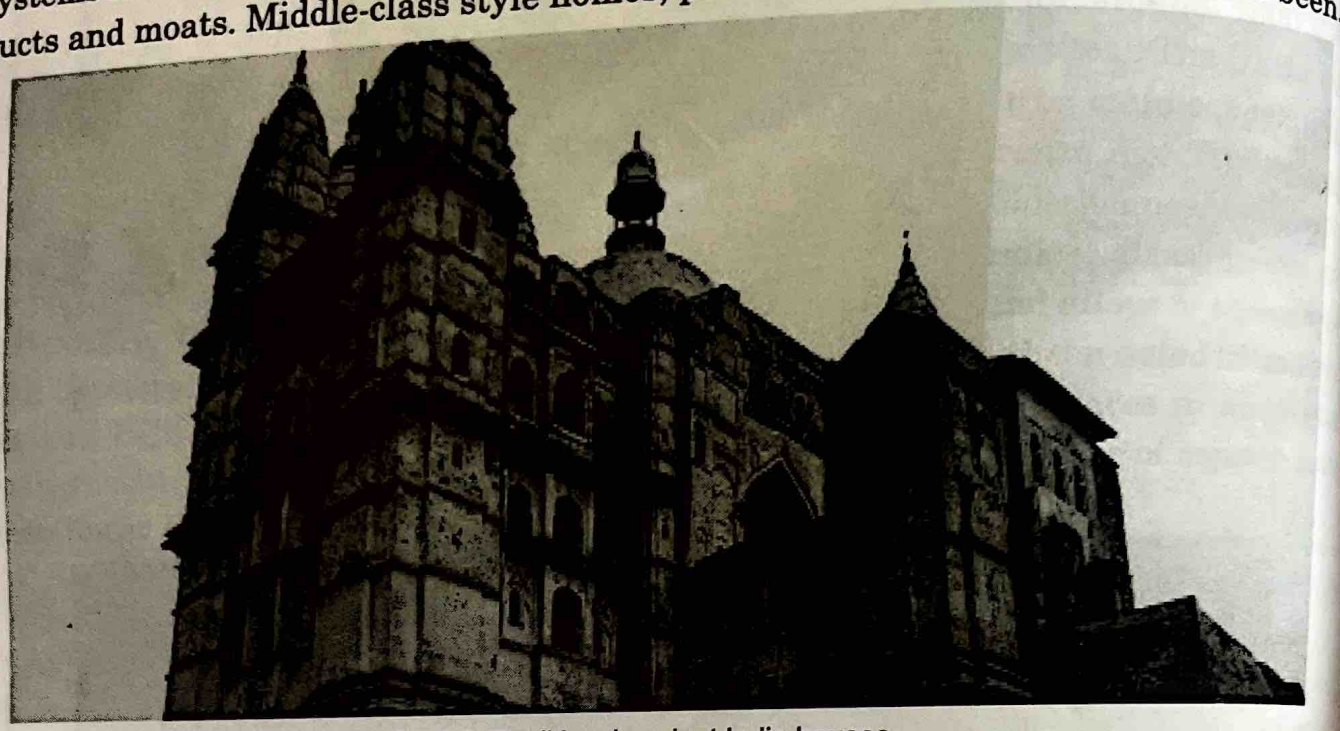

Fig.3.6. Traditional ancient India houses

3.7.6. Water management

Given the importance of fresh water in India, it is no surprise that the technologies to manage water resources were highly advanced from Harappan times onwards. For example, in Gujarat, Chandragupta built the Sudarshan Lake in late 4th century BCE, and was later repaired in 150 BCE by his grandson. Bhopal's Raja Bhoj Lake, built in 1014-1053 AD, is so massive that it shows up in satellite images. The Vijayanagar Empire built such a large lake in 14th – 15th century CE that it has more construction material than the Great Wall of China. Scientists estimate there were 1.3 million man-made water lakes and ponds across India, some as large as 250 square miles. These are now being rediscovered using satellite imagery. These enabled rain water to be harvested and used for irrigation, drinking, etc. till the following year's rainfall. Kallanai dam of Tirucharapalli in Tamilnadu built in 100 BCE-100 CE is great example of ancient India water management sincerity. It is the fourth oldest water diversion structures in the world and the oldest in India that is still in use.

