Sastrajyoti

Reference book for

‘Sastra Pratibha Contest’

A Science Talent Search Examination

Conducted among students of Indian Schools in Qatar

For Class 6, 7 & 8.

Organised by: Science India Forum, Qatar – A wing of SAMANVAYAM

shastrapratibha@gmail.com

CONTENTS

Education in Ancient and medieval India

Aim of education in ancient India

At a time when the art of writing and writing materials were still in their infancy, the vedic masters developed the concept of guru, the ideal relationship between the guru and the pupil, and system of training in conformity with this relationship and the new life the pupils had to live in the modest household of the guru.

The early realization of the all embracing character of education is a remarkable feature of ancient India. It came to be regarded as a source of illumination and an agency or improvement and for giving the correct lead in life. The "Mahabharata" declares that there is nothing like education, which gives one such unfailing insight and an agent for ensuring good character and behaviour.

Another primary aim of education should be the development of the individual in the service of the society, a point which has not failed to be emphasized in some of the Upanishads. Thus Chandogya Upanisad emphasizes the social role of the educated when it says : "Infinity is bliss, and only one who obtains bliss performs social duties."

The social responsibilities of the educated and the enlightened have been more clearly stated along with other qualities generated by education. The primary duty of a person who has completed his education and educational process is to propagate education to others so that continuity of education remains uninterrupted (*prajatantum ma vyacchetsih*). The process of acquisition of knowledge is an open-ended endeavor, and the ideal guru must always be engaged in it in order to remain at the vanguard of knowledge.

The Gurukula System

The system owed its inspiration to the private-teacher-system and was based on the direct personal relationship between the teacher and his pupils. The imperative necessity of the pupil's character and ideals being formed by the teacher's constant presence, his practical life-style and precepts required them to take residence with the teacher. Unlike the old hermitage concept, the Gurukula Schools were established in villages and cities like Banaras in a more or less secluded place away from the main settlements.

A modern variation of the ancient private-teacher-system is the tol for Sanskrit learning. The *tols* had a flourishing career in medieval times and due largely to liberal land-grants from the landlords and local rulers. In this type of schools some of which function even today the enrolment is usually limited to 20 or 25 students, classes are held in thatched mud huts and subjects of instruction include grammar, literature (Poetry), philosophy, (*Samkhya, Nyaya* etc.), and astronomy (*Jyotisa*). The tols of Nadia in Bengal which became famous in the medieval times for original studies offered courses in logic, smrti, jyotisa, grammar, kavya and tantra.

Ancient Indian Education Universities

Nalanda University

It had a residential accommodation for

7,500 students, 1,500 teachers and also for 12,000 assistants and workers. All were provided with free accommodation and free facilities like food, clothes, education etc. They maintained students v/s teachers ratio as 5:1.

Ancient Indian Universities

1. Nalanda
2. Takshasila
3. Vikrama Sila
4. Jagadala
5. Uddandapura
6. Valabhi
7. Mithila
8. Ujjayini
9. Nadiyad
10. Amaravati
11. Kanchi
12. Madhura

Specialization

All the Universities used to impart education in many subjects and branches. However every University specialized in certain fields such as:

1. Nalanda – Darsans
2. Thakshasila – Ayurveda
3. Nadiyad – Tarka
4. Amaravati – Gandharvayurveda (Rasayana Sastra) Silpa Kala
5. Ujjayini – Jyothisha
6. Madhura – Itihas
7. Kashi – Vedanata

Out of the above Universities Nalanda and Takshasila were world famous. Students from Korea, Mongolia, Japan, China, Tibet and so on used to study at Nalanda.

Takshasila used to attract students for Ayurveda from China to Rome.

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Astronomy in India

Ancient and Medieval Periods

Astronomy is the most ancient branch of science. In India its existence dates back to the period of *Rigveda*. The main source of astronomical information is *Vedanga Jyothisha* (200BC). In ancient days, astronomers used to study the positions of sun, moon etc. by supporting a framework of steller constellations in an orbital circle. In India this came to be known as 'stellar system'. Arabs and Chinese people also followed this system. The most ancient reference available on this subject is in 'Thahtireeya Collections'.

References are available in S*hathapatha Brahmana* on *Krithika (Karthika)* Constellation. It describes the star as rising in the eastern horizon. Similarly references on planet Jupiter can be found in Vamadeva's *Rigvedasooktha*. Some people attribute the finding of jupiter planet to Rishi Vamadeva.

Evidences are available on the prevalence of a calendar based on moon in India also, during the reign of Indus Valley civilization, akin to the one in Egypt and Babilonia. During the vedic and post-vedic period, gradually, the thinking of the sun being important in the control of seasons, gained acceptance. Following this a luni - solar calendar came into existence incorporating intermittently months having more days with lunar months of 29 or 30 days, for correlating the solar control aspects with the seasons of agricultural activities and festivities.

Twenty seven stars like Krithika, Rohini, etc. and 12 months viz. Karthika, Agrahayani, Margashirsha, Pousha, Magha, Phalguna, Chaitra, Vaisaka, Jaishta, Ashada, Sravana, Bhadrapada and Ashwina, based on those twenty seven stars were familiar to Indus Valley civilization. But their views on origin and structure of universe is still unrevealed despite all studies.

Ancient people did know that day and night and change of seasons are caused by sun. Further they were aware of the differences in the duration of day and night. It had been stated that the moonlight is the reflection of the light of the sun. During vedic period, one lunar day or *thithi* was the period from one moonrise to next moonrise or alternatively, from one moonset to the next. Six days constituted one week and 29 or 30 days constituted a month and 12 month together formed an year. Duration of a lunar year was 30 x 6 + 29 x 6 = 354 days. Average duration of lunar month was $29^{1}/_{2}$ days. As a result of so many reforms in calender preparation to the fourth year coming after 3 years of 360 days, one additional day was alloted totalling the number of days to 361. Following the system thus evolved, the total duration of four years was calculated as 1441 days and the number of days in an year was worked out as $365\ ^{1}/_{4}$ days. This lunar-solar correlation was effected also by adding a few days to some months intermittently. The duration of the year was calculated based on the rotation of seasons. A clearer picture of further growth of Astronomy can be found in the astronomical hypotheses of Jains, followed by *Panchasidhantika* of Varahamihira. *Aryabhatiya*, the celebrated work of Aryabhata and his work on midnight calculation system are milestones in the path of evolution

of Astronomy in India.

In the history of Indian Astronomy, more important is the middle ages. The first phase of this age of unprecedented growth begins at about 500 AD from Aryabhata and conclude with Bhaskara at about1200 A.D. Second phase of this age is the period from 1200 AD to 1800 AD. Influence of modern Astronomy in Europe began to be felt in India during this phase.

Aryabahata I to Bhaskara II

(From AD 550 to 1200)

The main treatment in *Vedhanga-Jyothisha* is the preparation of calendar. It doesn't have any sceintific enquiry on the characteristics of motion of celestial bodies, as against those findings in some theoretical books which came out later. Studies of this sort are available in works like *Aryabhatiya, Panchasidhanthika, Suryasidhantha* which came out in fifth century AD or later. So far as Mathematics is concerned, the most ancient work is the *Silbasutras* which form part of *Vedangas*.

The mathematical achievements of that age was mainly of geometry. With the growth of scientific astronomy, mathematics, became complemented with it. From the reign of Aryabhata I, mathematics became part and parcel of astronomy. Arithmetic, algebra etc. also did grow along with astronomy and they found a place in astronomy books. Major astronomers were also major mathematicians during those days.

Outstanding work during the period is the *Panchasidhanthika* of Varahamihira which is an abstract of five astronomical hypotheses viz., Suryam, Paithamaham, Vasishtam, Pouseelam and Romakam.

Aryabhata I, Varahamihira, Brahmagupta, Aryabhata II, Sreepathi, Bhaskara II (Bhaskaracharya) were the eminent who contributed much for astronomy and mathematics between 5th and 12th century AD.

Aryabhata I

Celebrated book *Aryabhatiya* is the work of Aryabhata. The author of *Aryabhatiya* and the author *Mahasidhanta* who lived in 10th Century AD are not one and the same person. In order to distinguish the personalities, they came to be called as Aryabhata I and Aryabhata II respectively. The first Indian satellite launched on April 19, 1975 was named after Aryabhata, in order to indicate our reverence and respect towards Aryabhata 1.

Aryabhata was born on 21 March, 476 AD (a Mesha - Sankranti day) as indicated in a stanza (*sloka*) of *Aryabhatiya*. The reference in *Aryabhatiya* of he being a resident of "Kusumapuram" is the strongest evidence with regard to his place of dwelling. Bhaskara I who is the first commentator of Aryabahata (AD 629) says that Kusumapuram is the Pataliputra of ancient Magadha. A number of commentators including Bhaskara I refer Aryabhata as "Ashmaka". From this we can presume that birthplace of Aryabhata is Ashmakadesa. There is a strong argument that Ashmakadesa is an area in South India, particulary in Kerala. The fact that Aryabhata's commentators in the succeeding years were all Keralites corroborate the above argument. Perhaps, he might have moved from Ashmakadesa to Kusumapuram later.

No information is available on the personal life of Aryabhata. The works of Bhaskara indicate that Aryabhata was a teacher by profession, and Pandurangaswami, Ladadevan and Nisanku were prominent among his students. In ancient days, Magadha was a well known centre of knowledge. The headquarters of world famous "Nalanda" University was Pataliputra (the present day Patna District). Nalanda has special facilities for astronomical studies. Aryabhata had been often referred as 'Kulapan' (i.e., Kulapathi or head of the University). He might have been the Kulapathi of Nalanda University which was at its zenith of reputation during 5th and 6th century AD.

It is "Aryabhatiya" which provided repu-

tation and position to its author Aryabhata I, as an astronomer. It was recognised as an authoritative text book on the subject till 16th century AD. His emergence was at a time of decline of astronomy in India. The "Panchasidhantas" prevailed then were not amenable to fool-proof analyses, so that forecasts of positions of planets, eclipses etc. often proved incorrect. Aryabhata revived Indian astronomy at its running stage of loss of credibility among people, and placed it in a most scientific frame work, proving himself eligible to be called as father of Indian Astronomy.

Aryabhatiya has 121 stanzas dealing with Mathematics and Astronomy. They are comprised in four chapters.

In the first chapter known as *Geethikapadam*, important astronomical constants including sine table are given. Mathematics is dealt with in the second chapter called *Ganithapadam*. Geometrical shapes and its characteristics, mensuration formulae, problems on shadow of gnomon, series, algebraic equations, simple simultaneous, quadratic equations, indeterminates are all included in this chapter. Moreover, principles for finding square root, cube root etc. of a figure, inversion principles, method of preparing sine table, value of π are also dealt with. Third chapter is known as *Kalakriyapadam*. This include various measures of time, determinations of real positions of sun, moon, planets etc., description of year, month and day under various methods, definition of origin of cyclic motion of time, explanation on the motion of sun, moon and planets with the help of lecentic circles and epicycles, method for determining longitudes of planets etc. Contents of fourth chapter called *Golapada* are aspects of spherical astronomy. Motion of planets, sun and moon in celestial circles, celestial motion while viewing from north/south poles, and from equator, hypotheses on planets, visibility of planets and other subjects are dealt with in the fourth chapter.

Value of π

Aryabhata was able to correctly find the value of π upto fourth decimal π = 3. 1416. Even today we use this value. Aryabhata had stated that this was the approximate value of π. Mathematicians before Aryabhata calculated its value as π = 10.

Sine Table of Aryabhata

Aryabhata might be the first astronomer to prepare the table of sine differences. He had explained both the methods for preparing that table.

Formula for determining sine of angles through 90^0 ($\pi/_2$)

The following formulae are given in *Aryabhatiya.*

Sin ($\pi/_2$ + q = Sin $\pi/_2$ - Ver Sin θ

Sin (π + θ) = Sin $\pi/_2$ - Ver Sin $\pi/_2$ - Sin θ

Sin (3 $\pi/_2$ + θ) = Sin $\pi/_2$ - Ver Sin $\pi/_2$ - Sin $\pi/_2$ + Ver Sin θ

(Here formulae are written in modern method).

4. Aryabhata has in his work solved the following types of indeterminate equations.

(i) N= a x + b = cy + d = ez + f .....

(ii) (ax $\pm$ C) /b = an integer

Division of time

1 Kalpa = 14 Manus or 1008 yugas

1 Manu = 72 yugas

1 yuga = 43,20,000 years

Further, one yuga has been divided into four shorter yugas of equal duration. Aryabhata was scientifically revising the prevailing illogical time division. As per both the methods, origin of the present Kaliyuga is on the same date i.e., Feb.18, 3102 BC, Friday. He does not believe in the intermittent creation-destruction of the universe. Universe is a continuum, he believed.

Principle of Rotation of Earth

The general belief during that period was that earth which remain stable in its position was the centre of the universe, and celestial bodies including sun were revolv-

ing round the earth. Against this belief, Aryabhata put forth the doctrine that earth was rotating in its axis and stars are stationary in its positions. He calculated the time taken for one rotation of the earth in its axis as 23 hours, 56 minutes, and 4.091 seconds. The wonderful correctness of his calculation is remarkable.

Aryabhatiya was a first class text book for astronomical studies for centuries. It was able to lay the foundation for a novel method of astronomical studies. Those who followed this new system came to be called by themselves as "disciples of Aryabhata". The most intelligent among them was Bhaskara I and he not only prepared a commentary for *Aryabhatiya* but also authored two works on astronomy viz. *Mahabhaskariyam* and *Laghubhaskariyam*, which further explained the principles of Aryabhata.

Among the many other commentators of *Aryabhatiya*, names of Someswaram, Suryadevan (born in 1191 AD, Choladesa) Parameswaram (1380 -1450 AD, Kerala), Yallayam (1480 AD, Andhra), Neelakantan (1500 AD, Kerala), Reghunatharaja (1597 AD, Andhra), Virupakshan , Son Madhavan (Andhra), Ghadigopan (Kerala), Bhoothivishnu (period of writing of all-19th century), Kodandaraman (Andhra), Krishnan (Kerala), Krishnadasan (1756 A.D, Kerala) *et al.* deserves special mention. Apart from the commentaries of these eminent persons, so many other books based on *Aryabhatiya* came out. *Mahabhaskariya, Laghubhaskariya* Haridatha's (Kerala), *Grahacharanibandhanariya* (683 AD), Deva's *Karanaratnam* (689 AD), Damodaran's Bhatathulya (1417 AD) Puthamana Somayaji's (Kerala), *Karanapathathi* (1732 AD) and Sankaravarma's *Sathnatnamala* (AD 1823) are a few among those books.

Aryabhata has another book to his credit-*Aryabhatasidhantha*. This work was very popular throughout India till 7th century. The astronomical constants and hypothetical methods are different from those in the *Aryabhatiya* to certain extent. This work is not available today. But an abstract of it is available with the title "*Khandakhadyakam*" authored by Brahmagupta.

Varahamihira

Varahamihira from Avanti (Ujjain) was well versed both in astronomy and astrology. He was the son of Adityadasan who had in-depth knowledge in these subjects. From the references in his work *Panchasidhanthika* it can be presumed that he was born in 505 AD and from the book *Khyadyakakarnatika* of Aryaraja, presumption can be made of his death in 587 AD. Varahamihira was a (an younger) contemporary of Aryabhata. It is presumedthat he was born and brought up in agadha, studied the works of Aryabhata and then moved to Ujjain. *Panchasidhanthika* (astronomy), *Bruhat-jataka* (astrology) and *Bruhatsamhita* are his important books.

The treatise in Varahamihira's *Panchasidhanthika* is the five old astronomical system viz., *Paithamaham, Vasishtam, Romakam, Pouleesam* and *Souram*. Original proponents of *Romaka* and *Pouleesam* might be foreigners. The names itself indicate so. In them and in other works, Greek technical terms are abundant. Varahamihira can best be described as an expert compiler rather than an independent astronomer.

Brahmagupta

He was born to Jishnugupta in 598 AD. Engaged in writing his famous book on astronomy viz. *Brahmaspuda-sidhantha* between 30-70 years of age. His place of birth might be the Bhillale town in between Multan and Ahirvahan. It is an urban location at the northern boundary of present day Gujarat. *Brahmasphudasidhantha* is a voluminous work having 24 chapters, motion of planets, time, distance, eclipses, rise and set of planets and effects of planetary combinations are the main subjects dealt with in it. In chapter 12 and 18 Mathematics and in chapter 22 astronomical

instruments are treated. Though the supposition of zero was prevailing earlier, its application and principles were formulated for the first time by Brahmagupta. Solving of second degree indeterminate equations is yet another outstanding contribution of Brahmagupta.

Brahmagupta was a strong opponent of Aryabhata's theories. His criticism was especially towards division of Yugas into four equal parts, theory of rotation of earth, arguments on the happening of eclipse due to formation of shadows of earth and moon, rejection of Rahu-Kethu principle, etc. But, towards the last phase of his life, he wrote the book, *Khandakhadyaka* based on the principle of midnight system of Aryabhata. Ancillary to it, in *Utharakhandakhadya*, mathematical portions have been excluded and astronomical problems alone treated.

Both the works of Brahmagupta have been translated into Arabic.

Bhaskara I

Bhaskara I was the contemporary of Brahmagupta. Some people calculate his life time as between 550 and 628 AD and some other sections slightly move it forwards. He has written three books viz. *Maha-bhaskariyam, Laghubhaskariyam* and *Aryabhatiya Bhashyan. Mahabhaskariyam* is the commentary of some chapters of *Arya-bhatiyam.* At the sametime, it has some own approaches and self findings. *Laghubhaskariyam* is an abridged version of *Mahabhaskariyam.* The elaborate commentary on *Aryabhatiyam* amply proves the indepth knowledge of Bhaskara in astronomy.

Bhaskara II (Bhaskaracharya)

He was Born in 1114 at Bijapur (Karnataka) in western ghats. His renowned work *Sidhanthasiromani* is presumed to be written in 1150 AD. In the spheres of astronomy and mathematics, no work better than this has been brought out. It contains four segments. First is *Lilavati* and the next is *Beejaganitha* (algebra). In *Leelavathy*, arithmetic and geometry are dealt with. *Beejaganitha* is for algebra. The subject matter of third and fourth chapters (*Gruhaganithadhyayam* and *Goladhyayam*) is astronomy.

It is said that Bhaskara II wrote *'Lilavati'* to commemorate the name of his unmarried daughter and to console her in being remained so. At the same time, some people say that *Lilavati* was the name of his beloved wife. Perhaps, a more logical conclusion should be that, *Lilavati* was a curious name which attracted his imagination in the background of his extraordinary poetic power.

In Bhaskaracharya's celebrated work *Lilavati*, eight mathematical applications (*parikarmashtaka* - addition, subtraction, multiplication, division, squaring, cubing, square root determination, cube root determination) have been described. So also, applications with zero (*soonya parikarma*). Other topics dealt with in it are the following:

1. Method of inversion
2. Unitary method
3. Method of elimination i.e., the method of finding a, b when a + b, a - b are provided.
4. Root eliminaion i.e., method of finding a and b when a - b, a^2 -b^2 are provided.
5. Square method. How to find out a and b when $a^2 + b^2 - 1$, $a^2 - b^2 - 1$ are complete squares.
6. Root multiplicant - problems involving square roots i.e., problems leading to quadratic equations.
7. Rule of three.
8. *Bhandaprathibhandaka*-manufacturing and marketing.
9. Mixed series.
10. Infinite series
11. Permutations and combinations.
12. Indeterminate analysis.

Of the above, the last three come under

the purview of algebra.

The chapter on geometry begins with the statement of hypotenuse square theorem. This has been applied in solving the problems with right-angled triangles, and those wih distance and height. Principles for finding the altitude, area etc. of triangles and various types of quadrilaterals, principle for calculating the hypotenuse of quadrilaterals, relation between chord and arc of circles, sound formulae for finding the circumferential area, volume of spheres etc. have been treated in succession.

In algebra, positive, negative constants, zero, original mathematical calculations, symbols, surds, indeterminate simple equations, indeterminate square equations, single power/multi-power equations of unknown constants etc. are the topics.

Grahaganithakhanda begins with the description on importance of astronomy. In its second chapter, a number of astronomical problems have been introduced. Its discussion follows in the succeeding chapters. In the third chapter, viz. *Bhuvanakosha,* the non-supported position of earth in the space, and the position of nonliving and living things in the planetular level is detailed. In the next, circumference of earth as a sphere, its surface area, volume etc. are calculated. In these calculations, value of ∏ is reckoned as 3.1416. In the following chapters, motion of sun, moon and planets, celestial models showing their orbits, methods for determining relative duration of day and night in different latitudes in different seasons, times of sun set and sunrise, latitude of a particular place, eclipses, instruments for observing celestial bodies, movements of equipoises etc. are the topics. Bhaskara has written a commentary entitled '*Vasana*' for chapters on *Grahaganita* and *Goladhyaya* together. This commentary is also a part of the book under reference.

Sidhanthasiromani had been accepted most respectfully from Kerala to Kashmir. This work marked by the in-depth knowledge of its author and the resplendent style of presentation got the reputation of being a most authoritative work on astronomy in every nook and corner of India. This work based on the previous works of the subject under treatment and incorporating own contributions, draws the whole picture of Indian astronomy. The books followed on the subject are all perhaps commentaries only on this work.

Karanakuthuhala is a simple text which help solving astronomical hypothesis. Even today, this book is used in various parts of India in preparing calendar.

Second Phase of Middle Ages
(AD 1200 to 1800)

The period starting from Aryabhata I to Bhaskara II was the golden age of the Indian astronomy. After Bhaskarachaya, there was no substantial improvement in astronomical studies in the country. At the sametime a good number of books on astronomy came out during this period. But all of them were commentaries, but not original works.

The regression experienced here for centuries in the area of science and technology might be attributed to the prevailing environment not conducive for dissemination of knowledge in the wake of onslaught of foreigners and internal riots. In the southernmost parts like Kerala and other places which were free from the consequences of political instability experienced in the north, astronomical studies continued unaffected. In a Malayalam palmyra script preserved in the Oriental Institue in Baroda, information regarding the heirarchy of a series of scholars and disciples engaged in astronomical studies for a very long period of six centuries from 1237 AD to 1846, is available. From the studies of Shri. K.V. Sarma on astronomers from Kerala, details of more than 100 scientists and more than 700 books has been compiled under the title "A Bibliography of Kerala and Kerala based

Astronomy and Astrology".

Contributions of Kerala

A group of astronomers who assembled in Thirunavaya, near Shornur in 684 AD had redefined the celestial constants formulated by Aryabhata. Haridathan in his work *Grahacharaniban-dhanam* has applied this revised scheme. The scheme is known as parahita system. This enjoys more correctness than Aryabhata system.

The parahita system had been revised further by Parameswaran (1360 -1460 AD) in his well known work "Drigganitham". It has been recorded in "*Drikkaranam*" that he attempted this revision in 1431 AD, since he found that after the elapse of centuries, the parahita system theories and actual observations did disagree in so many terms. *Drikkaranam* is an astronomical manual prepared by Jaishtadevan in Malayalam in 1608 AD. In tune with the changing times, through consecutive observations, the parahita system has been subjected to so many revisions. (eg. by Neelakantan Somayaji, 1444 -1545)

Jayasingh's observatories

Other documents regarding observatories in the ancient times are not available today.

During earlier ages, astronomical phenomena were observed by naked eyes. Gradually simple instruments were devised. Later 'Open Air' observatories came into existence for observing the rise and set of sun, moon and planets. Gnomon and waterclock were the devices for time determination in these observatories. Baber had recorded that during Vikramaditya's period, there was a sky observatory in Hindustan. The observatories established by Raja Jaysingh in 18th century are still in existence.

Raja Jaysingh Savay (1686 - 1743 AD) established sky observatories at Delhi, Ujjain, Jaipur, Mathura and Varanasi (Banares). Of these, that in Mathura is defunct now. The other four are still in existence. Raja Jaysingh who founded the city of Jaipur was not only a warrior and administrator, but one interested in Mathematics and Astronomy also. Mirza Ulug Begg's astronomical table viz. *Sarahgeej,* Mirza Uclid's 'Elements', Flam Steed's *'Historia do coelests',* Ptolomy's *'Synstax'* were all familiar to him.

Jaysingh had considerable knowledge in astronomy and he scrupulously studied the books of Coppernicus, Galieleo, Kepler and the metallic instruments of Ulug Begg and others at Samarkhand. He installed his observation instruments with bricks and stones to make it immovable. His intention might be the shakeproof viewing of the sky through the instruments. His observatories are known as Jantar Mandirs. 'Jantar' is a modified form of the word 'Yantra' which means instrument.

So many instruments like Laghu-samrat yantra, Dhruvadarshak yantra, yantraraj. Narivalaya yantra, Samratyantra, Jayaprakasha yantra Rasivalaya yantra, Ramayantra, chakra yantra and Misra yantra are installed in the Jantar Mandirs.

The biggest among the observatories is in Delhi. All the instruments installed here are stone-made. Samrat yantra is a device to determine time, *kranti* or *apakrama* (declination). This is a type of sundial. Altitude and azimuth of celestial bodies are determined by Rama yantra. Jayaprakash yantra is a device to find out directly the declination, azimuth, altitude etc. by observing sun and the shadow falling on the moon. Misra yantra which is a combined system of instruments, consists of devices used to determine the declination of sun at fixed times during morning and evening, to observe the mid day at four important centres situated in eastern and western hemispheres, to find out the altitude of a celestial body when it enters the meridian and a device to find out the orbit through which the sun is going.

Jaysingh had published a set of astronomical tables prepared by him based on the information collected from these observatories for more than six years, under title "Zij Mohammed Shahi'. The work was named to indicate his respect towards the Mughal emperor ruling then. Jaysingh was able to correct a good number of errors in the tables prevailed in the western world then.

Modern European Astronomy in India

In 1609 AD, Europe had an outstanding invention of optical telescope. Through its extensive use, Galieleo had revolutionised the astronomical studies. In India, the modern astronomical studies were initiated by the French Jesuit Priest Father Richard in 1689 when he used the telescope for the first time in the country. From his observations from Pondicherry, he was able to discover a comet and further to understand, the binary nature of the comet "alpha centauri".

India's first sky observatory was established by British East India Company in 1792 at Madras. Even before this, by the efforts of William Petry, sky observation began here as early as in 1787.

First Govt. astronomer in Madras was J. Goldingham; Taylor, Jacob and Pogson were his successors.

The Maharaja of Travancore established an observatory in Thiruvananthapuram in 1837. Instruments installed here included not only the sky observation devices but also the instruments for study of magnetism, meteorological observation etc. Observations of Mr. Brown (who was the Director here from 1851 to 1865) on magnetic fields are world famous. His discovery of magnetic turbulence not as being a unicentered phenomena and as a universal phenomenon has characteristic importance in geomagnetic studies. The occurrence of turbulence in the sun at fixed intervals of 27 days and the changes brought by it in the magnetic power position of the earth is yet another notable discovery of Brown. Gradually this observatory became defunct in its functioning.

The largest telescope (20" Grub Reflector) of that time was in the Maharaja Thakhtha Singhji observatory establised in 1890s in Pune. This observatory functioning under the control of K.D. Nayagamvala enjoyed the partial financial assistance of Maharaja of Bhavanagar. Functiong of this observatory was discontinued in 1912 and 20" reflector telescope was shifted to Kodaikanal observatory.

The three total solar eclipses visible in India at that time was highly important with regard to Indian astronomy. First among those was in 1868. French astronomer Janseen while observing the eclipse using spectroscope from Gundur near Madras identified during totality of the phenomenon, a new spectral line in the solar spectrum, near the yellow lines, beside the blue lines. It was for the first time that a spectroscope was used for observing eclipse. From the high intensity of the spectral lines, it was presumed that this might be visible at any time. During the next observation, next day, it became visible again as expected. Another observation team led by J.F. Tennent also viewed the D_3 line. Sir Norman Lockeyer opined that this line was emitted by an element so far unknown. This finding ultimately led to the conclusion of presence of Helium in the sun. Identification of helium in the laboratory was done 27 years later by Ramsey.

Solar eclipse of 1871 was visible in Ootty and Pudukkotai. This time Janssen saw some peculiar lines in the spectrum of solar corona. That was the moment when F-corona was identified for the first time.

Next solar eclipse was in 1898. Total eclipse was visible in Ratnagiri of old Vindhya pradesh and adjoining areas. Elaborate arrangements for comprehensive study of sun's chromosphere and corona had been done under the guidance of Nayagamwala, Evershed and Lockeyer.

Indian Astronomy in 20th Century

Pre-independence period: In the 20th century, Indian scientists were able to have notable achievements in the field of astronomy. Halley's comet appeared in 1910 as expected. This triggered a lot of interest in astronomy. Establishment of modern observatories at Kodaikanal and Nainital and extension of science education in the country boosted this interest and provided conducive atmosphere for the studies.

Kodaikanal Observatory

This started functioning in 1900. Complete spectroscopia system required for study of solar phenomena was available here. Numerous pictures of various processes taking place in the solar atmosphere have been collected here. Such elaborate collection can be claimed only by two other centres in the world, Mt. Wilson observatory and Meudon observatory in Paris. John Evershed who joined the centre in 1905 and later elevated to the position of its Director conducted very careful studies on sun spots which led to two very inportant discoveries.

1. *Radical motion of sunspots.* This is called Evershed Effect.
2. *Characteristics of spectra of sunspots.*

In the spectra, various Framer Hoffer lines were seen transpositioned towards the red end. Evershed was able to establish this as due to Doppler Effect.

In addition to this, Evershed had published a number of highly important observation results. T. Royd and A. L. Narayanan deserve special reference among those who organised notable research activities here during the earlier days of this observatory.

Nissamia Observatory

Started functioning in 1908. Even before this, Nawab Safargung had started sky observation here in 1901 using a 15'' Grubb reflector received from England. What Arthur Eddington had said about Saha's ionisation formulae was that it was one of the 10 greatest inventions in astronomy, after the invention of telescope.

Saha was one among those who initially pointed the importance of observing ultraviolet radiations. He also stressed the necessity of having observations in the outer atmosphere for proper understanding of steller phenomena.

Allahabad University

M.N.Saha moving from Calcutta to Allahabad in 1925 began his reaserch work in Astrophysics there and tried to build up and support a strong theoretical group. Eminent sceintists like P.L. Bhatnagar, A. C. Banerji, H. K. Kothari, R.D.Majumdar, etc. commenced their reaserch work here.

Post Independence Period

In India, the formation of a committee headed by Meghnad Saha as Chairman for submitting recommendations for the advancement of study and research in astrophysics in the country should be considered as a great noteworthy event of the century as regards the promotion of astronomincal science studies in India. The recommandations of this committee paved the way for a big leap in astronomical studies. Majority of the recommendations of the committee, like establishment of an observatory with large apperture telescope, necessity of a large apperture schmidt telescope and solar telescope, establishment of a naval observatory, and introduction of courses on astronomy and astrophysics at post-graduate level in universities will be implemented within few years.

First radio telescope in the country was established at Kodaikanal in 1952.

Vainubappu, Kodaikanal and Kavalur Observatories

When the Saha Committee recommendations were about to be implemented, so many people felt it necessary to receive the lost great past. In the light of a suggestion of establishing the new observatory at Ujjain, an inspection committee headed by the Director A. K. Das of Kodaikanal observatory was engaged. After two years of observations and studies, it was revealed

that, the atmosphere in Ujjain did not have the stability and clarity required for modern astronomical telescopes. The committe felt it desirable to imporve the facilities available at Kodaikanal for solar observation. Accordingly, the telescope and other instruments brought from England were installed there.

Vainubappu who succeded Das as Director of the Kodaikanal observatory, gave valuable contributions to the growth of modern Indian astronomy.

Bapu, who post-graduated in Physics in 1948, got his doctorate in "Stellar Spectroscopy" from Harward University in America in 1952. While continuing his work as a research student, he identified a comet. This is known as "Comet Bappu, Bohk and New Kirk". After his studies, he joined the Helley observatory at Pasadena. In that way he got the opportunity to use the then largest telescope "Palomer Zoo". His work together with the work of Olin Wilson, helped to formulate a new method to unveil the secrets of steller surface. Their new finding is known as "Wilson-Bapu Effect".

When returned to India in 1953, Bapu was entrusted with the establishment of an observatory in UP. Within a few years, a new observatory with all modern facilities was set- up in the Manora peaks of Nainital. After entrusting the responsibility of this observatory with young sciectists there, he at the age of 32, took the responsibility of Kodaikanal observatory. Following this, he began his efforts in implementing the most important suggestion of the Saha Committee. Establishment

VYNUBAPPU OBSERVATORY

of a large centre comparable to the best observatory in the world was the aim. The centre was decided to be in South India, as it was felt that Southern sky had not been subjected to scientific studies well. After investigative inspections of the sites from Kanyakumari to Thirupathi, for three years, it was decided to locate the centre among thick sandalwood forests in the Javadi Hills of Tamil Nadu. Name of a small village Kavulur adjoining it was given to the project. Construction was completed in 1967. Initially, a 15" (38 cm) aperture telescope was erected. Later, in 1972, system for a 40" (102 cm) telescope was completed. Notable observations were also made with it. Most important among the findings were the identification of atmosphere around the satellite Ganymade of Jupiter. Such an atmosphere was identified only to the largest satellite Titan of Saturn, till then. Yet another important achievement is the identification of circles around Uranus, and another circle network in addition to the known circles of Saturn. Now, Asia's largest telescope having 93" (236 cm) apperture has been made functional with in the centre.

"We owe a lot to the Indians, who taught us how to count, without which no worthwhile scientific discovery could have been made."

Albert Einstein (Scientist)

Indian Contributions to Medical Science

The history of Medical Sciences in India takes us back to remote antiquity. Medical Sciences is as old as the Vedas. It was based on the practical experience and careful methods of investigation pursued by the Sages in the old days.

Among the four Vedas, Atharva Veda has the maximum verses on medical knowledge. The Rig Veda, the oldest of the Vedas, contains lot of verses on medical sciences whereas Yajur Veda has very little about this science.

Although the Vedic medical system was contemporary of the Mesopotamian and Chinese religious and ritual based medical systems, it was not crude as those systems. Since the period of Atharva Veda itself there were professional medical practitioners who followed a pure stream of medical system (shudha vaidyam). Praises about Atharvas, a separate group of medical practitioners can be found in certain hymns. Usually medical practitioners were classified into different categories such as surgeons, physicians, magicians, toxicologists and so on. Perhaps the details of medical systems explained in Vedas could be the remnants of pre-vedic

The traditional, age-old belief about Ayurveda is that Prajapathi has passed on the knowledge to Ashwini brothers. Rig Veda has mentions about the brothers' ability to treat and their caring approach towards patients. How old men have regained their youth, how infertility was cured, how blind and lepers were cured, are all explained in Rig Veda. Ashwini brothers passed on their knowledge to God Indra and from Indra humans acquired the ability to treat. That is the belief. Thus the origin of medical science came from epics to semi-epics and finally to history.

AYURVEDA-Philosophy and Principles

The basis of diagnosis and treatment in Ayurveda is the principle of *Tridosha-Vata, Pitta* and *Kapha. Tridosha* control all the functions of the body. Health is said to be the equilibrium of three *Doshas* and ill health, the disturbance of their equilibrium.

VATA

This is responsible for movement and all important physiological process. *Vata* is concerned with the production of the nerve impulse and its conduction through nerves. It maintains equilibrium between *Tridoshas* and also between the enzymes and metabolities.

PITTA

This is responsible for heat production and metabolism. Pumping of heart, maintenance of skin temperature etc. is also its functions.

KAPHA

Kapha is responsible for cooling process, and lubrication between body parts. Growth, nutrition and sperm production also comes under its influence.

According to the site and action each of the *Tridoshas* exist in five different forms.

Vata

Pranan (regulates respiration) *Udanan* (sounds and speech), *Samanan* (separate enzymes), *Vyanan* (carries body fluids), *Apanan* (execretes like urine)

Pitta

Pachaka (facilitates digestion and heat

production), *Ranjaka* (Give red color to blood), *Sadaka* (Increases power to brain), *Alochaka* (gives vision), *Bhrajaka* (increases beauty)

Kapha

Kledaka (gives fluid nature to blood), *Avalambaka* (separates energy and power), *Bodaka* (taste), *Tharpaka* (functioning of senses), *Sleshmaka* (lubricates the joints)

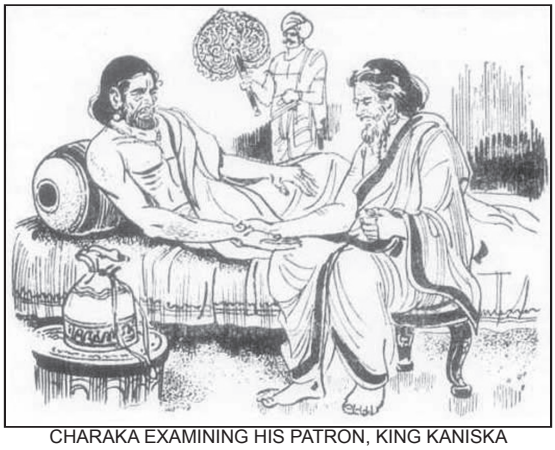
Mostly, one of the *Tridoshas* will be prominent in every individual. So there will be an inherent in equilibrium in every individual. If this is aggravated by wrong foods, wrong deeds or environmental factors, disease occurs. Even though Ayurveda accepts the chance of spreading of diseases, it does not believe that germs are causing diseases. It believes that like many other factors, which cause diseases, the germs also disturbs the equilibrium of *Tridoshas* and lead on to disease state. Ayurvedic medicine has 8 branches of study.

1. *Kaya Chikitsa* (General medicine)
2. *Shalya Chikitsa* (Surgery)
3. *Salakya Tantram* (Diseases of eye, ear, nose, throat)
4. *Bhoota Vidya* (Psychiatry)
5. *Kaumara Bhrithyam* (Paediatrics)
6. *Rasayanam* (Rejuvenation)
7. *Agadasastram* (Toxicology)
8. *Vajikarana Sastram* (Aphrodisiacs)

AYURVEDA- The Pioneers and the Texts

ATHREYA: In the hey days of Indian speculative thought Athreya taught his elaborations of the theory of drug and disease and ushered in the age of scientific medicine. He lived in the 7th century BC and taught medicine at Taksasila. Taksasila became a famous seat of learning by the 7th century BC and its glorious period was from 700 BC to 500 AD. Some of the great scholars of Taksasila are Jivaka, Brahmadatta, Kautilya, Patanjali and Panini.

Athreya was a great teacher of medicine and can be called the "father of medicine". His clarity of definitions of diseases and ability to link diseases and medicines made



CHARAKA EXAMINING HIS PATRON, KING KANISKA

him the greatest ayurveda acharya. Athreya passed on his knowledge and ability to his six disciples – Aginivesha, Bhela, Jadukaman, Parasharan, Harithan and Charapani. Among them Agniveshan was the most talented. He wrote the first exclusive medical text known as Agin-veshathantram, which gradually merged with Caraka Samhita .

BHELA SAMHITA: This is one of the oldest texts on Ayurveda. But we have got only an incomplete manuscript of this text. The references of this in other texts clearly demonstrate its antiquity and its importance.

CHARAKA SAMHITA

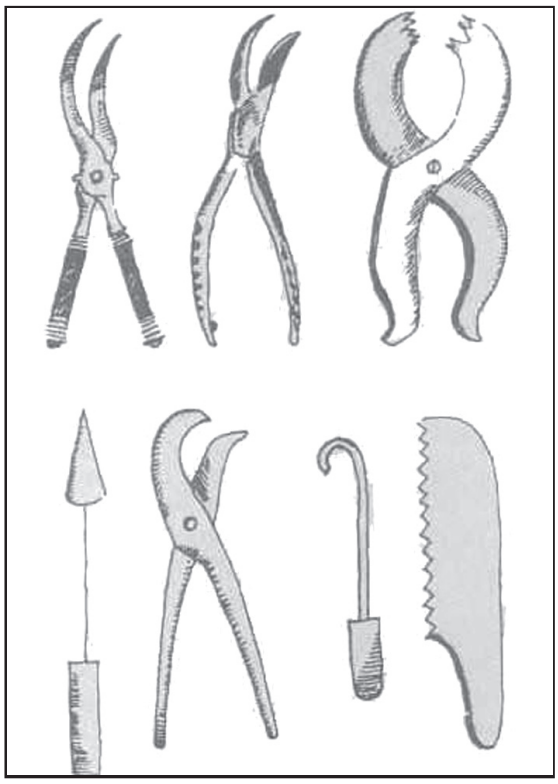
Caraka Samhita is the oldest text received in its entire form. Even though it is a comprehensive work on general medicine it also mentions about surgery and other six branches of medicine. *Caraka Samhita* is available today as revised by Dridabala in 7-8 century AD. *Caraka Samhita* is based on Agnivesa Samhita. Every chapter in *Caraka Samhita* opens with the words "thus spake the worshipful Athreya". Agnivesa is regarded as the golden link between the preachings of Athreya and the expositions of later medical authors.

SUSRUTA, SUSRUTA SAMHITA

The King of Kashi, Devadas, first taught surgery. He claimed himself to be an incarnation of Lord Dhanvantri. His main disciples were Aupadhenava, Aurabharan Pushkalavada, Gopurarakshidha, Bhoja

and Susruta. Among them Susruta was the most favourite. In the days of war between various ethnic communities, which left many wounded and incapacitated, surgery developed into an independent branch of medical system called Shalya Thantram.

Susruta Samhita is held in high esteem



SURGICAL INSTRUMENTS USED BY SUSRUTA

as a great authority on surgery. It describes about 650 medicines, 101 surgical instruments, more than 300 surgical operations and 42 surgical techniques. *Acharya Nagarjuna* revised *Susruta Samhita* in 3rd century AD.

KASYAPA SAMHITA

Kashyapan-II, a contemporary of Lord Buddha was an eminent pediatrician. Parvathakan and Bhadran were two other famous pediatricians.

Kasyapa Samhita, which deals with diseases of children and childcare, is a concise form of an earlier work *Vridha Kasyapam*

JEEVAKAN

Jeevakan studied under Athreya for seven years in Takshasila University and joined as the palace physician of King Bimbasara. He is known as the father of neurosurgery. Later he became the personal physican of Lord Bhuddha and embraced Buddhism. Jeevakan built many viharas and dedicated them to the Bhudha and his disciples. These viharas were later converted to hospitals and are said to be the first hospitals in the country.

VAGHBHATA

Vaghbhata lived in the second century BC. He wrote Ashtanga samgraham and Ashtanga Hridayam, later became one of the Trimurthis of Ayurveda . Charaka and Sushrutha are the two others. *Ashtanga Hridaya* written by Vaghbhata contains the most concise scientific information on Ayurveda. Vagbhata's two books deal with both medicine and surgery. Ashtanga Hridayam is the most popular text in Kerala. Indu has written a commentary - *Sasilekha* - to Astanga Hridayam, which has been widely acknowledged in Kerala. Indu is believed to be a member of *Astavaidya* family in Kerala. Recently a manuscript of a commentary written by Indu on *Astanga Hrdayam* has been found from an *Astavaidya* family.

Arunadattan, Chandranandan and Hemadri have also written commentaries for *Astangahridaya.* This is the book, which produced maximum commentaries in Malayalam.

While the text *Astanga Hridayam* was written in a poetic language *Astanga samgraham* is written in a mixed way. The basic concepts were beautifully presented in *Astanga Samgraham.*

NAGARJUNA

Nagarjuna belonged to Vidharba. He is said to have resided in the great University of Amaravathi, which flourished on the banks of River Krishna. Distillation, subli-

mation, calcination, colouring, production of alloys, separation of copper from its ore and application of metallic oxides in treatment methods were also contributions of Nagarjuna. Both Nagarjuna and Vagbhata were followers of Bhuddhism.

PATHANJALI

Pathanjali was a great philosopher, grammarian, and scientist. He is the originator of *Yoga Sastram*. Yoga is a system, which combines concentration of mind, respiratory control, control of thoughts and physical exercises. It has eight branches *Yamam, Niyamam, Asanam, Pranayanam, Prathiyaharam, Dhyanam, Dharana* and *Samadhi.*

MADAVACHARYA

He was born in Kishkinda now called Golkonda and was Prime Minister of Raja Vira *Bukka of Vijaya* Nagar in the 12th century. His book *Madhava Nidana* deals mainly with diagnosis of diseases and is considered an authority on this subject.

BHAVA MISHRA

He lived in 16th century AD. He had compiled and published a book Bhavaprakasham, which deals with topics ranging from origin of universe, human anatomy, fetal science, physiology, and diseases and so on.

In his book *Bhava Prakasam* he summaries the practice of all the best previous writers on medicine. He was the first to mention some of the drugs found in countries outside India. He described about Syphilis and its treatment, which reached India with the arrival of Portuguese.

ASTAVAIDYAS

Some Brahmins who migrated from Angavarta learned *Astangayurveda* and practised medical profession. They specialized in the eight fields of kayachikitsa-Balachikitsa, Grihachikitsa, Urdhvangachikitsa, Salyachikitsa, Vishachikitsa, Rasayanachikitsa and Vajeekarana chikitsa. Since they and their generations specialized and practised in the eight fields of Ayurveda, they were called *Astavaidyas.* To maintain continuity in their family profession, they married within the astavaidya families. But some got married from outside the group and engaged in other professions and thus the member of Astavaidhya families got reduced gradually. Earlier there were 18 astavaidya families in Kerala. Now the number in reduced to eight. Vayaskara Moos, Chirattaman Moos, Elayadathu Thycatt Moss, Pazhanellipurathu Thaikatt Moos, Vellode Moos, Pulamanthole Moos, Aalathoor Nampi and Vaidya Matom are the existing Astavaidya families.

It is believed that Vagabhata, author of *Astanga samgraha* and *Astanga Hrdaya*, taught Astangayurveda to *Astavaidyas*. Since *Astavaidyas* had to perform autopsy, surgery etc they were not allowed to participate in *yagas.* But since it has been found that medical assistance is required to priests in longer yagas. Vaidya matom Nampoothiris were asked to stay away from autopsy and surgery and were permitted to yagas.

TEXTS LOST

We have lost many valuable texts in Ayurveda. They include the *samhitas* of Agnivesa, Sharapani, Hareethan, Viswamithran, Kapilan, Gouthaman, Aupadhenava Aurabhran, Gopurakshidan, Vaitharanan and Bhoja.

SURGERY IN AYURVEDA

Surgery had advanced a great deal in ancient India. Many complicated procedures were used at that time. Plastic operations are characteristic of Indian medicine, which did not come to use in the rest of the world until the late medieval period. They performed couching for cataract, amputation of limbs, removal of fistulas and piles, curetting of uterus, removing tumors from vagina, plastic repair of ear lobes and nose which were used to be cut as punishment for various crimes and even intracranial surgeries.

Surgical instruments were made of good quality steel. There are mentions about anaesthesia also. A drug named *Sammohini* was used as anaesthetic and after operation another drug *Sanjeevini* was given to restore conciousness. Ancient Indians had a fairly good knowledge of anatomy of human body. Dissection was practised at that time. Susruta has given very elaborate instruction for preparing the human body for dissection.

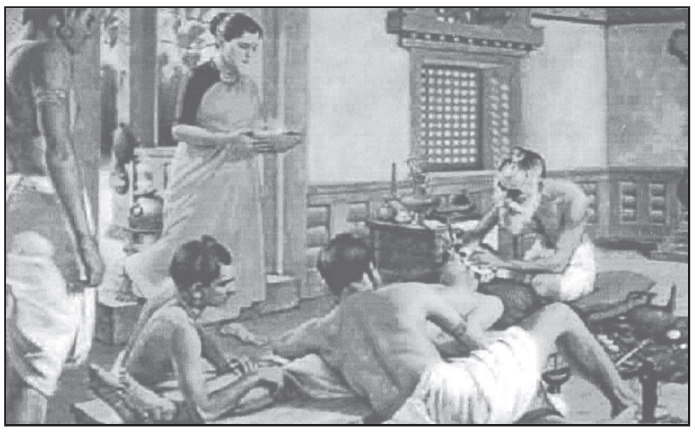
A broad array of surgical instruments was used. According to Susruta, the surgeon should be equipped with 20 sharp and 101 blunt instruments of various descriptions. The instruments were largely of steel. Cutting instruments, Susruta maintains, should be of "bright handsome polished metal, and sharp enough to divide a hair lengthwise. "Alcohol seems to have been used as a narcotic during operations, and hot oils and tar stopped bleeding.

In two types of operations especially, the Indians were outstanding. Stone in the bladder (vesical calculus) was common in ancient India, and the surgeons frequently removed the stones by lateral lithotomy. They also introduced plastic surgery. Susruta invented improved form of facial surgery. He devised what came to be known as the pedicle flap method of plastic surgery as a solution for the punishment for adultery - the chopping of the nose. In the procedure, tissue from one part of the body was sewed onto another to repair defects. Skin transplanted to the nose area was kept alive by remaining attached to healthy tissue. As the Susruta Samhita explained: "When a man's nose has been chopped or destroyed, the physician takes the leaf of a plant which is the size of the destroyed parts. He places it on the patient's cheek and cuts out of this cheek a piece of skin of the same size (but in such a manner that the skin at one end remains attached to the cheek). Then he freshens with his scalpel the edges of the stump of the nose and wraps the piece of skin from the cheek carefully all around it, and sews it at the edges. Then he places two thin pipes in the nose where the nostrils should go, to facilitate breathing and to prevent the sewn skin from collapsing. There after he strews powder of sapan wood, licorice-root and barberry on it and covers with cotton. As soon as the skin has grown together with the nose, he cuts through the connection with the cheek." Modern surgeons have never found better substitutes for Susruta's techniques.