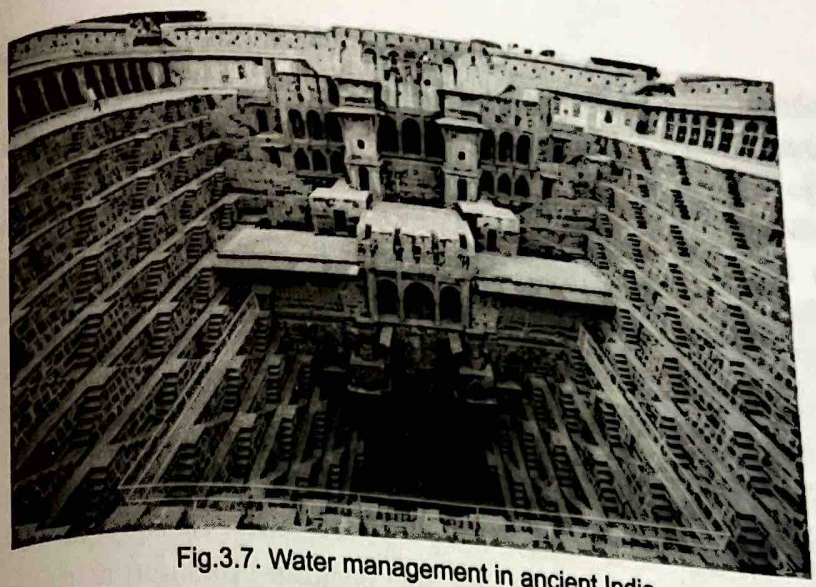

Fig.3.7. Water management in ancient India

3.8. MEDICAL SCIENCE

During the ancient period in India, the emphasis on the scientific methods led to a much greater level of accuracy with respect to the efficacy of different medicines and medical procedures. Evidence for the existence of well-organised system of medicine in India can be traced back to the archaeological remains of Harappa and Mohenjodaro. Ayurveda was the developed medical care facility in India, which has been discussed in chapter 2. The gift of Ayurveda in health care is unparalleled to any other system. The birth of modern surgery is well linked with Ayurvedic inventions. The main aim of ayurveda has been health and longevity. It is the oldest medical system of our planet. A treatise on Ayurveda, Atreya Samhita, is the oldest medical book of the world. Charak is called the father of ayurvedic medicine and Susruta the father of surgery. Susruta, Charak, Madhava, Vagbhatta and Jeevak were noted ayurvedic practitioners. Charka was the Raj Vaidya (royal doctor) in the court of Kanishka. His Charak Samhita is a remarkable book on medicine. It has the description of a large number of diseases and gives methods of identifying their causes as well as the method of their treatment. He was the first to talk about digestion, metabolism and immunity as important for health and so medical science.

The records of Indian medicine begin with the *Atharvaveda*. The *Atharvaveda* lists eight divisions of Ayurveda: internal medicine, surgery of head and neck, ophthalmology, surgery, toxicology, psychiatry, paediatrics, gerontology or science of rejuvenation and the science of fertility. Besides this, Ayurveda deals with the medical subjects like genetics, gynaecology, aetiology, surgery, physiology, biology, diet, ethics, personal hygiene, social medicine, allied subjects like animal biology,

botany, cultivation, pharma, chemistry, cosmology, etc. In 500 BC, Indian medicine practitioners were knowing how to control the birth rate by the theory that during twelve days of the menstrual cycle, impregnation is impossible. Foetal development was described with considerable accuracy. Sushruta, the writer of text of medical science on Ayurveda mentions more than 300 different operations employing 42 different surgical processes and 123 different types of instruments. This included lancets, sounds, forceps, catheters, and rectal and vaginal speculums.