The British learned the modern plastic surgery we use today while they worked for the East India Company. Although the pedicle flap was developed over 2,000 years ago, it is the same procedure that the British learned. Susruta practiced a type of cataract surgery known as couching, in which the cataractous lens was removed from the pupil to lie in the vitreous cavity in the back of the eye. This displacement of the lens enabled the patient to see well. Vision, however, was still blurred because of the unavailability of corrective lenses.

A typical operation performed by Susruta for removing cataracts is described below. "It was a bright morning. The surgeon sat on a bench, which was as high as his knees. The patient sat opposite on the ground so that the doctor was at a comfortable height for doing the operation on the patient's eye. After having taken bath and food, that patient had been tied so that he could not move during the operation. The doctor warmed the patient's eye with the breath of his mouth. He rubbed the closed eye of the patient with his thumb and then asked the patient to look at his knees. The patient's head was held firmly. The doctor held the lancet between his forefinger, middle finger and thumb and introduced it into the patient's eye towards the pupil, half a finger's breadth from the black of the eye and a quarter of a finger's breadth from the outer corner of the eye. He moved the lancet gracefully back and forth and upward. There was a small sound and a drop of water came out. The doctor spoke a few words to comfort the patient

and moistened the eye with milk. He scratched the pupil with the tip or the lancet, without hurting, and then drove the 'slime' towards the nose. The patient got rid of the 'slime' by drawing it into his nose. It was a matter of joy for the patient that he could see objects through his operated eye and the doctor drew the lancet out slowly. He then laid cotton soaked in fat on the wound and the patient lay still with the operated eye bandaged. It was the patient's left eye and the doctor used his right hand for the operation. "The first written description of the cataract and its treatment in the West appears in 29 AD in On Medicine, the work of the Latin encyclopedist Cornelius Celsus. Physicians used his book for 1,700 years. As recently as the middle of this century, couching was still practiced in Egypt, India, and Tibet.



SUSRUTA OPERATING A PATIENT

MATERIA MEDICA

The *materia medica* of Ayurveda is very extensive. Herbal, Animal and Mineral substances were used as medicine. Various methods and instruments were used to prepare drugs and to isolate active principle from organic materials. Weighing balances and measuring jars were used to take exact quantity of materials for preparation of medicines.

Apart from oral there were other methods of administration of drugs like external applications, *vasti*-injection through rectum or urethra., *Dhumapana*-inhalation, *Nasya karma*-snuffing and *Dhupana*-fumigation of wounds and ulcers.

ANCIENT HOSPITALS

Bharat was the first nation to establish hospitals, and for centuries they were the only people in the world who maintained them. The Chinese traveler, Fa-hien, speaking of a hospital he visited in Pataliputra says: "Hither come all poor and helpless patients suffering from all kinds of infirmities. They are well taken care of, and a doctor attends them; food and medicine being supplied according to their wants. Thus they are made quite comfortable, and when they are well, they may go away."

"The earliest hospital in Europe," says historian Vincent A. Smith "is said to have been opened in the tenth century."

ANIMAL MEDICINE

Ayurveda not only dealt with diseases of human being but also that of animal kingdom and plants. Alleviating the sufferings of all living being was the goal of Ayurveda.

GAVAYURVEDA

Gouthama's *Gavayurveda* is a book, which deals only with the medical aspects of cows.

ASWAYURVEDA

Shalihotran is the father of ancient Indian veterinary science. An expert in treating horses, he had written Shalihotra samhita, which contains about 1200 verses and most of it deals with horses.

Aswavaidyakam of Jaya Dutta Suri and *Aswasastram* of Nakula were based on this text. The former is a voluminous text with 68 chapters and deals with the classification of horses and their characters, salient features, diseases and treatment. In Nakula's text many information regarding various aspects of horses are compiled together. It contains on the anatomical structure of

horses, which reveals the sound knowledge that was available at that time.

HASTYAYURVEDA

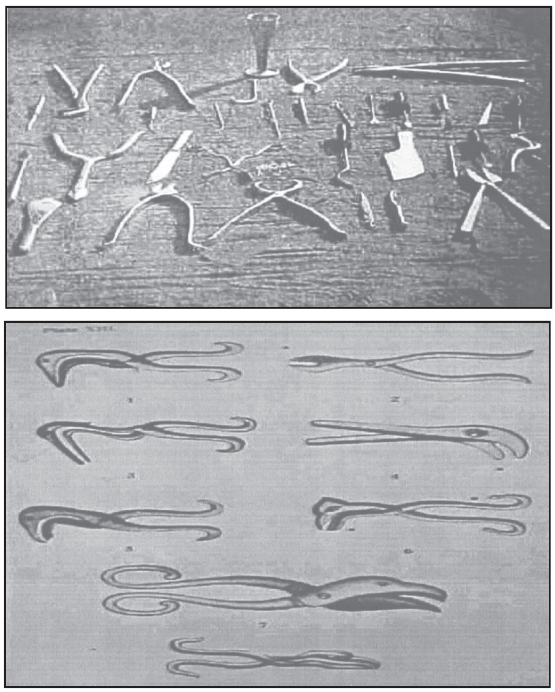
Elephants were used for carrying loads and in war. *Hastyayurveda* of Palakapya is a text on treatment of elephants. It is as big as *Charaka Samhita.*

VRIKSHAYURVEDA

It gives us information about plants. We get information on this branch of Ayurveda scattered in many textbooks. A chapter in Sarangadhara's medical text '*Upavana Vinodam*' deals with this branch. *Susrutha Samhita, Upasakaram* of Sankara Misra, *Brahat Samhita* and *Manu Samhita* also contains knowledge regarding botanical sciences.

In these books there are references of creating new species of plants with required characters. It is really surprising that our ancestors had thought two thousand years ago, of the techniques practised by botanists today.

SIDDHA MEDICINE



SURGICAL INSTRUMENTS DESCRIBED IN SUSRUTA SAMHITA

The Siddha system of medicine is the system of medicine popular in South India especially in Tamil Nadu. According to epics, Maharshi Agasthya crossed mountains of Vindhyas to reach Tamil Nadu and settled in South India. This could be perhaps an indication of peaceful north Indian migration and settlement in South India. Agasthyan practised Siddha and refined it in the North Indian style thus a unique Siddha system was evolved. This system is practised widely even today in countries like Srilanka, Singapore, Myanmar, Tibet and in Tamil Nadu, Andhra Pradesh and Maharashtra within the country.

The science of chemistry was well developed in the Siddha system. They used many metallic compounds including mercury and arsenic effectively in practice. In Siddha system, there are 25 types of salts, 64 types of rare rocks, 9 metals, 120 metallic salts and 1009 types of herbs applied for preparing medicines. Mercury was used in the treatment of venereal diseases and arsenic in the treatment of leprosy. *Siddhanar Krithikal* written by Siddhars in Tamil is a treasure house of knowledge of medicine, chemistry and related subjects. There are more than 500 medical works containing over 3000 valuable formulae, composed of five lakh stanzas.

These books written thousands of years before Christ reveals the depth of knowledge Indians had in chemistry.

MODERN MEDICINE

It was the Portuguese who first introduced the modern medicine to India, when Albuquerque founded the Royal Hospital in Goa in 1510. Although the Portuguese brought modern medicine first, it was the French and later the British who established and consolidated it in India widely and firmly.

But all the efforts of the colonial rulers in establishing modern medical institutions were guided by the need to protect the health of Europeans.

All the early hospitals were military

hospitals. The first hospital established by East India Company was at Madras in 1664. One in Bombay in 1670 and another in Calcuttain 1707 followed this.

The earliest reference we find of the establishment of any hospital meant for treating the sick native civilians was that of General Native Hospital founded in 1792 at Calcutta. This was the result of the realization of the rulers that if their surroundings remained diseased, and uncared for, it was difficult to fully protect themselves even at their secluded and spacious hill station and civil lines.

By the middle of 19th century the number of hospitals increased considerably. So also the number of patients attending hospitals increased. In spite of all these, the mortality among the natives was very much higher than the Europeans. The official explanation for the high rate of mortality among the natives was that Europeans had a better constitutional build up. But the actual reason was, while the best medical treatment was provided to Europeans, the condition of hospitals meant for natives were deplorable.

British rule was not only political slavery for India but it initiated the process of subjugation and captivation of India's traditional scientific systems by the fast developing modern scientific systems of the west. With the colonial power at the apex, the western sciences, without facing any recognizable resistance, gradually dethroned and out-distanced the indigenous scientific systems.

For the creation and maintenance of the empire, the British had to conquer diseases also. Preservation of European health in new and hostile lands was colonial medicine's first responsibility. Though the name given to efforts in this direction was tropical medicine, there was hardly anything tropical about it. Most of the so-called tropical diseases cholera, plague, small pox, etc. were found in Europe as well.

SMALLPOX

One of the oldest and deadliest diseases of recorded history - the small pox had no cure in any system of medicine. But inoculation, a preventive measure against small pox, was extensively practised long before the British arrival. This variolation - inoculation with small pox matter, had made most of natives resistant to the disease. Thus small children and Europeans became the easy target for the disease. A later estimate by the Superintendent General of Vaccine in 1804 noted that fatalities among the inoculated counted one in 200 among the Indian population and one in 60 to 70 among the Europeans. There is an explanation for this divergence. Most of the Europeans objected to the inoculation on theological grounds

In 1796 Edward Jenner discovered a vaccine for small pox. Jennerian vaccination was introduced in India in 1802 and the Britishers tried to spread the vaccination by all means. The native inoculations, in the eyes of Britishers, suddenly got metamorphosed into 'disease spreaders' and 'murders'. The government banned inoculation and gave all support to vaccination.

(Now smallpox has been eliminated from the world. The last Indian smallpox victim was found in 1975 May 17th and an imported case from Bangladesh was detected in 1975 May 25th. On April, 1977 India was declared free of small pox. On 1980, May 8 WHO declared small pox as eradicated from the world.)

CHOLERA

Though Cholera was known in Asia and Europe much before the British arrival in India, its appearance in extremely virulent and fatal form was properly recorded only in the first quarter of ninteenth century. The first full and accurate account of Cholera epidemic dates back to the outbreak of the disease in 1817. The outbreak of Cholera in 1861 was the worst ever epidemic and resulted in the highest fatalities the European army had experienced, when one tenth of the

British troop perished in north India.

As a result of the sanitary measures taken, the army camps slowly became free of Cholera. But epidemics continued to rage among the general population.

Even though Cholera was very frequent in India, no research was carried out on this desease. In 1883 a German Commission led by Robert Koch discovered Cholera bacilli in Egypt and visited Calcutta in the same year to confirm his discovery.

The government did not bother to take preventive steps even after the causative organism became known. In 1892 the Russian born French trained bacteriologist W. M. Haffkine developed anticholera vaccine. The Indian authorities offered him facilities for a trial. Trials proved that vaccine was effective. But government did not take up inoculation measures on an extensive basis because of cost considerations.

MALARIA

Important discoveries regarding malaria were done in India. In 1897 Sir Ronald Ross discovered the life cycle of malarial parasite in mosquito. This discovery had thrown open the methods to control malaria.

Sir Ronald Ross was born in India at Almore in Kumaon hills situated about the centre of the Great Himalayas, northeast of Nepal on 18th May 1857. His father was a distinguished officer in the Indian Army. Ross joined Indian Medical Services in 1893. He carried out his experiments on transmission of Malaria by mosquitos, virtually alone and without a word of sympathy or a pat by his superiors. On August 20, 1897 after years of ceaseless toil, Ross claimed with proof that the culprit was the anopheles mosquito and demonstrated the parasite on the outer wall of its stomach. Few months later he solved the last riddle of transmission by describing the way how the parasite reaches the salivary gland of mosquito and how it passes into the blood of victims.

His request for special leave to pursue his research was rejected and soon he was transferred from Perumbur in Madras to Kherawar in Rajasthan, a place free of mosquito. Finally after Dr. Manson intervened, leave was granted to Ross, but he was asked to study Kala azar also. "Columbus having sighted America was ordered off to discover the North Pole" was Ross's remark on this instruction.

The government failed to take steps to control Malaria based on the new discovery. It was a time when, more than 13 lakh people were dying per year from malaria. The number of diseased should have been much more.

In sheer frustration Ross retired from IMS in 1899 and went back to England where he served as professor of Tropical medicine in Liver pool University.

PLAGUE

Plague called as *Mahamari* was known to Indians from very early times. There are references in *Bhagawat Purana* (BC 1500-800), that those houses should be abandoned soon, once dead rats are spotted. The first record of plague as an epidemic was during the invasion of Muhammed in AD 1031-1032. During subsequent invasion also there used be plague epidemics in India.

Before 1896 plague affected India rather mildly. In 1895 - 1896 plague reached India from Hong Kong and spread very fast. The British authorities instead of taking measures to tackle the disease here were more interested in preventing the disease from spreading to Europe.

Under international pressure the government summoned W.M. Haffkine who had already acquired fame with the discovery of cholera prophylatic to produce antiplague vaccine. Within a period of 3 months, in 1897 January, Haffkine came out with an effective anti-plague inoculation. As usual government did not show much interest in the discovery. Hoffkine emotionally drained out and spent his old age in loneliness and in company of Judaism. (In 1994 plague re-emerged in India after a gap of 28 years.)

MEDICAL EDUCATION

It was in 1822 that the East India Company established the first Medical School in Calcutta. Similar schools were started in Bombay in 1826 and in Madras in 1827. To begin with, instruction was imparted through the medium of Sanskrit or Urdu. A controversy arose regarding medium of instruction. A committee was appointed and it was decided that the instruction should be in English. By the end of 9th century we had four medical colleges.

Even though more and more natives came forward for modern medical education, they had to face very severe discrimination regarding employment and salary. Native doctors were called 'Medical coolies' 'Black doctors' etc. At least till 1832 native doctors, when at fault, were subjected to flogging by the officers of the regiments like ordinary native sepoys. In pay and other allowances the natives were far behind Europeans.

This did not mean that Indians were less qualified or less efficient. They were found equal to the best in Europe. To site one example, after examining the chemistry students of Calcutta Medical College, J.Princep wrote to the director of Indian medical service, "The extent and accuracy of the information on the single subject selected to test the aptitudes of the pupils has far surpassed my expectations and I do not think that in Europe any class of chemical pupils would be found capable of passing a better examination".

PHARMACEUTICAL INDUSTRY

Consumption of European medicines kept increasing enormously as number of hospitals increased. But of all the British medical activities, pharmacy (the science of compounding and dispensing drugs) and drug manufacturing were the slowest to grow, mature and expand in the country. Hospitals and dispensary suppliers of allopathic drugs almost entirely depended upon the imports from Britain. Even the drugs common to the British Pharmacopoeia and Indian Pharmacopoeia were denied the opportunities of indigenous production. In the Medical Schools and Colleges of India, pharmacology was never taken seriously. But at the same time this branch of medicine was making rapid progress in Europe and America.

In India drug manufacturing could take a start only towards the end of 19th century at the initiative of Acharya Prafulla Chandra Ray, the eminent chemist who wrote 'History of Hindu Chemistry'. He started his company in 1892 at Calcutta with a modest capital of Rs. 700 only. In the beginning of the 20th century several others firms cropped up following the lead taken by Acharya P. C. Ray.

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"Whenever I have read any part of the Vedas, I have felt that some unearthly and unknown light illuminated me. In the great teaching of the Vedas, there is no touch of sectarianism. It is of all ages, climbs and nationalities and is the royal road for the attainment of the Great Knowledge. When I read it, I feel that I am under the spangled heavens of a summer night."

Thoreau (American Thinker)

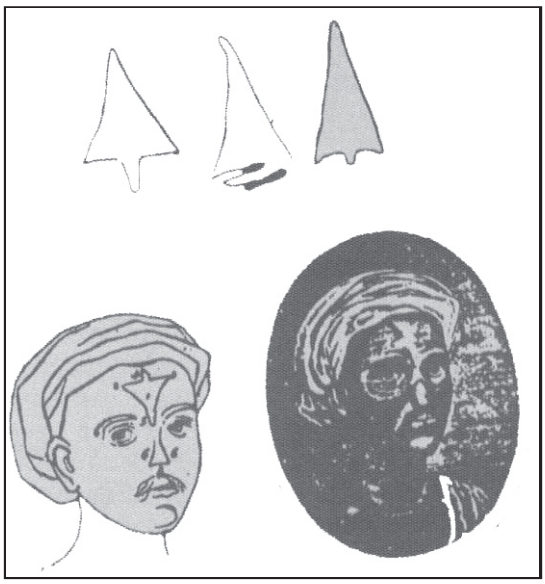
Plastic Surgery In Ancient India

From 1769 AD to 1799 AD, four Mysore Wars were fought between Hyder Ali and his son Tipu Sultan and the British. As a result of these wars the British learnt two very important Indian techniques-rocketry and plastic surgery. Both these Indian techniques were further improved first in England and then in other European countries. How the British learnt the art of Indian plastic surgery is a fascinating story.

"INDIAN NOSE"

A Maratha cart-driver, Kawasajee, who had served the British, and four tilanges (Indian soldiers of British army) had fallen into the hands of the Sultan of Srirangapattanam. Their noses and right arms were cut off as a punishment for serving the enemy. They were sent back to the English command.

After some days, when dealing with an Indian merchant, the English commanding officer noticed that he had a peculiar nose and scar on his forehead. On inquiry, he learnt that the merchant's nose had been cut off as a punishment for adultery and that he had a substitute nose made by a Maratha *Vaidya* of the *Kumhar* (potter) caste. The commanding officer sent for the *Vaidya* and asked him to reconstruct the nose of Kawasajee and others.



NASAL PLASTIC SURGERY PERFORMED BY KAWASAJEE

The operation was performed near Pune in the presence of two English doctors. Thomas Cruso and James Findlay. An illustrated account of this operation, carried out by an unnamed *Vaidya*, appeared in the *Madras Gazette*. Subsequently, the article was reproduced in the *Gentleman's Magazine* of London in October 1794. This article fired the imagination of the young English surgeon J.C. Carpue, who after gathering more information on the "Indian nose" performed two similar operations in 1814 with successful results. After Carpue published his account, Graefe, a German surgeon, performed similar plastic operations of the nose using skin from the arms. After this plastic surgery became popular throughout Europe. All replacement operations which use a flap of skin in the immediate victinity of the loss are known as Indian plastic surgery.

PLASTIC SURGERY

Plastic surgery has little to do with plastics, the synthetic substances so common today. The term 'plastic', derived from the Greek *plastikos*, means to mould or shape. The task of plastic surgery is to restore the appearance and function of parts of the body destroyed or damaged by disease or injury. Contrary to popular belief, plastic or

reconstructive surgery is not merely cosmetic surgery but an important discipline that aims of correcting all sorts of physical deformities. Though a very old technique, plastic surgery has made great strides only after the first World War.

In ancient Europe, there was no tradition of plastic operations. The plastic operation on nose done by Branca in 1442 was very similar to the one described in the Sushruta-Samhita, an Ayurvedic compendium composed in the early centuries of the Christian era. In India, from ancient times to the early nineteenth century, we find a living tradition of plastic operations of the nose, ear and lip. The Kangra (correctly pronounced as 'Kangada') district in Himachal Pradesh was famous for its plastic surgeons. Some scholars are of the opinion that the world 'Kangada' is made from '*Kana + gadha*' (ear repair). The British archaeologist Sir Alexander Cunningham (1814-93) has written about the tradition of Kangra plastic operations. We have information that in the reign of Akbar a *Vaidya* named Bidha used to do plastic operations in Kangra.

PLASTIC SURGERY IN THE SAMHITAS

The *Carakasamhita* and the *Sushrutasamhita* are among the oldest known treatise on Ayurveda. Chronologically, Carakasamhita is believed to be an earlier work, and deals with medicine properly containing a few passages on surgery. The Sushrutasamhita, a work of the early centuries of the Christian era, mainly deals with surgical knowledge. The exact Sushurtasamhita is, according to its commentator Dalhanacharya (twelth century AD), a recension by Nagarjuna. The original Sushrutasamhita was based on a series of discourses of Kashiraj Divodas (or Dhanvantari) to his disciples, Sushruta and others.

There has been a tradition to divide the Ayurveda works into 120 chapters. the *Susrutasamhita* also contains 120 chapters, groupued into five *sthanas* (books): Sutrastana, Nidanasthana, Sharirasthana, Chikitsashana and Kalpasthana. Besides, the compendium contains an appendix, called Uttaratantra, consisting of 66 chapters.

OTOPLASTY

The plastic operations of otoplasty (plastic surgery of the ear) and rhinoplasty (plastic surgery of the nose) are described in the 16th chapter of the first book (Sutrasthanam) of the compendium. First, methods are described for piercing the ear-lobes of an infant which still is a widespread practice in India. Often these ear-lobes, due to the use of heavy ornaments, get considerably expanded and ultimately sunder. Sushruta has described 15 methods of joining these cut-up ear-lobes. For these plastic operations, called *Karnabandha*, a piece of skin was taken from the cheek, turned back, and suitably stiched on the lobules. Further treatment of the operation, periodic dressing of the wound and the use of various ointments is elaborately described.

MINOPLASTY

In describing the method of minoplasty (*Karnabandha*), Sushruta says that the portion of the nose to be covered should be first measured with a leaf. Then a piece of skin of the required size should be dissected from the living skin of the cheek, and turned back to cover the nose, keeping a small pedicle attached to the cheek. The part of the nose to which the skin is to be attached should be made raw by cutting of the nasal stump with a knife. The physician then should place the skin on the nose and stitch the two parts swiftly, keeping the skin properly elevated by inserting two tubes of "eranda" (the castor-oil plant) in the position of the nostrils, so that the new nose gets proper shape. The skin thus properly adjusted, should then be sprinkled with a powder composed of liquorice, red sandal-wood and barberry plant. Finallly, it should be covered with cotton, and clean sesame oil should be constantly applied to it. After some days the wound heals up and the grafting is successful. Sushruta also

mentions the reconstruction of the broken lip and harelip (Oshtha-sandhana).

PLASTIC SURGERY MARCHES AHEAD

Thus, plastic surgery is a very old science. It is, however, difficult to say when the first plastic operations on man were perfomed. Primitive man knew how to do grafting in plants. This might have given him the idea of transferring tissues in man and animals. The necessity arose when he lost such parts of his body as the nose, which has been a common form of injury in all periods of history. In olden days, removal of the nose was also one of the most common form of punishment. Manu, the famous lawgiver, mentions the ears and the nose among the ten parts of the body on which punishments are to be executed (*Manusmruti*:8125). Thus it became a social necessity to find a substitute for the lost nose. The development of plastic surgery is closely connected with the operative techniques used in the field known as rhinoplasty.

After getting fresh impetus from India, plastic surgery has made great progress in the past two hundred years. In 1933 the first international congress of plastic surgery was held in Paris. Basically, the task of plastic surgery is to restore the parts of the body destroyed or damaged by disease or injury. But in recent years, "cosmetic surgery" as beauty treatment has become very fashionable. Anyway, we should always remember that the sources of modern plastic surgery are in the Sustrutasamhita and it was from India the Europeans learnt the technique of rhinoplasty.

(Courtesy: Ganakar Muley, Dream 2047, Vigyan Prasar, New Delhi)

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"India is the cradle of the human race, the birth place of human speech, the mother of history, the grand mother legend and the great grandmother of tradition. Our most valuable and most constructive materials in the history of man are treasured up in India only."

Mark Twain

Chemistry and Chemical Technology in India

Introduction

Chemistry has been hailed as a practical art from time immemorial and promoted in all parts of the world. Chemistry is essentially an experimental science and has helped mankind to prepare and manufacture their required articles making use of the natural resources like minerals, forest and agricultural products. Chemistry has also helped mankind to prepare remedies to cure diseases and improve the health of both animals and human: Chemistry has thus developed from both industry and medicine.

Today chemistry and chemical technology contribute about 10% to the national income (GNP) of different countries of the world including India. Most of the chemical industries established in our country even after independence are based on the costly imported technology of multinationals of the industrially advanced countries. This trend continues even today.

Excellence of Steel

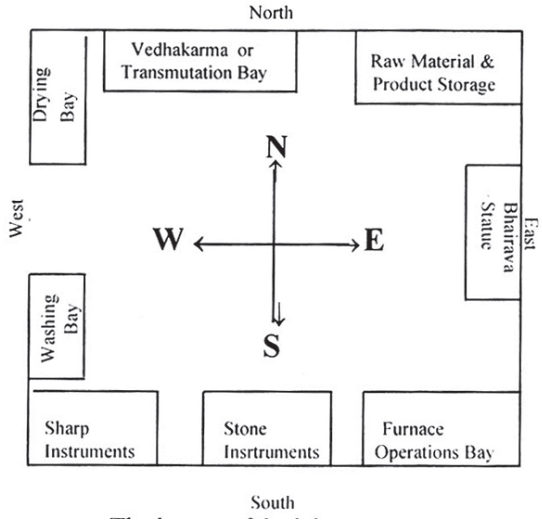
India was considered to be the industrial workshop of the world till the end of the 18th century. Everyone is familiar with the chemical excellence of cast iron produced in ancient and medieval India. The tempering of steel was brought to perfection in India when it was unknown to Europe. Alexander received a precious gift of 30 pounds of not gold but of steel from the Indian king. India was the leader of several chemical and pharmaceutical industries including dyeing, tanning, soap making, glass and ceramics, cement and metallurgy. Indians were far ahead of European experts in several technologies involving melting, smelting, casting, calcination, sublimation, steaming, fixation and fermentation. There were experts in the preparation of a variety of metallic salts, compounds and alloys, pharmaceutical preparations, perfumery as well as cosmetics.

Technology Drain

It is appropriate to mention that it is the Muslims, who took much of the Indian chemistry, medicine, astronomy and mathematics and other branches of science and technology to near east and then to Europe. It is well established that the secret of manufacturing of Damascus-Steel was taken by the Arabs from Persians and the Persians from India.

Chemical Excellence in Indus Valley

Archaeological excavations at Mohenjodaro in Sindh (now in Pakistan) and Harappa in Punjab (also now in Pakistan) have shown that the people of the Indus Valley Civilization (2500-1800 BC) were skilled in employing a wide variety of chemical processes. Bricks, water-pots, vessels, jars, earthenwares, faience, terracotta, jewellery, metal-vessels and implements, seals, painted pots, chrome glazed pottery and glass vessels and many other items have been found. The Indus Valley people used mortar consisting of lime, gypsum and sand plaster as construction materials for building houses and mansions. In metal working also the Indus people were experts in casting and forging. Copper and bronze (an alloy of copper and tin) were utilized for making tools and weapons, domestic utensils, statuets, bangles, finger-rings,



THE LAYOUT OF THE LABORATORY

ear-rings, amulets, wires and rods. Gold and silver were used for jewellery and ornamental vessels. Later excavations have unearthed specimens of iron implements. Recent excavations in several other parts of India have revealed similar objects hidden under the ground.

It is evident that the technology of extracting Gold, Silver, Copper, Lead, Tin and

PAVED BATHROOM AND BRICKWALL MOHENJO-DARO
(C. 3300BC)

Iron was known and that there were professional experts who were smiths, potters, carpenters and chariot builders. However, we do not find the details of metallurgical operations in the ancient literature.

Preparation of Alkali

Causatic Alkalis play an important role in our daily modern life. They are essential for a variety of industries which manufacture consumer articles for every day life such as paper, textiles, soap and detergents, plastics, medicines, mettallurgy and several other industries. Today over million tons of caustic soda is manufactured in India every year from sea salt by an electrochemical process. Our ancestors in India however, prepared this essential commodity from wood ashes and line stones and sea shells. The details of the method of preparation of Alkali are described in Susrutha Samhita.

Rasa Vidya

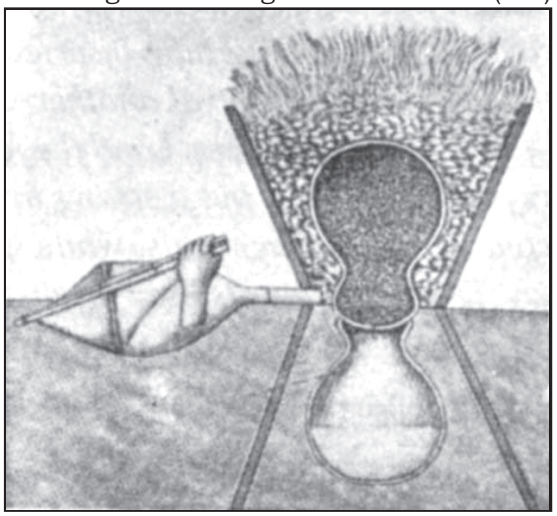
Several methods of preparation of variety of chemicals and drugs are given in old works on Indian Alchemy, known as 'Rasa Vidya', after a large number of trails and errors. These experiments were conducted in a Chemical laboratory is described in one of the most well known works on ancient Indian chemistry 'Rasaratna Samuchaya'.

Laboratory Yantras

There were more than 32 pieces of apparatus used for chemical and pharmaceutical investigations and they are called Yantras. Descriptions of only two Yantras viz. Kosthi Yantra and Tiryak Patana Yantra are given for illustration.

Kosthi Yantra

Furnace having the width of 17 angulas and length and height of one hasta (18")

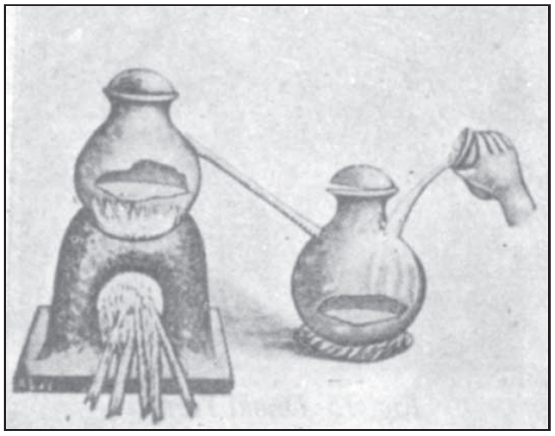


KOSTHI YANTHRA

and uniform on all sides is known as Kosthi Yantra. It is used for extracting the metal content from ores and minerals.

Tiryak Patana Yantra

The chemicals are placed in a vessel provided with a long tube inserted in an



TIRYAK PATANA YANTRA

inclined position. Mouth of the vessels and the joints are luted with clay and cloth. Strong fire is put at the bottom of the vessel. This appartus is used for distillation.

A modified type of appartatus Dekhi Yantra was also in use.

Rasa Sastras

Several preparations were made from materials of mineral, plant and animal origin which were extensively used in medicine and industry. One of the most important chemical activity carried out in such a well equipped laboratory was known as the killing of metals. Sulphur was used to 'kill' all the metals and sulphur was known as the enemy of metals (copper) . Sulphur is compared to a lion and a metal to an elephant. "Just like a lion kills an elephant so the sulphur kills all the metals".

The main goal of all experiments described in *Rasa Sastras* is two fold: one is to transform base metals to noble metals *i.e., Loha Vedha* and the other is to strengthen the body and maintain in a fresh and healthy state just like a youth. This is *Deha Vedha* or *Kaya Kalpa*. These ventures gave stimulus for experimentation and also for exaggerated claims. For instance, one chemist claims that he has produced gold from copper in one of these experiments.

Corrosion

The Indians observed that base metals like iron easily undergo corrosion while the noble metals do not. In their assessment among the six metals gold, silver, copper, iron, tin and lead, the resistance to waste (corrosion) is in the order in which they have been named.

This conforms to the present day electrochemical series. The noble metals were therefore extensively used for jewelry and coins.

Alum

Ancient Indian chemists were very familiar with the preparation, properties and use of the Alum [$K_2SO_4A1_2(SO_4)_3$. 24 H_2O]. It was used an astringent for the treatment of eyesore. Alum was extensively used in the textile industry for fixing the colour of the madder root as a mordant.

Alum was also known as 'Saurastra Lavana'. It occurs extensively in Gujarat. This was mined not only to meet the local demands but also to export to other countries.

Scientific Debates

It was customary in ancient India to hold periodic conferences to discuss scientific and technical works. Caraka makes its obligatory for the medical experts to meet periodically and hold discussions. He also prescribes the procedure for debates in greater detail in Caraka Samhita.

Caraka says: *"One should have friendly discussions with persons of learning possessing scientific knowledge, proper argument, who do not get irritated, who are endowed with correct knowledge, who are competent in convincing others, who are capable of facing difficult situations and who can address in a sweet tone. One should confidently discuss with such persons and put questions to them. When he asks anything, it should be elaborately described*

with confidence. One should not get worried under the apprehension of getting defeated. One should not rejoice by defeating his opponents. One should not boast of having defeated such opponents. One should not hold extreme views under delusion. One should not try to describe a thing which the other party does not know. One should try to bring round the other party with politeness and not by deception. One should be very careful to behave politely with his opponents."

Biotechnology

In addition to these conventional chemical operations, many biochemical works were also in vogue from time immemorial. The use of milk, curds, butter, butter milk, ghee and cheese for everyday living finds extensive mention even in vedic literature. Intoxicating liquors were prepared by a fermentation process and consumed extensively during religious ceremonies and at other social gatherings on several occasions.

Many such alcoholic 'exhilarating and intoxicating' beverages were extensively used to cure a variety of illnesses and diseases. The beneficial and harmful effects of alcoholic drinks were fully recognized by early Indian medical experts like Charaka and Susruta. Their works viz., Charakasamhita and Susrutasamhita give a charming description of the three stages of human and animal behavior after the intake of alocoholic drinks. Various kinds of liquors are described in the above mentioned works and also in Kautilya's *Arthashastra*.

Cosmetics and Perfumes

India is a tropical country. It is needless to emphasize the importance of both cleanliness and use of perfumes in every day life cutting across all the strata of society even from early stages of civilization. Indian chemists had made significant contributions to the field of cosmetics and perfumery, right from the Vedic times down to the eighteenth century.

It is possible to find observations on the technical details of process of manufacture of different perfume products such as scented waters, oils, sticks, powders and essences scattered over several works. Some of oils such as Sukumara Taila, Amritha Taila etc. are made of varied aromatic materials. It is possible to presume that scented oil was developed side by side with the preparation of medicinal oils. The aromatic ingredients were derived from leaves, flowers, fruits, barks, woods, roots, exudation of plants and organic products.

Dyes and Colouring Agents

As already mentioned, India was in the forefront of the textile industry also till the end of the 18th century. This was one of the most competitive industry of the country and probably the most successful textile industry of the world. Its beautiful and coloured textile products of cotton, silk, wool and jute attracted the whole world from time immemorial. The Indus valley people were acquainted with red colour of the madder root (*mangista*). There were more than 100 colouring agents of both mineral and vegetable origin and possibly a few of animal origin for dyeing the fabrics and other articles of every day use. Indigo was the other most famous dye extracted from the plant '*Indigofera tinctoria*' for dyeing various shades of blue. It may not be out of place to mention that indigo plantation was prevalent in India on 1.6 million acres of land till the beginning of 20th century. Germany began to manufacture this coveted dye with cheap industrial raw materials on a commercial scale from 1897 onwards and gained the world monopoly. This practically killed the Indian indigo industry by 1914.

Several vegetable dyes were derived from roots, trunks, woods, seeds and resin. Lac is obtained by the secretion of an insect which is a parasite on some specific plants and trees. Lac contains 10% of the red dye. The word lac is a technical term in the dyeing technology which is a conglomerate of a dye and a mineral salt like Alum or Iron Sulphate that makes the dye to stick firmly to the fibers, which otherwise would not. The

mineral salt is called a mordant and Alum is known as 'Raga-bandhini'. The word 'lake' has been traced to the word 'lac'.

Theoretical Basis for the Experimental Works

While the results of the experimental works carried out by Indian Alchemists were appreciated, admired and applied to meet the demands of the community, it is worth while to speculate on the theoretical basis behind all these practical achievements. The intellectuals of ancient India have speculated and strenuously tried hard to understand the nature of the physical world and its origin. The early philosophers invoked a theory to account for the varieties of materials found in nature and also the man made articles. They visualized five different elements which constitute the physical world. These are earth, water, wind, fire, and sky/ether. These five elements were supposed to be endowed with individual characteristics (*Gunas*) or qualities. With diverse combinations of these elements different materials are formed. They tried to explain the different properties and qualities on the basis of these different combinations. They also speculated that these elements must have evolved from a primordial matter, just as a piece of stone can be cut out into different shapes and forms. They also considered the possibility of converting a base metal like iron or lead into gold a precious metal. This is the basis for all the attempts made to achieve this goal. They also tried to find out an agent which could by its touch would convert base metal into gold 'touch stone'.

Another line of approach was to keep the human body in good health and youthful condition. Experiments were conducted to prepare this agent which could bring about the youth and good health by its administration for older people. Such treatments were termed Dehavedha, Kayakalpa and Sanjivani.

Concept of Atom

There was another school in India which visualized that this gross universe is made up of tiny individual particles called atoms. Kanada was the leader of this school called *Paramanuwada*. These atoms combine and give rise to different substances. Such combined atoms were known as molecules '*Anu*' which can contain two atoms or three atoms. Of course the nature of the force that would combine these atoms was still on speculation. It was remarkable indeed to find that Indians had already pictured that atoms are invisible because of the small size. They could also estimate the size of atoms in term of the known units familiar to them. According to the *Shevetaswataropanishat* - "Tip of the human hair is divided into hundred parts and each part in its turn is divided into 100 parts."

This works out to be roughly 10^{-8}cm. It is amazing to find that this agrees well with the present day estimate for the size of the atoms in terms of the Angstrom unit (10^{-8} cm = 1Å).

Similar concepts about the elements and the atoms were also made in the ancient western world. These concepts remained latent till the beginning of the 19th century. It was an English school teacher Dalton, who made use of these concepts and postulated the atomic theory of matter. This could explain satisfactorily all the laws of chemical combinations known at that time. The atomic theory of matter and the theory of evolution of life heralded the modern concept of the universe. It is unfortunate that these theories did not originate in India in spite of such great achievements of the earlier times.

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Life Sciences in India

India has a rich tradition of Science and Technology wereas development of Life Sciences has been realized only recently. The western media and researchers dealing with the history and evolution of biological sciences failed to recognize the contribution of India in this field. The information on the early development of life sciences in India remains scattered in various literary works.

Botanical Documents of Vedic Period

The history of documented Science and Technology in India begins with Harappan phase (2900 - 2800 BC). During this phase intensive agriculture was practised in the Indian subcontinent. Wheat and Barley were grown as spring (rabi) crops and cotton and sesamum as autumnal (kharif) crops. Agriculture equipment like hoes and wooden ploughs must be in use at Mohenjodaro and Harappa

The urban civilization at that time was based on mass production of food grains and agricultural surplus. They also practised mixed crop pattern. There were huge granaries to store the grains. It is almost certain that spinning and weaving were known to Harappans. Probably Harappans were the first in the world to utilize cotton for manufacturing clothes and garments.

The proofs for the presence of these plants during Harappan period remain as excavated plant-remains or as motifs on pottery.

Agriculture had become the main occupation of the people by the Vedic period. The religions and social customs of that time were associated with agriculture. The Vedic Indians were aware of different kinds of grains, irrigation, harvest etc. They had sound knowledge of medicinal plants and effective treatment modalities were prevalent.

The Vedic literature demarcated the body parts of plants into roots, shoot, leaves, branches, flower and fruit. Further, plants were grouped into flowering and non-flowering. *Taittiriyasamhita* and *Atharvaveda* considered that the ecology of a particular area is determined by the plant

The following are the plants known to Harappans:

A.	Cereals	:	Wheat, Barley, Millets and Rice(?)
B.	Leguminous Plants	:	Peas and gram
C.	Oil yielding plants	:	Mustard and sesamum
D.	Fruits	:	Ber, Coconut, Date, Banana, Watermelon, Lemon and Pomegranate
E.	Timber plants	:	Rose wood (*Dalbergia lattifoia*), *Acacia* sp., *Albizzia* sp. *Tectona grandis*, *Adina cordifolia* and *Soymida ferbrifuge*
F.	Fibre-yielding plants	:	Cotton and bast
G.	Dye-yielding plants	:	Madder
H.	Miscellaneous	:	Reed, Bamboo, Neem, Pipal and Palm

community present.

There are a series of flourishing literature in Sanskrit to deal with Medicinal plants. The first authentic work on medicine is the Charaka Samhita written by Charaka in the first century AD. Charaka describes medicinal plants in detail in his book. He reiterates that a physician should be aware of the medicinal plants, both botanically and pharmaceutically. He also proposes the term *Bheshaja vidya* to denote the branch of science, which describes the plant, based on their medicinal properties.

Vrkshayurveda

In *Arthasastra, Agnipurana* and *Brahasamhita* there are separate chapters dealing with Botany. Kautilya's Arthasastra narrates the role of agricultural officer. *Vrkshayurveda* written between BC 100 and AD 100 by Parasara deals exclusively with plants. *Vrkshayuveda* was considered as one of the 64 arts in ancient India. There are also instances in Vedic literature describing the anatomy of plants. *Vrkshayurveda* narrates various transporting vessels (xylem and phloem in modern science) in plants for transporting water and nutrients.

Krishitantra and *Gulma Vrkshayurveda* are the other books of this period dealing with plants. In post-vedic period Botany developed into a separate branch of science.

The plants were believed to germinate from the fertilized seed and were classified into monocotyledonous and dictyledonous types. The role of air, water and climate (temperature) for seed germination was better realized. Parasara explained that the growing plants absorb nourishment initially from the cotyledons and then from the soil.

The criteria adopted by Parasara in *Vrkshayurveda* for classifying plants were more elaborate and scientific compared to those of Manu, Charaka and Susrutha. He classified plants into different *kulas* such as *Sameeganeeya*(Leguminosea), *Pupleekaganeeya*(Rutaceae), *Swasthikaganeeya*(Crusiferae, *Thripushpaganeeya*(Cucurbitaceae), *Mallikaganeeya*(Apocynaceae), *Kurchapushpaganeeya* (Compositae), etc. based on the character of flowers and other morphological peculiarities of plants.

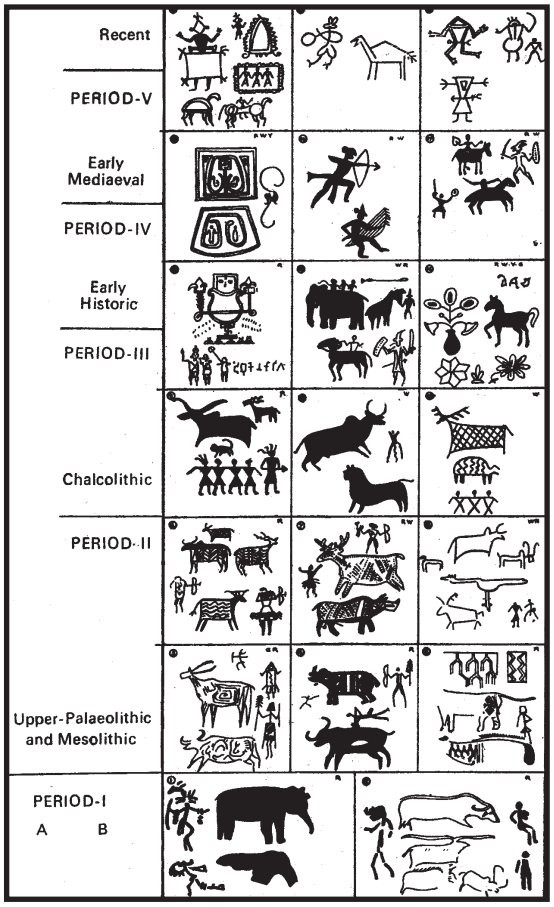
Energy Storage in Plants

Now we know that plants synthesize their own food by the process of Photosynthesis and the food (Chemical energy) is stored in the body. This principle of energy storage in trees was mentioned in *RigVeda* (II, 10-13).

The *Bharatheeya Darsanas* explain that plants possess biological properties such as growth, movement, sleep, diseases, etc.

Phototropism and Plant Breeding

The phenomenon of phototropism in plants is explained in *Charaka Samhitha*. The process of movement of plant parts



CHRONOLOGICAL AND STYLISTIC DEVELOPMENT OF ROCK PAINTINGS IN INDIA

towards sunlight and drooping of leaves in some plants during night were described in ancient literature of medieval period. In *Samarangana Soothradhara* one could find the first written records about the aging process in plants. Plant diseases and their treatment methods were mentioned in *Brahatsamhita* and *Agni Purana*.

The Samhitas in Vedic period also mention various agricultural practices and methods of plant breeding. It was also mentioned that the seed encloses structures of mature plants in a miniature form. Now we realize the role of genes in shaping the characters of organisms.

Grafting

The grafting technique in plant breeding and its procedure for improving the quality of plants were explained for the first time in detail in Varahamihira's *Brahat Samhita* (AD 505).

Taxonomy

Plant taxonomy was relatively well developed in medieval period. The plants were named and classified based on morphological peculiarities, special characters and ecology. Later, Carl Von Linnaeus, the father of modern taxonomy also adopted a similar methodology for classifying plant kingdom.

The ecological requirements of plants were better realized during this period. The soil was classified into various types based on its quality. *Caraka Samhita* categorized different kinds of plants suitable for cultivation in different areas by Debiprasad Chattopadhyaya in his book *History of Science and Technology in Ancient India* (1991) describes that *Uddalaka Aruni* of the Gautama clan was the first nature-scientist in global history as against the popular belief that science began in Ancient Greece with the teaching of the reputed sage called Thales. He was the first person to formulate and apply the essentials of the method of experimental verification.

Agriculture

The rice cultivation became more common during later Vedic period. Apart from rice, wheat, barley and cotton figured among the cultivated crops. Plough, sickle and draught animals were employed in agriculture operations.

Rotation of Crops

The farmers of Vedic period practised rotation of crops. The famous British botanist (also, the father of Indian Botany) William Roxberg opines that this practice came into the West only very late.

In Sarangaradara's *Padhati* (an encyclopedic Sanskrit treatise of the 13th century), a chapter called *'Upavana-Vinoda'*, includes several aspects of plants, Dhanvantri's *Rajanighantu* and Bhavamisra's *Bhavaprakasa* contain much information on medicinal plants.

During Mughal period rice, wheat, barley, millets, pulses, oil seeds, sugar cane and cotton form the major cultivation. Millets were cultivated mainly for feeding cattle. Indigo (*Indigofera tinctoria*) was cultivated during 17th century for making blue dyes. Plants such as Henna (*Lawsonia inermis*) and Al (*Morinda tinctoria*) were also cultivated for manufacturing dyes.

Sweet smelling shrubs, creepers and trees were extensively cultivated in gardens as well as in houses. The cultivation and use of flowers became a part of life style. The flowers were also utilized for making perfumes and cosmetics.

The land that does not yield a good crop was made more productive by growing Egyptian beans in it.

Directions were also given for sowing, to save the seeds from diseases, mixed cropping and grafting to increase the yield, etc. The capacity of agriculture to accept new crops could be gauged through the rapid and extensive cultivation of tobacco, maize and a variety of fruits (cherry, pine apple etc.) during Mughal period. *Tuzuk-i-Jahangiri* contains descriptions of 57 plants.

The Europeans who came to India as traders, adventurers, missionaries and later as colonizers have contributed to the study of biological sciences in India. At the same time original contribution from

India reduced considerably in 16th to 19th centuries because of colonization, political unstability, lack of recognition for scientific pursuits, caste system and tradition-bound nature of people.

Documentations on plants

The Dutch medical doctor Garcia da Orta studied the medicinal plants of Goa and published a book called *Cologuios dos simples e drogas he caucase medicinalis da India* in 1563. A traditional medical practitioner, Itty Achuthan from Kerala, collected numerous plants and provided descriptions. These were compiled, edited with drawings and published by Heinrich Van Reed Drackenstine, the then Governor of Malabar East India Company in his book *Horthus Malabaricus* in 1686 - 1703 period in 12 volumes. This is the first text book dealing with the plants of Kerala more systematically. Linnaeus followed this for classifying Indian plants in his work *Species plantarum*. Dutch scientists such as George Everhand Rumphins, Paul Hermann and John Hermann also published their works on the plants of Kerala.

The plants collection of Hermann were supplied to Linnaeus by the Dannish King. Linnaeus included the details (which contained many new generia) in his work *Flora zealanicum.*

John Gerald Koening, student of Linnaeus, first used Linnaeon classification to Indian plants. First Botanical Garden in India was started at Calcutta by Rober Kead. Later the famous British botanist William Roxberg became the Director of the garden and he prepared a catalog of 3,500 species of plants in the garden. Roxberg was known as Indian Linnaeus. Roxberg made the famous contribution entitled *Plantae Coromandelinae* in 1795 and subsequently was known as the father of Indian Botany. Later in 1814 William Cary published Roxberg's findings in the book *Horthus bengalensis*.