Tools for excision, incision, puncturing, probing, organ or part extraction, fluid drainage, bloodletting, suturing and cauterization were developed. Various types of bandages and ointments were used as were basic procedures for ensuring cleanliness and limiting contamination. The caesarean section was known, bone-setting reached a high degree of skill, and plastic surgery developed far beyond anything known elsewhere at the time. Indian surgeons also became proficient at the repair of noses, ears and lips lost or injured in battle or by judicially mandated mutilation.

Fig.3.8. 123 surgical Instruments mentioned in Sushruta Samhita

"The ancient Hindus," says Garrison, "performed almost every major operation except ligation of the arteries." Limbs were amputated, abdominal sections were performed, fractures were set, haemorrhoids and fistulas were removed. The contract surgery is said to be performed by the ancient Indian Physician Sushruta in 6th BCE. Knowledge of cadaver dissection in ancient India was well known too.

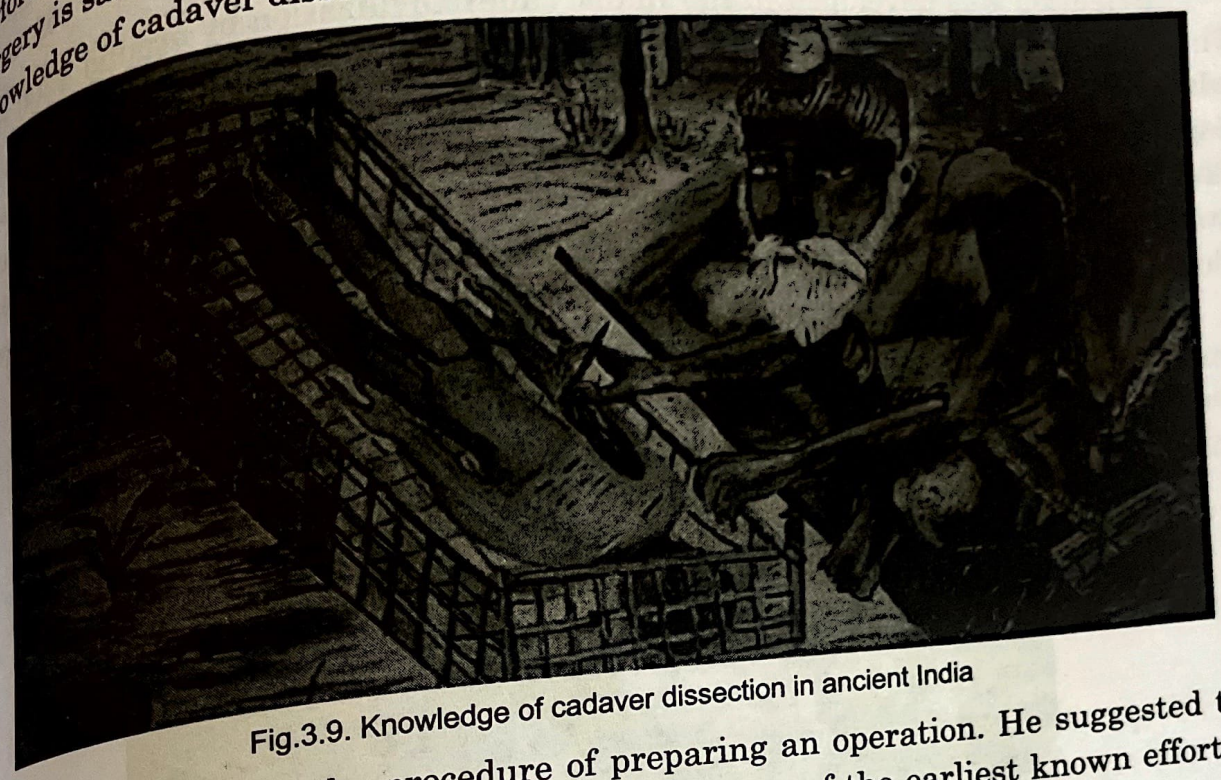

Fig.3.9. Knowledge of cadaver dissection in ancient India

Sushruta had set the procedure of preparing an operation. He suggested that the wound be sterilized by fumigation, which is one of the earliest known efforts at antiseptic surgery. Both Sushruta and Charaka mention the use of medicinal liquors to produce insensibility to pain.

In the Ayurvedic viewpoint, successful medical treatment depends on four factors: the physician, substances (drug or diets), nurse and patient. Samhitas described these four factors properly. Thus, Aurveda was self sustaining medicine system of India for very long time.

3.9. Agriculture Science

The excavation of the Mehrgarh period sites which was around 8000-6000 BC, throws some startling facts about Indian agriculture that began as early as 9000 BC. The domestication of plants and animals are reported in the subcontinent by 9000 BC. Wheat, barley and jujube were among crops while sheep and goats were among animals that were domesticated. This period also saw the first domestication of the elephants.

The Mauryan Empire (322–185 BCE) categorized soils and made meteorological observations for the agricultural use. Other Mauryan facilitation included construction and maintenance of dams and provision of horse-drawn chariots—that was quicker than traditional bullock carts.

Irrigation 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 innovation, which eventually led to more planned settlements making use of drainage and sewers. Sophisticated irrigation and water storage systems were developed by the Indus Valley Civilization, including artificial reservoirs at Girnar dated to 3000 BCE, and an early canal irrigation system from 2600 BCE. Archeological evidence of an animal- drawn plough dates back to 2500 BC in the Indus Valley Civilization

Fig.3.10. Pulling out water from well by oxen for cultivation

The Greek diplomat Megasthenes (300 BC) in his book *Indika* provides an eyewitness account of Indian agriculture at that time. He writers, "India has many huge mountains which abound in fruit-trees of every kind, and many vast plains of great fertility. The greater part of the soil was under irrigation, and consequently bears two crops in the course of the year. In addition to cereals, there grows millet, and different sorts of pulse and rice throughout India. Since there are two monsoons in the course of each year the inhabitants gather in two harvests annually".

3.10. Mythological Inventions

Indian mythology is full of superficial thought and tales. Still those technical talks are being proved by today's science and technology. A brief descriptions of some of words, which have been used first time in any literature of world are given below.

1. Pushpak Viman has been mentioned in Ramayana. Pushpak Viman was arial Vehicle used by Ravana. The viman was navigable and was able to land anywhere. It could carry many people from one place to another by air route. Those statements are now true to the world. Wright brothers invented and flew the first airplane in 1903, recognized as "the first sustained and controlled heavier-than-air powered vehicle.
2. It is mentioned in Mahabharat that Sanjay got the superficial vision due to which he could see the battle of Mahabharta being fought between Kaurav and Pandavas from far from the battle ground. Sanjay narrated full happenings of battle to his king of Hastinapur, Dhritrashtra. This concept has been proved in reality by invention of Television by Philo Farnsworth in San Francisco (US), in 1927.
3. The concept of making bridge on sea has been mentioned in Ramayana. Lord Ram constructed bridge over sea at Rameshawaram (Tamilnadu) with floating stones to cross over the sea, inorder to attack on Lanka in search of Godess Sita. Such unbelievable construction are the reality of today.

QUESTIONS

1. What are the contributions of Indians in the field of science?
2. Write about the contribution of Indian mathematicians.
3. What are the main contributions of India in the field of science?
4. Illustrate the Indian achievements in medical Science.
5. Describe the engineering and technology of Ancient India.
6. What are the achievements of India in field of water transportations?
7. What are the inventions of ancient India in the field of music and musical instruments?
8. Write about the medical achievements of ancient India. How is Ayurveda guiding the allopath of today?
9. How India has progressed in water management?
10. Explain development of Agriculture since ancient time of India.
11. What do you understand by mythological inventions which are being proved correct in recent centuries?