The public interest in India in scientific research, adopting new technologies actually began with the foundation of Asiatic Society in Calcutta in January 1784. An Agricultural Society of India was established in 1820. Through the effort of Asiatic Society, Indian Museum of Calcutta was founded in 1866. It was meant for depositing plant and animal collection and documents related to scientific investigations.

The Indian Association of Cultivation of Science in Calcutta founded in 1876 by Dr. Mahendra Lal Sircar provided laboratory facilities and became one of the foremost scientific research centres in the country. Bombay Natural History Society (1883), Agricultural Society of India (1890) Indian Botanical Society (1920) Botanical Survey of India (1930) and National Academy of Sciences (1938) were the other institutions engaged in botanical investigations.

By the beginning of 20th century, a series of universities and colleges were established in the country. However, science education remained as a dream for majority of Indians. The first Indian contribution on plant sciences came from Jagadeesh Chandra Bose. He fabricated an instrument called crescograph to record very minute growth rate in plants. He studied the responses of stimuli on plant and some nonliving objects and published a book titled *Comparative Electrophysiology* in 1938.

In post independence era, however, the plant sciences became more diversified. New technologies were adopted and employed domestically. As a result of the Green Revolution (thanks to Dr. M.S. Swaminathan) the era of "ship to mouth" or "begging bowl" was over and India is now self-sufficient in food grain production.

Zoological Sciences in Ancient India

The examination of bones from excavation, haematite drawings of animals on rocks, depiction of animals on seal, toys and paintings over pottery reveal the great interest of Harappans on the animals surrounding them. Close observation of nature and peaceful co-existence with fellow organisms enabled them to draw these pictures so precisely. Indepth knowledge of the organism surrounding them and sustainable

utilisation of natural resources were part of their existence.

They successfully domesticated humped and humpless cattle, buffalo, ass, sheep, goat, camel, pig, dog, cat, domestic fowl, black patridge and probably horse in the later days of their civilization. The wildlife depicted on the art material of India's civilization includes rhinoceros, Indian bison, various species of deer, jackal, wolf, tiger and probably lion (The haematite drawings show that rhinos were once distributed throughout the country.) In total 41 species of mammals, 31 species of molluscs, 12 of reptiles, 2 of birds and one coral have been identified. Their interest in fishing is attested by the finding of fish hooks and depiction of fishing nets over the pottery.

In Vedic period animals were categorised based on their morphology and behavioural patterns. Mc Donald and Keith recognised nearly 260 species of animals from Vedic literature.

In *Puranas* python was known as *Ajagar* (one who swallows goat). The Indian koel which deposits egg in the nest of crow was known in ancient classics as *Anyavapa.* The spiders were known as *Oonanabha* as they produce silk fibers from the abdomen. These are some of the examples depicting the close observation of animals by the Vedic Indians. In Rig Veda the croaking of frogs was believed to forecast rain. Similarly, reporting the toxic effect of snake bite and winter sleep of snakes could be located in Rig Veda.

The medical books of Charaka and Susrutha document almost all the animals known till that time. Zoology, human biology, taxonomy, physiology and nutrition are some of the aspects dealt with in these books.

The description of human anatomy given in *Susrutha samhita* is so precise to enable one to do the surgery. The number and arrangement of arteries and veins in human body are mentioned in both *Charaka samhita* and *Susrutha samhita.*

The dissection of animal bodies was almost essential in connection with vedic rituals which eventually led to the better understanding of anatomy. *Sarira-padmini* by Bhaskarabhatta is a work on anatomy.

The digestion of food inside the stomach and the circulation of nutrients in various parts of the body through blood vessels are explained in *Charaka samhita.* It is mentioned in *Mahabharatha* that the food we consume is responsible for maintenance of body temperature (*Agnir nasyathyabhojanath*). According to *Yogavasista* the oxidation of food yields body heat and oxygen is capable of moving through the arteries without any hindrance. These explain the understanding of human physiology during Vedic period.

Veterinary Sciences

Reports also indicate that veterinary science is a very ancient science in India. A classical work on the treatment of elephant is *Gajayurveda* by Palakapya, an ancient sage *Aswa sastra (Aswayurveda)* deals with methodologies for treating horses. Salihotra is supposed to be the first propagator of this science. In *Agnipurana* there is a chapter on the treatment of cattle. Susrutha described fishes based on their morphology and locomotion. Kautilya in *Arthasastra* described various methods of fish culture and capture. Since the concept of *ahimsa* became deep rooted in Jaina-Budha period. *Abhayaranyas* (national parks) were established for the first time to project wild animals.

In post Vedic literature nature and living organisms were narrated beautifully. Though animals were classified into various categories in *Atharva veda* and *Taittiriyasamhita*, a more or less scientific approach was followed in *Chadogyo-panishath* in which animals are classified into *Jeevana* or *Jarayuja* (those born live), *Udbhija* (those formed by budding) and *Andaja* (those formed by hatching from eggs).

In *Manusmrithi* organisms were categorised into *Sthavara* (mobile) and J*angama* (immobile) and the latter was grouped in *Jarayuja, andaja* and *daswetha* (those formed

from the heat and moisture of earth). The great Indian philosopher Prasasthapada classified animals generally into *Ayonija* (asexual) and *Yonija* (sexual).

Development of embryos also aroused interest among Vedic Indians. Probably *Garbhopanishath* is the first book in the world dealing with human development. Susrutha and Charaka believed that fertilized eggs carry the primitive form of all the organisms. They also suggested transmission of hereditory characters. The hypotheses forwarded by Charaka and Susrutha 1,600 to 1,800 years ago without even the support of proper experiments could be compared to the Darwin's theory of evolution.

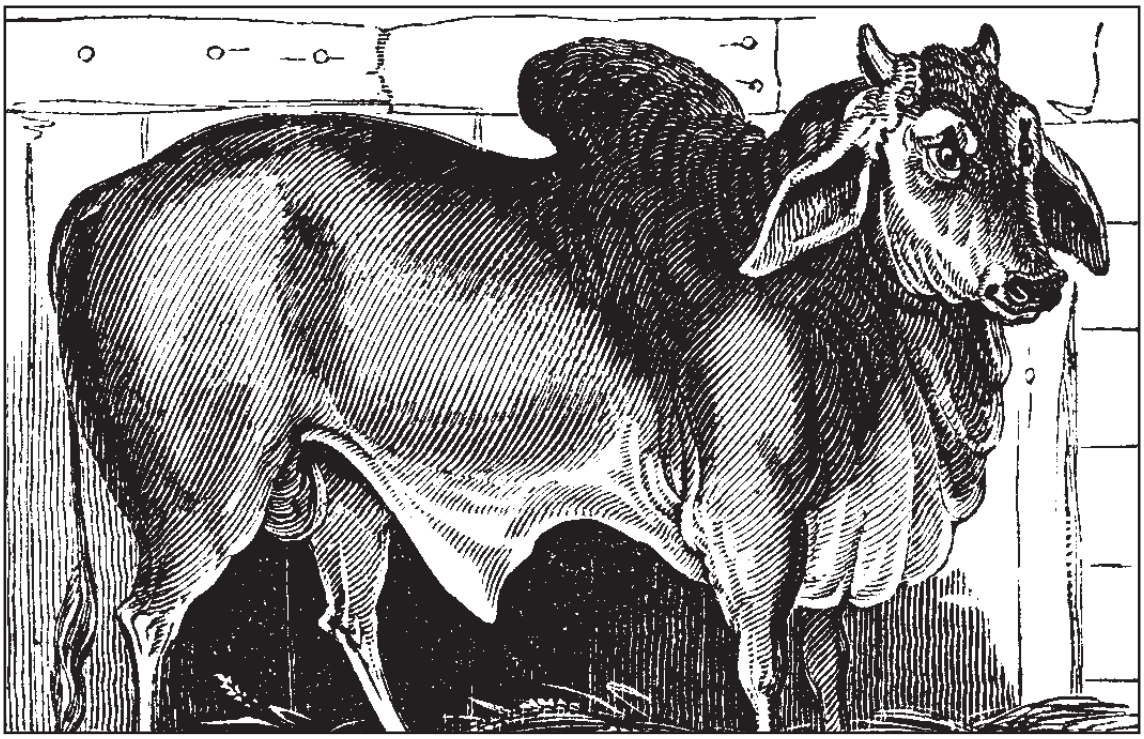
The ideas framed by observing nature and living organism were documented in the Middle Ages. In his book *Manasikollasa* King Somasekhara described sport fishing in a separate chapter. Famous Indian Ichthyologist Hora opined that this book is unique even now.

Mrgapakshisastra by Hamsadeva, (13th century AD) was the only book in this period dealing exclusively with Zoology. It deals with Zoology in 1712 verses describing the characteristics of birds and animals.

Mughal emperors were expert hunters; they had horses, dogs and kites to help them in hunting. Akbar hunted nearly 9,000 cheetahs and ironically, no cheetahs remain in India today. Many mughal emperors kept private zoos.

Animal husbandry was well developed during Mughal period. The breeding was undertaken for elephant, camels, ox, horses, buffaloes, cow, goat and poultry. Jahangir in his book *Tuzuki Jahangiri* explained experiments in breeding animals. He was also interested in storing the information about the animals he found in the form of paintings. Dodo, the extinct Mouritian bird also appeared in the paintings of his period.

Zoological investigations became more scientific by 18th century, i.e., after the invasion of Europeans. However, Zoology was not as much developed as Botany during this period. Asiatic Society and Bombay Natural History Society pioneered zoological



investigations. General Wellesly started a College at Fort William by 19th century for studying animals.

The first comprehensive volume dealing with the fauna of India was published by W.T. Branford and his colleagues in between 1888 and 1891. Investigators such as W. Theobald (molluscs, amphibians and snakes), S.Benson (molluscs), I Hunter (molluscs), G.Neveel (estuarine molluscs), H. Godwin Austin (birds), G.E. Dobson (mammals), McClelland (fishes), A.L. Adams (mammals), Jerdon (birds and mammals), A.O. Hume (birds), Hamilton-Buchanan (mainly fishes), Rond (bears), R.C. Roten (rodents), Moore etc. butterflies), Anderson (rats) and Walsh (spiders and ants) contributed to the understanding of faunal elements in India.

The first authentic book on the fish fauna of India was by Sir Francis Day published during 1875-78. Investigations on the marine ecosystem with the help of research vessel investigators under the leadership of Lt. Colonel Alcock brought to light several marine organisms, particularly corals and crustaceans. He published the research finding in his book "Materials for a Carcinological Fauna of India" in 6 volumes. Even now this remains as a reference book to study the crabs of Indian Ocean.

In the modern era biological sciences underwent drastic transformation and now it is not just Botany and Zoology alone but collusion of various subjects such as physics, chemistry and technology. In the post independent period many individuals and institutions in India started investigating biological sciences in detail. Green revolution, white revolution and blue revolution yielded good results. Yet there are handicaps as even the biological diversity of the country in some ecosystems remain unrecorded. Further, the quality of original research in many fields remain sub-standard.

Table 1
Zoology books published during 19th century from India

Sl No.	Name of Book	Author	Year
1.	Catalog of mammals of Maharashtra	Waltor Eliot	1839
2.	Catalog of Birds	E. Blyth	1852
3.	Mammals	E. Blyth	1863
4.	Birds of India	T. C. Jerdan	1862-63
5.	Stray Feathers	A. O. Hume	1873-88
6.	The Fishes of India	Francis Day	1875-78
7.	Game Bird of India, Burma and Ceylon	Marshall	1879-81
8.	Indian Lepidoptera	Hevinston and Moore	1879-88
9.	Butterflies of India, Burma and Ceylon	Marshall and De Nicenilla	1882-90
10.	Natural History of the Mammalia of India and Ceylon	Sterndale	1884
11.	Avifauna of British India	Murray	1888-90

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Agriculture in India

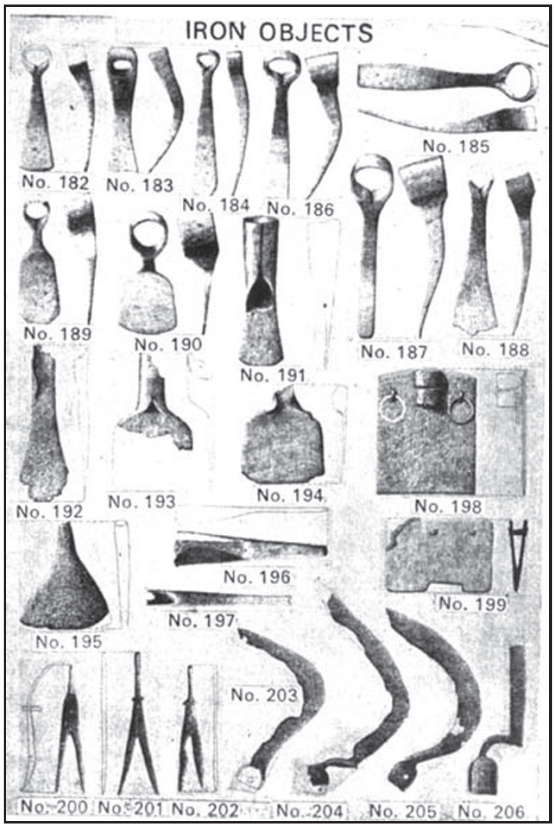
Agriculture is the process of producing food, feed, fiber, fuel and other goods by the systematic raising of plants and animals. It can also be defined as The science, art, and business of cultivating soil, producing crops, and raising livestock; farming. Agriculture was started by man during the neolithic age which is just ten thousand years old. It was agriculture which made man to reside permanently at one place. It was with the beginning of agriculture that domestic life, art and culture, science and so on originated and developed.

Harappan-Mohanjodaro Civilization-the Cradle of World Agriculture.

Mohanjodaro-Harappa is considered as the world's oldest civilization. Evidences from there tells clearly that there was cultivation of wheat, barley, sesamum, datepalm etc. in India thousand of years ago and hence Mohanjodaro is considered as the craddle of world's agriculture. India is the birthplace of cotton cultivation and cotton textiles. The sudden decline of Harappan-Mohanjodaro townships which were the first man made township of the world was due to the destruction of forests also. Varieties of timber trees were grown which were used to make furniture, sailing boats, coffins etc. Burned bricks were made to construct multi storied buildings.

Kasyapa's 'Krishisookthi'

'Krishisookthi' written by Kasyapa is a very ancient book giving detailed information on ancient farming in India. There are several references of the ancient work in Varahamihiras *Brihatsamhita*. *Vrkshayurveda* is an important chapter of *Brihatsamhita*. *Vrkshayurveda* is an authentic document touching the various aspects of farming. We are to perceive Kasyapa's *Krishisookthi* as a basic work forming the foundation of this. It is accepted by all, that the period of *Brihatsamhita* is fifth century B.C. But no one could so far ascertain when the book *Krishi sookthi* was written. If the author of *Krishi sookthi* is the Kasyapa Muni mentioned in Vedas and Purnas, it would be a pre-Vedic period that would suit the work.



IRON OBJECTS USED IN AGRICULTURE (330 BC)

The maize ears recovered from Mexican caves have been officially recognised as belonging to 4400 B.C. Then it must be thousands of years earlier that a group of people from India had migrated there with the original wild species of those maize varieties and American cotton varieties. It must have been after their settlement in their new place of migration that the maize and cotton got subjected to evolutionary changes. When this fact is also taken into account, the dating of India's original agricultural culture will be found to go back to a very distant part. We can only imagine that these evidences are such that would indicate the reality of our "Chathurvarnya" concepts.

Agriculture in the modern India

Agriculture in India is one of the most prominent sectors in its economy. Agriculture and allied sectors like forestry, livestock and fishing accounted for 18.6% of the GDP in 2005 and employed 60% of the country's population[1]. It accounts for 8.56 % of India's exports. About 43 % of India's geographical area is used for agricultural activity. Agriculture is still the back bone of Indian economy and plays a significant role in the overall socio-economic development of India.

India has made lot of progress in agriculture since independence. It has gone through a green revolution, a white revolution, a yellow revolution and a blue revolution. Today, India is the largest producer of milk, fruits, cashewnuts, coconuts and tea in the world. our country is the second largest producer of wheat, vegetables, sugar and fish and the third largest producer of tobacco and rice.

The Agro-climatic zones of India

As India possess a wide variety of geographical features and extreme climates, same crop varieties can't be raised in same pattern in all regions. Moreover, natural factors like flood, drought etc also poses threat to Agriculture hence, agro-climatic zone planning for scientific management of regional resources to meet the food, fiber, fodder and fuel wood is done by scientists. There are such fifteen major zones.

Green revolution

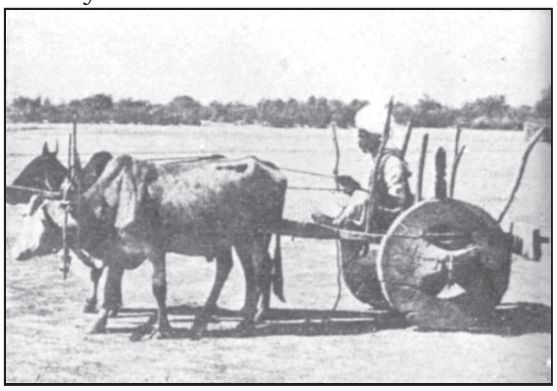
The Green Revolution was the worldwide transformation of agriculture that led to significant increases in agricultural production between the 1940s and 1960s. This transformation occurred as the result of programs of agricultural research,transferring the new technologies like new varieties, new cultivation practices etc. The Green Revolution in Indian agriculture helped food production to increase very much. The "green revolution" has been followed by the "white revolution", "yellow revolution" and then the "blue revolution", leading to an increase in the output of milk, oilseeds and fish and fish products, respectively.

Blue revolution

Today, India is moving ahead with a Blue Revolution, the rapid increase of fish production in small ponds and water bodies, a boon to small farmers, the nation's nutrition and its gross domestic product.

Yellow revolution

India recorded a spectacular increase both in area under oilseeds as well as its production, The production doubled from 11 million tonnes in 1986-87 to 22 million tonnes in 1994-95, thereby justifying the term "yellow revolution"'.



BULLOCK CART USED BY THE HARAPPANS

White revolution

Milk production in the country was stagnant during the 1950s and 1960s, and annual production growth was very low in many years.During the late 1960s, the Government of India initiated major programmes for the dairy sector to achieve self-sufficiency in milk production. Producing milk in rural areas through producer cooperatives and moving processed milk to cities was the main approach. This gave a boost to dairy development and the milk production in India increased very high. It is called White revolution.

As a result of all these, India has achieved great progress in Agriculture. At the same time, the unscientific and greedy way of cultivating crops just to get maximum profit for the farmer has resulted in the destruction of the soil quality and nature itself. Hence, world over, there is a move towards sustainable agriculture. It is defined as agriculture that meets the needs of the current generation while conserving resources for the use of future generations. Under this focus is given to make agriculture nature friendly. Here importance is given to make Agriculture organic.

Organic Agriculture

A concept and practice of agricultural production that focuses on production without the use of synthetic pesticides and fertilizers. This is an agricultural system with minimum damage to nature.

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"How long is a Day?
23 Hours 56 Minutes 4 Seconds 0.1 fractions"

Aryabhata

"23 Hours 56 Minutes 4 Seconds 0.091 fractions"

modern value

Metallurgy in India

The Damascus steel – the world's first high carbon steel – was a product of India known as woortz. Woortz is the English for ukku in Kannada and Telugu, meaning steel. Indian steel was used for making swords and armour in Persia and Arabia in ancient times. The pre Islamic Arab word for sword is 'muhannad' meaning from Hind.

In the early 1800s, Europeans tried to reproduce woortz on an industrial scale. Michael Faraday tried to duplicate the steel by alloying iron with a variety of metals but failed. Some scientists were successful in forging woortz but they still were not able to reproduce its characteristics.

The iron pillar

The rustless wonder called the iron pillar near the Qutabminar at Mehranli in Delhi did not attract the attention of scientists till the second quarter of the 19th century. Scholars consider the pillar to be of early Gupta period (320-495 AD) on ground of paleography, content and language of the inscription on the piller and the style of execution. The pillar was perhaps a standard for supporting an image of Garuda, the bird carrier of Lord Vishnu.

In 1965, the pillar (23 feet and 8 inches high, weighing 6 tones) was dug out for chemical treatment and preservation and reinstalled by embedding the under ground part in a masonry pedestal. Chemical analyses have indicated that the pillar was astonishingly pure or low in carbon compared with modern commercial iron.

Even after 15 centuries of exposure, the excellent state of the iron pillar has amazed scientists all over the world. High phosphorus, low sulphur, low manganese and high slag contents contribute individually and collectively to the good corrosion resistance.

Zinc

Zinc is better known as a constituent of brass. Zinc is very complicated as it is a very volatile material under normal pressure it boils at 907^{O}C. To extract Zinc from its oxide, the oxide must be heated to about 1200^{O}C in dark container for distilling. In an ordinary furnace the Zinc gets vaporized, so there has to be a reducing atmosphere. By an indigenous method of reverse distillation ancient metallurgists saw to it that there was enough carbon to reduce the heat.

Zinc metallurgy traveled from India to China and from there to Europe. As late as 1735, professional chemists in Europe believed that Zinc could not be reduced to metal except in presence of copper. The alchemical texts of the mediaeval period show that the tradition was alive in India.

In 1738, William Champion established the Bristol process to produce metallic Zinc in commercial quantities and got a patent for it. Interestingly, the medialval alchemical text, *Rasaratnasamedaya* describes the same process. down to adding 1.5 per cent common salt to the ore.

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Space Science in India

The world entered the space era in 1957 whenRussia launched the Satellite, Sputnik-I into the orbit.The idea of conquering space has been a long cherished desire of man.

In 1890, Count von Zepplin, a German built a great air ship with a petrol motor attached to it. Upto that time balloons were used for travelling in the air but since they depended on air currents for their movements, they were uncertain and risky to use. The German air ship depended on its big gas bags for keeping it afloat in the air and overcoming the weight of the engines, but was provided with a motor and a propeller that it could be flown in any direction. The air ship remained in the atmosphere for 20 minutes. On landing, it was completely wrecked.

The pioneers in aeroplane construction were two American brothers Wilbur and Orville Wright. In 1903, they made a machine which flew a few metres and two years later, they made a flight of 24 miles at a speed of 38 miles an hour. During World War II, the use of aeroplanes increased rapidly.

The first treatise on air travel is however due to Bharadwaja, who lived during the vedic period. In the work called *Vaimanika prakaranam*, the various factors to be observed in the construction of aeroplanes are described. A large number of commentaries like *Vimanachandrika*, *Vyomayana thanthram*, *Yanthra kalpam, Yana bindu* and *Kheta yana pradeepika* attest to the interest shown by the ancient people for space travel. As early as in 1895, an Indian teacher named Sivakumar Bapuji Thalapathe constructed an aeroplane based on the details described in a book *Rig vedadi Bhashya Bhoomika* written by Maharshy Dayananda Saraswathy. It is said that he made a trial flight in the Chaupathy beach of Bombay.

VIKRAM SARABHAI

The era of space research in India began in 1961 when the Government of India entrusted the subject of space research and the peaceful uses of outer space to the Department of Atomic Energy, headed by Bhabha. In 1962, the Department set up the Indian National Commmittee on Space Research (INCOSPAR) under the Chairmanship of Vikram Sarabhai to organise a national space programme. On November 21st 1963, a two stage rocket called Nike-Apache was launched from Thumba Equatorial Rocket Launching Station near Trivandrum.

Mission	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008
IRS		P4		TES		RESOURCESAT-1	CARTOSAT-1	CARTOSAT-2	OCEANSAT-2	RISAT-1
INSAT	2E	3B		3C		3A 3E		4A 4B	4C 4D	4E
METSAT					KALPANA-1					INSAT-3D
Expt/ Tech Payloads				GSAT-1		GSAT-2	EDUSAT HAMSAT	SRE-1	GSAT-4	GSAT(MK III)
SPACE SCIENCE										CHANDRAYAAN ASTROSAT
PSLV		C2		C3	C4	C5	C6	C7	C8	C9 C10 C11
GSLV-MK I & II				D1		D2	F1		F2 D3 F3	F4 F5
GSLV-MK III										D1

MAJOR INDIAN SPACE MISSIONS 1998 - 2008

In 1969, INCOSPAR was reconstituted as an advisory body under the Indian National Science Academy and a new entity called the Indian Space Research Organisation (ISRO) came into being. In 1972 the Government of India set up the Space Commission and Department of Space under which ISRO was brought. ISRO has the overall responsibility of formulating and implementing programmes concerning space technology. The main objective of the Indian space programme is to provide operational space services for the nation in the fields of communication and remote sensing. These services include telecommunications, TV networking, natural resources survey and management, environment monitoring, meteorological data collection and disaster warning. The space programme also emphasise self-reliance in satellite and launch vehicle technologies.

The first satellite designed and fabricated in India was Aryabhata (360 kg) launched by the then Soviet Union on April 19, 1975. Bhaskara I and II satellites (each 440 kg) which were also launched by the Soviet Union in June 1979 and November 1981 respectively helped ISRO to conduct experiments in earth observation using TV cameras and Radiometers. These satellites were preliminary to the Indian Remote Sensing Satellites (IRS) for surveying and management of national resources.

IRS - IA launched from the Soviet Union on March 17, 1988 weighed 950 kg and carried cameras for gathering data on agriculture, forestry, hydrology etc. IRS - IA has imaged the country many times giving information on India's natural resources. IRS - IB launched from the USSR in August 1991 is similar to IRS -IA. Further a series of remote sensing Satellites were developed and operationalised. The INSAT-I multipurpose satellites have served the needs of the country in telecommunications, nation wide TV coverage, radio networking, metereology and disaster warning. INSAT-1A was followed by INSAT -1B, IC and ID. The INSAT II series is indigenous. The first in the series INSAT II-A (1906 kg) was launched on July 10th 1992. INSAT II-B-was launched into orbit on July 23 rd 1993. Parked in the geostationary orbit INSAT II-B together with INSAT II-A and INSAT 1-D augmented significantly the INSAT space segment capacity for telecommunication, direct TV broadcasting and nation wide TV distribu-

tion etc. Recently INSAT-III Satellites are also operationalised. Specially designed Satellites for education, telemedicine, mapping, search and rescue, global positioning and informations also have been launched. India's capabilities in designing, fabricating and launching satellite launch vehicles have been demonstrated in the three successful launches of SLV (Satellite Launch Vehicles) in 1980, 1981 and 1983 to launch 40 kg Rohini satellites into low earth orbits.

The ASLV (Augmented Satellite Launch Vehicle) is designed for launching Stretched Rohini Satellite series each 100-150 kg into circular low earth orbit. The third launch of ASLV was successfully conducted on May 20, 1992. PSLV (Polar Satellite Launch Vehicle) is designed to launch 1000 kg remote sensing satellites into polar sun synchronous orbit. The GSLV (Geo Synchronous Satellite Launch Vehicle) is able to launch 2500 kg communication satellites into geostationary transfer orbits. The ASLV that was successfully launched used a solid propellant. The first stage of PSLV carried a soild propellant, the second stage carried a liquid propellant, the third stage used a solid propellant and the fourth stage used a liquid propellant. In the GSLV, the two upper stages of the PSLV are replaced by a single cryogenic engine and the six solid propellant strap-on motors by four liquid propellant strap-ons derived from the PSLV II stage. A giant launch vehicle (GSLV-MK III) is under development which can launch 2000 kg class Satellites to geostationary orbit Reusable launch vehicles, manned flights, inter planatory mission like Chandrayaan are also planned as future space programme

An integrated missile development programme as resulted in development of missiles for various purposes. Agni, Akash, Prithvi etc. are some of them. India has now developed an advanced missile "Brahmos" in collaboration with Russia.

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Information Technology In India

Information Technology has been defined as the technology which provides all information about any phenomenon or event taking place anywhere in the universe at anytime to any person, anywhere in the world. Information can be considered as the root cause of the development of the society. Knowledge and ideas are at the heart of development process and are increasingly overshadowing the natural resource base. "Acquiring and adapting global knowledge and creating knowledge locally, investing in human capital to increase the ability to absorb and use knowledge and investing in technologies to facilitate both the acquisition and the absorption of knowledge..." represent the best possible strategy for the overall development of any region or people "because knowledge generation and information processin g are at the roots of a new productivity".

"Although information and knowledge have been critical for the economic accumulation and political power throughout history, it is only under the current technological, social and cultural parameters that they become directly productive forces".

The impact of IT (Information Technology) is so great that it is characterized as the second industrial revolution. It is the chief determinant of the progress of nations communities and individuals. IT is the fastest growing industry in the world and is expanding steadily to become the largest global industry in the world. IT is rated as the "magical technology that combines the skilful hand with the reasoning mind". Information Technology is treated as a strategic industry and is a generic technology. The general misconception is that IT means computers. The fact is that IT is a union of many fields in which computers is only a part.

Internet in India

The Internet in India started of in the late 80's,when the ERNET(Educational and Research Network)initiative with, funding support from Department of Electronics(Do E),Government of India and The United Nations Development Programme(UNDP) was launched. The project involved 5 premiere institutions, The National Centre for Software Technology (NCST) Bombay, Indian Institute of Science (IISc) Bangalore, the 5 IITs and the DoE. While the ERNET has spread its wings and is today a nation wide provider of bandwidth to the education and research community, it is not allowed to provide service to the public, on account of the terms of its charter. The second major networking initiative was the National Informatics Centre(NIC) which set-up a national network connecting most district headquarters. Today NIC interconnects 1400 points in different parts of the country through their network, predominantly based on Very Small Aperture Terminals (VSAT).

For the average citizen The Internet arrived on 15th August 1995, when VSNL (Videsh Sanchar Nigam Limited) launched its gateway services. The opening up of the telecom sector in 1999 saw several new entrances that came up with extremely competitive alternative increasing the user base.

Efforts by governmental agencies to ensured that the common man benefitted from I.T. Initiatives such as the establishment of the computerized reservation systems by the Indian Railways, TWINS (Twin -City

Information System) by the Government of Andhra Pradesh, FRIENDS (Fast, Reliable Instant Efficient Network for Disbursement of Services) by the Department of Information Technology, Government of Kerala, were some of the earliest initiatives in this directon. Today there are many service providers and internet is available in every nook and corner of the country.

Indians in IT

Who were the founders of the Silicon Valley?

Who were involved in the development of popular intellectual software?

Who created the worlds most popular emailing program?

The answers to these queries are Indians.

We Indians have played a pivotal role in shaping the digital revolution from the inception of the transistor till the coming of age of the Internet. Our contributions to the field of Information technology and Computer sciences are so varied and numerous that it would take countless publications to note down each and every one of them.

From the crude counting machines like the abacus to the phenomenal computing monsters like PARAM, we Indians have time and time again showed the world our prowess in this field.

A large proportion of the design team for the development of world-class software packages like windows 9x,Office, Xp had Indians. Statistics have shown that a major chunk of the qualified software engineers and architects in the world are Indians. Some of the technical design teams, which made revolutionary breakthroughs in chip design, were lead by prominent Indian scientists.

Some say we are the most computer literate people in the world, with a large educated middle and upper class, which is equivalent in populations to some entire European countries!

The digital revolution started 40 years ago when the transistor was invented which allowed the possibility of manufacturing small chips with large computing capabilities. As the technology grew the chips got smaller as well as cheaper which in turn allowed the computing power to reach the masses. India being a powerhouse of enterprising intellectual was waiting for the right opportunity to jump at the digital bandwagon. It was just a matter of time, as we lacked the infrastructure. But when it was considered literally impossible for a developing country one where to get a foothold in this industry, we pulled one of the greatest technological surprises by becoming one of the largest software exporters in the world.

India's Super Computer : PARAM - 10000

"The restrictions imposed by the United States of America on the transfer of know-how in frontier areas of Technology, and its consistent refusal to make available to India a range of hardware for its development, have proved to be a blessing in disguise, because Indian scientists and engineers have now managed to develop, indigenously, most of the components and hardware required for its rapidly advancing space and nuclear power programmes.

It was again the refusal of the U.S. administration to clear the shipment to India of a Cray X-MP super computer, for use by the Institute of Sciences (IISc.), Bangalore, in the 1980's, along with severe restrictions on the sale of computers exceeding 2000 Mega Theoretical Operations per Second (MTOPS), that led India to build one of the most powerful super computers in the world. In fact, the unveiling of the "PARAM-10000" super-computer, capable of performing one trillion mathematical calculations per second, stands out as a shining example of how 'restrictions and denials' could be turned into impressive scientific gains.'PARAM' is a Sanskrit word meaning 'supreme'. It is also a handy acronym for parallel machine. For the Pune-based Centre for Development of Advanced Computing (C-DAC), which built this super-computing machine, it was a dream come true.

Karmarkar's Algorithm

When a postman wants to deliver letters he makes mental calculations of the shortest routes so that all letters can be delivered with least time and less effort. But it may not be humanly possible to handle more complex situations like landing and taking off of airplanes in a busy airport after loading and unloading cargoes, delivering variety of goods in diverse places like factories, offices, houses etc. In such situations one has to seek the help of mathematics.

Computers are employed to perform such complex calculations quickly using a set of steps called "Algorithms". Efforts have been on to find algorithms to make computer to do the job fast. It was a dream till a young Indian Narendra Karmarker of AT&T Bell Laboratories discovered an algorithm in 1984.This is now known all over the world as Karmarkar's Algorithm. He was hardly 26 when this discovery was made. Initially many mathematicians did not believe Karmaker.His Algorithm could make computer to perform calculations 50 to 100 times faster. Karmarkar's Algorithm has not only revolutionized the field of computer engineering, but also introduced a new concept in mathematics.

Karmarkar was born in 1958 in Gwalior, M.P. and took Ph.D. from the University of California.Karmarkar had intuitive ability to look into the problem in entirely different manner. At present he is using his knowledge of mathematics to design new supercomputers, which will surpass the speed of existing computers.

The overall development in the society is taking place today on the global level through the synergy of information, knowledge and wisdom of the 6 billion population of the Global Village." Vasudheyva Kutumbakom"-One family of the mother earth which has been the essence of the age old Indian Philosophy is about to materialise. This happy, prosperous, healthy, creative, intellectual family will be the unique outcome of the Information Age.

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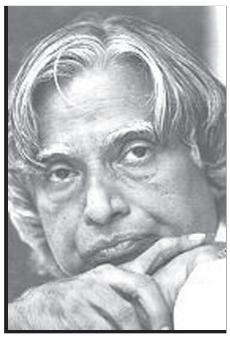
The Scientists of India

A. P. J. ABDUL KALAM

Arul Pakir Jainu-labdeen Abdul Kalam represents a model to millions of Indians. Born in 1931 in Rameswaram, Tamil Nadu, Kalam has a unique career as scientist, technologist and has received the highest Civilian award Bharat Ratna. His book *Vision India 2020* is a remarkable one, which will motivate every Indian to take up journey forward with optimism. His autobiography *Wings of Fire* brings out the best in him as a scientist and a human. In his own words *"it is the story of national aspiration and of cooperative endeavor and the saga of India's search for scientific self-sufficiency and technological competence".* He says: *"We are all born with divine fire in us. Our efforts should be to give wings to this fire and fill the world with the glow of its goodness".*



After graduation from Madras Institute of Technology, Abdul Kalam started his career as Senior Scientific Assistant in the Ministry of Defence in 1958. His team designed and fabricated a hovercraft as a ground equipment machine called Nandi. In 1962, he joined Indian Space Programme and came to Trivandrum to develop the establishment which later grew as VSSC. Abdul Kalam gave leadership in making India's own rocket-launching vehicles, which ranges from SLV to ASLV, PSLV and GSLV. The story of Kalam is the story of Agni, Prithvi, Akash, Trisul and Nag missiles that are now familiar names in India. Kalam leads ascetic vigour of personal life working 18 hours a day.

He established Cardiovascular Institute, Hyderabad which develops cost effective medical devices using indigenous defence technology. At present Dr. Kalam is the President, Government of India.

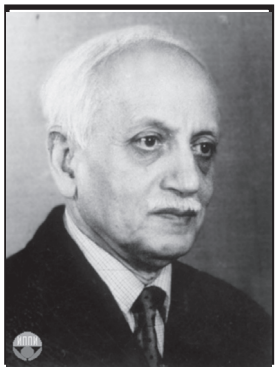
After the successful experiment of Agni in 1989, Abdul Kalam wrote in his diary,

Do not look at Agni
As an entity directed upward
To deter the ominous
Or exhibit your might;
It is fire
In the heart of an Indian
Do not even give it.
The form of a missile
As it clings to the
Burning pride of their nation
And thus is bright

And he wishes "let the latent fire in the heart of every Indian acquire wings, and the glory of their great country light up the sky".

A. S. PAINTAL

We feel tired and breathless when climbing a mountain or multistoried building by stairs. This is a warning that we need rest. If one ignores it, he will die of congestion of lungs called pulmonary congestion. How does our body get such warning? It is the nerve terminals in lungs called Juxta Pulmonary Capillary Receptors or J-Receptors. Similarly, gastrointestinal stretch receptors that warn us when stomach is



full and stop eating or drinking. These important receptors in human body were discovered by Dr. Avtar Singh Paintal, now Director of Vallabhai Patel Chest Institute, Delhi. In 1981, he became the first Indian medical scientist to become FRS. Paintal was born at Mogok, Burma, where his father was a Doctor. After graduating from Lucknow Medical College, Paintal did Ph.D. in 1950 at Edinburgh. In 1954, he joined Patel Chest Institute as Assistant Director. His work on receptors in human body helps to identify persons who will be affected by sickness due to high altitude.

ARYABHATA - I

Aryabhata was born in 476 AD in Kodungallur, Kerala and completed studies in Nalanda of Kusumapura (Patna). At the age of 23, Aryabhata wrote his treatise "*Aryabhatiya*" which deals with mathematics and astronomy. It is said that Aryabhata is only a title given to the scientist who wrote his book in Arya metre. As a recognition to the work, the then Gupta ruler Buddhagupta made him the *Kulapathi* (Head) of Nalanda.

Aryabhata was the first to deduce that the earth is round and that it rotates on its own axis creating day and night. He declared that heavenly bodies like moon and mercury shine due to reflection of sunlight. He also gave the correct explanation for lunar and solar eclipses. Aryabhata used geocentric concept of the universe because observations are made from the earth. He also knew that movements of the sun and stars from east to west are due to rotation of the earth from west to east. To explain "erratic" movements of some of the planets as observed from the earth, Aryabhata made use of the concept of "epicycles" which was superior to the concept put forward by Ptolomy.

Contributions of Aryabhata to the field of Mathematics are valuable. He gave value of (ratio of circumference to diameter of a circle) as 3.1416 describing for the first time that it was only an approximation. Aryabhata also gave for the first time what later on called table of sines (sine is a trignometric ratio).His method to find integer solution to indeterminate equations of the type ax - by = c is now recognized world over. He also devised a method to express numbers using letters (now known in computer science as alpha-numeric system). Aryabhata's astronomical data are used to prepare Indian Calendar called *Panchanga*.

A number of books are now available on *Aryabhatiya* written by experts. Even after 1500 years of it publication, relevance of the book is not yet lost. Experts say that even 1% of the work has, not yet been understood by the present day generation.

It was in appreciation of his scholarly contributions to the field of Mathematics and Astronomy that India's first satellite was named as Aryabhata.

BHASKARA II

Bhaskara was born in 1114 AD at Bijda Bida (Bijapur, Karnataka). He learnt mathematics from his saintly father. He was inspired by the works of Brahmagupta and devoted the entire period of his life to mathematics. At the age of 30, Bhaskara wrote his famous book "Siddantha Siromani". To solace his daughter Lilavati from her personal tragedy, Bhaskara tried to arouse in her an interest in mathematics and made her immortal by titling one of the parts of Siddhantha Siromani as "Lilavati". There has been a popular saying that who so ever is well-versed with " Lilavati" can tell the exact number of leaves on a tree.

One part *of Lilavati* deals with arithmetic while the other three parts called *Bijaganitha*, *Goladhyaya* and *Grahaganitha* deal with algebra, spheres and planetary motions respectively.

Siddantha Siromani was a text book for students to help them to understand the works of Brahmagupta, Mahavira and

Sridhara. The book contains problems presented in such a way as to stimulate the interest of students in mathematics. It was so popular and authoritative that four to five centuries later it was translated twice into Persian.

Bhaskara method called “Chakrawal" or cyclic method to solve algebraic equations is a remarkable contribution. It was only after six centuries that European mathematicians like Galois, Euler and Lagrange rediscovered this method and named as “inverse cyclic”.

Determination of arc and volume of sphere using integral calculus was mentioned for the first time by Bhaskara along with important formulae and theorems in trignometry and permutation and combination. Bhaskara was also the founder of Calculus several centuries before Newton and Leibniz. He had even given an example of what is now called differential coefficient. He also described what is now called "Rolles Theorem" . It is a tragedy that no one in India took notice of the excellent work did by Bhaskara on Calculs. For example he is renowned for his concept of *tatkalik agathi* or instantaneous speed which enabled his astronomers to determine the motion of planets accurately. At the age of 69, Bhaskara wrote “ Karanakuthuhala”, a book on astronomical calculations and is still referred in making calendars.

Bhaskara I (lived in 600 AD) was an astronomer who used solutions of indeterminate equations for solving astronomical problems. His books *Aryabhatiyabhashya* and *Mahabhaskariya* are famous.

Aryabhata I who lived around 950 AD wrote a book called *Mahasidhanta* which deals with three branches of mathematics, called *Pati, Kuttaka* and *Bija.*

BIRBAL SAHNI

Birbal Sahni is a famous palaeobotanist. Palaeobotany is the study of plants of past ages, which was introduced by him in India for the first time. Sahni was born on Nov.1891 at Bhera (Punjab), now in Pakistan. After his studies from Punjab University, he went to Britain in 1911. In 1919, he got D.Sc. from London University. In 1936, Sahni became an FRS. Palaeobotany is a mix of botany and geology. He was the first botanist to study flora at Indian Gondwana. He explored Rajmahal Hills in Bihar which is a treasury of fossils and ancient plants. He discovered new genus of plants like Rajamahalia Paradora. He also discovered new group of fossil gymnosperms (conifers) called pentoxyleae which made him world famous. Some of his palaeobotanical studies have even given support to the continental drift theory. Using palaeobotany he showed that age of salt range is 40-60 million years and not 100 million years as believed. Sahni had interest in archaeology too. He discovered coin moulds in Rohtak in 1936.

BRAHMA GUPTA

Even though the concept of zero was known earlier, it was Brahmagupta who first framed rules of operations with zero systematically. He also gave solutions to indeterminate equation of the type $ax^2+ 1 =y^2$ (which is usually known as Diophantane equation after a 17th century mathematician of the west) and is considered to be the father of a branch of higher mathematics called “Numerical Analysis”. Bhaskara, the great mathematician , conferred on him the title of “Ganakachakra Chudamani". Brahmagupta was born at Bhillamala of Gujarat in 585 AD. He became the court astronomer to King Vyaghramukha belonging to Chapa Dynasty. His famous work is “ Brahmasphuta Siddantha” which is the correct version of earlier astronomical work “Brahma siddhantha”. The work of Brahmagupta was translated to Arabic as “Sind Hind”. For several centuries this book was the standard reference in India and Arab.

“Brahmasphuta siddhantha” contains the details of operations with zero, rules to solve $ax + b =0$ and $x^2+ax^2 + bx + C=O$ and a study of geometric series. Brahmagupta

is the first mathematician to treat arithmatics and algebra as separate branches. Brahmagupta also prepared a handbook of astronomical calculations. He criticized Aryabhata who said that earth was not stationary.

C. K. N. PATEL

Laser is an artificial source of light, which is powerful and highly coherent. It has wide applications in different fields like physics, chemistry and industry. The invention of Ruby Laser by Maiman in 1960 had only limited applications. But it was only by discovery of Carbon Dioxide laser in 1962, that laser found applications in wide variation of fields like industry and medicine. Such laser can cut steel and can be used for bloodless surgery.

Carbon Dioxide laser was discovered by C. K. N.Patel, now the Director of one of the divisions of the prestigious AT &T Bell laboratories in USA. Born on July 2,1938 at Baramati near Pune, Patel went to Stanford University and took Ph.D. in electrical engineering at the age of 23. The same year he joined AT &T and took up the challenge of making a laser. CO_2 laser light is invisible and lies in the infra red region. Its wavelength is 10.6 μm. CO_2 laser can be used for LIDAR and to detect air pollution.

C. R. RAO

Calyampudi Radhakrishna Rao is a renowned statistician. Born on 20th September 1920 at Hadagali in Karnataka, Rao had his schooling at Andhra University and Indian Statistical Institute, Calcutta. Rao became famous when he put forward in 1945 *The Theory of Estimation*, which helps one to find an unknown quantity from a pile of data. His formulae and theorems like *Cramer-Rao Inequality, The Fischer-Rao Theorem* and *Rao-Blackwellisation* are now part of standard statistics text books. Rao's design of experiments explains the technique that assists industry to increase production. His contribution to Biometry is well known in the field of Biology. In 1965, in collaboration with Ronald A Fischer, Rao mapped chromosomes in mice using the technique of statistics. In 1967, he became FRS. His book *Linear Statistical Inference and its Applications* has been translated into several languages. At present he edits *Sankhya*, the highly reputed Indian Statistical Journal.

C. V. RAMAN

Raman was born on November 7, 1888 at Tiruchirappally, Tamil Nadu. He took his MA from Presidency College, Madras. He took up an administrative job in the Finance Ministry in Calcutta. Simultaneously he started research in Physics in the laboratory of Indian Association for Cultivation of Science, Calcutta.

Raman was initially interested in acoustics, the science of sound. He studied Physics of bowed string instruments like violin and percussion instruments like *Mridangam*. He visited London in 1921 and on his return, the blueness of the sea intrigued him. By the time he reached Calcutta, Raman discovered that the blue colour of the sea is due to the scattering of light by water molecules. This was the starting point of his research in optics, the science of light. In 1927, Crompton got Nobel Prize in Physics for his discovery that X-rays change wavelength when scattered by electrons. Raman, along with his student K. S. Krishnan devised an experiment to check similar results for light scattering

with molecules. On March 16, 1928 Raman announced the discovery of new radiation to an audience of Bangalore. He found that when light is scattered by a transparent medium, radiations with frequencies higher and lower than those of original light were obtained. The change in frequency of light is related to energy change taking place in the molecules. Thus the new discovery called *Raman effect* has later on became a tool to study energy states of molecules. Raman got Nobel Prize for Physics in 1930 for his work on scattering of light. Application of Raman effect is found in diverse fields like Physics, Chemistry, Biology, Biochemistry, lasers etc. and it is said that maximum time a scientist's name appearing in literature is that of Raman. With the advent of lasers, studies on Raman effect have further intensified.

In 1924, Raman was elected fellow of the Royal Society. In 1930, Raman became Professor of Physics at Tata Institute, Bangalore (Indian Institute of Science) and in 1943, he founded his own institute, Raman Research Institute in Bangalore. Here he continued his research till his last breath on November 20, 1970. He advised young students "The essence of science is independent thinking and hard work, not equipment". Raman effect is used by thousands of scientists all over the world not only in the study of the structure of molecules and crystals but also to develop new type of lasers called spin flip Raman laser and Raman shifted lasers. Life and work of Raman is an ideal example for those who want to enter the wonderful world of science. Raman's family has provided other scientists also to Nation like Professor. S. Chandrasekhar and Pancharatnam.

CARAKA

Caraka was a physician who lived between 1st century BC and 1st century AD and is famous for his book on Ayurveda, *Caraka Samhita*. It describes topics like physiology, etiology, embryology, etc. Caraka was the first scientist to present the concept of digestion, metabolism and immunity. According to him, body functions since it contains three doshas called *vatham*, *pitham* and *kapham*. Illness is produced when balance among these is disturbed in the body. Medicinal drugs are given to restore the equilibrium of the *doshas*. Caraka also knew about the circulation of blood, with heart as the controlling centre, which is connected to entire body through 13 main channels and countless other big and small channels.

A student of Atreya called Agnivesha wrote a book during 8th century BC on Ayurveda. But it was Caraka who revised this to be known later as *Caraka Samhita* which remained as the standard text on the subject and has been translated to many foreign languages like Arabic and Latin.

D. R. KAPREKAR

A genius does not need formal schooling. An example is Ramanujan. Another example is Dattaraya Ramachandra Kaprekar , who was born on June 17, 1905 at Bombay in a poor family. He inherited astrology from his father and this made Kapraker to enter into the fascinating world of numbers. He made many significant discoveries of which Kapraker constant is best known out side India. In 1927, he won the Wrayler Mathematical Prize for original work in Mathematics. In 1929 he took B.Sc from Ferguson College, Pune and became a school teacher.

Kaprekar is also known for his contribu-

tions to recreational mathematics.

E. C. G. SUDARSHAN

E. C. G. Sudarshan is one of the leading theoretical physicists working in the University of Texas in Austin, USA. Born on September 16, 1931, in Kottayam, Kerala, Sudarshan graduated from Madras Christian College. He joined TIFR and came under the influence of world class physicists like Dirac and Pauli who visited TIFR.

Sudarshan went to Rochester University, USA to work under Professor Marshak on problems of particle physics. One of the famous works he had done during that time was on weak interactions. Somehow he missed the Nobel Prize.

Sudarshan is popularly known for his hypothesis of Tachyons, particles which travel faster than light. No one has yet discovered a tachyon. Narliker has shown that absorption of tachyon by a black hole will reduce the size of the latter. Thus monitoring the reduction in the size of black hole is a method to discover Tachyon.

He has also propounded *Quantum zero paradox*. Sudarshan is one of the physicists who discovered parallels between eastern mysticism and modern science.

G. N. RAMACHANDRAN

In 1952, at the age of 30, G. N. Ramachandran became Head of the Department of Physics of the University of Madras. He had his training under two giants of Physics C.V. Raman and L. Bragg of Cambridge. G. N. Ramachandran is a pioneer in applying X- ray diffraction technique to study the structure of complex protein molecules. He started work on collagen, which is a commonly occurring protein in human body and is formed in connective tissues of skin, bones as well as linings of many organs. Leather, for instance is entirely collagen. He discovered that collagen has triple helical structure and with this discovery he became world famous.

G. N. Ramachandran introduced a new subject of study called Molecular Biophysics in Indian universities and he trained a number of students who became famous later on in this branch of research. His grasp of molecular biophysics was great. His group at Indian Institute of Science, Banglore studied a number of giant molecules like protein, nucleic acid and polysaccharides.

HAR GOBIND KHORANA

Hargobind Khorana is one of those who laid foundations to what is now called genetic engineering. Khorana was born on January 9, 1922 at Raipur, now in Pakistan. After graduating from University of Punjab in Lahore, he went to University of Liverpool, Britain in 1945 to take Ph.D. in Biochemistry. On returning to India, he could not get a job since Biochemistry was still alien to India. When his application for teaching post at University of Delhi was turned down, Khorana decided to go back.

While in British Colombia, Khorana produced a chemical called Coenzyme A in 1957 which is essential for biochemical reactions in human body. He was invited by the University of Wisconsin in USA to join as its faculty member. He became Alfred Solan Professor of Biology and Biochemistry in 1970 at MIT, USA.

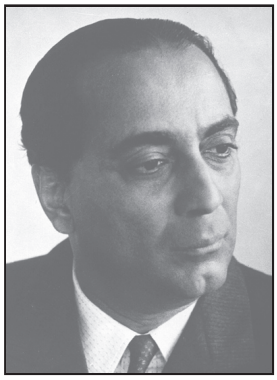
Khorana produced a part of gene of yeast cell in his laboratory which helped him breaking the genetic code. At the age of 46, Khorana shared 1968 Nobel Prize for medicine with Nirenberg and Holley for their contributions in the field of genetic engineering.

Breakthrough came in August 1976. Khorana and his group built up 207 gene of a bacteria *E.coli* (a bacterium living in the intestine of human) and included chemicals which will signal stop and start to the gene. The man made gene was inserted into *E.coli*

and it started working like its natural gene. This achievement is considered as a major triumph of modern biology and stage was set for man to play God. Khorana at present is studying how a gene functions in a cell and how gene alterations can be made. This will help us in understanding genetic defects and methods to correct them. It may also help us to wipe out cancer from the human race.

H.J. BHABHA

Cosmic rays are showers of elementary particles from outer space. In 1937, Homi Jehangir Bhabha and the German physicist W. Heitler studied cosmic rays to solve some of their mysteries. Amongst cosmic rays, Bhabha discovered a new particle called meson. Study of decay time of this particle provided a proof for Einstein's special theory of relativity.



In 1940, Bhabha returned to India and joined Indian Institute of Science, Bangalore. In 1945, with the financial help from Tata, he established Tata Institute of Fundamental Research. He had close association with Nehru, who wanted India to be self sufficient in science and technology. He gave Bhabha a free hand to do whatever he wanted.

In 1948, Bhabha became the founder chairman of Atomic Energy Commission. Three reactors Apsara, Cirus and Zerlina were built under the guidance of Bhabha. Country's first atomic power plant began at Tharapur in 1963 and two years later a plutonium plant was installed. Bhabha showed his countrymen and the world that Indians were second to none in gaining scientific know how. The climax came when on May 18, 1974, a nuclear device for peaceful purpose was exploded at Pokhran in Rajasthan and India became the sixth country to join the nuclear club. Further development showed successful nuclear test including hydrogen fusion at Pokhran on May 11th, 12th and 13th of 1998.

Bhabha also encouraged research in electronics, space science, radio astronomy and microbiology. The radio telescope at Ooty is one of his creations. In 1967, while on a trip to abroad for a conference, Bhabha died in 1967 in a plane crash. Bhabha was only 57 at that time. In 1967 Atomic Energy Establishment at Trombay was renamed as Bhabha Atomic Research Centre.

Bhabha was born on 30 October 1909 in a wealthy Parsi family. He was sent abroad to do engineering. But Bhabha's interest shifted to Physics. He also worked with eminent physicists like Fermi and Pauli.

Bhabha was a bachelor and he used to say that he was married to creativity. He was a first class painter and some of his paintings are preserved in British Art Gallery.

JAHANGIR

Jahangir, son of Akbar was born on 30 August 1569. His mother was the daughter of Raja Bhar Mal of Amber. Jahangir was a famous naturalist or ornithologist. His observations are recorded in *Tuski Jahangiri* (Memoirs of Jahangir). His memoirs are a veritable gazetteer of natural history of India of his day, according to Salim Ali. Even until the 19th century, zoologists were unaware of Jahangir's work. They did not know the gestation period of elephants. Jahangir wrote that it was 18 to 19 months. Jahangir also had interest in science. He used to record lunar and solar eclipses, noted and gathered information regarding the growth and decay of comet tails. He tried to cultivate high altitude tree like sandal and pine in plains.

His catalogue was a faithful description of natural history of the day. With the disintegration of Mughal Empire, those treasures also disappeared.

J. B. S. HALDANE

John Burdon Sanderson Haldane was born on November 5, 1892 at Oxford. His father John Scott Haldane was a physiologist who maintained a laboratory of his own at home. JBS Haldane used to do experiments on himself and this English born Indian biologist preserved this quality till his death. Young Haldane followed his father during hazardous scientific trips. He learnt several languages and had interest in several subjects. He won Russel Prize in Mathematics at the age of 16. Haldane had basic training in humanities but he took up a scientific career. Under the guidance of his father he did research in physiology at Oxford. In 1922, he joined Cambridge to study biochemistry. In 1925, he switched over to Genetics,which fetched him the prestigious FRS in 1932. In 1933, he became the Professor of Genetics in the University College, London.

Haldane made original contributions in diverse subjects like physiology, medicine, evolution, genetics, mathematics, biochemistry and cosmology. According to him an ounce of algebra is worth a ton of verbal argument. He was the first to use mathematics in genetics. He proved the correctness of Darwin's theory of evolution applying mathematics to mutation.

His discovery in biochemistry became the law of enzyme chemistry. Experimenting on himself he studied how CO_2 and ice cold temperature affect breath. This led to the discovery of tetanus.

JBS Haldane was a social worker too. He wrote popular science articles and gave public lectures. He left UK in 1957 and came to live in India, his country of choice for settlement and used to wear dhothi and kurtha instead of western dress. It was the manifold diversity in the flora and fauna, which prompted him to settle here. He was first appointed as Professor at Indian Statistical Institute, Calcutta and later he became the Director of the Genetics and Biometry Laboratory in Bhubaneswar. He died of cancer at the age of 71.

J. C. BOSE

Jagadish Chandra Bose was born on Nov.30, 1858 at Mymensingh, now in Bangaladesh. He is known more for his discovery that "plants and metals have life" than his valuable contribution to the field of radio waves, micro waves and wireless telegraphy.

J. C. Bose took B.Sc. degree and Natural Science tripose from Cambridge, UK and returned to India in 1885 to become a lecturer at Presidency College, Calcutta. Bose was an experimental scientist and invented a number of instruments, which are still in use by a number of scientists all over the world.

It was in 1894 that Bose was inspired by the work of Henrich Hertz on radio waves. In 1895, he invented wireless telegraphy and demonstrated in public, both in India and UK. It was after this that Marconi patented it. It is an irony of fate that Nobel Prize for inventing wireless telegraphy went to Marconi in 1909, even though Bose is rightly called the inventor of telegraphy. IEEE has recently recognised Bose's contribution in wireless telegraphy. He also studied microwaves and their applications in communication and in understanding the structure of materials. One of his devices called the *waveguide* forms an essential component of sophisticated electronic and nuclear equipments at present.

Bose invented a device called *coherer* to detect radio wave. He found that coherer becomes less sensitive after some use. But the sensitivity was regained if the device received some rest. This indicated that metals have feelings and memory. We now call it material fatigue. This made Bose to switch over to the study of plant life. He invented an instrument called *crescograph*, which can magnify movements to that extent that

plant growth can be measured. He discovered that plants have emotions and feelings. Bose showed that plants have small cells, which behave like nerve cells.

Before he died on 23rd November, 1937, Bose founded Bose Institute at Calcutta.

J. V. NARLIKAR

Jayant V. Narliar is one of the astrophysicists who do not believe that the Universe was born with a bigbang. Narlikar along with his teacher Fred Hoyle developed a theory, called *Steady State Theory of the Universe* according to which Universe has neither a beginning nor an end.

Narlikar was born to a family of mathematicians on July 19, 1938 at Kolhapur, Maharashtra. Narlikar went to Cambridge to do research under Hoyle of King's College. After coming to India in 1972, Narlikar became a Professor at TIFR. At present he is the Director of Inter University Centre for Astronomy and Astrophysics at Pune which helps Universities in popularising Astrophysics and Astronomy among students. He is a popular science fiction writer.

K. K. PANDEY

Kamala Kant Pandey is a leading plant geneticist in the world who heads the Genetic Unit, Department of Scientific and Industrial Research, New Zealand.

Pandey was born on 11 December, 1926 at Naranagi. After taking Ph.D. in plant genetics in 1954 from John Innes Institute in London, he went to New Zealand and settled down there. In1975, Pandey discovered a revolutionary technique in plant breeding. We know that gene controls some characteristics of plants (like height and colour). Conventional breeding techniques by crossing two plants, transfers both desirable and undesirable characteristics of the genes of the parents to the offspring. Pandey used nuclear radiation to break genetic material and separated desirable genes from undesirable. This was hailed in New Zealand as the most *important discovery by a New Zealander since Lord Rutherford split the atom.*

Pandey found that the S-gene that governs a plant to self pollinate or cross pollinate is a composition of gene or a super gene. The super gene he discovered is important for evolution of flowering plants and controls the ability of a plant to cross with another species. Pandey used the irradiation technique to change the mechanism of S-gene to alter breeding mechanism of plants. By this method he was able to convert cross pollinating plants to self pollinating ones.

K. S. KRISHNAN

Born on December 4, 1898 in Tamilnadu, K.S.Krishnan had basic education in Madras. In 1920, he joined the Indian Association for Cultivation of Science to do research in Physics under C. V. Raman. Their joined effort resulted into what is called Raman effect. In 1948 he became the first Director of National Physical Laboratory, New Delhi. Krishnan studied the structure of solids. He became an FRS in 1940. Krishnan died in 1961.

KANADA

Kanada was one of those philosophers who probed into the secret of universe and the structure of matter. Kanada, during 600 BC, propagated " Vaiseshika Sutra" which includes atom theory of matter. He gave the name *Paramanu* (atom) to an indivisible entity of matter. According to Kanada *paramanu* does not exist in free state (just

like atoms)nor can it be sensed by human organ.

There are varieties of different *paramanus* as there are different classes of substances (same as elements). An inherent urge makes one *paramanu* to combine with another to produce new substances (the modem concept of molecules).

Idea of chemical change was also put forward by Kanada. He claimed that heat brings out change. He asserted that everything is made of *paramanus* and they combine in various ways.

M. K. VAINU BAPPU

Vainu Bappu's name will always be remembered in the history of modern Indian astronomy. He is the first Indian astronomer whose name is linked to a comet Bappu-Bok-New Kirk. Born on 10 August, 1927 at Madras, Vainu Bappu had colourful college days. He did higher education in Astronomy at Harvard in 1949, where he along with B. J. Bok and G. New Kirk discovered a comet and studied its details.

At Mount Palomar Observatory, USA, Bappu with Colin C. Wilson discovered a relationship between luminosity of a type of stars and the spectral property of light emitted by them. This effect now known as Bappu- Wilson effect is currently used by astronomers for the study of stars.

With brilliant career in astronomy Bappu returned to India without accepting jobs in USA. To his surprise he did not get a job for one year. Without losing heart, he tried to pull on and finally got a job at UP State Observatory and later became the Director of Kodaikanal Observatory. He succeeded to establish the Indian Institute of Astrophysics at Banglore. His ambition of setting up a powerful 2.34m telescope was materialised only in 1986, four years after his death. The Kavalur observatory is dedicated to the memory of Vainu Bappu.

M. N. SAHA

Meghnad Saha is famous for his discovery of Ionisation formula, which explained the nature of light, emitted by sun and stars. Saha was born in Dacca on October 6, 1893. His father was a grocer who barely managed to keep his family from starvation. After winning a scholarship, Saha joined Presidency College, Calcutta, where he was not only taught by eminent teachers like J.C. Bose and P.C. Ray but also had brilliant classmates like S. N. Bose and P.C. Mahalanobis who became famous in due course. Saha stood second in M.Sc. (first place went to S.N. Bose). Due to his association with nationalists like Subhash Chandra Bose, he was not allowed to take up government job.

M.N.Saha earned his living by taking tution. In 1917 Saha and S.N. Bose became lecturers at the newly started University College of Science in Calcutta. He taught latest topics like thermodynamics, atomic theory and relativity. His book *The Treatise on Heat* is still regarded as a bible in the subject.

At the age of 25, Saha discovered the secret of light emitted by stars. Saha's ionization formula has enabled astronomers to know the temperature, pressure and other aspects of interior sun and stars. This formula was a breakthrough in astrophysics and astronomers called it twelfth major discovery in astrophysics.

In 1927, Saha became an FRS. He joined Allahabad University and began research in spectroscopy, the study of light emitted by atoms and molecules. Saha founded an institute for nuclear physics in 1948 which is now known as Saha Institute of Nuclear Physics. Saha was also a social worker and was fearless and frank in his criticism of some government policies. He had full faith in industrialization and was against the back to village movement. He studied the

origin and control of floods and suggested a number of river valley projects, which included Damodar valley, Bhakranangal and Hirakud. In 1952, he was elected as an M.P. that also was with a wide margin. M.N. Saha died on February 16,1956.

M. S. SWAMINATHAN

Mankombu Sambasivan Swaminathan was destined to start green revolution in India during 60's. Swaminathan was born on August 7, 1925. He took Ph.D. from School of Agriculture in Cambridge in 1952. He developed HYV of wheat and rice and succeeded in crossing potato and jute species. He worked under Nobel Laureate N. E. Borlang and developed new variety called Mexican Dwarf wheat variety, which solved the wheat scarcity. In 1973, he became FRS. He was the Director of International Rice Research Institute, Philippines.

At present he is Chairman of M.S. Swaminathan Research Foundation, Chennai. He is the first agriculture scientist to win Albert Einstein World Science Award in 1986.

NAGARJUNA

Nagarjuna was born at Fort Daihak near Somnath in Gujarat in 931 AD. He was a chemist in its most modern sense. His book " Rasaratnakara" is written in the form of dialogue between himself and gods.

Rasaratnakara deals with preparations of *rasa* (Mercury) compounds, principles of chemical metallurgy, extraction of metals like silver, gold, tin, copper etc. from their ores and their purification. The process of distillation, liquefaction, sublimation and roasting are also mentioned along with proper instruments to be employed. Nagarjuna describes technique to produce gold-like substances which shine.

Nagarjuna also wrote a supplement to Susrutha Samhitha called *Uttharatantra* which deals with preparation of medicinal drugs. His books *Arogyamanjari*, *Yogasara* and *Yogasatak* are also famous.

NARENDRA KARMARKAR

When a postman wants to deliver letters, he makes mental calculations of the shortest routes so that all letters can be delivered with least time and less effort. But it may not be humanly possible to handle more complex situations like landing and taking off of airplanes in a busy airport after loading and unloading cargoes, delivering variety of goods in diverse places like factories, offices, houses etc. In such situations one has to seek the help of mathematics.

Computers are employed to perform such complex calculations quickly using a set of steps called "Algorithms". Efforts have been on to find algorithm to make computer to do the job fast. It was a dream till a young Indian Narendra Karmarkar of AT & T Bell laboratories discovered an algorithm in 1984. This is now known all over the world as Karmarkar's algorithm. He was hardly 26 when this discovery was made. Initially many mathematicians did not believe Karmarkar. His algorithm can make computer to perform calculations 50-100 times faster. Karmarkar's algorithm has not only revolutionised the field of computer engineering but also introduced a new concept in mathematics.

Karmakar was born in 1958 in Gwalior, M.P. and took Ph.D. from the University of California. Karmarkar had intuitive ability to look into the problem in entirely different manner. At present he is using his knowledge of mathematics to design new super computers which will surpass the speed of existing computers.

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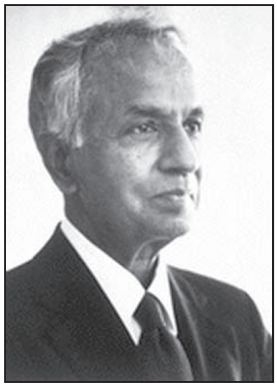
PATANJALI

Although Upanishads and Atharva Veda mention yoga, it was Patanjali, during 2nd century BC, who described its fundamentals and techniques in a self contained book called "Yoga Sutra". Yoga contains eight stages called *Yama* (universal moral commandments), *Niyama* (self purification), *Asana* (postures), *Pranayama* (breath-control), *Pratyahara*(withdrawal of mind from the external), *Dharana* (concentration), *Dhyana* (meditation) and *Samadhi*. Yoga can also be employed to cure disease through what is now known as Yoga therapy.

Recently scientists have recognized the powers of Yoga in improving the quality of human life. Researches are being carried out all over the world to understand and tap the potentialities of Yoga.

S. CHANDRASEKHAR

The name of Chandrasekhar is immortalised by the term *Chandrasekhar limit* which is important in astrophysics. If the mass of a star is more than 1.44 times that of the sun, it will, instead of changing to white dwarf towards the end of its life, explode to form supernova. The restriction of mass to 1.44 solar mass for white dwarf to be stable is called *Chandrasekhar limit*.



S. Chandrasekhar was born on October 19, 1910 and was a nephew of C. V. Raman. Before he was 18, Chandrasekhar started publishing research papers. By the time he completed studies in Presidency College, Madras, many of his research papers appeared in international physics journals. At the age of 27, his reputation as famous astrophysicist had been established. Contemporary astronomers and astrophysicists including Eddington did not accept the epoch making discoveries of Chandrasekhar. Hence by 1935, even though he came close to speculate the formation of black holes, he left the subject and went to USA in 1937. Director of Yekes Observatories invited him to join there.

Chandrasekhar's various discoveries on stars are now text book materials. His approach to the problems was such that no room would be left for further studies. In 1946, he used to drive 160 km from Wiscorgim to University of Chicago to teach a class of two students, Tsung Dao Lee and Chen Ning Yang. In 1957, whole of his class got Nobel Prize in Physics. Yet the teacher had to wait till 1983, to receive the coveted prize for his studies on stars. The name of Chandrasekhar is immortalised by the term *Chandrasekhar Limit* which is important in astrophysics. If the mass of a star is more than 1.44 times that of the Sun, it will, instead of changing to white dwarf towards the end of its life, explode to form Supernova. The restriction of mass to 1.44 Solar mass for white dwarf to be stable is called ***Chandrasekhar Limit.*** Chandrasekhar passed away on August 21, 1995.

S. RAMANUJAN

Sreenivasa Ramanujan was born at Kumbha-konam, Tamil Nadu in December 1887. From early childhood, he proved himself as a mathematical prodigy. At the age of 13, he got Loney's Trignometry from a college library. Not only did he master the book, but also discovered many mathematical theorems and formulae, which were not given in the book. Later on he found that great mathematicians had discovered them much earlier.

A turn in his life came when one of his friends showed him Synopsis of Elementary Results in Pure and Applied Mathematics

written by Carr. This book triggered the genius of the fifteen year old Ramanujan. Ideas flodded in his mind and he could not write all of them. Before he went abroad, he filled three notebooks, which later became Ramanujan's Frayed Notebooks. Even today mathematicians are doing research on results given in them.

Ramanujan could not complete F. A. examination (equivalent to present Predegree) in college since he neglected other subjects like History, English and Physiology. The disappointed father saw the boy scribbling numbers and not doing much else. He thought the boy had gone mad. He forced Ramanujan to marry 8 year old Janaki. Ramanujan, now married was badly in need of a job. He needed about 2000 sheets of paper every month. Ramanujan used scraps of sheets found in the street. Sometimes, he used red pen to write over what was written in blue ink on pieces of paper he picked up.

He went to many offices saying that he knew mathematics and could do clerical job. He showed the Frayed notebooks as proof. But, no one understood him. Francis Spring, Director of Madras Port Trust was impressed and gave him a clerical job on a monthly salary of Rs. 25. Gradually his fame spread. On May 1, 1913, Madras University granted him fellowship of Rs.75 per month though he had no qualifying degree. Ramanujan had sent a letter to the famous mathematician Hardy of Cambridge, in which he included 120 theorems and formulae. Hardy found that most of them were discovered earlier. He along with his colleague J. E. Littlewood understood that they discovered a genius. They invited Ramanujan to Cambridge in March 1914.

In 1918 February 28, Ramanujan became an FRS and became the first Indian to be a fellow of Trinity College. Hardy Ramanujan Littlewood Circle Method in number theory, Ragar Ramanujan identity in partition of integers and similar others in number theory and algebra of inequalities are famous. His work on continued fractions is considered to be equal in importance to that of great mathematicians like Euler and Jacobi.

The famous Ramanujan Number 1729 is an example of the smallest number which can be written as a sum of cubes in two different ways:

$1^3 + 12^3 = 1 + 1728 = 1729$

$10^3 + 9^3 = 1000 + 729 = 1729$

Tuberculosis made Ramanujan to return to India. He died on April 26, 1920 at Chetpet in Madras.

S. K. MITRA

Sisir Kumar Mitra is well known for his study of ionosphere. Born on October 24, 1890 in Calcutta, Mitra had a chance to watch J C Bose and P C Ray engaged in laboratory and this influenced him to take up radio science as his career. Thanks to his untiring efforts, the subject of electronics and radio communication gained importance in India. Mitra discovered that UV radiation from the sun produced E-layer of the ionosphere. His book on Upper atmosphere is a treatise on the subject, which received worldwide appreciation. In 1958 Mitra became an FRS. He died on August 13, 1963 at the age of 73.

S. N. BOSE

The name of Sathyendra Nath Bose has become a part of Physics, when he discovered a new type of statistics obeyed by certain particles like particles, photons (quanta of light)etc. while changing their energy states. The elementary particles obeying what is called Bose-Einstein particles are called Bosons. Einstein in 1925 even predicted a new type of phenomenon, which is later on known as Bose-Einstein condensation. About 70 years later scientists produced Bose-Einstein conden-

sation in the laboratory by cooling nitrogen gas to nano Kelvin temperature. It is said to be the coherent form of matter.

S. N. Bose was born on January 1,1894. Teachers used to give him 110 out of 100 in mathematics. In 1916 he along with Saha became Lecturers in Physics at the University College in Calcutta. Both studied German language so that they could read papers written by famous scientists. They translated Einstein's paper from German to English. When Saha went abroad Bose moved to Dacca University. There, one of his friends presented Bose with a copy of Max Planck's famous book on Thermodynamics and Heat. This book contained the original work of Max Planck including quantisation of light. While solving a problem handled by Plank, Bose found certain approximation suggested by Plank. At the age of thirty, Bose found an alternative and elegant way of working at the same problem to arrive at what is known as Planck's formula for black body radiation. His paper was rejected by Indian and foreign research journals. In desperation Bose sent his paper to Albert Einstein in 1924. The daring concept put forward by Bose impressed Einstein who himself translated the paper into German with a comment "An important forward step". The paper was published by German journal *Zeitschrift fur Physik*. Einstein extended the work of Bose to other fields and thus gave birth to what is termed as Bose-Einstein Statistics. However, Bose did not get much recognition. He even had to get a letter from Einstein to make his job secure. Only in 1958 that he became an FRS.

Bose realised the importance of popularisation of science amongst the masses. He urged scientists to write in mother tongue.

To mark the golden jubilee of the discovery of *Bose Statistics,* an International Seminar was held in Calcutta, in which Bose said that he had no desire to live any longer as his work was being recognised world wide. A month later on 4th February 1974 he died leaving a half-finished problem relating to theory of numbers on his table.

S. S. BHATNAGAR

Shanti Swarup Bhatnagar was a scientist who established a number of national laboratories with the blessings of Pandit Nehru. These laboratories are now considered as the temples of modern India. Bhatnagar was born on February 21, 1894 at Shahpur now in Pakistan. He took D.Sc. from London University in 1921 in the field of chemical engineering where he did excellent work on emulsions and their characteristics. Emulsions are mixtures of inseparable liquids which may sometimes create problems under practical situations. Returning from London, Bhatnagar joined Punjab University in Lahore (now in Pakistan) where he solved major problem for a British Company while drilling for oil near Rawalpindi. The mud that was drilled out became hard and rocky and drilling came to a standstill. Mud problem which is a type of colloid was studied by Bhatnagar who advised the company to add an Indian gum to the mud drilled out. The gum made the mud less viscous which did not allow it to harden. This quick and simple solution saved company from heavy loss. The reward of the company was donated by Bhatnagar to Punjab University.

Bhatnagar's contributions to magneto chemistry are also valuable. The famous Bhatnagar Mathur Interference Balance used for such studies is being manufactured by a British firm for worldwide sale.

During World War II, Government of India made Bhatnagar, the Director of what later became CSIR. The purpose of the council was to utilise scientific results of laboratories in industries to produce

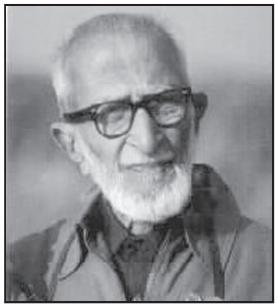
better results. In his laboratory, Bhatnagar produced anti gas cloths, unburstable containers and plastics from waste. He became FRS in 1943.

After independence, Bhatnagar laid foundation for science and technology, with the encouragement of Nehru. He was responsible for installing oil refineries, metal purification plants, survey system for atomic mineral exploration and petroleum department.

Before his death on June 1,1955, Bhatnagar established 12 National Laboratories to give modern facilities to fresh graduates for doing research without going abroad. In his name, CSIR awards every year Shanti Swarup Bhatnagar Prize for Science and Technology to scientists below 45 years for their outstanding contributions in science and technology.

SALIM ALI

Salim Moizuddin Abdul Ali was a famous ornithologist who loved birds till his last breath. He was born on Nov.12, 1896.



He did not complete university education because of his dislike for mathematics especially algebra and logarithm. He went to Burma to help his brother in mining. There also he was a failure. Returning home, he did a course in Zoology and became a guide at the museum of Bombay Natural History Society. He went to Germany for advanced training but when came back he was jobless because the post occupied by him was abolished. By this time he was a married man and was in dare need for a job. Luckily his wife had a small income and could support him. They moved to a small house at Kihim across the harbour where there was a colony of weaverbirds on a tree near his house. Only very little was known about this kind of bird at that time. Three to four months observation made Salim Ali to publish detailed findings on weaverbirds which brought him recognition in the field of ornithology. His study on racket-tailed drongo and discovery of Finn's Baya at Kumad hills brought him fame. In 1941, he wrote The Book of Indian Birds, which helped even laymen to spot birds exactly.

In 1948, he published ten volumes of the book "Handbook of Birds of India and Pakistan", which is the authentic book in this field till present. Salim Ali visited the Thekkadi Bird Sanctuary in Kerala a number of times and identified many migrating birds there. He also wrote a book, "Birds of Kerala. Salim Ali died in 1987.

SAMBHU NATH DE

Sambhu Nath De was a medical doctor who also did research - a rare combination - to discover the basic cause of Cholera. De was born in 1915 in Garibati near Calcutta. After taking Ph.D. from the University of London, he joined Nilratan Sircar Medical College, where he did research to understand the cause of Cholera. Since 1883, people believed in the discovery of Robert Koch that Cholera was due to bacteria and it enter the human body through food.

He discovered a technique to create some symptoms in rabbits as observed in Cholera infected humans. He found that Cholera is caused not by bacteria but by a poisonous substance "enterotoxin" that bacteria secreted in the conditions available in the digestive tract of human body. This discovery was published in the prestigious British Journal "Nature" in 1959. Today, it is hailed as a corner stone of research of Cholera all over the world.

SUSRUTA

Susruta's lifetime is during 6th century BC and was a descendent of Visvamitra. He

learnt surgery from Dhanvanthari at Varanasi. He became an authority in surgery and other branches of medicine.

Susruta was the first to carryout Plastic Surgery. An international seminar on Susruta's technique of Plastic Surgery was organized in California during mid seventies. Susruta was the first physician to advocate what is now known as "Caesarian"operation. He was expert in removing urinary stones, locating and treating fractures and doing eye operations for cataract. He put forth the concept of asepsis several years before Joseph Lister. His suggestion to give wine to patients before operation makes him the father of anesthesia.

Susruta's work "Susruta Samhita" is relevant even today. In this book, he lists 101 types of surgical instruments. His samdamsa yantras are first forms of modern surgeon's spring forceps, dissection and dressing forceps. His crocodile forceps and hawksbill forceps are adopted even today.

Susruta Samhita was translated into Arabic in 8th century AD as *Kitab-i- Susrud.*

SAWAI JAI SINGH II

Jai Singh II was born at 1686 in Amber Fort, Jaipur. At the age of 13, he became the king of Amber. Emperor Aurangzeb honoured him with the title, '*Sawai'* meaning that he was a quarter more than a man. Jai Singh patronised four *Jantar Mantar* (observatories) in New Delhi, Jaipur, Varanasi and Ujjain. *Jantar Mantar* means instruments and formulae.

In 1727, Jai Singh planned capital Jaipur which shows his skill in town planning and architecture. He collected books, treatises, tables etc. on astronomy that included Ptolomi's Almagest. Jai Singh got telescopes later in life.

In 1724, first Jantar Mantar was built in Delhi and in 1734 he published his observation in Persian title *Zij Muhammad Shahi.* Later on he made other Jantar *Mantars.* He designed instruments by himself which included *Samrat yantra* and *Rama yantra* and he made his observatory available to anybody who was interested in studying astronomy, thereby making science popular.

Two fundamental contributions of Jai Singh are the measurement of the precession of equinoxes and the measurement of obliquity of eclips.

VARAHAMIHIRA

Varahamihira was born in 499AD at Kapitha near Ujjain. His father Adityadasa taught him astrology. Mihira (who later on became Varahamihira) was inspired by Aryabhata when they met at Kusumapuram. This meeting made Mihira to decide on taking up astrology and mathematics as his subjects of studies.

Vikramaditya made Varahamihira one of the nine Gems in his court. He travelled as far as Greece. He died in 587 AD. Varahamihira was not a blind believer. He was a true scholar like Aryabhata. He was the first to claim that some "force" might be keeping the bodies to fall and to stick on the surface of earth (similar to force of gravity). Varahamihira made a number of observations in the field of ecology, hydrology and geology. His discovery that certain types of plants and termites serve as indicators of underground water is now receiving attention in the scientific world. His mastery of Sanskrit grammar and poetic abilities enabled him to express ideas in a unique style.

Varahamihira's famous works are *Panchasiddhantika*, *Brihatsamhita* and *Brihatjataka* which put him on a high pedestal in astrology as Kautilya in political philosophy, Manu in law and Panini in grammar.

He had many progressive ideas. He gave scientific explanation for the eclipse and methodology for identifying underground

water sources by observing the species of trees, shrubs and grass.

VIKRAM SARABHAI

Sarabhai was born on August 12, 1919 in a wealthy family. After his studies on cosmic rays in U K, Sarabhai returned to India and founded Physical Research Laboratory in Ahammedabad, an institute devoted to the study of cosmic rays and outer space. In 1955, he set up a branch of the laboratory at Gulmar (Kashmir), Trivandrum and Kodaikanal. P R L provides the technology and scientists needed for country's space programme.

Sarabhai established I. S. R O. Amongst a number of projects he planned, included India's first satellite (Aryabhatta, launched in 1975) and the Satellite Instructional Television Experiment (SITE). However, he could not see his dreams, fulfilled since he died prematurely at the age of 52. Sarabhai established a number of institutions devoted to modernisation of textile industries, development of management skills and another to popularise science.

The International Astronomical Union named after him a crater on the moon in the Sea of Serenity.

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"We have made significant achievements in the last fifty years in food production, health sector, higher education, media and mass communication, industrial infrastructure, information technology, science and technology and defence. Our nation is endowed with natural resources, vibrant people and traditional value system. In spite of these resources, a number of our people are below the poverty line, undernourished and lack primary education… Along with speedy development aimed at elimination of poverty and unemployment, national security has to be recognised by every Indian as a national priority. Indeed, making India strong and self –reliant –economically, socially-is our foremost duty to our motherland and to us and to our future generations."

A.P.J. Abdul Kalam

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"A scientist does not belong to a particular nation. He belongs to the whole world. The doors of science should be kept open to all those who work for the welfare of humanity."

Homi Jehangir Bhabha

SPECIAL TOPIC-1

VEDIC MATHEMATICS

1.1 Profile on Swamiji:

His Holiness Jagadguru Sankaracarya Sri Bharati Krsna Tirthaji Maharaja

HIS HOLINESS JAGADGURU SANKARACARYA SRI BHARATI KRSNA TIRTHAJI MAHARAJA is a magnificent and divine personality who gracefully adorned the famous Govardhan Math, Puri. His research achievements in the field of Vedic Mathematics and his devotion to the service of humanity are boundless.

Education

His Holiness, better known among his disciples by the beloved name 'Jagadguruji' or 'Gurudeva', was born of highly learned and pious parents in March, 1884. His father, Sri. P.Narasimha Shastri, was in service as a Tahsildar at Tinnivelly (Madras Presidency). Jagadguruji, named as Venkatraman in his early days, was an exceptionally brilliant student. He was a student of National College, Trichanapalli; Church Missionary Society College, Tinnivelli and Hindu College, Tinnivelli. He was extraordinarily proficient in Sanskrit and on account of this he was awarded the title of 'Saraswati' by the Madras Saskrit Association in July, 1899 when he was still in his 16th year.

After winning the highest place in the B.A Examination, Sri Venktaraman Saraswati appeared at the M.A. Examination of the American College of Sciences, Rochester, New York, form Bombay Centre in 1903; and in 1904 at the age of twenty he passed M.A Examination in seven subjects simultaneously securing the highest honours in all, which is perhaps the all-time world record of academic brilliance. His subjects included Sanskrit, Philosophy, English, Mathematics, History and Science. As a student, Venkatraman was marked for his splendid brilliance, superb retentive memory and ever-insatiable curiosity. Study of the latest researchers and discoveries in modern science continued to be Sri Jagadguruji's hobby till his very last days.

Study of science of science

His deepest attraction was the study and practice of the science of science -the holy ancient Indian spiritual science or Adhyatma-Vidya. In 1908, therefore, he proceeded to the Sringeri Math in Mysore to lay himself at the feet of the renowned late Jagadguru Shankaracharya Maharaj Sri Satcidananda Sivbhinava Nrisimha Bharati Swami.

He devoted several years for the advanced studies on Vedanta Philosophy and practice of the Brahma-sadhana. After several years of the most advanced studies, deepest meditation, and highest spiritual attainment, Prof. Venkatraman Saraswati was initiated into the holy order of Samnyasa at Banarras (Varanasi) by his Holiness Jagadguru Sankaracharya Sri Trivikraman Tirthaji Maharaj of Sharadapeeth on the 4th July 1919 and on this occasion he was given the new name, Swami Bharati Krsna Tirtha.

Within two years of his stay in the holy order, he proved his unique suitability for being installed on the pontifical throne of Sharada Peetha Sankaracharya and accordingly in 1921, he was so installed with all the formal ceremonies. His winning personality, his charming innocence, his eager

thirst for knowledge, his religious zeal, his earnest belief in the *"sastras"*, his universal kindness, his retentive memory, all these attracted towards him every living soul that came in contact with him.

1.2 Mathematical Application

Vedic Mathematics was written by Sri Bharati Krsna Tirthaji. It forms a class by itself. It is based on 16 Sutras and 13 auxiliary sutras. It has wider applications than Trachtenberg Speed Mathematics. It does not just deal with numbers, but also with advanced mathematical theories including calculus, solving differenciation and integration problems. It unfolds a new method of approach. It relates to the truth of numbers and magnitude applicable to all sciences and arts. Bharat, our Motherland, is gifted with the teachers and revelations of scientific truth by our ancient sages and rishis, from pre-historic period, Vedas.

Fundamentals of Vedic Mathematics:

Base System

Perhaps you may be aware that the decimal system of numbers is an Indian contribution. In this system the values of digits are assigned in powers of 10.

For example, the number 231 has 3 digits. The values assigned to the digits are shown as

10^2	10^1	10^0
2	3	1

"Nikhilam"

Nikhilam sutra stipulates subtraction of a number from the nearest power of 10 ie 10, 100, 1000 etc.

Consider the following results:

Number	Base	Nikhilam
9	10	1
97	100	03
882	1000	118
9786	10,000	0214

The powers of 10 from which the difference is calculated are called Bases. These numbers are considered to be references to find out whether given number is less or more than the base.

If the given number is 104, the nearest power of 10 is 100 and is the base. Hence the difference between the base and number is 4, which is positive it is called "NIKHILAM". The value of Nikhilam may be positive or negative considering 100 as the reference base, the Nikhilam of 87 is -13 and that of 113 is +13 respectively.

Ex:

- Nikhilam of 998 is -002.
  (998-1000 is -2 and 10^3 has 3 zeros; so-2 is written as -002)

- Nikhilam of 104 is +04.
- ,, 107 is +07

	Number	Base	Nikhilam
i.	12	10	+2
ii.	112	10^2	+12
iii.	91	10^2	-09
iv.	975	10^3	-025
v.	10008	10^4	+0008

(Note: No of '0's in base and no. of digits in Nikhilam should be equal)

Nikhilam Sutra –Multiplication

Nikhilam sutra can be used for several mathematical operations. To multiply 2 numbers close to power of 10 easy method:

i)
	03	103
	04	104
	103+	03
	4	04

i) 100-base
ii) (Difference or Nikhilam)
iii) Add I number and 2nd nikhilam
ie. 103 + 4 = 107 is I part of product.
iv) Multiply 03 x 04 = 12 is II part
answer is 10,712.

ii) 106 x
102

100 12

i) base is 100
ii) Nikhilams are +06 and +02
iii) part is 106 + 02 =108
iv) II part is 06x 02 = 12
Product is 10812.

iii
```
105 x      +05
104        +04
-----------------
105+04     05x04
109        20
```

iv
```
104 x
102
-----------
104+       04x
02         02
-----------
106        08
```

(Note: 10^2 has 2 Zeros; So II part - the product of nikhilams should be 2 digit number)

v
```
103 x
103
-----------
103+       03 x
03         09
-----------
```

```
106          09
```
vi
```
1005 x
1012
-----------
1005       005 x
+12        012
-----------
1017       060
```

(10^3 has 3 Zeros so II part should be 3 digits)

viii
```
10008 x
100025
-------------
10033, 0200
```

How easy!!!!

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"Scientists are often accused of living in the 'Ivory Tower' and not troubling their mind with realities and apart from my association with political movements in my juvenile years, I had lived in ivory tower up to 1930. But science and technology are as to the country in my own humble way."

Meghnad Saha

SPECIAL TOPIC-2

ENVIRONMENTAL POLLUTION

Pollutants may be defined as the substances present in the environment in harmful concentrations. They are often the residues of the materials we make, use or throw away. For example, smoke from industries and automobiles, sewage (waste matter) from houses and hotels, radioactive substances from nuclear plants, and discarded household articles are the common pollutants. However, all pollutants are not waste materials. Nitrogen and phosphorus are used to enrich the soil for increased crop yields, but pollute the water if present in excess.

Classification

The pollutants are classified from different points of view.

A. According to their existence in nature, they may be quantitative or qualitative.

1. *Quantitative Pollutants:* These are the substances, which normally occur in nature but are also added in large quantities by man. For instance: carbon dioxide. It is always present in the air, and is also released by industries and automobiles.

2. *Qualitative Pollutants:* These are the substances that do not occur in nature but are added by man. The insecticides, for example, are qualitative pollutants.

B. According to their natural disposal, the pollutants may be biodegradable or nondegradable.

1. *Biodegradable Pollutants:* These are quickly degraded by natural means. Sewage and heat are pollutants of this category.

2. *Nondegradable Pollutants:* These are not degraded or are degraded very slowly in nature. D.D.T., arsenic and plastics are the pollutants of this category. These pollutants accumulate and may get biologically magnified as they pass through the food chains.

C. According to the form in which they persist after release into the environment. The pollutants may be primary or secondary.

1. Primary Pollutants: These persist in the form in which they are added to the environment. Plastic wares are primary pollutants.

2. Secondary Pollutants: These are formed from the primary pollutants. For example, two primary pollutants, namely, nitrogen oxides and hydrocarbon, from motor vehicles, react in the presence of sunlight to form two secondary pollutants, viz., Peroxy Acyl Nitrate (PAN) and ozone. These are more toxic than the primary pollutants. This phenomenon of increased toxicity by reaction among the pollutants is called synergism.

Types of Pollution: Pollution is of five main types: Atmospheric or Air Pollution, Water Pollution, Soil and Landscape Pollution, Radioactive Pollution and Noise Pollution.

Definitions

Atmospheric or Air Pollution: Air pollution refers to the release into the atmosphere of materials that are harmful to man, other animals, plants and buildings or other objects.

Water Pollution: Water pollution is defined as the addition of some foreign substance (organic, inorganic, biological or radiological) to water, or change in its physical property (heat) that constitutes a health hazard or otherwise makes it less fit

or unfit for use.

Soil and Landscape Pollution: Alteration in soil causing reduced productivity is called soil pollution. Here, soil productivity includes both the quantity and the quality of the produce.

Radioactive pollution: Radioactive Pollution is the physical pollution of air, water and soil with radioactive materials.

Noise Pollution: Noise pollution is the result of modern industrialized urban life and congestion.

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"Progress in every country depends mainly on the education of its people. Without education, we are a nation of children. The difference between one man and another, apart from birth and social position, consists in the extent of knowledge, general and practical, acquired by him. We may safely assume that man in all countries within certain limits start with the same degree of intelligence. A civilized nation is distinguished from an uncivilised one by extent of its acquired intelligence and skill."

"The Indian mind needs to be familiarized with the principles of modern progress, a universal impulse for enquiry and enterprise awakened, and earnest thinking and effort promoted. A new type of Indian citizenship purposeful, progressive and self respecting should be created, and self-reliant nationhood developed".

Mokshagundam Visvesvaraya.

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"If there was been any success in my life that was built on the unshakable foundation of failure....."

J.C. Bose

SPECIAL TOPIC-3

SOME SALIENT CONTRIBUTIONS OF INDIA

- India invented the number system. Zero was invented by Aryabhata.
- India never invaded any country in her last 10,000 years of history.
- The world's first university was established in Takshasila, in 700 BC. More than 10,500 students from all over the world had come there to study more than 60 subjects there.
- The University of Nalanda, built in the 4^{th} century BC was one of the greatest achievements of ancient India in the field of education.
- Sanskrit is the mother of all European languages. Sanskrit is the most suitable language for computer software (A report in *Forbes Magazine* July 1987).
- Ayurveda is the earliest school of medicine known to human race. *Caraka,* the father of medicine consolidated Ayurveda 2,500 years ago. Today Ayurveda is fast regaining its rightful place in our civilization.
- Although modern images of India often show poverty and lack of development, India was the richest country on the earth until the British invasion in the early 17^{th} century.
- The art of navigation was emerged in the river Sind 6,000 years ago. The very world Navigation is derived from the Sanskrit word *Navgathi.* The word *Navy* is also derived from Sanskrit *Nou.*
- Bhaskaracharya calculated the time taken by earth to orbit the sun hundreds of years before the astronomer Smart. Time taken by the earth to orbit the sun, according to Bhaskaracharya is 365.258756484 days.
- The value of π was first calculated by Budhayana and he explained the concept of what is now known as Pythagorian theorem. In 1999 British scholars officially published that Budhayan's works dates to the 6^{th} Century, which is long before the European mathematicians.
- Algebra, trigonometry and calculus came from India. Quadratic equation was by Sridharacharya in the 11^{th} century. The largest numbers the Greeks and Romans used were 10^6 whereas Indians used numbers as big as 10^{53} with specific names as early as 5000 BC during the Vedic period. Even today, the largest number used is tera = 10^{12} .
- According to the Gemological Institute of America, till 1896, India was the only source for diamonds to the world.
- USA based Institute of Electronics and Electrical Engineers(IEEE) has proved among the world scientific community that the pioneer of wireless communication was Prof. Jagadish Chandra Bose and not Marconi.
- Chess was invented in India.
- Susruta is the father of surgery. 2,600 years ago he along with other health scientists of his time conducted complicated surgeries like cesareans, cataract, artificial limbs, fractures, urinary stones and even plastic surgery & brain surgery. Usage of anesthesia was well known in ancient India. Over 125 surgical equipment were used.
- When many cultures were only nomadic forest dwellers, Indians established Harappan culture in Indus valley.
- The place value system (decimal system) was developed in India in 100 BC.
- Who is the co-founder of Sun Microsystems? Vinod Khosla (Ref: CBS 60

Minutes 03/02/03)

- Who is the creator of the Pentium chip (needs no introduction as 90% of today's computers run on it) Vinod Dahm.
- Who is the third richest man on the world? Azim Premji (According to the latest report in Fortune Magazine, it is Azim Premji, who is CEO of Wipro Industries.)
- Who is the founder and creator of Hotmail (the world's No.1 web based email program)? Sabeer Bhatia.
- Who is the president of AT & T-Bell Labs(AT & T-Bell Labs is the creator of program languages such as C, C++, Unix to name a few)? Arun Netravalli.
- Who is the GM of Hewlett Packard? Rajiv Gupta.
- Who is the new MTD (Microsoft Testing Director) of Windows 2000, responsible for ironing out all initial problems? Sanjay Tejwrika.
- Who are the Chief Executives of Citibank, Mckensey Stanchart? Victor Menezes, Rajat Gupta, and Rana Talwar.
- 38% of doctors in USA are Indians.
- 12% scientist in USA are Indians
- 36% of NASA scientists are Indians.
- 34% of Microsoft employees are Indians.
- 28% of IBM employees are Indians.
- 17% of INTEL scientists are Indians.
- 13% of XEROX employees are Indians.

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"I have always been associated with many prominent figures eminent in other ways, but Dr. S.S. Bhatnagar was a special combination of many things, added to which was a tremendous energy with an enthusiasm to achieve things. The result was he left a record of achievement which was truly remarkable. I can truly say that but for Dr. Bhatnagar you could not have seen today the chain of national laboratories."

Jawaharlal Nehru

Special Topic-4

Atomic Energy in India

Homi Jehangir Bhabha, the prime architect of the Indian nuclear programme initiated effort in March 1944 to start nuclear research programmes in India so that *"When nuclear energy has been successfully applied for power production in, say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at hand".*

After Bhabha's observation, the feasibility of achieving a self sustaining nuclear chain reaction was established by Fermi in Chicago and this fact was a kept secret known only to a very limited number of individuals in USA, UK and China. Even the discovery of nuclear fission was hardly five years old at that time. Very few believed at that time that nuclear fission would provide economically viable electrical power before the end of the century. Bhabha realised that nuclear energy is of utmost importance for the industrial development of India.

Nuclear research was started with the establishment of the Tata Institute of Fundamental Research (TIFR) in 1945 with Bhabha as its first Director. Work directly related to the exploitation of nuclear energy for the benefit of India was started with the passing of the Atomic Energy Act in April 1948 and the setting of the Atomic Energy Commission a few months later in August 1948. On January 3, 1954 the Atomic Energy Commission decided to set up the atomic energy establishment at Trombay where some work on atomic minerals was already under way. During the period 1948-54 the Atomic Energy Commission functioned with in the Ministry of Natural Resources and Scientific Research. On August 3, 1954, the Department of Atomic Energy (DAE) was created with Dr. Bhabha as the Secretary to the Government of India for the Department. The Department was under the direct charge of the Prime Minister. With the creation of the Atomic Energy Establishment, Trombay (AEET), all the scientists working on programmes of direct relevance to applications of nuclear power were transferred from TIFR and became part of AEET. AEET was formally inaugurated by Jawaharlal Nehru on January 20, 1957. In 1967, the then Prime Minister Indira Gandhi renamed it as Bhabha Atomic Research Centre (BARC).

India conducted the first nuclear explosion test on May 11,1974 in the Pokhran desert of Rajasthan. It was a Plutonium fission bomb. The second test also was in Pokhran which included fission and fusion types. On May 11, 1998, three explosions were tested which consisted of a thermonuclear device, a fission and a sub kiloton device. Two more nuclear devices experimented two days later were sub kilo types.

India has built reactors for the production of power. They are at Tharapur, Kota, Kalpakam, Narora and Kakrapur.

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